Regulatory framework for CCUS in the EU and its Member States

An analysis for the EU, six Member States and the UK

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2. Executive summary

Due to the relative high degree of innovativeness, the realization of a Carbon Capture and Usage (CCU) or a Carbon Capture and Storage (CCS) project requires a positive strategic, legislative and financial supporting framework from policy. The political strategy to aim for ambitious climate targets is a pre-condition for the application of CCU and CCS technologies in a Member State. Legislation regulates the operation of capture, transport and storage sites. A well defined framework is highly relevant for operators to know the risks and potential costs related to a project, to know their own responsibilities and responsibilities of others, expectations by the competent authorities and making clear the roles of all participants in the whole project. It helps the authorities to take adequate decisions in granting procedures in decent time. Financial support is needed as long as the current CO_2 price itself is not sufficient to make the application of CCU or CCS technologies economically viable. Although it is to be expected that costs for CCU and CCS activities will fall over time when it moves from being a very innovative first-of-a-kind application to a more mainstream technology, in particular the first-of-a-kind applications require specific support to cover for high costs under high risks. At the same time, a strong CO_2 price in the European Emissions Trading System (EU ETS) (in February 2022 prices reached levels as high as 90€/t CO_2 and more) along with the expectation that CO_2 prices will remain high in the future, and a clear signal that there will be a market for low-CO_2-products present strong financial incentives to invest into CCU and CCS projects.

In the present report, the political, legislative and financial support system for CCU, but mainly for CCS activities on the EU-level along with seven Member States and the UK are being analysed. The countries studied comprise the PilotSTRATEGY countries (Portugal, Spain, France, Poland and Greece) and in addition the Netherlands as a Member State and the UK, both as countries more advanced on developing frameworks for CCS. The report highlights the role of EU legislation in the context of development of CCS projects in the Member States. In addition, it analyses the transposition of EU legislation into national law and provides information on further national legislation or support instruments relevant in the context. It shows that while countries such as the UK and the Netherlands have put a strong political focus on the development of CCS clusters, other Member States so far can mainly refer to what has been developed on the EU level, making it clear that developing own CCS or CCU projects within the country require significant additional efforts on the legislative framework. Clear political signals along with additional national support instruments can help the development of project initiatives.

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3. Introduction

Due to the relative high degree of innovativeness, the realization of a Carbon Capture and Usage (CCU) or a Carbon Capture and Storage (CCS) project requires a positive strategic, legislative and financial supporting framework from policy (the role of public acceptance, also a key element in the realization of CCU or CCS projects will be discussed in the further actions[1] of PilotSTRATEGY project). The political strategy to aim for ambitious climate targets is a pre-condition for the application of CCU and CCS technologies in a Member State. Legislation regulates the operation of capture, transport and storage sites. A well defined framework is highly relevant for operators to know the risks and potential costs related to a project, to know the own responsibilities and responsibilities of others, expectations by the competent authorities and making clear the roles of all participants in the whole project. It helps the authorities to take adequate decisions in granting procedures in decent time. Financial support is needed as long as the current CO_2 price itself is not sufficient to make the application of CCU or CCS technologies economically viable. Although it is to be expected that costs for CCU and CCS activities will fall over time when it moves from being a very innovative first-of-a-kind application to a more mainstream technology, in particular the first-of-a-kind applications require specific support to cover for high costs under high risks. At the same time, a strong CO_2 price in the European Emissions Trading System (EU ETS) (in February 2022 prices reached levels as high as 90€/t CO_2 and more) along with the expectation that CO_2 prices will remain high in the future and a clear signal that there will be a market for low-CO_2-products present strong financial incentives to invest into CCU and CCS projects.

In EU Member States typically political and regulatory provisions from the EU level mix with national views and regulations and sometimes even regional ones. Hence, EU-level targets and laws, regulations and directives and support instruments and the national implementations of those directives along with national policies provide the relevant framework for developing a CCU or CCS project in a Member State. In the following sections, we first present and discuss the framework the EU provides before looking into the frameworks on the national level for the countries France, Greece, Poland, Portugal and Spain. These are the countries where regions are explored for CO2-storage within the project. In addition, we present the framework conditions in the Netherlands and the UK as examples of countries where a relatively high activity level can currently be seen in the development of new CCU and CCS project activities to have running CCU and CCS facilities by the mid of the decade.

The analysis looks into the three main policy areas relevant for the development of a CCU or CCS project: we start with an analysis of the political strategy to reach net-zero (which can be seen as a precondition for the commitment to develop CCUS projects) and the role that CCU and CCS plays in the available policy documents (in particular the long-term strategies and related scenarios). The second pillar of the analysis looks into the regulatory framework for allowing for the use of CCS technologies and in particular the relevant regulatory policies supporting or hindering the development of capture, transport and storage. The final building block is provided by an analysis of the existing support policies. Due to the nature of CCU and CCS projects, CO_2 prices will in the long-term play an important role to make CCU and CCS technologies competitive. However, due to the novelty of the technologies and the implementation of the full CCU or CCS chain, additional support

[1] https://pilotstrategy.eu/node/9

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policies are the main factor to allow for the development of pilot projects in the short- to medium-term.

While this report addresses both, CCU and CCS projects, a clear focus can be found on the CCS side in all three areas: political strategy, legislative framework and - although lesser developed than in the other two areas - support systems. The focus is particularly strong when we look into the legislative framework, where we find an existing framework for CCS, but no mentioning of CCU in the documents so far. Part of the financial support systems address CCS as well as CCU projects, however, in many countries the strong political focus on CCS translates into a strong focus on support for CCS projects, although support of CCU projects is in general often also possible. Hence, the following report focuses on CCS unless CCU is explicitly mentioned.

4. CCS and CCU framework on the EU level

4.1 Policy strategy

By the end of 2018, the EU Commission presented a long-term strategy for the EU including scenarios aiming at reaching net-zero GHG emissions by 2050 (EC, 2018a and EC, 2018b). Only 2 out of the 8 scenarios presented in the Commission's document "A clean planet for all - A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy" reach net-zero by 2050: 1.5LIFE and 1.5TECH. In particular in the 1.5TECH scenario, CCU and CCS play an important role in reaching the net-zero target, but also the 1.5LIFE scenario requires CCU and CCS to reach carbon neutrality. In total, CCU and CCS activities reduce emissions by 281-606 Mt in 2050 in those scenarios. 80-298 Mt CO_2 are stored underground, 201-307 Mt CO_2 are being used, going mainly into the production of synthetic fuels and partly into synthetic materials. Based on those figures, CCU and CCS are seen as one of seven key technology areas to reach carbon neutrality by the middle of the century.

In 2021, the EU adopted the European Climate Law (EU, 2021) which enshrines in law the EU's objective to become climate neutral by 2050. As interim target, the EU aims at reducing emissions by 55% below 1990 levels by 2030. Documentation on the European Green Deal and the European Climate Law further strengthens the role of CCU and CCS, which is seen as an important factor and plays a major role in the policy packages to be developed to reach those ambitious climate targets.

Not existing so far is a European CCU and CCS strategy as proposed by the CCUS SET-Plan (CCUS SET-Plan 2021). Available is, however, a Roadmap for CCU and CCS ("CCUS Roadmap") to 2030 developed under the CCUS SET-Plan. The European Strategic Energy Technology Plan (SET-Plan) is an activity to better coordinate energy technology development in the EU and its Member States and informs policy makers. In the CCUS Roadmap targets are being formulated for 2030 that should be met within the EU to be on track to meet its net-zero target by 2050. It includes the delivery of 15 commercial-scale industry CCS projects with another 10 having completed a Front-End-Engineering-Design (FEED) study and five of them having made an investment decision, along with the delivery of 10 commercial-scale power- or heat-related CCS projects and the first large-scale commercial CCU installations. As another important piece, the CCUS Roadmap also defines targets for the strategic planning and development of CO_2 infrastructure and identifies the need for national CCS strategies and/or roadmaps by the Member States.

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Another piece of legislation strengthening the role of CCS and CCU in the European policy strategy is the document on the "sustainable management of the carbon cycle" published by the European Commission by the end of 2021 (COM 2021b). It highlights the role of negative emissions and of developing a carbon cycle for reaching a net-zero EU economy by 2050.

4.2 Regulatory framework

The regulatory framework for CCS in the EU consists of two major parts along with amendments to a number of existing legislations.

The **Directive on the geological storage of CO_2** (EC 2009, "CCS" Directive), implemented more than ten years ago, focuses on the establishment of a legal framework for the safe geological storage of CO_2. The main purpose is to allow for storage only if there is no significant risk of leakage and no significant environmental and health risks (Article 4). Among other aspects, the CCS Directive lays down requirements for selecting and operating storage sites. Exploration and storage permits are required in determining and using a storage side. The Directive further states that the CO_2 stream being stored underground shall consist overwhelmingly of carbon dioxide (Article 12), although not giving a percentage figure for the purity of the gas. In the case of leakage, the storage site operator has to take corrective measures immediately and notify the competent authority (Article 16). If the operator is not able to take adequate corrective measures, the competent authority takes over and has the right to retrieve the costs from the operator. The competent authority is responsible for organizing periodic inspections of the storage sites and facilities. Post-closure, the operator is responsible for monitoring and corrective measures in the case of leakage for at least another 20 years before the responsibility can be transferred to the competent authority (Article 18). Financial security to cover related costs (e.g. for monitoring and corrective measures) have to be proven by the operator before a storage permit can be obtained. In addition, a financial mechanism exists to transfer the responsibility for a storage site to the competent authority to cover at least the anticipated costs (for monitoring, but where applicable also for other activities needed to maintain the storage) for the following 30 years, so that if implemented well financial coverage of the potential costs of a storage site remains with the operator for 50 years after closure.

Transport is only a relatively small aspect in the CCS Directive. It states that transparent and non-discriminatory access to transport pipelines has to be provided by the operators of such infrastructure systems. Other forms of transport and other aspects of pipeline transport are currently not part of the CCS Directive. Capture activities are also not part of the CCS Directive.

All relevant decisions on permits for storage sites lay within the responsibility of the competent national authority such as dealing with monitoring and liability costs as well as connected to the closure of the site and the taking over of accountability after a certain period of time. However, the European Commission has the right to publish a non-binding opinion on the decision by the competent authority.

All Member States were required to implement the CCS Directive into national law by mid of 2011. With some delay, by October 2013, all Member States had communicated transposition measures. In 2017 the Commission reported that it considered the implementation in 16 of the Member States to be fully conforming with the Directive. Ways of implementation differ significantly between Member States, though. While some countries merely transposed the Directive by the wording, other Member States with a higher interest in CCS tried to fill the remaining gaps as far as possible.

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Another group of Member States such as Austria, Ireland, Latvia or Finland transposed the CCS Directive but also implemented a ban on storage.

Highly relevant in the context of CCS is also the **EU ETS Directive** (EC 2003) with its amendments. All three parts of the CCS process, i.e. carbon capture, transport (although so far restricted to pipeline transport) and geological storage, are activities mentioned in Annex I of the Directive. As a result, all CO_2 emissions in any of the process steps (including leakages) is regulated under the EU ETS and operators have the obligation to hand in an equivalent amount of allowances. All CO_2 captured and safely stored will be considered as not emitted under the EU ETS. This regulation under the EU ETS is supposed to provide an important financial incentive to store CO_2 instead of emitting it into the air and to provide finance for the additional costs for CCS activities in the future.

An aspect so far lacking from the EU ETS is other forms of transport apart from pipeline transport of CO_2. As a result, only CO_2 transported by pipeline qualifies for an exemption from CO_2 pricing under the EU ETS at the moment. The proposal for the revision of the EU ETS Directive in the context of the EU's Fit for 55-Package now foresees an inclusion of all forms of transportation (COM 2021a).

In addition to those two Directives, several legislation were amended to include CCS activities. Those are in particular:

- The **Environmental Impact Assessment Directive** (EEC 1985) requires environmental impact assessment procedures for all CCS activities, including a life cycle evaluation on environmental issues and social and economic effects of the project and a related risk assessment. It also requires monitoring significant effects on the environment and effectiveness of the control measures (see Barros, Oliveira and Lemos de Sousa 2012).

- The **Large Combustion Plant Directive** (EC 2001) was amended to require an assessment of the technical and economic conditions necessary for future application of CCS for the operation of combustion plants with a rated electrical output of 300 MW and more. In case of a positive assessment the operator is required to set aside suitable space on-site for the equipment needed to capture and compress the CO_2.

- CCS was also included in the **Waste Framework Directive** (EC 2008) to exclude the CO_2 captured and transported from the instruments associated with this Directive and the **Industrial Emissions Directive** (2010/75/EU) now covers capture as one of the activities that can help to control emissions from the industrial sector.

Not part of the EU legislative package, but highly relevant in the context of CCS activities within the EU are the London Protocol and the OSPAR Decision. The London Protocol prohibits all dumping of waste into the marine environment except for substances and activities listed on a "reverse list". In addition, it also prohibits the transboundary transport of substances for the purpose of dumping or incineration at sea. Not prohibited by the London Protocol are CO_2 storage activities in the context of enhanced oil recovery or as part of the offshore processing of natural gas streams (as is the case at the storage activities at the Sleipner field in Norway). An amendment to Annex I, that entered into force in 2006, opens up the opportunity for offshore storage activities in general when it is safe to do so and provides regulation on the injection of CO_2 into sub-seabed geological formations. In 2009, an amendment was adopted to also allow transboundary transport of CO_2 for sub-seabed geological storage. However, for the amendment to become effective 2/3rds of the contracting parties need to ratify the amendment, which is currently not the case. In 2019 it was decided by the Parties to the

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London Protocol to allow for a provisional application of the 2009 amendment. Thus, at the moment it is possible for countries to agree to export CO_2 for sub-seabed geological storage on a bilateral basis without breaking the London Protocol (IEAGHG 2021).

Also relevant in that context is OSPAR Decision 2007/02 by the OSPAR Commission (OSPAR 2007), a group of 15 country governments and the EU cooperating to protect the marine environment of the North-East Atlantic. The Decision states that OSPAR guidelines for Risk Assessment and Management of Storage of CO_2 Streams in Geological Formations need to be taken into account by a competent authority in the process of granting a CCS permit. The overall target is to avoid significant adverse effects on the marine environment.

4.3 Financial support framework

With low CO_2-prices for a long period of time, the **EU ETS** did not provide sufficient incentive for the investment into CCU or CCS projects in the past 15 years. However, recently a strong increase in prices could be seen with prices reaching close to 100 €/t CO_2 in December 2021 and in February-March 2022 price levels between 70 and 80 €/t CO_2 (see https://ember-climate.org/data/data-tools/carbon-price-viewer/ for current EU ETS prices). CO_2 prices like that will very likely play an important role in providing financing for CCU and CCS projects in the future.

Due to the long period with low prices and the low activity in developing CCU and CCS projects (and the cancelling of planned projects) resulting from that, the EU currently has different support programs in place for projects to get additional funding for CCU and in particular CCS projects (see Figure 1). The main source for funding of commercial scale demonstration plants is the **Innovation Fund**, which allows for funding of CCU and CCS projects in the energy and industry sectors. Resources initially available for the innovation fund were 450 million European Union Allowances (EUAs) from the EU ETS. The money that can be spent on projects is dependent on the price development of CO_2 in the EU ETS. Currently, the Commission is expecting a funding volume of 25 billion € for the period 2021-30 (https://ec.europa.eu/clima/system/files/2021-12/com_2021_800_en_0.pdf). The revision of the EU ETS under the fit-for-55 package foresees an additional 200 m EUAs to increase the budget available to fund innovative projects. The increase in resources is partly linked to a widening of the scope of the Innovation Fund to projects from road transport and buildings, two sectors that are proposed to become regulated under a second ETS on the EU level.

For the first large-scale call in 2020 a budget of 1 billion € was available. Four out of seven projects that were being chosen in the first round are large CCU or CCS industry projects (see https://ec.europa.eu/clima/system/files/2021-11/policy_funding_innovation-fund_large-scale_successful_projects_en.pdf for information on the projects being funded). For the second large-scale call open from 2021 another 1.5 billion € of funding is available. Up to now, support is granted in the form of grants. In the proposal for the revision of the Innovation Fund legislation, the Commission intends to also include support of operational costs on the basis of carbon contracts for difference (COM 2021a).

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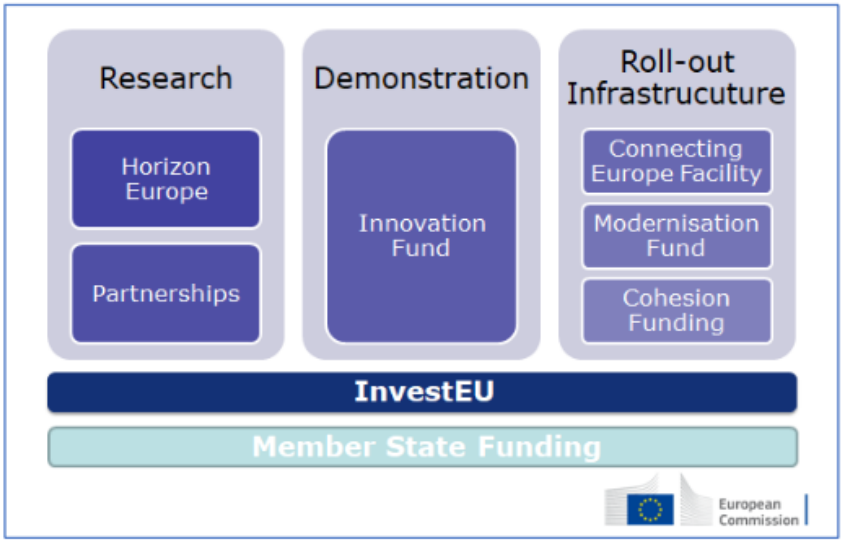
Figure 1: Support mechanisms for CCU and CCS in the EU



Source: CCUS SET-Plan, 2021

The NER 300 program, predecessor to the innovation fund between 2013 and 2019, was open for projects aiming at applying CCS in the energy sector, while industry projects were not eligible for funding. However, while several renewable energy projects were being funded, only one CCS project was awarded support under the NER 300 program. The White Rose project planned in the United Kingdom was never realized and financial support was not retrieved.

Another source for funding is the **Horizon Europe** program, the follow up to Horizon 2020, which also provided funding for CCU and CCS projects. Support from this program concentrates on supporting research and innovation activities.

Support for the roll-out of infrastructure for CCU and CCS activities can come from three different sources. Under the Connecting Europe Facility so called **Projects of Common Interest (PCIs)** can be supported. In the category cross-border carbon dioxide network, currently six PCIs are receiving support for the development of an EU-wide CO_2 transport infrastructure.

Another two sources of support for transport facilities are the **Modernisation Fund** as part of the support for energy networks and the **Cohesion Fund** as part of the support for trans-European transport networks (TEN-T). Both mechanisms are available to lower-income Member States only.

Under the **Just Transition Fund** 40 billion € of funding are being provided to support the transition in a Member State's most affected regions. Facilities regulated under the EU ETS can receive support for substantial emission reduction activities including CCU and CCS activities if they are located in such a most affected region listed in a Member State's just transition plan.

The European Green Deal is mentioned as one out of six Commission's priorities for the years 2019-24 under the recovery plan for Europe (InvestEU programme). 0.6 trillion € from the Next Generation EU Recovery Plan along with the EU's seven-year budget will finance the European Green Deal. Under the **Recovery and Resilience Fund**, part of the EU's recovery package, Member States have to hand in their Recovery and Resilience Plans. Some countries such as Denmark use their plans

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to include support for CCS activities (Jan Steinkohl, Policy Officer, DG Energy, European Commission in a webinar on The Role of CCS in the EU Green Deal, 25 February 2021, https://cleanenergysolutions.org/training/ccs-eu-green-deal and Global CCS Institute 2021).

CCU and CCS are also one of ten identified priority actions under the **European Strategic Energy Technology Plan (SET-Plan)**. Under the SET-Plan, activities in the priority areas are coordinated and exchange is being organized. Limited funding is being provided for the activities of the Cooperation and Support Action project. However, information collected under these cooperation activities provide useful information on the status and funding of CCU and CCS projects in the EU. According to the 2020 report on the implementation of the SET-Plan (EC 2020) 645 millions € are currently being spent in 81 SET-Plan projects on CCU and CCS activities. About 50% of the money is coming from EU support programs (see the above mentioned).

Another source of financing for CCU and CCS activities that is in planning is a **certification scheme for carbon dioxide removals**. After the publication of the policy paper from the Commission on the "sustainable management of the carbon cycle" (COM 2021b), a legislative proposal is planned for the final quarter of 2022 (https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-carbon-removal-certification).

Another piece in the support framework for CCU and CCS will be the **EU sustainable Taxonomy**. CCU and CCS, listed under the sustainable technologies provides access to European Green Bonds, an instrument to channel private investments to sustainable projects.

4.4 Summary

In the EU, quite early on a basis was developed for the legal implementation of CCS activities. In particular, the CCS Directive and other instruments such as the EU ETS provide the basis for the current or future implementation of CCS, but also CCU projects in the Member States. This fact results in a comparatively high ranking for all EU member states in the 2018 published CCS Policy Indicator report by the Global CCS Institute (Global CCS Institute 2018). Existing shortcomings such as the lack of other means of transport apart from pipeline transport in existing EU legislation are part of revision proposals under the fit-for-55 package and should soon be addressed. As usual in such cases, the CCS Directive gives leeway in some aspects that have to be filled by the Member States to provide the necessary clarity for project developers to take an investment decision.

The legislative framework was supplemented with a clear political signal in the development of the EU's long-term vision and with the implementation of the climate law and the net-zero target by 2050 as part of the climate law. Existing impact assessments and accompanying documents show the importance of CCU along with CCS for the EU to reach net-zero emissions in the announced timeframe.

An important factor in the restart of project development on CCS and for the development of CCU projects in the EU plays the Innovation Fund. It broadened available funding from energy-related CCS projects to energy- and industry-related CCU and CCS projects. Together with the currently high CO_2 price under the EU ETS, which helps in itself to make CCU and CCS projects financially profitable, it provides a significant amount of funding for the realization of large-scale CCU and CCS projects in the coming years, further underlining the important role of CCU and CCS for the EU.

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A further strengthening of the role of CCU and CCS in EU climate policy can be expected from the ongoing work on carbon cycles, which is expected for the end of 2022 and will be negotiated in the coming years. It is likely that in that context also more legislative documents will become available for CCU in addition to what is already available for CCS.

5. Country examples

5.1 Netherlands

5.1.1 Current status of project development

The Netherlands is one of the countries of the European Union that decided early on that CCS should play an important part in reaching medium- to long-term climate targets. As a result, three projects had been started, but failed between 2000 and 2017, two of them being onshore storage projects, one of them being an offshore storage project. Two of them, both onshore storage projects, were stopped as a result of public acceptance issues, one was cancelled as a result of a lack of political support and a sustainable business case for coal-fired power generation in combination with CCS (Akerboom et al. 2021).

At the moment, the Zero Emissions Platform (ZEP) lists a total of eight CCU and CCS projects in the Netherlands and two joint projects on transport and storage between the Netherlands and Belgium. Of the eight projects, two are labelled as low-carbon hydrogen production projects (H-Vision and Hydrogen 2 Magnum) and two projects are labelled as CCU projects (AVR-Duiven and Twence Waste-to-Energy CO_2 Capture and Utilisation). Three of the remaining four projects are aiming at collecting, transporting and storing CO_2 from industry clusters (Aramis, Athos, Porthos), one project is a CCS project in a steel plant (HIsarna Pilot Plant). The Porthos project in the Port of Rotterdam is awarded 2.1 billion € from the Dutch government under the SDE++ scheme. The final investment decision for the project was awaited for the end of 2021/ early 2022, but is still pending and is now announced for 2022. If the project is continued, the full project shall be taken into operation in 2024. The project also receives funding (102 million €) as a project of common interest by the Connecting Europe Facility. Athos and Aramis are also listed under the cross-border carbon dioxide networks by the Connecting Europe Facility.

5.1.2 Policy strategy

Emissions in the Netherlands lay at around 200 Mt CO_2e in 2019 (see EEA GHG data viewer, 2021). In May 2019, the Dutch Government adopted its Climate Act which includes the target to reduce emissions by 95% below 1990 levels by 2050. By 2030, greenhouse gas emissions shall be reduced by 49% below 1990 levels. The National Climate Agreement contains information on the sector's contribution to reaching the climate targets. It states that CCS is an important building block in the decarbonisation of industry (about 7 Mt CO_2 by 2030 could be stored via CCS) and that funding will be provided over an extended SDE+ (see SDE++ in section 3.1.3) funding scheme. Until today, the Netherlands have not officially adopted the target to reach net-zero emissions.

5.1.3 Regulatory framework

In order to implement the CCS Directive the Dutch Government amended the Mining Act and subordinate legislation (Mining Decree and Mining Regulation) in 2011. The amendments particularly aim at the implementation of the following issues from the CCS Directive (see Akerboom et al. 2021 and van der Weijden 2011):

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- CO_2 storage: Even before the amendments necessary to implement the CCS Directive, the Dutch Mining Act contained a general permit obligation for the storage of substances that included CO_2. The amendments that were being made to implement the CCS Directive particularly addressed the content of the permit (i.e. the application) and regulations associated with the transfer of responsibility for CO_2 stored after closure of a storage site. In particular, a monitoring plan, a termination plan and a provision of financial security have to be part of the storage permit in line with the EU CCS Directive while in other cases these aspects can be agreed at a later stage. The Mining Decree elaborates on the elements that must be regulated in the integral storage permit, including on the risk management, closure of a storage site and financial security. In case of severe leakage or other irregularities, a permit can be withdrawn.
- Exploration of storage site: The Mining Act was amended to enable the issuance of CO_2 exploration permits. According to the CCS Directive, those permits are required in case of drilling activities to gather information on a potential geological storage site. It is expected that in the Netherlands they will primarily be necessary in case of the exploration of aquifers as a sufficient amount of information should be available for depleted gas fields to apply for a CO_2 storage permit immediately.
- Exclusivity: Holders of a storage permit or an exploration permit have the exclusive right to develop activities there. As a result the holder of a regular exploration, production or storage permit, who decides to use the area for CO_2 storage must first return its regular permit to then apply for a CO_2 storage permit. In the Netherlands once the competent authority has received an application for a permit, other parties have the opportunity to also hand in applications for the same storage site. The decision on who is granted the permit is then made based on the information provided in the application. So it is not clear that the holder of an exploration permit will also get a storage permit for the same site. However, the holder of an exploration permit who has proven the suitability of a storage site should be prioritised in the process of granting a storage permit.
- Leakages: In case of leakage or significant irregularities - in line with the CCS Directive - the operator of a storage site has to notify the competent authority and has to take the necessary corrective measures. The competent authority can take over if the operator is not able to do so. In case the competent authority takes over from the operator, the operator has to surrender emission allowances under the EU ETS for resulting emissions for at least 20 years, a timeframe that can be shortened or prolonged by the competent authority. Circumstances for a shortening or prolonging of the timeframe are not clear from the available legislative framework.
- Transport: So far, third-party access to transport infrastructure or other details on the transport of CO_2 in the Netherlands are not regulated.
- Closure of a storage site: Closure is managed by a post-closure plan. In particular, the operator is responsible for monitoring and - if necessary - corrective measures for another 20 years. After that timeframe, responsibility can be transferred to the competent authority, however, financial resources have to be provided by the operator for at least the monitoring of the site for another 30 years. A prerequisite for the transfer of responsibility to the competent authority is that the authority is convinced that the CO_2 is stored safely underground. In addition, in case the operator has not acted carefully the minister of Economic Affairs, Agriculture and Innovation can recover costs resulting from leakage from the permit holder beyond 20 years.

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- Competent authority: The Minister of Economic Affairs and Climate Policy is responsible for permit application, inspection of storage sites, dealing with monitoring and liability costs and closure of a site. The European Commission has a consultancy role with the option to issue a non-binding opinion on the decision by the competent authority.

The Directive on Environmental Liability deals with the liability for damages to the environment. Damage to health and property is dealt with at the Member States level. In the Netherlands, the Dutch Civil Code foresees a length of liability between 5 years after discovery to 20-30 years after the activity has caused damages. After 30 years, any liability for damages under the Dutch Civil Code ends.

Although on-shore storage is not forbidden in the Netherlands, as a result of public opposition against on-shore storage projects in the past the Dutch Government decided to concentrate on off-shore storage for the time being (Akerboom et al. 2021).

Akerboom et al. (2021) see three main shortcomings in the current legislative framework in the Netherlands: (i) although roles, tasks and responsibilities are clearly defined by the legislative framework uncertainties exist in particular with regards to receiving a storage permit as the permit procedure is a competitive one and it is not clear in advance that an operator holding an exploration permit for a site will actually get the storage permit for that site. According to van der Weijden (2011), though, the holder of an exploration permit should be prioritized by the permitting authority, a fact that should at least limit this risk. (ii) Due to the possibility to shorten or prolong timeframes for liabilities, costs arising from those liabilities are not clear beforehand. (iii) In the current legislative framework is a lack of rules for access to existing transport infrastructure.

5.1.4 Financial support framework

In 2020, the Dutch Government broadened its support instrument for renewable energy technologies to also include emission reduction technologies such as CCU und CCS. Under the SDE++ ("Stimuleren Duurzame Energie") CCU and CCS projects are able to receive a subsidy, paid as a top-up on market prices to eliminate existing price risks. The maximum rate a project is able to apply for is fixed by the Government. In case of CCS projects, the maximum rate is between 62€/t for existing CCS installations and up to 194€/t in later application phases for new CCS projects in existing installations that are not regulated under the EU ETS (2020: 100€/t CO_2 for new CO_2 capture in existing production processes). In the case of CCS projects in installations regulated under the EU ETS, the maximum rate is reduced by the price for EU ETS allowances to reflect the financial incentives for storing CO_2 under the EU ETS. Operators applying for less than the maximum rate are more likely to receive funding. An SDE++ call is organized in 4 phases with an increasing CO_2 intensity limit. In Phase 1, projects could only apply for projects with CO_2 reduction costs of 60 (in 2020: 65) €/t CO_2. The maximum CO_2 price increases to 80 (2020: 85) €/t in Phase 2, 115 (2020:180) €/t in Phase 3 and 300 €/t CO_2 in Phase 4. The subsidies over all categories (i.e. not only CCS and CCU funding) are provided on a competitive basis with applicants with lower costs being more likely to receive funding than applicants with higher costs. This process shall help to ensure that the necessary subsidies decrease over time. Rates are paid for a maximum of 15 years (see Aurora 2021).

In the first call for projects under the broadened SDE++ in 2020, 5 billion € were available for funding, of which 4.7 billion € were being awarded. 2.1 billion € were awarded to CCS projects (see

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Aurora 2021). CCS project applications were found in Phase 1 and 2 of the first call. A second call for projects started in October 2021.

In addition to the SDE++ framework, the Dutch government also introduced a minimum price for CO_2 emissions from industry and power plants. A minimum price of 30€/t CO_2 in 2021, increasing by about 10,50€/t CO_2 per annum, was introduced via the Klimaatakkoord. The minimum price is implemented via a carbon tax reduced by the price for EUAs. Negative tax rates are excluded. In times of lower CO_2 prices under the EU ETS this minimum price can help to keep up the incentive for investments into CCU and CCS projects.

5.1.5 Summary

Interest for CCS projects was high in the Netherlands from the beginning. Between 2000 and 2017 three CCS projects started, but were never realized due to different reasons. Two of them, both on-shore storage projects, were stopped as a result of public acceptance issues, one was cancelled as a result of a lack of political support and a sustainable business case for coal-fired power generation in combination with CCS. Currently, the focus of Dutch CCS projects is on the installation of transport and storage infrastructure. Three large transport and storage projects are being developed in the Netherlands: the Porthos project at the port of Rotterdam, the Athos project in the North Sea Canal industrial cluster close to Amsterdam and the Aramis project at the port of Den Helder and more projects are under consideration. One CCU project (AVR Duiven) is up and running since 2019 capturing CO_2 from waste incineration and supplying it to greenhouse horticulture.

Despite the fact that the Netherlands so far have not adopted a net-zero target, the development of the new CCS projects was triggered by a clear political signal that CCS is seen as a key element in the decarbonization of industry in the Netherlands. Already by 2030 up to 50% of the emission reductions in industry according to current policy planning could come from CCS processes. The political willingness to use CCS projects to reduce industrial emissions was combined in 2020 by the broadening of the SDE++ funding mechanism, formerly used for the support of renewable energy technologies only and now open also to other technologies meant to reduce CO_2 emissions. With more than 2 billion € of the available 5 billion € going to CCS projects in the first call for projects in 2020 the mechanism has become an important source of funding for Dutch CCS projects. In addition, the introduction of an - over time strongly increasing - minimum price for CO_2 from industry and power plants further strengthens the investment case for CCU and CCS.

Although plans to realize a full CCS process in the Netherlands are at an advanced stage, no such project has yet been realized. While the Netherlands implemented the European CCS Directive into national law by amending its Mining Act to include important aspects related to the storage of CO_2 and access to pipelines, the legal framework still contains a number of uncertainties that could become barriers to the implementation of CO_2 pipeline transport and storage sites in the Netherlands, such as costs related to cover for monitoring and unexpected leakage. Other open questions can be expected to be addressed (including the introduction of sufficient legal security) in the process of realizing the first CCS projects in the Netherlands once one of the quite advanced CCS projects come to realization.

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5.2 United Kingdom

5.2.1 Current status of project development

Similar to the Netherlands, the UK was also quite early on very active in developing CCS projects. Currently ZEP lists 14 CCU and CCS related projects in UK, the CCS project database from the global CCS institute even lists 16 CCU and CCS projects including a Direct Air Capture project.

In October 2021, the Government named two CCS clusters which will be funded via the UK CCS Infrastructure Fund (see below): the East Coast Cluster and HyNet. They can now start negotiations with the Government on the specific amount of funding they need to become operational. The goal is to build up a transport and storage infrastructure by mid of 2020 (see https://www.upstreamonline.com/energy-transition/uk-government-picks-ccus-clusters-in-england-for-state-funding-cop26-host-scotland-loses-out/2-1-1084639).

5.2.2 Policy strategy

In 2019, the UK Government committed to reach net-zero GHG emissions by 2050 as recommended by the British Climate Change Committee. Already by 2035 a 78% reduction of GHG emissions below 1990 levels shall be reached.

In a report from 2019 by the Committee on Climate Change it states that "CCUS is a necessity, not an option." (Committee on Climate Change 2019). This is reflected in the "Ten Point Plan for a Green Industrial Revolution" (HM Government 2020), published in November 2020, which lists CCS as one central point for reaching the net-zero target. It aims at having the capacity to capture 10 Mt CO_2 annually by 2030. To reach that target CCS shall be established in two industrial clusters by mid of 2020 and another two in the second half of the decade. The Ten Point Plan also announces that business models will be established to attract the necessary investment to meet this target.

5.2.3 Regulatory framework

The Energy Act of 2008 and the Carbon Dioxide Regulations from 2010 provide the basis for CCS activities in the UK and transpose the requirements from the CCS Directive into national law. According to the legislations, storage is allowed in offshore areas comprising UK territorial sea and beyond which are designated as gas importation and storage zones under the Energy Act of 2008. Licensing powers, which were originally given to the Secretary of State for Business, Energy and Industrial Strategy (BEIS) were in 2016 transferred to the Oil and Gas Authority (OGA). Licensing powers for storage sites located within the territorial sea adjacent to Scotland are being held by the Scottish ministers. While OGA is in charge of the issuance of storage permits, the Crown Estate & the Crown Estate Scotland hold the seabed rights for CO_2 transport and storage. In addition to perceiving the required permits from OGA and conditional on reception of such a permit project developers also have to obtain a grant of the appropriate rights from the Crown Estate respectively the Crown Estate Scotland (see https://www.gov.uk/guidance/uk-carbon-capture-and-storage-government-funding-and-support#regulatory-regime-for-ccus-in-the-uk). According to the Government, while no CCS project has so far been realized under the existing legal framework, the Scottish Government coordinated a scenario project to test the existing regulatory framework in Scotland (which is quite similar to the UK). The report states that the legal framework is emerging well, but also highlighted the complexity and size of CCS projects and that a large number of permits are being required further complicating the process (DECC 2012).

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In addition to regulating offshore carbon dioxide storage, approving and issuing storage permits OGA also maintains a carbon storage public register where all UK offshore carbon storage sites are listed.

In 2021 the Government started a consultation process for the installation of an economic regulator for carbon dioxide transport and storage networks. This regulator is supposed to oversee the activities of the monopolistic transport network structures that are foreseen. Ofgem, the British energy regulator, is proposed to take over this position as regulator (BEIS 2021a).

5.2.4 Financial support framework

While no longer part of the EU ETS, the UK has since 2021 established its own UK ETS, applying similar rules than the EU ETS. CCU and CCS activities are - as under the EU ETS - included and CO_2 that is being captured and stored is exempted from the allowances obligation. Prices in the UK ETS reached 70 £/t CO_2 in October and December 2021.

In addition, a set of different support schemes is being established in the UK to further support the development of CCU and CCS. Funding will be provided for different areas with differing support systems addressing the particular challenges for the development of technologies in that area: transport & storage (addressing the development of the four planned clusters and more), power, industrial carbon capture, bioenergy with carbon capture and storage (BECCS) and low carbon hydrogen production. Further, in most areas the support instruments include a funding scheme on the one hand to support up-front investments (mainly grants) and a business model development on the other hand to support active projects in receiving the required return on investment.

The key instrument to support the development of transport and storage infrastructure as well as for the early development of early industrial capture and storage projects is the **CCS Infrastructure Fund** (BEIS 2021b). It was announced at Budget in March 2020 and an allocation of 1 billion £ was confirmed in November 2020. The aim of the fund is to develop 2x2 CCUS clusters with the necessary transport and storage network infrastructure. The first two clusters shall be operational by 2025, another two clusters by 2030. The choice of the first two clusters funded under track 1 were announced in October and are now in the process of negotiating funding conditions with the Government.

Transport & storage business models (BEIS 2021c) are available to the operator of the infrastructure to grant the licensee a regulated revenue stream. The payments are based on a "User Pays" revenue model ensuring that users of the infrastructure also cover for the costs for their usage of the infrastructure. Based on an "Economic Regulatory Regime", the monopolistic infrastructure operator has an annual allowed revenue reflecting efficient operating costs and a reasonable rate of return. Potential revenue gaps for the operator (in particular due to the fact that a network's capacity in the beginning is likely to be higher than what is demanded by firms for transport and storage) are expected to be filled with the up-front investment from the CCS Infrastructure Fund.

Industry CCS projects can receive financial support under the **Industrial Energy Transformation Fund** (BEIS 2020). With 315 million £ the fund is meant to support capital expenditures for on-site capture projects. In Phase 1 funding is technology-neutral and can be used either to finance feasibility and engineering studies or early movers to complete on-site carbon capture projects. From Phase 2 onwards the scope is extended to include decarbonisation deployment projects.

Business models for industrial carbon capture (BEIS 2021d) are designed to cover for higher running costs (e.g. operational expenses, fees to be paid for the use of the transport and storage

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infrastructure or repayment of capital investment). The so-called ICC Contracts define a strike price that is negotiated bilaterally on a project basis. The strike price takes into account capital expenses along with operational expenses required for the capture, transport and storage activity as well as - where relevant revenues from free allocation of allowances under the UK ETS. While the latter two will be taken into account for the whole period of time of the contract, the add-on for the capital expenses shall only be paid until the capital expenses have been paid back. The contract has a contractual period of 10 years with an option to extend the contract once for another five years.

CCS projects in the power sector will be funded through a **Dispatchable Power Agreement** (BEIS 2021e). The mechanism consists of two payments: a payment for low carbon generation capacity along with a variable payment in case of production.

CCS projects in combination with hydrogen production can be supported under the **Net Zero Hydrogen Fund** with a volume of 240 million £. In addition, specific business models will also be made available for hydrogen to support the variable costs of production. However, the process is ongoing and more information on the business models is currently not available.

5.2.5 Summary

In the UK, a clear political will come together with a strong legal framework (based on experience from oil and gas exploitation and other energy market regulations) and with a strong support package. A special feature of the support package is the fact that it includes (mainly grant-based) funding instruments to cover for high up-front investment costs together with business model packages which shall help to cover - in particular in the beginning, but e.g. for transport & storage infrastructure over the total lifetime of the infrastructure - running costs that arise from using CO_2 capture and storage opportunities. With the nomination of the two first clusters that will be supported and backed by the currently relatively high UK ETS CO_2 prices, development of a transport and storage infrastructure along with the development of capture projects could speed up in the coming years. Realization of at least one of those projects will also serve as test for the existing regulatory framework and allow to identify existing shortcomings.

5.3 Portugal

5.3.1 Current status of project development

According to ZEP and the 2021 CCS status report there are currently no CCUS project planned or under development in Portugal.

5.3.2 Policy strategy

With roughly 80 Mt GHG emissions (including emissions from LULUCF) Portugal is a medium emitter in the EU (EEA GHG data viewer, 2021). They have the target of reaching net-zero GHG emissions by 2050 in their long-term strategy published in 2019 (República Portuguesa 2019a). The low-carbon roadmap does not identify CCS as a solution for the Portuguese economy so far due to its very limited applicability and relatively high costs. According to the roadmap, the main sectors for which CCS could be an option are cement and lime. The limited role of CCS in the roadmap corresponds with the fact that CCS is currently not very high on the political agenda, Portugese politics does not see itself as a frontrunner in the development of CCS technology. Currently, Portugal does not address CCS in its national energy and climate plan (Republica Portuguesa 2019b). To being able to open the debate at a later point in time the roadmap states that the role of CCS could change if costs

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for the technology decrease significantly. The National Hydrogen Strategy (Resolution of the Council of Ministers 63/2020) can be seen as another entry point into a later discussion of CCS as it states explicitly the need for CO_2 to produce e-fuels which could be derived from CCS processes.

5.3.3 Regulatory framework

As required, Portugal implemented the EU's CCS Directive into national law with the Decree-Law 60/2012, published in March 2012 (https://dre.pt/home/-/dre/553447/details/maximized). The implementation of the CCS Directive includes amendments required in other legislations such as the legislation on environmental impact assessments to implement the need for an impact assessment for CCS activities or the Legal Regime of Liability for Environmental Damages (Decree Law 147/2008) to cover for potential damages from CCS activities. This includes in particular the need to set up "one or more financial guarantees, ... which enable them to assume the environmental liability inherent to the activity they perform" through "insurance policies, obtaining bank guarantees, participating in environmental funds or constituting own funds reserved for this purpose". Another amendment is being made to the legal regime concerning integrated pollution prevention and control by adding CO_2 capture for storage purposes to the list of installations covered.

The legislative package names the Member of Government in charge of Geological Resources and the Directorate-General of Geology and Energy as the person in charge of the acts foreseen in the diploma.

5.3.4 Financial support framework

As CCS is currently not seen as key building block in bringing down emissions in Portugal, no additional national financial support for CCS activities is currently available. However, there is the possibility to open up the national Environmental Fund to CCS projects in the future.

5.3.5 Summary

Due to the limited applicability of CCS in Portugal and high abatement costs, CCS is not very high on the political agenda in Portugal at the moment. Besides the fact that the CCS Directive has been implemented into national legislation - without additional specifications -, no further activities to support the development of CCS activities in Portugal from the Government could be found.

5.4 Spain

5.4.1 Current status of project development

ZEP currently lists one CCU project in Spain. The project aims at capturing the CO_2 from a cement plant in Carboneras and to recycle the gas for use in the agricultural sector for accelerated crop production. Until 2021, Spain was the only country having an active onshore injection site in the European Union. At the Hontomin Technology Development Plant (close to the city of Burgos) injection of CO_2 and its effects to the surrounding as well as whether the CO_2 actually stays underground was monitored. In 2018, it was granted a storage permit for a period of 30 years (10 years to inject a maximum of 100 kt of CO_2 and 20 years for site monitoring) conditional on the environmental bond which was never actually provided by the Ministry of Ecological Transition. At the end of 2021, the Ministry announced the official closure of the storage plant. Hontomin Technology Development Plant was officially recognized by the European Parliament as a key test facility.

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5.4.2 Policy strategy

Total greenhouse gas emissions in Spain in 2019 were estimated to be 296 Mt CO_2e (EEA GHG data viewer, 2021). This makes Spain the fifth largest emitter in the EU. In 2020, the Spanish Government adopted a law to cut emissions to net zero by 2050. The role of CCU and CCS is specified in the documentation to Spain's long-term strategy (MITECO 2020a and 2020b). The long-term strategy aims at a reduction of emissions by 90% by 2050. The remaining 10% shall be offset by natural sinks (LULUCF). CCU and CCS are seen to be relevant in particular for the lime and cement production, for the production of fertilizers and in pulp and paper production. Steel and refineries might present other options for the use of CCU and CCS technologies dependent on the development of other alternatives for decarbonization. However, the long-term strategy also highlights that CCU and in particular CCS is still in the early stages of development and does not include negative emissions from BECCS for reaching the net zero target.

5.4.3 Regulatory framework

The transposition of the CCS Directive into Spanish law took place in December 2010 by the adoption of the law on Geological Storage of CO_2 (40/2010 Law). The law focuses on the storage of CO_2 and does not regulate transport or capture activities. Further, it explicitly states that planned storage capacity of less than 100 kt is not regulated under this law (in line with the requirements of the CCS Directive), but under Law 22/1973, of 21 July on Mines.

An assessment of the law (Sun et al. 2021) came to the conclusion that there are a number of aspects in the law that have not been further developed in the transposition of the CCS Directive into Spanish law, but that require further normative development for a useful application. Hence, the law presents a limited framework for the storage of CCS and requires further specifications in the future. Parts that are particularly well developed according to the assessment are the presence of a penalty system as well as the substantial technical content in particular for site characterization and the monitoring requirements of prospective storage sites.

As required additional amendments have been made for:

- Environmental impact assessments (Law 21/2013) to require for an environmental impact assessment for all activities in the context of CCS activities (drilling, storage sites, capture facilities, pipelines for the transport of CO_2)
- Compatibility with the marine environment (Law 41/2010) to require compatibility reports to be carried out on the protection of the marine environment
- Integrated environmental authorisation (Royal legislative Decree 1/2016) to reduce and control pollution of the atmosphere, water and soil. Therefore an integrated environmental authorisation is required.
- Authorisation of greenhouse gas emissions (Law 1/2005) under the EU ETS (required for capture, pipeline transport and geological storage of CO_2)
- Environmental liability (law 26/2007 and Royal Decree 2090/2008) requiring a quantitative environmental risk analysis as well as the provision of environmental financial guarantees to cover the environmental liability of operators activities

Still missing is a regulatory framework for the permitting process of CCS activities at larger scale. Exploration and storage permit for the storage site at Hontomin have been issued under the Mining Regulation. The storage permit requirements were established by a Task Force from the Mining Authority (IGME and CIUDEN). Law 40/2010 was taken into account in the process where the Mining

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Regulation itself was not sufficient. Based on the work of the Task Force a storage permit was granted in July 2018 to the Hontomin Technology Development Plant (Sun et al. 2021).

5.4.4 Financial support framework

To our knowledge, currently no additional national funding is available for the development of demonstration projects in Spain.

5.4.5 Summary

Despite Spain being one of the first countries of adopting the net-zero target by 2050 in law, CCU and in particular CCS currently are not a key pillar in the Spanish decarbonization strategy. While a role is seen for CCS in the context of some industry sectors, negative emissions are so far solely based on natural sinks and also not coming from the application of BECCS technologies in the available roadmap documents. As a result, there is no clear political dedication and hence no additional national financial support for CCS in Spain. Also, the CCS Directive has been transposed into national law without any further advancements. Hence, shortcomings in the European Directive were taken over into national law. However, a positive aspect for the development of new CCS pilot projects in Spain is the fact that the process of granting an exploration and afterwards a storage permit has been applied once for a test storage site, i.e. some first experience exist with the provision of exploration and storage permits, despite, the fact that the process was not applied on the basis of the CCS Directive but on the basis of mining law as applicable to small storage sites. Exchange with the persons in charge of the application and granting process from all actors involved might be useful to learn from their experience in the process.

5.5 France

5.5.1 Current status of project development

In France, currently three CCS projects are being listed by ZEP: A low-carbon hydrogen production in Port Jerome (Port Jerome CO_2 capture plant), a CCS-equipped steel-making plant in Dunkirk (3D Projekt DMX Demonstration in Dunkrik) and a CO_2 transport and storage project in the Dunkirk harbor. In addition, with the K6 Program, France won one out of four CCU or CCS projects funded under the first EU Innovation Fund call for proposals round. The project in the Lumbres cement plant aims at significantly reducing CO_2 emissions from cement production by maximizing the use of biomass-containing and alternative fuels, using already-decarbonated raw materials and applying an oxy-fuel kiln which will be able to capture 90% of the remaining CO_2 (see https://ec.europa.eu/clima/system/files/2021-11/policy_funding_innovation-fund_large-scale_successful_projects_en.pdf).

A CCS pilot-scale project in Lacq-Rousse was operated by Total (2006-2013) and injected more than 51 kt of CO2 during 2010 and 2013 (Total 2013).

5.5.2 Policy strategy

With 460 Mt CO_2e in 2020, France is the second largest absolute emitter in the European Union following Germany (EEA GHG data viewer 2021). Already in 2019, France adopted in its law no. 2019-1147 on energy and the climate the target to become carbon neutral by 2050. Details of reaching this target are specified in the national low carbon strategy. The first version of the strategy was published in 2015 (aiming at a target of 75% reduction below 1990 levels by 2050) and it was amended in 2020 to reflect on the updated target of carbon neutrality by 2050 (Republique

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Francaise 2020). In the amended low carbon strategy from 2020 different policy objectives towards CCU and CCS are presented. CCS technologies are seen as an integral part to reduce non-energy emissions in industry by 81% by 2050 compared to 2015. According to the report, up to 6 Mt CO_2 from industry could be captured annually by 2050. Sector roadmaps for steel, chemicals and cement from 2021 go even further and explicitly name CCS as a lever for decarbonization by 2030 (steel and chemicals) or 2035 (cement). Explicitly no future role is seen for CCS in the energy sector after 2050 except for the combination with biomass to generate negative emissions (BECCS). A potential of about 10 Mt CO_2 is seen for BECCS activities in 2050. CCU is mentioned as a priority area for research.

5.5.3 Regulatory framework

According to the national low-carbon strategy the legislative framework for CCS activities in France is ready. The CCS Directive has been implemented into national law in 2011 (French national decree on the geological storage of CO_2 - Decree n°2011-1411).

Further legislation relevant is that from 2009 any new coal fired power plant needs to be CCS read and have a full-scale demonstration program.

Already in May 2010 the French parliament had adopted exploration permit principles and granting processes based on the country's mining code, which handles access rights to underground resources. In addition to the approval, injection tests must include public consultations. In France, the Ministere de la transition ecologique is the competent authority dealing with the operation of CCS projects.

5.5.4 Financial support framework

Different sources can be accessed for the support of CCS projects (ADEME 2019). Projects in the R&D phase can find national financial support either via the ADEME thesis program, a program designed to support students in writing a phD thesis, or via specific calls for R&D projects. Investments into demonstration projects and for further industrial development can be accessed via the Investments for the future program. The program as a whole has a budget of 57 billion €, of which 4 billion € are available for funding of projects for the environment and in the renewable energies sector. This part is operated by ADEME. There are two support possibilities: via state-aid combining grants and refundable loans (up to 2.8 billion € are spent that way) or via capital investments by ADEME in the form of co-investments either with corporates or financial partners in project companies or with venture funds in SME's companies. For the later part 1.2 billion € are available. A broad spectrum of projects can be funded under the Investments for the future program including renewable energy projects, environmentally friendly buildings, green chemistry, energy storage, hydrogen production, water and biodiversity, waste and industrial ecology projects, polluted site remediation and projects in the area of transport for the future. Specific funding programs focusing on CCU or CCS activities were not identified.

5.5.5 Summary

Although since the increase in ambition of the target to net-zero by 2050 CCS is explicitly mentioned as part of the decarbonization strategy particularly for industry, but also to generate smaller amounts of negative emissions via BECCS, the financial support framework in place so far is not specifically tailored to the needs of CCS projects. Similarly, translation of the CCS Directive into French law took place quite early on, but so far no experience has been gained with the instruments as no projects have been implemented under the framework provided. In spite of a succesful and

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completed CCS project (consisting of capture, transport and geological storage) by TotalEnergies in the South-West of France between 2007 and 2013 (Total 2013), it is not clear that the implementation of the CCS Directive in place is fit for the realization of CCS projects in France at the moment.

5.6 Poland

5.6.1 Current status of project development

Currently, ZEP shows only one CCS-related project in Poland. The project aims at the development of an open access multi-modal CO_2 hub in the Port of Gdansk. The project is being funded as one out of six projects of common interest related to the development of cross-border CO_2 networks (Poland EU CCS Interconnector, see https://ec.europa.eu/energy/sites/default/files/fifth_pci_list_19_november_2021_annex.pdf).

In September 2021 HeidelbergCement announced the launch of a new CCS project at the Gorażdże cement plant in Poland under the lead of the Norwegian Sintef Energi AS. The project ACCSess, which receives 15 million € funding under H2020, builds on a consortium of 18 industry partners and research organisations. It aims at testing an enzyme-based capture unit. The project is running until 2025 (see https://www.heidelbergcement.com/en/pr-17-09-2021).

In March 2021, the 3-years project 'CCUS.pl' (*Strategy for the development of technologies for capture, transport, utilization and storage of CO_2 in Poland and the pilot of the Polish CCUS Cluster*) of Ministry of Economic Development, Labour and Technology began. The project is only concerned with the development of a disposal strategy, but through the participation of relevant actors, it may be an opportunity for faster amendment of the law for CCS in Poland.

5.6.2 Policy strategy

GHG emissions in Poland were at 380 Mt CO_2e in 2019 (EEA GHG data viewer), fourth highest in the EU. For the time being, Poland has not implemented a net-zero target for 2050 yet and has also not formally endorsed the EU's 2050 climate neutrality goal. Further, Poland so far has not submitted a long-term strategy from which information could be taken on the country's approach to decarbonize its economy. In September 2020, Poland's deputy climate minister stated that "climate neutrality is something that we are committed to", which was seen as a positive signal (https://www.euractiv.com/section/energy-environment/news/warsaw-says-committed-to-eus-climate-neutrality-goal/). In January 2021, Greater Poland, the country's second largest region announced that it intends to become climate neutral by 2040. In the region, one coal-fired power plant and seven coal mines are in operation. Greater Poland sees itself as a "laboratory on the road to climate neutrality" (https://www.euractiv.com/section/energy/news/west-poland-subregion-aims-to-be-first-in-the-country-to-hit-net-zero/).

Research scenarios from independent organisations (Kobize, a Polish Think Tank part of the Institute of Environmental Protection - National Research Institute) indicate that CCS, CCU and BECCS could play an important part in the decarbonization strategy of Poland's economy (see https://climatecake.ios.edu.pl/wp-content/uploads/2021/07/POLAND-NET-ZERO-2050.-The-roadmap-toward-achievement-of-the-EU-climate-policy-goals-in-Poland-by-2050.-Summary_FINAL.pdf). In contrast, a report by WWF Poland reaches climate neutrality without the use of CCS technology.

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In October 2021 the Ministry of Climate and Environment launched public consultations on the role of CCS projects in Poland in the future. An attempt to put CCS to the political agenda is the publication of a green paper by an industry group consistent of LOTOS Petrobaltic, LOTOS Group and Azoty Group, representatives of the Polish oil and gas industry as well as a chemical company in November 2021. The "Green Paper for CCS development in Poland. Business proposals in the legislative process" identifies shortcomings in the existing legal framework and makes recommendations for changes in the existing legislation to allow for CCS development in general (https://grupaazoty.com/en/news/green-paper-for-ccs-development-in-poland).

5.6.3 Regulatory framework

In Poland, implementation of the CCS Directive into national law took place in 2013 by the announcement of the uniform text of the Act of June 9, 2011 Geological and Mining law. It solely allows for and regulates the underground storage of CO_2 in order to conduct a CCS demonstration project. Furthermore, only one offshore storage site in the Baltic Sea is currently approved for storage, onshore storage is hence currently banned. By the end of 2024, a report containing an analysis of the projects carried out is to be prepared to present the experience. The national authority in charge of storage projects is the Polish Geological Institute - National Research Institute, who is the National Administrator of Underground Carbon Dioxide Storage Sites (KAPS CO_2).

In 2014 (Journal of Laws of 2014, item 1272) the Minister of the Environment issued a regulation on the areas where it is allowed to locate an underground carbon dioxide storage complex and an ordinance on the register of mining areas and closed underground carbon dioxide storage (Journal of Laws of 2014, item 1469).

The Regulation of the Minister of the Environment of December 8, 2017 on mining plant operation plans (Journal of Laws of December 11, 2017, item 2293) contains the detailed requirements for the mining plant operation plan required for underground storage of carbon dioxide. In line with the requirements from the CCS Directive, the operation plan should specify the quantity composition and characteristics of the injected gas, characteristics of the underground storage site, geological, hydrogeological and engineering conditions of the underground carbon storage complex, a description of the mining area, natural, technical and environmental hazards, anticipated organizational and technical measures necessary for ensuring occupational safety and universal safety as well as protection of mineral deposits, groundwater and other elements of the environment as well as envisaged undertakings aimed at preventing carbon leakage.

5.6.4 Financial support framework

Currently, there is no national financial support framework for CCU or CCS in place in Poland.

5.6.5 Summary

In Poland, a key barrier for the development of CCS projects at the moment is the missing political will. It is unclear which role the Government foresees for CCU or CCS activities and whether the country is actually willing to commit to reaching net zero by 2050. Despite the missing political will and the related missing national support, an announcement has been made for the start of a CCS project in a cement plant in Poland funded mainly by EU sources. This project could be valuable in providing a first test to the legal framework in place. A political restart for CCS could be realized from 2024 when revision of the current legislation is foreseen, although experience with CCS projects by then is very limited.

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5.7 Greece

5.7.1 Current status of project development

Up to today, to our knowledge no CCS projects are under development in Greece.

5.7.2 Policy strategy

Emissions in Greece were 86 Mt CO_2e in 2019 (EEA GHG data viewer). Industrial installations under the EU ETS with annual emissions over 0.5 Mt are very limited (8 in 2020). Therefore, the applicability of CCS in industry in Greece is likely very limited.

Transposition of climate neutrality into law shall be enacted via the government bill "National Climate Law - Transition to Climate Neutrality and Adaptation to Climate Change", in particular Article 7. A draft text is currently in the Ministry of the Environment where stakeholder input from a public consultation is considered.

5.7.3 Regulatory framework

As required the CCS Directive has been implemented into national Greek law without extensions to the EU text. The competent authority for CO_2 storage in Greece is the Ministry of Environment (Gazzetta B' 2516/7-11-2011).

The implementation of the CCS Directive restricts storage sites. Accordingly, storage is not permitted in areas where the storage complex extends beyond Greek territory (Shogenova et al. 2014).

5.7.4 Financial support framework

Currently, no specific funding for CCU or CCS projects is in place.

5.7.5 Summary

So far, CCU or CCS activities are not high on the political agenda in Greece and no commercial projects exist. But the need for it is also limited. Hence, support frameworks or legal frameworks in addition to what has been decided on the EU level are not existing at the moment. It is to be expected that for the realization of a CCS project (likely also in case of a CCU project) in Greece further work from and with the Government and competent authorities is needed to close the existing gaps.

6. Key findings

The EU provides a well-established framework for CCS projects consisting of a clear political willingness to make the EU climate-neutral, regulatory requirements and financial support instruments. In particular, the EU Commission decided quite early on to develop a common legal framework for CCS activities. The CCS Directive along with the Directives on the EU ETS and amendments to key directives such as the Environmental Impact Assessment Directive, the Large Combustion Plant Directive and the Waste Framework Directive present the existing legal requirements for the realization of geological transport and storage projects in EU Member States. While in particular the CCS Directive provides certain minimum standards and requirements for transport and storage projects, it is itself not sufficiently detailed, giving leeway to the Member States in formulating their own standards and regulations. In addition, in the past the existing financial support from the EU level (i.e. CO_2 prices and funding of projects from NER 300) was not sufficient to provide a business case for the realization of CCS projects in the Member States. Therefore, in 2020/21 an update in the provision of financial support was developed by the

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introduction of the Innovation Fund and the opening up of funding availability not only to power-related projects, but also to projects from industry along with CCU projects. In addition, increases in CO_2 prices under the EU ETS to prices close to 100 €/t CO_2 further set increasingly strong incentives for saving CO_2 emissions with the help of CCU or CCS technology.

The activities on the EU level show effects in the Member States. Most of the countries analyzed for this report have introduced or are on their way to introduce a net-zero target by 2050 into national legislation. The examination of this net-zero target in long-term strategies along with their implications for the medium term targets for 2030 in the NECPs have resulted in an examination of the role of CCU and CCS in many of the countries. While the outcomes of that process are quite heterogeneous, certain clusters can be identified:

- A specifically high level of activity can be found in particular in the UK and the Netherlands. Both countries possess of large storage capacities in offshore regions which they plan to use not only for themselves, but which could also be used for providing other countries the opportunity to store CO_2 there. That is, those countries see clear market potential by offering storage capacities to countries with limited storage capacities, but in need of storage due to their economic structure. While the approaches taken to support the development of CCS infrastructure differ between UK and the Netherlands, both countries provide significant (additional) financial support and formulate a clear political will to have CCS clusters running in the next 5-10 years. Also, quite similarly in both countries, the focus is currently on the development of the transport and storage infrastructure with the development of actual capture projects following in a second phase. In particular in the UK, but also partly in the Netherlands, it can be seen, that the transposition of the CCS Directive into national law included not only the implementation of the minimum requirements but that additional regulations were being developed to clarify the process and liabilities arising from CCS activities.
- At the other end of the spectrum are countries like Greece or Portugal. Their economic structure does not require the development of strong CCS capacities and so far strong political signals for the realization of CCU or CCS projects are missing. The implementation of the CCS Directive was merely a 1-to-1 translation of the European law into national law, leaving open questions for project developers that would need to be addressed by the government in the process of realizing a CCS project (likely also partly in case of CCU projects). As a result of the missing political signals and legal uncertainties activity in those countries are low.
- For Spain, France and Poland, the situation is different again. Here, the economic structure opens up a way for CCU and CCS projects being a suitable way to reach climate neutrality. As a result, a certain activity level can be found driven by the private sector and particularly concerned industries. However, in all three countries a clear political signal is to date missing. Hence, neither a dedicated financial support system for CCS (or CCU) projects nor a very much adapted legal framework for the transport and geological storage of CO_2 can be found in these countries. In particular the second one can present a high barrier for the timely realization of CCS projects as it means that, on the one hand, a high level of uncertainty exists on costs and liabilities for the project and, on the other hand, approval procedures may take a lot of time in cases where specific details have to be clarified along the way.

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Finally, it shall be highlighted once more that in none of the countries analysed for this report - except for the testing installation in Spain - a transport system or storage site is currently running. Hence, the real world testing of the existing frameworks will come in the coming years when final investment decisions are being made and applications are being filed by companies.

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