

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

Central and Eastern European CCS Roadmap

[Integrated Policy Roadmap]

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Aim of the roadmap: to prepare a first-of-its-kind Central and Eastern European (CEE) policy roadmap to support successful CCS deployment across the region. It should set a course for a broader political discussion and engagement of CEE national-level policy-makers into EU-level initiatives and platforms. It falls under a broader integrated policy roadmap, which consists of three separate reports focused on CCS deployment: (1) this policy roadmap developed by the Institute for European Integration with the support from the EUROPEUM Institute for European Policy; (2) a roadmap for regional cooperation initiatives prepared by WiseEuropa and (3) an analytical input on the links between the CEE policy roadmap and the European-level initiatives prepared by The Bellona Foundation.

Scope: An executive summary of the national policy roadmaps covers 10 countries of the CEE region. The summary roadmap does not include all the detailed information, such details remain part of the national roadmaps.

Target group: European and national policy-makers, public and private CCS stakeholders, research institutions, financial institutions and civil society.

Note: Due to the current situation, Ukraine is excluded from the scope of this roadmap. Our thoughts and prayers are with Ukraine.

[1] Next and immediate steps

Executive summary

There are several key elements to enable successful CCS deployment in the CEE region. This policy roadmap outlines necessary actions to be implemented by 2050, with a particular focus to accelerate these actions in the current decade to deliver net-zero climate targets. The report summarises 21 short-term actions that stakeholders deem critical, which will be further elaborated and implemented in the next stage of our project (Work Package 5).

Each CEE country faces its own legal challenges to fully enable CCS development, including amendments to respective national acts that transpose the EU CCS Directive, missing CCS aspects in the main energy and climate-related governmental strategies and/or a need to eliminate CO₂ storage bans in selected countries. For the latter, these selected governments are recommended at the minimum to consider allowing the utilisation of depleted oil and gas fields for safe and permanent CO₂ storage.

Even though CO₂ utilisation is not a core focus of the project, many carbon capture projects will not materialise without a market for CO₂ as feedstock or final product. CO₂ utilisation should however be limited only to applications that do not lead to the later release of CO₂, such as carbonation and mineralisation. To address that, there is a need for further unresolved regulative aspects for low-carbon products and different types of production (such as blue hydrogen) to be assessed closely in connection with the CCU guidelines proposed by the European Commission. Governments should consult the European Commission on that in order to better understand what CCU can be considered a “storage” option.

Our first important recommended milestone is launching CCS-dedicated platforms as one voice of CCS in the country, which will focus on generating and disseminating knowledge and engaging in advocacy. Currently, no CEE country operates such a platform. This is particularly urgent considering that no government representative is currently directly responsible for the CCS agenda, which further delays projects going online.

There is a lack of engagement with international fora and initiatives. While governments are members of some of these initiatives (e.g., the EU SET-Plan CCUS) and companies are represented by their mother company (e.g., the EU ZEP), there is no active engagement and further dissemination of knowledge to broader stakeholders in CEE. Our second important recommended milestone is actively engaging in existing fora and initiatives and building networks to access knowledge and finance. Governments should be motivated to focus on capacity and knowledge building and increase the research interest in the area of industrial collaboration, such as cluster or hub formation with the right incentives and support for infrastructure development.

The built-up knowledge through the CCS platform and engagement in the international fora and initiatives should enable more informed decision-making processes, which are our next important recommended milestone: the inclusion of CCS into national decarbonisation strategies, finalisation of required amendments to align the regulations with EU Directives and operationalising such strategy by developing enabling regulatory and financial frameworks.

Fiscal policy should be set up to support pilot and demonstration projects. While R&D receives support across the region, a pilot/demonstration stage is usually left to private finance. CO₂ transport and storage projects should also be co-financed from public funds, in addition to EU funding.

In line with operationalizing the decarbonisation strategy, more research and public finance should be targeted at updating local CO₂ storage potential and establishing a national CO₂ atlas covering in-depth the potential uses of depleted oil and gas fields and saline aquifers, including incentivising oil and gas companies to inspect the potential of almost depleted fields for future CO₂ storage. Technical and sustainability aspects and readiness of the CCS value chain would require thorough monitoring by the government. Our final recommended milestone is to develop nuanced communication strategies to increase public awareness and acceptance to enable accelerated CCS deployment.

The list below represents a complete list of 21 actions we propose and further elaborate in Chapter [5] *Policy roadmap for the scaled-up deployment of CCS and its related technologies in the CEE*.

Scaling up RD&D activities and building national knowledge and experience

- Launch national CCS platforms to advocate for CCS deployment in the CEE with one voice.
- Scale up stakeholder activities in the international CCS networks and initiatives.
- Governments should incentivise research within CCS clusters and identify new networks.
- Public finance should go beyond R&D activities and support pilot and demonstration projects.
- Further support for storage exploration is needed with a focus on potential of saline aquifers.
- Multi-level cooperation for transport and storage requires foremost governments actions.

Policy, standards and regulations

- Re-assess the role of and include CCS in the national development and strategic documents.
- Proper guidance and dissemination of already existing standards for CCS is key.
- Regulation must be amended to address critical aspects of CO₂ transport and storage.
- Industrial associations should develop sector-specific decarbonisation pathways.
- CO₂ market opportunities and instruments must be carefully examined and disseminated.
- Governments should strive for resilience through interministerial and multipartisan groups.

Stakeholder engagement, cooperation & know-how dissemination

- Common aim of the CCS platform should lead to closer cooperation and shared values.
- Local cooperation, cross-border initiatives and international projects all play their role.
- Corporate partnerships and joint ventures should develop the CO₂ market.

Social aspects and public support

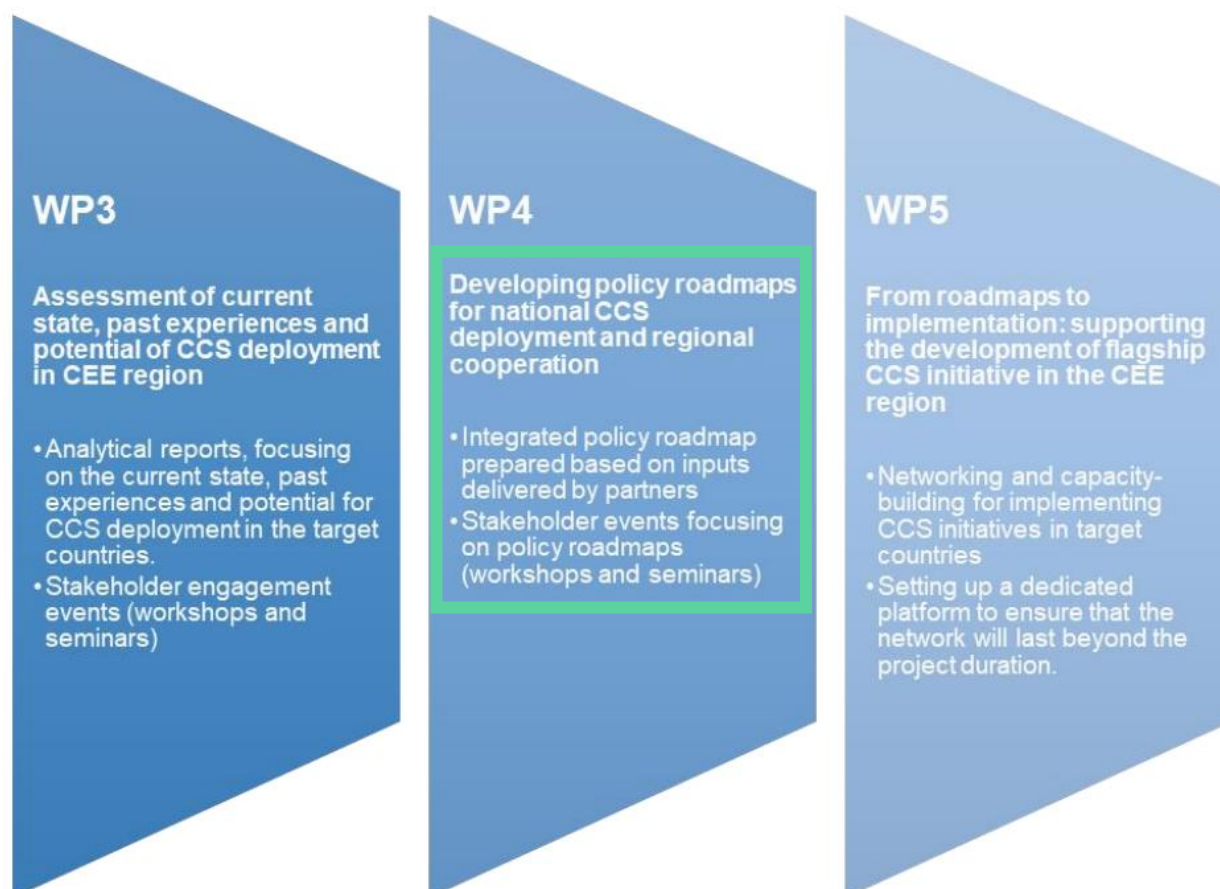
- The nature of CO₂, its transport and storage operations should be explained in simple words.
- CCS must be promoted as one of the decarbonisation and climate change mitigation tools.
- No community should be left out of discussions on CCS deployment.
- Government should strive for full transparency of pros and cons of CCS technologies.
- Local and regional context matters, especially in the industrial and Just Transition regions.
- Governments should involve third parties to avoid CCS debate becoming politicized.

[2] CCS4CEE project overview

The “*Building momentum for the long-term CCS deployment in the CEE region*” project (CCS4CEE) aims to reinvigorate discussions and engage stakeholders on the potential of long-term deployment of CCS in the CEE region. Building evidence-based consensus among key stakeholders will pave the way to designing concrete policies, enabling regulatory frameworks and joint ventures. This requires a combination of analytical work with outreach, communication and capacity-building activities in the form of a series of national and regional publications and events advancing CCS deployment and international cooperation.

The project targets national and local policymakers, the private sector, research institutions and civil society and seeks their support for a socially acceptable mix of appropriate policies, enabling regulatory frameworks, financial instruments, RD&D and deployment activities. The project will ultimately benefit the CEE societies by supporting the implementation of CCS technologies and infrastructure necessary for a smooth transition to a low-carbon future.

Figure 1: Main work packages (WP) of the CCS4CEE project¹



¹ https://ccs4cee.eu/wp-content/uploads/2021/11/PUBLICATION_CCS4CEE-Summary-report.pdf

The project is formed of three main work packages that run in sequence across a period of three years (2020-2023). Intended outcomes of the project include improved stakeholder communication at the national and regional level, concrete plans for national or regional pilot projects and input into policy-making to accelerate the deployment of CCS projects in CEE countries.

Work package 3 (WP3) assessed the current state of CCS in CEE countries through desk research and stakeholder engagement (interviews and workshops with relevant stakeholders). Each country partner produced a national report on the current state and the outlook for CCS, which were then synthesised into a summary report.

In Work Package 4 (WP4) each partner prepared a national policy roadmap which was subsequently discussed at national workshops with relevant stakeholders and its final version presented in national seminars. A workshop in Brussels in the fall of 2022 will aim for an international audience and will provide a project overview and present all roadmaps. The workshop is partially designed as a matchmaking event to bring CEE stakeholders closer to other regional and European-level initiatives focused on CCS deployment.

See WP3 reports on the current state, past experience and potential for CCS deployment in the CEE region:

- All national reports included in the previous work package – [WP3](#)
- Focus on CCS development in the CEE region – [Summary report](#) – Energy Policy Group
- CCS technologies and the EU policy framework – [Summary report](#) – Bellona Europa
- Regional cooperation for CCS – [Summary report](#) – WiseEuropa

See WP4 national CCS roadmaps:

- [Croatia](#)
- [Estonia](#)
- [Latvia](#)
- [Poland](#)
- [Slovakia](#)
- [Czechia](#)
- [Hungary](#)
- [Lithuania](#)
- [Romania](#)
- [Slovenia](#)

The CCS4CEE project is led by WiseEuropa and supported by Bellona Foundation as an expert partner. The project is funded by the EEA and Norway Grants Fund for Regional Cooperation. Other partners include Energy Policy Group, Institute for European Integration and Civitta Latvija. The project is supported by the EUROPEUM Institute for European Policy.

[3] Role of CCS in decarbonisation pathways

CCS technological perspective

In 2019, the EU launched the European Green Deal to transform the EU into a modern, resource-efficient and competitive economy, cut greenhouse gas (GHG) emissions by at least 55% by 2030 and reach net-zero GHG emissions by 2050. Many 1.5°C compatible scenarios have assessed these targets and shown that a credible but narrow pathway exists and will require the use of all decarbonisation tools available. **Renewables and energy efficiency** are key components of that pathway, accounting for 80% of emissions reductions. But to reach net-zero emissions, renewables and energy efficiency **need to be supplemented by CO₂ capture and storage (CCS), utilisation (CCU) and carbon dioxide removal (CDR)** (particularly bioenergy with CCS/CCU also known as BECCS/BECCU) **technologies** (Figure 2), particularly in sectors such as cement, chemicals, iron and steel, waste incineration, and power and heat production. To address emissions from other sources as well as historic emissions, the role of direct air capture with storage (DACCS) or utilisation (DACCU) should be further explored. While these technologies are distinct in some ways, they use the same components of the value chain: CO₂ transport, storage and utilisation. Together they can mitigate **20% of global CO₂ emissions**, but to do so, **the scale of their deployment has to increase significantly** (Figure 3) from the current 0.04 gigatonnes (Gt) of CO₂ per year to approximately 8.5 Gt of CO₂ per year in 2050².

The **benefit of CDR processes is that they remove CO₂ from the atmosphere**, not simply reduce what was added and in combination with long-term storage can result in negative emissions. As such **they are a critical component of net-zero pathways** in the European Green Deal and most recently in line with the COP26 Glasgow Climate Pact. There are however preconditions to be assessed, such as biomass for BECCS needs to be sourced sustainably, while DACCS requires access to abundant and low-cost renewable energy.

The pace of progress in validating and deploying these technologies across sectors has been slow to date and in many cases with significant cost overruns. Currently, CCS, CCU and CDR plants **globally capture 40 megatonnes (Mt) of CO₂ per year**³, with **many more being developed. An increasing number of pilot and demonstration projects** focus on safety issues, environmental impacts and costs, and generate lessons learned to be used to further improve these technologies and bring their costs down.

To remain on track to reach net-zero emissions by 2050, activities and changes to the current status quo have to be significantly accelerated already in the current decade. That requires **activities at the national and regional levels to enhance the collective understanding** of the issues surrounding CCS, CCU and CDR, **build confidence** and massively **scale up CCS deployment to reduce costs** of these technologies and related infrastructure.

² https://irena.org/-/media/Files/IRENA/Agency/Technical-Papers/IRENA_Capturing_Carbon_2021.pdf

³ Ibid.

Figure 2: Carbon cycle with the use of CCS/CCU, BECCS/BECCU and DACCS/DACCU technologies⁴

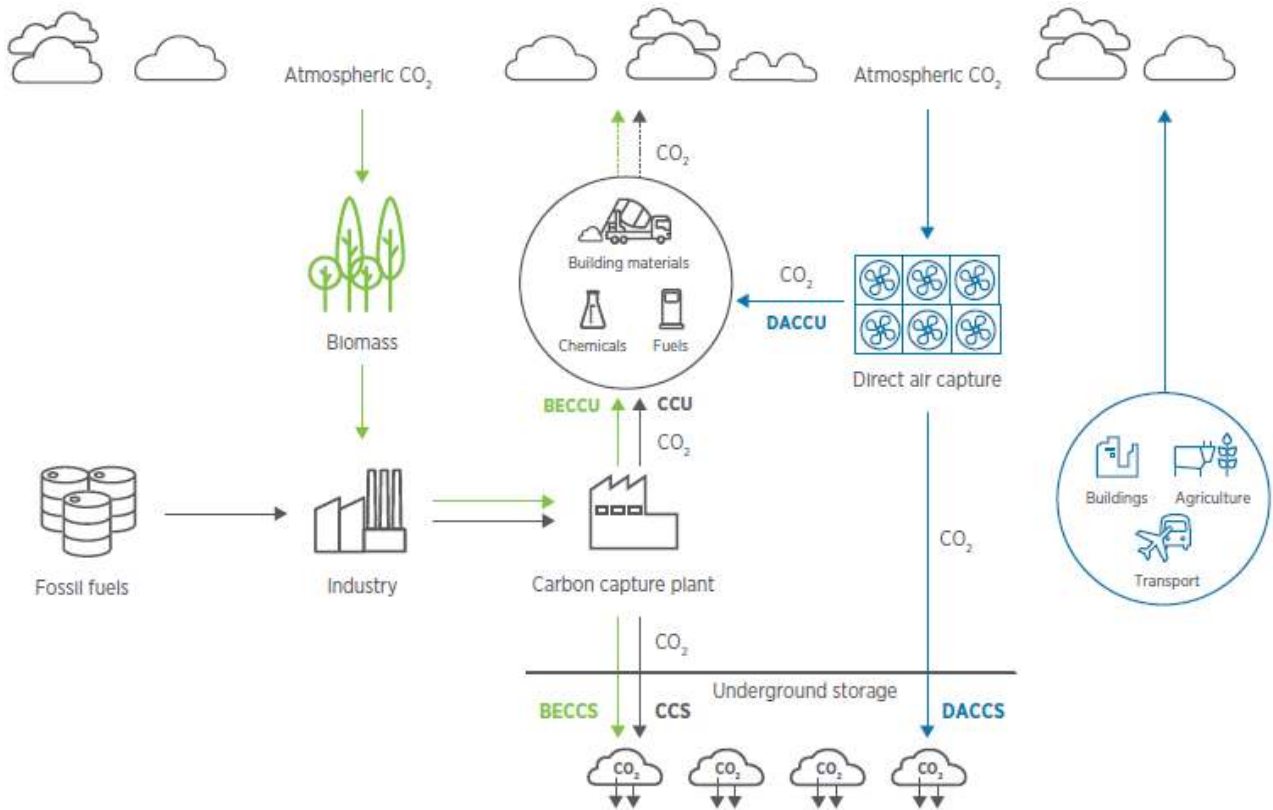
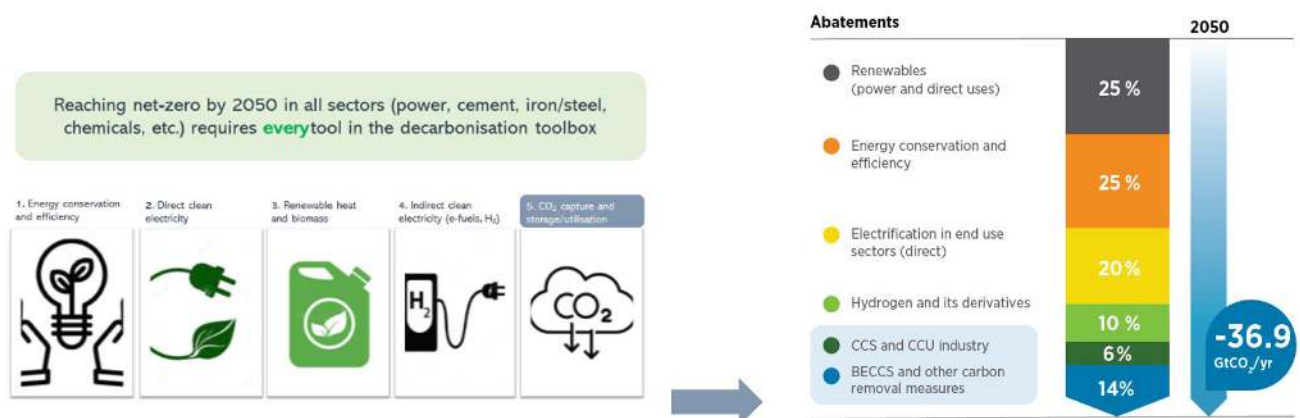


Figure 3: Carbon capture and storage as a part of the global decarbonisation toolbox⁵



⁴ Ibid.

⁵ Ibid.

CCS deployment at the European level⁶

The EU has put forward several mechanisms and instruments to enhance the understanding of various decarbonisation pathways consistent with the 1.5°C scenarios and trigger action. One of the mechanisms, the **European Strategic Energy Plan (EU SET-Plan)** aims to accelerate the development and deployment of low-carbon technologies. Its Implementation Working Group 9 (IWG9, or **CCUS SET-Plan**) specifically focuses on **strengthening international cooperation** and **speeding up the deployment** of CCS and CCU technologies. While all CEE countries are members of the EU SET-Plan, only Czechia and Hungary are members of the CCUS SET-Plan.

IWG9 of the SET-Plan estimates that under the **1.5°C scenario**, **230-430 MtCO₂ per year would have to be captured and stored by 2030. This will increase to 930-1200 MtCO₂ per year in 2050.** BECCS itself would need to be scaled up **to capture and store approximately 30 MtCO₂ per year in 2030, increasing to 400 MtCO₂ per year in 2050**⁷.

In November 2021, CCUS SET-Plan published the CCUS Roadmap to 2030⁸, in which it advocates for the launch of the **EU strategy for CCS and CCU** as a pivotal component of net-zero GHG emissions goals. The Roadmap also proposes amendments to existing plans and regulations including **strengthening the role of CCS in National Energy and Climate Plans (NECPs), Trans-European Networks for Energy (TEN-E) Regulation, CDR accounting scheme and the CCU guidance.**

Furthermore, the **European Commission** initiated and launched the first high-level forum to engage and facilitate discussions on carbon capture, utilisation and storage in **2021 – CCUS Forum** – which gathered relevant stakeholders, representatives of the EU institutions and EU countries who discussed **how to facilitate deployment of CCUS technologies.** In 2022, the Commission also began to prepare the first-ever official EU CCUS vision document to guide the industries and set the CCUS deployment pathway – **CCUS Vision – which should be published in 2023.**

Focusing on CCS deployment in the CEE region

The CCS4CEE project focuses on the CEE region with this **first-of-a-kind report that summarizes necessary policy actions to enable and accelerate CCS deployment in the CEE region.** Many of the proposed actions are also addressed by CCS reports published by international initiatives and platforms covering the CEE region.

The CCUS Roadmap to 2030⁹ by **CCUS SET-Plan** sets a specific 2030 target for the region, which stresses a need for *“at least 10 additional EU Projects of Common Interest (PCI) for CO₂ transport infrastructure, with a focus on Central, Eastern, and Southern Europe.”*

⁶ For further information, see the analytical input on the links between the CEE policy roadmap and the European-level initiatives prepared by The Bellona Foundation available at <https://ccs4cee.eu/news-articles/>.

⁷ https://www.ccus-setplan.eu/wp-content/uploads/2021/03/CCUS-SET-Plan_Review-of-CCU-and-CCS-in-future-EU-decarbonisation-scenarios_09.2020.pdf

⁸ https://www.ccus-setplan.eu/wp-content/uploads/2021/11/CCUS-SET-Plan_CCUS-Roadmap-2030.pdf

⁹ Ibid.

The **CO₂GeoNet** network comments in the recent report¹⁰ that “*detailed and comprehensive national storage atlases and databases are available in Norway, the UK, Spain and the Nordic countries (Nordic CO₂ Storage Atlas), less detailed or partial assessments have been performed in many other countries, while in some countries, particularly in Eastern and South-Eastern Europe, only basic assessments have been carried out.*”

The most recent report¹¹ by **Clean Air Task Force** (CATF) notes that „*to ensure Europe’s emitting industries have equal access to the decarbonising potential of this infrastructure, it is vital to promote and facilitate the development of other suitable storage geology throughout the region, including onshore storage in Central and Eastern Europe.*” CATF then recommends to “*identify promising, large-scale onshore or offshore storage regions in Southern, Central, and Eastern Europe and ensure they are developed to the point where they are ‘injection ready’.*”

¹⁰ [Release of the CO2GeoNet report State-of-play on CO2 geological storage](#)

¹¹ https://cdn.catf.us/wp-content/uploads/2022/05/10050419/CATF_CCSEuropeStrategy_Report_final.pdf

[4] Opportunities and barriers to CCS deployment and its related technologies in the CEE

The CEE region is heavily industrialised, which opens opportunities for CCS deployment in some of the hard-to-abate sectors. In the WP3, the Energy Policy Group delved deeper into the economic added value of various sectors in each CEE country. Table 1 outlines important sectors and lists those countries (alphabetically) where selected sectors have higher than EU average gross value added. Carbon leakage, a re-allocation of selected industries outside the EU to avoid costs related to climate policies, could represent a threat to local economies under an influence of a mixture of different factors mentioned later in this chapter.

Table 1: Economic importance of selected sectors in 2019¹²

Sector	CEE countries with higher than EU average gross value added
Energy production	Croatia, Czechia, Estonia, Poland, Romania, Slovakia, Slovenia
Petroleum refining	Croatia, Estonia, Romania
Chemical products, including ammonia	Czechia, Hungary, Lithuania, Slovenia
Basic metals, iron, steel and aluminium	Czechia, Hungary, Poland, Romania, Slovakia, Slovenia
Non-metallic mineral products, including cement	All
Pulp and paper	Czechia, Hungary, Lithuania, Poland, Slovakia, Slovenia

Following the Communication of the European Commission, WP3 of the CCS4CEE project and findings of chapter [3] emphasised a potential for CCS in hard-to-abate industry sectors of cement, chemicals and iron and steel, followed by the blue hydrogen production and pulp and paper sector. In addition, power and heat production from biomass-to-energy or waste-to-energy plants could present a particular opportunity for bioenergy with CCS (BECCS) that could be carbon negative. Table 2 summarises the scale of CO₂ emissions from selected sectors for CCS in the last pre-covid year.

¹² https://ccs4cee.eu/wp-content/uploads/2021/11/PUBLICATION_CCS4CEE-Summary-report.pdf

Table 2: CO₂ emissions of selected sectors¹³ (FC = fuel combustion, PE = process emissions)

MtCO ₂ , 2019		Iron & steel		Chemicals		Non-metallic mineral products				Pulp & paper	
Country	Total	FC	PE	FC	PE	FC	PE cement	PE lime	PE glass	FC	PE
Croatia	17.9	~0	~0	0.3	0.6	1.3	1.2	~0	~0	0.1	X
Czechia	101.7	1.7	5.8	1.9	1.8	2.7	2.0	0.7	0.1	0.4	X
Estonia	12.4	~0	0	~0	0	0.3	0.3	~0	~0	~0	X
Latvia	7.7	~0	0	~0	0	0.3	0.6	0	~0	~0	X
Lithuania	13.9	0	~0	0.3	2.0	0.5	0.6	~0	~0	~0	X
Hungary	48.2	0.2	1.2	0.4	2.4	1.3	1.0	0.1	~0	0.5	X
Poland	318.5	4.5	1.9	6.8	4.5	9.6	7.7	1.4	0.6	1.5	X
Romania	77.0	0.8	3.8	3.1	1.0	3.2	3.8	0.8	~0	0.2	X
Slovenia	14.0	0.2	~0	~0	~0	0.5	0.5	~0	~0	0.3	X
Slovakia	33.8	2.4	3.6	0.5	1.4	1.4	1.4	0.5	~0	0.4	X
Total	645.1	9.8	16.3	13.3	13.7	21.1	19.1	3.5	0.7	3.4	X

National-level assessments under WP3¹⁴ outline the following regulatory barriers to be overcome across CEE countries to ensure successful CCS deployment:

- Lack of coherent enabling regulatory frameworks for CCS (in addition to the transposed provisions of the CCS Directive and adherence to the ETS Directive)
- Lack of coherence with other relevant legislation
- Low activity of competent authorities
- Lack of regulations on CO₂ capture and utilisation
- Lack of clarity on inclusion/exclusion of CO₂-EOR and EGR from national and EU CCS legislation
- Lack of enabling regulatory frameworks for CO₂ transportation
- Lack of provisions for offshore and onshore CO₂ storage
- Potential competing uses for geological formations and CO₂ transport (particularly pipeline)

In addition, industry considering CCS deployment pointed out to the following major barriers: high CAPEX, a lack of public finance and financial instruments, costs of finding alternative use to CO₂, exclusion of CO₂ storage from the regulatory framework, a lack of government involvement and industry inertia. Their recommendations reinstated a need to adjust existing regulatory frameworks, develop a financial framework, recognise CCS projects as of strategic relevance, incentivise pilot projects, consider creating public-private financial CCS framework, lower administrative burdens (such as licensing and permitting), fasten the permitting processes for infrastructure development, create CO₂ accounting models and implement national decrees for financial security.

¹³ http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_air_gge&lang=en and https://ccs4cee.eu/wp-content/uploads/2021/11/PUBLICATION_CCS4CEE-Summary-report.pdf

¹⁴ https://ccs4cee.eu/wp-content/uploads/2021/11/PUBLICATION_CCS4CEE-Summary-report.pdf

Table 3 with the CO₂ emissions per country and a theoretical CO₂ storage capacity offers insights into the CCS deployment potential for hard-to-abate sectors. Storage potential is vast in most CEE countries, particularly offshore storage in several countries. CCS is a part of national strategies, but they seem to only encourage R&D activities, leaving CCS deployment to a distant future. The current evolution of the EU carbon price and a reduced volume of free allowances drive an accelerated deployment of all decarbonisation solutions including CCS on the EU level with support from the Innovation Fund and other EU funds. This is particularly urgent when speaking of carbon and/or investment leakage which represents a major threat to local economies if regulatory and financial decarbonisation solutions are not available in the coming years.

Table 3: Overview of the CO₂ storage potential and current experience¹⁵

Country	Total MtCO ₂ emissions 2019	Industries from Table 2	Storage capacity in MtCO ₂ *	CO ₂ storage permitted**	Existing or completed pilot project ***	CCS mentioned in national strategies	Significant role
Croatia	17.9	3.5	3,361	Yes	Yes	Yes	No
Czechia	101.7	17.1	853	Yes	No	Yes	No
Estonia	12.4	0.6	0	Yes	No	Yes	No
Latvia	7.7	0.9	804	No	Yes	Yes	No
Lithuania	13.9	3.4	42	No	No	Yes	No
Hungary	48.2	7.1	847	Yes	Yes	Yes	Yes
Poland	318.5	38.5	15,500	Yes	Yes	Yes	No
Romania	77.0	16.7	22,600	Yes	No	Yes	No
Slovenia	14.0	1.5	94	No	No	Yes	No
Slovakia	33.8	11.6	1,850	Yes	No	Yes	No
Total	645.1	100.9	45,951	Mostly yes	Mostly no	Yes	Almost never

* Conservative estimates of the CO₂ GeoCapacity project.

** Permitted with restrictions.

*** In any part of the CCS value chain – capture, transport, storage.

¹⁵ Information collected during Work Package 4 and https://ccs4cee.eu/wp-content/uploads/2021/11/PUBLICATION_CCS4CEE-Summary-report.pdf

[5] Policy roadmap for the scaled-up deployment of CCS and its related technologies in the CEE

The roadmap defines policy actions along the innovation cycle, from research and development to the commercialisation of CCS technologies to reach climate targets set by the EU and national strategies. While it includes major steps and milestones needed to create an enabling environment to deploy CCS projects, it increasingly focuses on ways to develop transferable knowledge and skills by national stakeholders (government, research organisations, academia and the private sector) and set up channels to access knowledge and experience from international stakeholders. In addition, it underlines the importance of cross-border activities and the need for joint regional demonstration projects to increase stakeholders' prospects to access public and private funding. The policy roadmap is divided into 4 subchapters:

- Scaling up RD&D activities and building national knowledge and experience
- Policy, standards and regulations
- Stakeholder engagement, cooperation & know-how dissemination
- Social aspects and public support

Technical note

Proposed actions, which have no prescribed order, were bundled under a common title. This is an integrated CEE roadmap for CCS deployment and does not describe national-level actions in detail. These are found in national roadmaps (see Chapter 4) with each action including a description, relevant stakeholders and a proposed time frame.

Scaling up RD&D activities and building national knowledge and experience

- **Knowledge platforms**

Launch national CCS platforms to advocate for CCS deployment in the CEE with one voice.

Launching national CCS-dedicated platforms is an important milestone in achieving national-level coordination of CCS activities with relatively low costs and high impacts. The platform with its advisory board can provide support to the government and can be led by a different type of stakeholder, either ministry, private sector, or under the leadership of a national chamber of commerce with the same objective to provide one concerted, expert, advisory voice of CCS in the country. Platforms should establish channels to coordinate activities and pursue joint projects within the CEE region.

- **International engagement**

Scale up stakeholder activities in the international CCS networks and initiatives.

Regular and active participation of ministries and the private sector in international fora is critical to access knowledge and finance. There is currently low or no active participation of CEE countries in CCS networks and initiatives, neither by the public nor the private sector. Examples are the EU SET-Plan CCUS working group, Carbon Sequestration Leadership Forum, EU Zero Emissions Platform, Clean Energy Ministerial and IEAGHG. While in some cases mother companies are engaged in these fora, there is no further knowledge sharing or engagement with companies in the CEE region.

- **Identifying networks**

Governments should incentivise research within CCS clusters and identify new networks.

Industrial CCS clusters/hubs are currently non-existent in the CEE region. CEE countries should explore different possibilities for hub/clusters creation. Coastal countries (Poland, Baltics, Romania, Croatia and Slovenia) could use the existing port infrastructure of the oil & gas sector or connect it to newly announced CO₂ transport and storage projects. Landlocked countries, on the other hand, should develop a common CO₂ transport network and connect it to onshore storage sites or ports for offshore storage. Further studies should explore the opportunities based on geographical conditions.

- **Funding and fiscal policies**

Public finance should go beyond R&D activities and support pilot and demonstration projects.

No fiscal policies or public finance is available in the CEE countries to support CCS pilot projects. It is critical for governments to set up enabling fiscal frameworks for CCS support, regularly communicate EU-level funding opportunities under the guidance and with the support of national contact points and explore the EIB project assistance. The EU ETS revenues should be used to support hard-to-abate sectors. CEE countries should build on the EU framework for Carbon Contracts for Difference as soon as it is set and consult and learn from countries with established CCS policies and frameworks (such as selected countries in Western Europe).

Further support for storage exploration is needed with a focus on potential of saline aquifers.

- **Storage site exploration**

Several countries should consider removing the CO₂ storage bans and at minimum support the onshore storage of CO₂ in depleted oil and gas fields. Countries need to align their national CO₂ storage condition with the EU CCS Directive. Coastal countries should ratify the amendment to Article 6 of the London Protocol to enable cross-border offshore CO₂ transportation and storage. Landlocked countries should support further exploration and geological works on CO₂ storage in depleted hydrocarbon fields, and might start exploring saline aquifers as the potentially largest storage formations.

- **Bridging valleys of death**

Multi-level cooperation for transport and storage require foremost governments actions.

Wider collaboration among different stakeholders and the launch of clusters are urgently needed. All stakeholders should pay close attention to the calls of both large- and small-scale calls of the EU Innovation Fund. Different means of CO₂ transport should be assessed and supported and active engagement with international projects where pipeline infrastructure might be built or refurbished should be sought after. Existing and announced projects in Western Europe should be studied and potentially replicated.

Policy, standards and regulations

- **Policies**

Re-assess the role of and include CCS in the national development and strategic documents.

CCS is either not at all or only marginally mentioned in CEE national climate, energy or development plans and is usually seen as a non-viable decarbonisation option. International bodies such as IPCC, IEA and IRENA see the role of CCS as moderate but indispensable, particularly in decarbonising hard-to-abate sectors. For CEE countries to meet energy and climate targets, national governments should reassess the role of CCS and include it in national strategies.

- **Guidelines and standards**

Proper guidance and dissemination of already existing standards for CCS is key.

Accessing global knowledge of the best available technologies is key to successfully accelerating the deployment of CO₂ capture, transport and storage on the national and cross-border levels. This could be done by active engagement in the ISO CCS committee where CEE countries can either join as observers or become members. Acquired knowledge should be then disseminated to all stakeholders. The EU Taxonomy should be also analysed and used as a guide.

- **Regulatory framework**

Regulation must be amended to address critical aspects of CO₂ transport and storage.

Countries need to solve the issue of transboundary maritime transport of CO₂ by ratifying amendments to Article 6 of the London Protocol. Landlocked countries need to overcome barriers to enable onshore CO₂ storage. The rights and obligations for CO₂ infrastructure and storage sites could be negotiated with the respective gas infrastructure TSOs or oil & gas companies to guarantee all operations. Clarification of the financial security mechanism for CO₂ storage should be prioritised to support the first movers.

- **CCS industrial strategies**

Industrial associations should develop sector-specific decarbonisation pathways.

None of the industrial associations in CEE countries has developed sector-specific decarbonisation strategies for each hard-to-abate industry sector of cement, iron and steel and chemicals. Such strategies should explore European industrial energy and energy infrastructure projects of common interest. National and local governments and other stakeholders should be consulted.

- **Enabling CO₂ market**

CO₂ market opportunities and instruments must be carefully examined and disseminated.

The CO₂ utilisation market is an important prerequisite for the accelerated deployment of CO₂ capture at scale. CO₂ as a feedstock for various production could be supplied from hard-to-abate sectors, but public funding for such projects should be limited only to applications that do not lead to the later release of CO₂ (e.g. carbonation and mineralisation). For that, governments should consult and incorporate the foreseen European Commission CCU guidelines and its accounting into their national strategies, including Carbon Contracts for Difference, as an effective instrument to provide security of revenues.

- **Resilience of CCS strategies**

Governments should strive for resilience through interministerial and multipartisan groups.

While governments are adopting decarbonisation strategies, these are not fully reflected in the works across all ministries at national and local levels. Due to its cross-sectoral nature, a ministry primarily responsible for CCS should establish interministerial working groups with multipartisan involvement and scientific support from independent stakeholders and ensure a smooth reproduction of its main findings to the wider policy community. It could be linked to the CCS platform. IPCC and other international bodies should be invited to discuss and disseminate findings from their analytical work to policy-makers to enable informed decision-making.

Stakeholder engagement, cooperation & know-how dissemination

- **Stakeholder engagement**

Common aim of the CCS platform should lead to closer cooperation and shared values.

Cooperation between the private sector, universities, ministries, local governments and NGOs should be a priority. It should focus on including CCS in national strategies as one of the decarbonisation pathways and ensuring support from the local investment bodies and chambers of commerce. Different investment models should be examined to capture differences between small-scale CCS projects relying on trucks, trains or ships and large-scale CCS projects that require a vast infrastructure of CO₂ pipeline and storage.

- **International cooperation**

Local cooperation, cross-border initiatives and international projects all play their role.

Successful local cooperation should lead to cross-border cooperation, especially in countries with favourable geographical and geological conditions, such as availability and proximity to existing oil & gas infrastructure and seacoast. An increased number of projects should reach the status of projects of common interest (PCI) and secure financing through Connecting Europe Facility and important projects of common European interest (IPCEI). CEE governments should actively engage with countries leading CCS deployment including Denmark, the Netherlands, Norway, and the UK.

- **Cooperation in the CO₂ market**

Corporate partnerships and joint ventures should develop the CO₂ market.

Creating a CO₂ market requires cross-sectoral partnerships. Clusters of emitters in smaller countries could benefit from their proximity and share transport and storage infrastructure to reduce costs. Oil & gas companies should enable access to their transport and storage infrastructure, including the use of depleted fields and buffer storage facilities by retrofitting old gas storage.

Social aspects and public support

- **Building public support**

The nature of CO₂, its transport and storage operations should be explained in simple words.

Educating the public about the nature of energy and process-related CO₂ emissions, the environmental and safety risks of CO₂ storage, and the ways to manage and mitigate them, is a must. The public should be made aware of the CCS value chain and have free access to information from national geological surveys and about the role of oil & gas companies in building the infrastructure. Collaboration of private and public sectors with non-governmental organisations and research institutions to convey the message to the public should be considered.

- **Building awareness**

CCS must be marketed as one of the decarbonisation and climate change mitigation tools.

Any educational public campaigns on the impacts of climate change and decarbonisation pathways should include discussions of the role of CCS, the need to pursue activities beyond R&D to accelerate pilot and demonstration projects and exploit findings from successful international projects including underlying enabling frameworks. The analytical work of international organisations should be presented in a more accessible style, such as in social media.

- **Fairness of decision-making**

No community should be left out of discussions on CCS deployment.

Open public debates should be facilitated by third parties with affected communities, local and national governments, potential CO₂ transport network operators, storage companies and other stakeholders before any decision to carry out transport and storage projects is made. Compensation schemes similar to those paid to local communities by the oil, gas and coal mining/refining companies should be applied where appropriate.

- **CCS communication**

Government should strive for full transparency of pros and cons of CCS technology.

The role of CCS is contentious with opinions often divided, particularly due to NIMBY (not in my backyard) effect. CCS communication should be therefore more nuanced, aiming to create a better understanding of needed investments and future costs relative to alternatives, perception of the safety of CO₂ transport and storage, and effectiveness in reducing CO₂ emissions while stressing the benefits of the CCS value chain, socioeconomic factors including the creation of local prosperity by supporting local industries in their decarbonisation efforts.

- **Local-friendly context of CCS**

Local and regional context matters, especially in the industrial and Just Transition regions.

Local and regional communication campaigns must be carried out ahead of time when planning transport and storage projects. Since there is a legacy of systems built around the oil, gas and coal industries, Getica (RO) or Belchatow (PL) experience should be used as an example of how new discussions and new concerns are communicated to local people, including clearly and transparently discussed potential gains and risks.

- **Building public trust**

Governments should involve third parties to avoid CCS debate becoming politicized.

For long-term political stability, anchoring CCS in national energy and climate plans and other strategic documents is critical. The inclusion of CCS in the long-term climate and energy strategies is however influenced by policymakers and their political will. To break that requires neutral messengers and influencers to communicate CCS gains and risks. Researchers and NGOs should cooperate with the CCS platform and government to balance discussions.

[6] Conclusion

Ambitious strategies and actions are critical to reaching net-zero goals by 2050 in the CEE region. Achieving these goals will require a diverse and inclusive set of national, regional and international stakeholders to develop and share knowledge and capacity to allow for rapid CCS deployment. The inclusion of civil society along the way is vital.

This integrated policy roadmap is the final output of Work Package 4. It builds upon Work Package 3 and consultations with a diverse set of stakeholders. It is the summary of the national roadmaps and aims to set forward an agenda developed by all project partners for successful CCS deployment in the CEE region. The first four chapters provide a context on the importance of setting ambitious targets for 2050 across the CEE region and the need for accelerating action in this decade. Then Chapter [5] *Policy roadmap for the scaled-up deployment of CCS and its related technologies in the CEE* introduces 21 ambitious actions under 4 broad categories: *a) Scaling up RD&D activities and building national knowledge and experience; b) Policy, standards and regulations; c) Stakeholder engagement, cooperation & know-how dissemination; and d) Social aspects and public support.*

Work Package 5 will focus on the implementation of recommended actions. This final project phase aims to turn recommended actions into reality and ensure that project results are taken up by all key stakeholders.

