

Deliverable 3.3

RECOMMENDATIONS ON THE STEPS REQUIRED
TO DELIVER THE R&I ACTIVITIES 3: EU PROJECTS OF
COMMON INTEREST FOR CO₂ TRANSPORT
INFRASTRUCTURE

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Table of contents

Introduction.....	3
Background on the CCUS SET-Plan.....	3
Introduction on the European Green Deal.....	3
Background – Updated CCUS SET-Plan targets and Roadmap 2030.....	4
Policy developments to support the development of CO ₂ infrastructure	5
Projects’ development	7
R&I activities.....	9
The way forward.....	11
Where can developments be seen:.....	12
Conclusions.....	13



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Introduction

Background on the CCUS SET-Plan

The [European Strategic Energy Technology Plan \(SET-Plan\)](#) aims to accelerate the deployment of low-carbon technologies, improve new technologies and bring down costs by coordinating national research efforts. The SET-Plan brings together EU countries, the European Commission, industries, and research institutions. The SET-Plan defined ten priority areas, covering a wide range of sectors including CCUS, wind, solar, geothermal, renewable heating and cooling, biofuels, etc. The Implementation Working Group 9 (CCUS SET-Plan) has been established to help the progress of Research and Innovation (R&I) activities required to achieve the 2020 targets for CCS and CCU agreed by the European Commission, SET-Plan countries, and industry.

The [CCUS SET-Plan](#) is composed of 11 SET-Plan countries (Czechia, France, Germany, Hungary, Italy, Norway, The Netherlands, Turkey, Spain, Sweden and the UK), industrial stakeholders, non-governmental organisations, and research institutions. The work is chaired by the Netherlands, Norway, and the Zero Emissions Platform.

Introduction on the European Green Deal

Reaching climate neutrality by 2050 will require major efforts from all economic sectors and European society. Higher climate goals mean that all low-carbon technologies under the European Commission's SET-Plan will be crucial in contributing to the transition to a climate neutral economy by 2050 and to accelerate knowledge development as well as technology transfer and up-take. CCS and CCU will play an important role in the delivery of climate neutrality by 2050, enabling a cost-efficient trajectory towards a low-carbon economy with EU's climate objectives.

As part of the [European Green Deal](#) workplan, the European Commission has announced new initiatives – such as the [European Climate Law](#), the [Hydrogen strategy](#), the [Industrial strategy](#) – and intends to revise existing pieces of legislation, such as the [EU ETS directive](#) and [TEN-E regulation](#). All these initiatives are key to ensure that more CCS and CCU projects are deployed in Europe, overcoming current barriers and securing more announcements such as the Longship project and funding awarded through the Connecting Europe Facility for Energy (CEF) programme to European CCS and CCU projects (Porthos, Athos, Antwerp CO₂, Acorn Sapling, Ervia).

The European Green Deal, Europe's new growth strategy, set the legally binding target of net-zero greenhouse gas emissions by 2050, formally adopted in the European Climate Law. All economic sectors and member states will need to make strong efforts to reduce greenhouse gas emissions. This means that all low-carbon technologies with a scientifically proven role in achieving climate change mitigation should be developed and deployed. In this context, carbon capture technologies have been highlighted as necessary in order for Europe to reach climate-neutrality in all credible Integrated Assessment Models and scenarios (including the 1.5 degrees IPCC report and the European Commission Clean Planet for all, long-term strategy).



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Background – Updated CCUS SET-Plan targets and Roadmap 2030

The [updated targets of the CCUS SET-Plan](#) set new ambitions in the area of PCIs. For Europe to be on track to achieve higher 2030 targets, the CCUS SET-Plan endorsed a target of *‘At least 10 additional EU Projects of Common Interest (PCI) for CO₂ transport infrastructure, with a focus on Central, Eastern, and Southern Europe. Experience from the first full-scale CCS project should be taken into account in the SET-Plan activities linked to targets 3 and 4’.*

In the CCUS SET-Plan targets, there is focus on infrastructure. The three targets that are directly linked to infrastructure are targets 1, 2, and 3:

- Target 1: *Delivery of 10 CCS projects for clean, flexible power and heat generation, complementary to renewable energy generation.*
- Target 2: *At least 10 commercial-scale CCS projects linked to industrial CO₂ sources, having completed a FEED study and 5 having made an investment decision.*
- Target 3: *EU member states and external SET-Plan countries having completed national and regional CCS roadmaps for the development of dedicated CO₂ transport infrastructure (new, retrofitted and repurposed), including clusters of CO₂ sources and cross-border CO₂ infrastructure. The infrastructure being included in the European Ten-Year Network Development Plan (TYNDP).*

Together with target 4, these targets aim to provide support to additional PCIs and CO₂ transport infrastructure. Target 4 recognises the value of an integrated approach and the interaction between regional CCS developments in Europe and highlights the importance of revising the TEN-E and EU ETS legislations, and has been adapted in 2020 for several reasons:

- CO₂ infrastructure is the crucial for enabling cost-efficient decarbonisation in order for Europe to reach the objective of net-zero emissions by 2050 – therefore the development of such infrastructure should start immediately.
- There has been very good development with 5 cross-border CO₂ infrastructure projects on the list of projects of common interest (PCI), eligible for funding through the CEF.
- It is crucial to include in the TEN-E regulation, CO₂ storage, all modes of CO₂ transport –such as ship, train, truck, etc. – and hydrogen infrastructure. A necessary basis for the current cross-border CO₂ PCIs.



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Policy developments to support the development of CO₂ infrastructure

As part of the revision process of the TEN-E regulation, the European Commission published an [Impact Assessment](#) in December 2020. There, the Commission noted that CO₂ infrastructure should be included in the revised TEN-E regulation, since it is instrumental to support Europe's trajectory to net-zero GHG emissions by 2050. However, the Commission did not suggest any changes to be made to the category. Additionally, the proposal for a revised TEN-E regulation included a new category of Project of Mutual Interest (PMI) between a member state and a non-EU member state.

Currently, the category of CO₂ infrastructure is defined as follows:

for carbon dioxide transport projects falling under the energy infrastructure categories set out in Annex II.4, the project contributes significantly to all of the following specific criteria:

- (i) the avoidance of carbon dioxide emissions while maintaining security of energy supply;*
- (ii) increasing the resilience and security of carbon dioxide transport;*
- (iii) the efficient use of resources, by enabling the connection of multiple carbon dioxide sources and storage sites via common infrastructure and minimising environmental burden and risks.*

Following the [proposal](#) from the European Commission in December 2020 on a revised TEN-E regulation, fit for the objectives of the European Green Deal, political negotiations at the European Parliament and Council of the EU have kicked off. The [Regulation \(EU\) no 347/2013](#) on guidelines for trans-European energy infrastructure (the TEN-E Regulation) forms the legal basis for cross-border energy infrastructure, and it identifies nine priority corridors and three thematic areas that require urgent infrastructure upgrades.

The current formulation for the category of CO₂ infrastructure does not include CO₂ storage within the infrastructure category, nor does it take into account modalities of CO₂ transport other than pipeline.

To support the upcoming European CCS industry, it is critical that these changes are implemented:

- The inclusion of CO₂ storage. CO₂ storage infrastructure is as an essential part of the CO₂ infrastructure and component of a CCS project. CO₂ storage is a key element of delivering real climate change mitigation and it should receive funding as part of CO₂ infrastructure;
- All CO₂ transport modalities next to pipeline, including mobile assets – ship, barge, truck, and train – allowing all European regions and industries to connect to the European infrastructure. This change is vital to allow the transport of CO₂ during infrastructure development and to enable all CO₂ emitters in Europe to connect to safe, geological storage.

The Council of the EU adopted a [general approach](#) in May 2021, indicating an opening for the inclusion of CO₂ storage, whereas no progress was made on other modalities for CO₂ transport. Following the approval of the [ITRE report](#) on 28 September, the negotiations on the TEN-E regulation began.



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In the European Parliament's report, the following points are relevant for the category of CO₂ infrastructure:

- Inclusion of CO₂ storage in the description of the infrastructure category
- Inclusion of all modalities for CO₂ transport – ships, barges, trucks, train
- The focus is on industrial CCS clusters

The [four-column document](#) circulated by the Slovenian presidency ahead of the negotiations clarified the Council's position. The Council shared the view of the Parliament regarding the inclusion of CO₂ storage in the TEN-E regulation, while it shared the view of the European Commission regarding the transport of CO₂ by all modalities, which do not qualify as infrastructure.

An [update](#) to the document described the provisional agreement and highlights:

- Regarding CO₂ transport – the focus remains on pipeline transport. There is no indication about other modalities for CO₂ transport.
- Regarding CO₂ storage – in the document, storage infrastructure is included.
- The sustainability criteria for capture at industrial installations is still present, but the language is broader.

It is also worth noting that both texts create a new definition of “Projects of Mutual Interest” (PMI), to allow for a continued cooperation between the EU and non-EU countries. It is crucial to take into account cooperation among EU and non-EU countries.

Projects of mutual interest will need to contribute to the Union's climate and energy policy objectives and, regarding carbon-dioxide storage projects, the project needs to be necessary to allow the cross-border transport and storage of CO₂, between the EU and the third country, where the project is located. The final proposal is included [here](#).



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Projects' development

Europe is well positioned to develop cross-border, shared CO₂ transport and storage infrastructure, both via pipeline and by other modalities such as ship, barge, truck, and rail. With secure access to storage sites, positioned around the European North Sea and where existing natural gas infrastructure is positioned, which could be eligible for retrofitting and [repurposing](#), the European Union needs to act urgently to deploy and develop CO₂ transport and storage infrastructure.

Several CO₂ industrial emitters are already clustered around some industrial areas – and they will be more likely to invest in capture projects, bringing down costs of capture technologies. Without the possibility to transport CO₂ by ship and other modalities, planned CCS and CCU projects would be put at risk of not becoming operational. This scenario must be avoided at all costs, as CCS and CO₂ infrastructure are prime options for the decarbonisation of energy-intensive industries, where electrification is too costly or not feasible.

The European Commission has adopted the [fifth list](#) of energy Projects of Common Interest (PCIs) in November 2021, the first list of projects approved after the objective of climate neutrality has been adopted and is legally binding. These are key cross-border energy infrastructure projects for building a more integrated and resilient EU internal energy market and pursuing our energy and climate goals. This fifth PCI list comprises 98 projects: 67 projects in electricity transmission and storage, 20 in gas, six CO₂ network projects and five smart grid projects.

Following its adoption by the Commission, the Delegated Act with the 5th PCI list will be submitted to the European Parliament and the Council. Both co-legislators have two months to either accept or reject the list.

Many positive developments for European PCIs in the category of CO₂ infrastructure have been highlighted by the applications submitted to the 5th PCI list. The list encompasses both projects that were already on the 4th PCI list – such as Porthos, etc – but also new ones from other European regions, such as the Poland EU CCS interconnector and two projects from Germany, with a focus on CCU. It is also important to note that several projects foresee the production of low-carbon hydrogen with CCS.

With regards to the Athos project, the project still appears on the 5th PCI list. However, in September 2021, Tata Steel, the project promoter, decided to pull out of the project and choose a different technology for its decarbonisation, bring the Athos project to an effective stop.

In 2020, the Porthos project was awarded record 200M€ to continue their activities and advance with the project development. At the same time, Northern Lights took final investment decision, the Northern Lights JV was set up and began the construction of the transport and storage infrastructure, capture projects are starting to build installations and further funding is expected. Government is backing the developments.



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For CO₂ infrastructure projects that have gained the status of European Projects of Common Interest (PCIs), funding is made available under the [Connecting Europe Facility for Energy](#). This funding stream is connected to the Multiannual Financial Framework (MFF), and for the 2021-2027 period, the budget available under the CEF-E is €5.84 billion.

It is critical that funding opportunities at the EU and national levels are unlocked to enable the rapid deployment and development of a European CCS full-value chain. In addition to the CEF funding, the European Union disposes of the Innovation Fund, which provides support to [first-of-a-kind projects](#). Projects involving CCS components were selected and awarded after the first call for large-scale projects, partly because these the PCI projects related to these winners were able to mature sufficiently.

The Recovery and Resilience Facility and national recovery plans were available to member states who sought funding for green infrastructure projects – such as developing CO₂ infrastructure.

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R&I activities

R&I activities underpinned under the CCUS SET-Plan are important to support the large-scale development of CO₂ infrastructure. For Projects of Common Interest (PCI), developing economic instruments that can support the deployment of CO₂ infrastructure is critical. However, several areas where R&I activities can benefit further development of CO₂ infrastructure are also highlighted hereafter:

- Reviews of infrastructure re-use (pipelines, wells, platforms from hydrocarbon industry) for transport and storage should identify those assets of strategic importance to PCIs and wider Member State plans for CCS.
- A map of European CO₂ storage assets will strongly support the strategic planning of activities to develop CCS. A “white paper” describing the benefits, intended users, functionalities and operation of the “European CO₂ Geological Storage Atlas” was supported by IWG9. The use of big data and artificial intelligence should be further explored.

In line with a revision to the IWG9 Implementation Plan on CCS and CCU, a range of priority CO₂ storage geological appraisal activities should be supported to ensure the required CO₂ storage capacity is provided for the CCS deployment needed to achieve Europe’s decarbonisation targets.

This should include:

- Appraisal of storage regions which would include pre-competitive evaluation of storage options to encourage subsequent commercial project uptake.
- Detailed characterisation of storage sites across Europe to define the contingent storage resource and to provide storage hubs for CO₂ capture projects. This has strong links to the role of CCS in the energy system, described below, which will determine possible scenarios of rates of CO₂ capture at regional, national and European levels. This could include the testing of new formations to assess their feasibility for storage.
- Assessment of long-term and post-closure storage liabilities (technical risk and uncertainty) and the development of technical, regulatory, policy and commercial solutions.

At the same time, mapping CO₂ sources and utilisation capacities across the EU should be undertaken.

Many of the technical challenges related to CO₂ transport are further outlined in a recent ZEP report on CO₂ transportation. Further work is needed regarding whether or not the difference in quality requirements of captured CO₂ for utilisation influences the CO₂ transport specifications. A central requirement for the efficient and safe design and operation of CO₂ pipeline transportation networks is the accurate transient flow modelling of fluid phase and composition of the CO₂-rich mixture along the pipeline network and at the point of injection into the storage site. Further study is needed to assess the quality of CO₂ streams, as well as CO₂ density and pressure, ensuring ongoing monitoring of CO₂ flows and pipeline safety during operations.



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Further work should also address the combination of scenarios relating to changes in future energy supply mix and industrial landscapes alongside the development of CO₂ pipeline transport networks.

Areas for further R&I activities are:

- Value chain analyses (full chains, H₂, ammonia and liquid organic H₂ carriers)
- New CCS and CCU chain concepts and transport networks (including hubs, buffers)
- Impact of CO₂ composition and impurities
- Safety assessments and engineering design tools
- Non-pipeline transport of CO₂ (e.g. ships, rail, trucks, etc.)
- Injection of fluctuating CO₂ flows, particularly into low pressure reservoirs
- Improved understanding of thermophysical properties of CO₂ and CO₂ mixtures.



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The way forward

Transport of CO₂ by ship is a vital part – contributing strongly to equitable access for all member states – of the CO₂ infrastructure that will enable emitters across Europe to connect to safe and permanent storage. CCS projects, including both cross border European CO₂ infrastructure projects of common interest (ref.) and domestic projects, have identified the need for both inland and maritime shipping solutions. Transporting CO₂ by ship will be crucial for large-scale CCS deployment in Europe. Transport of CO₂ by ship has been recognised both at EU level – in the European Taxonomy for Sustainable Activities as well as within the EU ETS Directive – and on national level – e.g. in the Dutch SDE++ subsidy scheme and UK CCUS programme.

For CCS projects aiming at transporting CO₂ by ship, interoperability will be very important in order to optimise the development of CO₂ infrastructure. There is a need for standards on CO₂ specifications (composition, pressures, temperatures, etc.), ship design and specifications (e.g., referring to loading and off-loading). As many CCS projects will become operational in the mid-2020s, many new ships for CO₂ transportation will be needed within five years, making these standards urgent and needed. CO₂ infrastructure will need to be scaled up to decarbonise industrial and power plants.

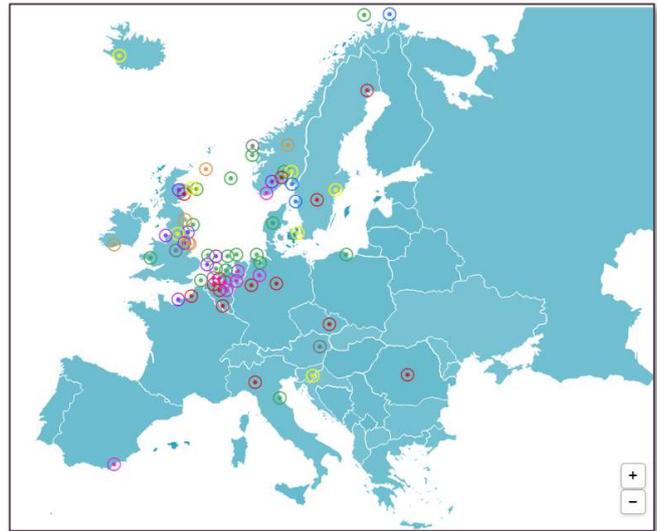
Priority regions for appraisal should be identified, using the proposed online open-access European Storage Atlas as a foundation and establishing recommendations and responsibilities for development. Detailed characterisation of storage sites across Europe to define the contingent storage resource and create a portfolio of ‘permit-ready’ sites that will meet future capture rates (including potential storage for greenhouse gas removal technologies such as BECCS and DACCS) will be necessary. These sites will serve both individual CCS projects, which will provide local solutions, and will enable development of storage hubs for CO₂ capture projects in strategic regions. These storage hubs can be driven by Projects of Common Interest (PCI) but should also support development in new regions. The portfolio of storage sites will include a mix of depleted oil and especially gas fields, and larger, regional saline aquifers.

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Where can developments be seen:

By means of the projects map, the aim is to show the geographical dimension and importance of CO₂ infrastructure:

- The Netherlands, the UK and Norway are at the forefront of CCS and CO₂ infrastructure development. The projects featured in the 4th and 5th PCI list aim to store CO₂ in storage sites offshore of the Dutch coast and the Norwegian continental shelf, and the UK is also developing their storage sites, with higher ambitions and targets for 2030.
- Belgium reports activities to develop CCS and CCU in the area of the Port of Antwerp, as well as in the region of Wallonia. The Kairos@C project was among the successful projects of the first call for large-scale projects of the Innovation Fund.
- Sweden is in the process of signing a bilateral agreement with Norway to allow for the import/export of CO₂ and is in the process of ratifying the London protocol amendment.
- In Italy, CO₂ infrastructure and CCS are in development in the Port of Ravenna, with the aim to use retrofitted gas infrastructure for CO₂ transport and storage in depleted gas fields, and for the production of low-carbon hydrogen.
- Two projects from Germany, linked to Wilhelmshaven and the area of Bremen and Hamburg, have applied to the 5th PCI list, without being successful. Activity is also noted in the region of North-Rhein Westfalen.
- In Poland, the EU CCS interconnector, which applied to the 5th PCI list, was selected among the successful candidates to be included in the least.
- Romania is exploring onshore storage to decarbonise their industrial activities. Romania also benefits from the proximity to the Danube River, thus shipping of CO₂ will be increasingly important for the country.



To meet higher climate targets and deliver on the CCUS SET-Plan updated targets, more projects will need to come forward in the next years – with a focus on Eastern Europe.



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Conclusions

In light of Europe's objective of climate neutrality by 2050, the CCUS SET-Plan has updated its targets to reflect the higher ambition. A higher number of projects of common interest will need to come forward in the next years to put Europe on the right trajectory to achieve 2030 and 2050 climate objectives. The regional focus is on Central and Eastern Europe, where CCS and CCU technologies can be enablers of a cost-efficient and just industrial transition.

For projects to come forward and move to final investment decisions, an enabling policy framework is needed. The inclusion of CO₂ storage and all modalities for CO₂ transport – next to pipeline – in the TEN-E regulation and linked national and European legislation is crucial to develop cross-border European CO₂ transport and storage infrastructure. In the next decade, the role of CO₂ transport by ship will also become increasingly important, and there is a need to take this into account in an enabling policy framework. Further opportunities may arise to support CO₂ transport – an important part of CO₂ infrastructure – in legislations such as the TEN-T regulation.

Further R&I activities will be needed to support the large-scale development of CO₂ infrastructure, increase the technologies' efficiency and bring costs down. Making the technologies investable, developing business models and a framework for long-term investments will also be crucial in the 2020s.

Finally, as argued in the [CCUS Roadmap for 2030](#), political recognition for CO₂ infrastructure and a EU strategy on CCS and CCU, with targets, timeline, objectives and resources allocated to it, are necessary to drive the needed CCUS development in the 2020s.



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