



Metal Organic Frameworks for carbon dioxide Adsorption processes in power production and energy Intensive industries



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PROJECT SUMMARY

This report is part of the deliverables from the project "MOF4AIR" which has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 837975.

Power supply and carbon-intensive industries account for a large share of CO₂ emissions. Shifting towards a low-carbon economy requires cost-effective carbon capture solutions to be developed, tested and deployed. Current solutions do not offer sufficient performances. Adsorption processes are promising alternatives for capturing CO₂ from power plants and other energy intensive industries as cement, steel, or petrochemical industries. In this regard, Metal Organic Frameworks (MOFs) are a widely studied class of porous adsorbents that offer tremendous potential, owing to their large CO₂ adsorption capacity and high CO₂ affinity. However, the performances of MOF-based carbon capture technologies have not been fully evaluated. MOF4AIR gathers 14 partners from 8 countries to develop and demonstrate the performances of MOF-based CO₂ capture technologies in power plants and energy intensive industries. MOF4AIR aims to foster the uptake of CCS technologies by providing a TRL6-reliable solution matching end users' needs, notably by cutting CCS energy penalty by more than 10%. The solutions developed will be highly replicable thanks to the consideration of a wide range of carbon intensive sectors and clusters, notably through the project's Industrial Cluster Board.

More information on the project can be found at <https://mof4air.eu>.

OBJECTIVE AND EXECUTIVE SUMMARY

The main objective of Deliverable 7.1 “Report on regulatory framework and recommendations” is to perform an overall assessment of the legislative and regulatory conditions in MOF4AIR participating countries (Belgium, France, Greece, Italy, Norway, United Kingdom, Turkey), as well as on an EU level, on capture, transport, and storage systems of CO₂. Furthermore, the barriers, principles, and differences among the 7 participating countries in the sense of licensing and permitting procedures is identified. Based on the legislative and regulatory assessment, a set of recommendations is proposed.

The deliverable contains:

1. The investigation and analysis of legislative and regulatory framework on the EU level, concerning capture, transport, and storage of CO₂ systems. Until now, specific EU legislation for the transport of CO₂ to storage sites does not exist. According to the European Commission, the Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 provides a comprehensive legal framework for capturing, transporting, and storing CCS. Furthermore, there are two Directives on environmental issues that mention the transportation of CO₂ by pipelines and one Regulation on shipments of waste that mentions the shipments of CO₂. The Regulatory framework that defines the capture and geological storage of CO₂ in the EU is Directive 2009/31/EC of the European Parliament and of the Council, of the 23rd of April 2009. The Directive 2009/31/EC (CCS Directive) established the key legislation for the environmentally safe geological storage of carbon dioxide (CO₂) to contribute to the mitigation of climate change.
2. An analysis of the legislative and regulatory conditions in MOF4AIR participating countries. Special attention was given in the sense of licensing and permitting procedures. In addition, a comparison between the participating countries on the legislative framework was comprised. According to the analysis:
 - The legislative framework of CCS in the EU Member States [Belgium (Walloon Region), France, Greece and Italy] is connected with the transposition of CCS Directive 2009/31/EC into national laws. This means that Member States ratified the CCS Directive by creating a CCS framework for their countries, without proceeding in any further legal reforms. As a result, CCS’s legal framework for these States is almost the same. Minor differences exist in some parts.
 - Norway has a comprehensive legislation and regulatory framework regarding CCS. Norway as a member of the European Economic Area has a framework that aligns with EU requirements. Norway and EU Member States (MOF4AIR participating countries) present many similarities in their CCS legal framework. The major differences identified between Norway and the EU Member States include a) the existence of a specific legal framework in Norway for the transportation of CO₂ in order to be stored and b) the restrictions in the selection of storage sites only to the Norwegian continental shelf.
 - The UK as a former Member State of the EU transposed the CCS Directive into national law. As a result, the CCS framework presents many similarities with those of EU Member States (MOF4AIR participating countries), as well as with Norway. The most important difference for the UK, in comparison to the EU Member States and Norway, is the absence of a legal framework for the transportation of CO₂ in order to be stored.

- There is no legal framework regarding CCS in Turkey. Turkey as an associated EU Member State will adopt and implement the CCS Directive in the future. This means that the legal framework regarding CCS will be close to the EU Member States, as well as to Norway and UK.
3. The barriers leading to delays of the proposed installations of CCS projects. Several barriers influence the political decisions in the countries, the process, and the implementation of CCS projects. These include social acceptance issues, the maturity of the CCS technology, CCS storage capacity determination possibilities, financial aspects of the CCS legal framework implementation and legal gaps.
 4. The proposal of a set of recommendations to enhance CCS technologies. The recommendations include: a) the creation of a European atlas matching all storage sites and capacities, b) the increase of EU and national instruments supporting CCS projects, c) the establishment of a new EU legislation, specified on the transportation of captured CO₂ to storage sites, d) suggestions for the improvement of Directive 2009/31/EC, e) development of a certification mechanism (system) for the power plants and carbon intensive industries that have implemented CCS technologies and f) development of a European Union Strategic roadmap for the development and deployment of CCS.

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1. INTRODUCTION

Today, tackling climate change is a significant issue. Carbon dioxide (CO₂) emissions from the combustion (burning) of fossil fuels are one of the main contributors to global warming, and they must be severely decreased to stay within the 2°C limit. The energy industry continues to be one of the largest contributors to CO₂ emissions, with fossil fuels, notably coal, dominating power production [1]. CCS (Carbon dioxide Capture and geological Storage) and CCUS (Carbon Capture Utilization and Storage) applications can make a significant contribution to climate change mitigation.

The European Union has set ambitious goals for climate change. It has set a long-term goal of reducing greenhouse gas emissions by 80% to 95% by 2050, compared to 1990 levels [2,3]. Intermediate goals include a 20% decrease in emissions by 2020 [4] and a 40% reduction by 2030 compared to 1990 levels [5]. According to the 2011 “Roadmap for moving to a competitive low carbon economy in 2050” [6] by 2050 industrial emissions should be 83 to 87% lower than 1990 levels, and the electricity sector should be nearly decarbonized.

CCS is expected to play a critical role in the European Union in meeting emissions reduction goals at the lowest possible cost [7]. CCS includes three processes: capture, transport, and storage of CO₂ from electricity production, industries, or other sources [8].

Investing in large-scale CO₂ transportation and storage infrastructure will be a strategic and essential policy choice that will be required to meet the EU's climate goal of future-proofing Europe for a global low-carbon economy. Considering that some large-scale CO₂ capture projects are almost ready, a CO₂ transportation network and storage infrastructure would link CO₂ emitters in industrial clusters and power plants to storage sites, allowing the broad decarbonization required to fulfil the net-zero goals [9]. The CO₂ transportation from the CO₂ capture sites to the storage sites will also require the development of a CO₂ pipeline network.

In Europe, a small number of carbon dioxide (CO₂) transportation and storage projects are in operation. These projects show that CO₂ transportation and storage are crucial technologies in the CCS chain and are mature enough to be deployed at a commercial scale [9].

Large-scale transportation of captured carbon dioxide in order to be stored on-shore or off-shore can be achieved through pressurized pipelines or ships [7]. The best choice is defined by the quantity of CO₂ to be transported, the distance between the CO₂ source and the storage site and the regulatory framework. Transport by ship is better for smaller quantities and greater distances, whereas pipeline transport, is better suited for larger quantities and shorter distances [8].

2. REGULATORY FRAMEWORK

The regulatory framework -chapter 2- is divided into two subchapters. The first one, chapter 2.1, includes the legislative and regulatory framework of capture, transport, and storage of CO₂ in the EU. The second one, chapter 2.2, consists of the legislative and regulatory framework of CO₂ in the MOF4AIR participating countries, giving special attention in the sense of licensing, and permitting procedures, as well as a comparison between the countries.

2.1. EUROPEAN UNION REGULATORY FRAMEWORK

Chapter 2.1 examines the legal and regulatory framework for CO₂ transportation in the EU, as well as the legislative and regulatory framework for CO₂ capture and storage.

2.1.1. EU REGULATORY FRAMEWORK FOR CO₂ TRANSPORT

Three different routes can be considered to transport CO₂ captured from industrial emission sites to storage sites: (i) pipelines (ii) ships and (iii) trains or trucks. Due to the huge volumes of CO₂ emitted/captured alone are considered on an industrial scale the only ways are through pipelines and ships.

Until now, specific EU legislation for the transport of CO₂ to storage sites does not exist. According to the document 52013DC0180 of the European Commission of 27 March 2013 [10], “Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006 [Text with European Economic Area (EEA) relevance]” (for more information see chapter 2.1.2) provides a comprehensive legal framework for capturing, transporting and storing CCS. Furthermore, there are two Directives on environmental issues that mention the transportation of CO₂ by pipelines and one Regulation, on shipments of waste that mentions the shipments of CO₂.

Directive 2003/87/EC

The first one is Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 published on the 25th of October 2003. The full title of the document is “*Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC*”¹ [11]. The Directive is in force as amended last time on the 1st of January 2020. The consolidated text is entitled “*Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a system for greenhouse gas emission allowance trading within the Union and amending Council Directive 96/61/EC (Text with EEA relevance)*”² [12].

The subject of the Directive is “to establish a system for greenhouse gas emission allowance trading within the Union (EU ETS) in order to promote reductions of greenhouse gas emissions in a cost-effective and economically efficient manner”. Furthermore, the Directive “provides for the reductions of greenhouse gas emissions to be increased so as to contribute to the levels of reductions that are considered scientifically

¹ Directive 2003/87/EC. <http://data.europa.eu/eli/dir/2003/87/oj>

² Consolidated text of Directive 2003/87/EC. <http://data.europa.eu/eli/dir/2003/87/2020-01-01>

necessary to avoid dangerous climate change". The scope of the Directive is "to apply to emissions from the activities listed in Annex I and greenhouse gases listed in Annex II". One of the activities in Annex I is "the transport of CO₂ by pipelines for geological storage in a storage site permitted under Directive 2009/31/EC". It should be mentioned that only this part (Annex I) of the Directive is referred to the transportation of CO₂ by pipelines.

According to this Directive, the operators of the activities listed in Annex I are obliged to hold a greenhouse gas emission permit to carry out any operation (Article 4, Chapter III). Article 5, Chapter III, of this directive includes all the information that shall accompany the application to the competent authority. More specific:

- a) "A description of the installation and its activities including the technology used;
- b) A description of the raw and auxiliary materials, the use of which is likely to lead to emissions of gases listed in Annex I;
- c) A description of the sources of emissions of gases listed in Annex I from the installation; and
- d) A description of the measures planned to monitor and report emissions in accordance with the acts referred to in Article 14".

The application shall also include a non-technical summary of the details referred in point (a).

The permits of the greenhouse gas emission (Article 6, Chapter III) contain among other: a) a description of the activities and emissions from the installation, b) a monitoring plan and c) reporting requirements.

Directive 2011/92/EC

The second one is Council Directive 85/337/EEC of 27 June 1985. The full title of the document is "*Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment*". This Directive is no longer in force and has been replaced by Directive 2011/92/EC of the European Parliament and of the Council of 13 December 2011, published on the 28th of January 2011. The full title is "*Directive 2011/92/EC of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment*"³ [13]. The Directive is in force as amended last time on the 15th of May 2014. The consolidated text is entitled "*Directive 2011/92/EC of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment (codification)*"⁴ [14].

The scope of the Directive is "to apply to the assessment of the environmental effects of those public and private projects which are likely to have significant effects on the environment". Annex I and Annex II of the Directive include the transportation of CO₂ by pipelines. More specific:

- Annex I (Projects referred to in article 4 (1))
Point (a) (16) mentions "Pipelines with a diameter of more than 800 mm and a length of more than 40 km" and (b) specifically "for the transport of carbon dioxide (CO₂) streams for the purposes of geological storage, including associated booster stations".
- Annex II (Projects referred to in article 4 (2))
Point (i) (10) (Infrastructure projects) mentions "Oil and gas pipeline installations and pipelines for the transport of CO₂ streams for the purposes of geological storage (projects not included in Annex I)".

³ Directive 2011/92/EU. <http://data.europa.eu/eli/dir/2011/92/oj>

⁴ Consolidated text of Directive 2011/92/EC. <http://data.europa.eu/eli/dir/2011/92/2014-05-15>

According to Directive 2011/92/EU (Article 2), the projects that are defined in article 4, are obliged to make subject to a requirement for development consent and an assessment about their effects on the environment, in case they probably have significant effects on the environment by virtue, *inter alia*, of their nature, size or location.

The environmental assessment (Article 3) is necessary to include the identification, description, and assessment, of all the significant direct and indirect effects of the project on the factors: a) population and human health, b) biodiversity, giving special attention to protected species and habitats, c) land, soil, water, air and climate, d) material assets, cultural heritage and the landscape and e) the interaction between the factors referred to in points (a) to (d).

According to Article 4 (paragraph 1), projects listed in Annex I made subject to an environmental assessment. In the same article (paragraph 2) it is mentioned that projects listed in Annex II, Member States shall determine whether the project shall be made subject to an environmental assessment considering a case-by-case examination (according to thresholds or criteria of Annex III or of Member States) or thresholds or criteria set by the Member State.

An environmental impact assessment shall include (Article 5, paragraph 1):

- a) "A description of the project (information on the site, design, size and other relevant);
- b) A description of the likely significant effects on the environment;
- c) A description of the features of the project and/or measures envisaged to avoid, prevent, or reduce and, if possible, offset likely significant adverse effects on the environment;
- d) A description of the reasonable alternatives studied by the developer;
- e) A non-technical summary of the information referred to in points (a) to (d); and
- f) Any additional information specified in Annex IV".

Article 7 of the Directive mentions that "where a Member State is aware that a project is likely to have significant effects on the environment in another Member State", the other Member State to participate in the environmental decision-making procedures.

Regulation (EC) No 1013/2006

The third one is Regulation (EC) No 1013/2006 of 14 June 2006. The full title of the document is "*Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste*"⁵ [15]. The Regulation is in force as amended last time on the 11th of January 2021. The consolidated text is entitled "*Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste*"⁶ [16].

The scope of the Regulation (EC) No 1013/2006 is "to establish procedures and control regimes for the shipment of waste, depending on the origin, destination and route of the shipment, the type of waste shipped and the type of treatment to be applied to the waste at its destination.

Article 1 (paragraph 3) of Regulation (EC) No 1013/2006, as amended by the CCS EU Directive, states that the following category **shall be excluded** from the scope of this Regulation:

⁵ Regulation (EC) No 1013/2006. <http://data.europa.eu/eli/reg/2006/1013/oj>

⁶ Consolidated text of Regulation (EC) No 1013/2006. <http://data.europa.eu/eli/reg/2006/1013/2021-01-11>

“(h) shipments of CO₂ for the purposes of geological storage in accordance with Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide”.

Note: Regulations and decisions become automatically binding throughout the EU on the date they take effect. **Directives** must be incorporated into national law by EU countries. The Commission monitors whether EU laws are applied correctly and on time and takes action if not [17].

London Protocol

Article 6 of the 1996 London Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter prohibits the Parties to export (and import) CO₂ for offshore CCS. This prohibition is immediately applicable in the EU under Regulation (EC) No. 1013/2006, article 11 (1) point f [9].

A large number of Parties didn't ratify the 2009 amendment of the London Protocol to allow the export of CO₂ for offshore CCS, however, the parties agreed on the provisional application of the 2009 amendment on October 11, 2019. As a result, Parties to the London Protocol that want to participate in a cross-border CO₂ network for the offshore storage of CO₂ are able to unilaterally declare the provisional application of the 2009 amendment and enter into relevant agreements with other parties, allowing CO₂ to be exported for offshore storage [9].

2.1.2. EU REGULATORY FRAMEWORK FOR CARBON CAPTURE AND GEOLOGICAL STORAGE (CCS)

The Regulatory framework that defines the capture and geological storage of CO₂ in the EU, is Directive 2009/31/EC of the European Parliament and of the Council, of the 23rd of April 2009. The Directive 2009/31/EC, named hereby “CCS (Carbon dioxide Capture and geological Storage) Directive”, established the key legislation for the environmentally safe geological storage of carbon dioxide (CO₂) to contribute to the mitigation of climate change.

Directive 2009/31/EC

Directive 2009/31/EC was published on the 5th of June 2009 and entered into force on the 25th of June 2009. The full title of the document is “*Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006 [Text with European Economic Area (EEA) relevance]*”⁷ [18]. The Directive is in force as amended last time on the 24th of December 2018. The consolidated text is entitled “*Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006 (Text with EEA relevance)*”⁸ [19].

This Directive includes the regulatory framework on the following topics:

- Carbon Capture and Storage (CCS) scope and definitions;

⁷ Directive 2009/31/EC. <http://data.europa.eu/eli/dir/2009/31/oj>

⁸ Consolidated text of Directive 2009/31/EC. <http://data.europa.eu/eli/dir/2009/31/2018-12-24>

- Selection of storage sites and exploration permits;
- Storage permits;
- Operation, closure, and post -closure obligations;
- Third parties access and general provisions;
- Amendments.

In the next paragraphs, each of these topics is analysed.

- Carbon Capture and Storage (CCS) scope and definitions

The scope of the CCS Directive is to establish a legal framework to permanently isolate CO₂ in a way that prevents and, where this is not possible, eliminates as far as possible the negative effects and any risks to the environment and human health.

According to the CCS Directive, Carbon dioxide capture and geological storage (CCS) consists of the capture of carbon dioxide (CO₂) from industrial installations, its transport to a storage site and its injection into a suitable underground geological formation for permanent storage. The definition given for the geological storage of CO₂ is “injection accompanied by storage of CO₂ streams in underground geological formations”.

The CCS Directive is applied to the geological storage of CO₂ in the territory of the Member States, their exclusive economic zones and on their continental shelves within the meaning of the United Nations Convention on the Law of the Sea (Unclos). This Directive is not applied to geological storage of CO₂, with total intended storage below 100 kilotons, undertaken for research, development or testing of new products and processes. It is also, not permitted to store CO₂ in a water column.

- Selection of storage sites and exploration permits

The right for the selection and the definition of the areas of the storage sites is the responsibility of the Member States. In case that a Member State intends to allow geological storage in CO₂, an assessment of the storage capacity should be established, taking into account the exploitation limits given in the CCS Directive. Specific criteria are set for the characterisation and assessment of the potential storage complex and surroundings, included as Annex I to the CCS Directive. In any case, it is allowed to select a geological formation as a storage site, only if under the proposed conditions of use there is no significant risk of leakage and no significant environmental or health risk.

Exploitation permits are also set in the CCS Directive. The procedures to be granted with an exploitation permit should be open to all interested entities. It is foreseen that a specific duration limit should be set for the exploitation of a site. This duration limit may be extended if properly justified.

- Storage permits

For the storage of CO₂, a storage permit is required. This permit should be given to only one operation for each site. The procedures for granting a storage permit should be open to all interested entities and the selection should be made on transparent criteria. For granting a storage limit, priority is given to the holder of the exploitation permit of the same site, providing that the exploitation of that site is finished successfully and that he has applied for a storage permit within the valid period of the exploitation permit. The CCS Directive sets a number of specific information that is required to be included in the applications for storage permits (Article 7).

For granting a storage permit, the competent authority should ensure that specific conditions are met by the applicant (Article 8), summarized here:

- The requirements of the CCS Directive and relevant Commission regulation are met;
- The operator is financially sound and technically competent and reliable to operate and control the site and that the operator and all staff will receive professional and technical development and training;
- In the case of more than one storage site in the same hydraulic unit, the potential pressure interactions are such that both sites can simultaneously satisfy the requirements of this Directive;
- The competent authority should submit the permit applicants to the Commission for review, a month after receipt (Article 10). Any opinion of the Commission on the draft permit issued should be taken under consideration by the competent authority.

The issued storage permit should contain at least specific information given in Article 9 of the CCS Directive. Certain steps are also foreseen for changes, review, update, and withdrawal of storage permits (Article 11).

- Operation, closure, and post -closure obligations

The CCS Directive set criteria and procedures for the CO₂ stream acceptance. Specifically, the CO₂ stream shall consist mainly of carbon dioxide. Specific exceptions are set for the existence of other substances. CO₂ stream may contain incidental associated substances from the source, capture or injection process and trace substances added to assist in monitoring and verifying CO₂ migration. The concentrations of these substances are limited to the levels provided in Article 12 of the CCS Directive.

The competent authority should ensure that the operator has established an accepted analysis of the composition and an accepted risk analysis of the injection of CO₂ stream. It is also necessary to have a register of the quantities and properties of the CO₂ streams delivered and injected, including the composition of those streams.

The operator is obliged to carry out monitoring of the injection facilities, the storage complex, and where appropriate the surrounding environment. The operator should also design and submit, for approval to the competent authority, a monitoring plan. This plan should include specific details given in Article 13 and follow the requirements given in Annex II of the CCS Directive. The plan should be updated, and re-submitted for approval to the competent authority, every 5 years. Once a year, the operator shall submit to the competent authority a report, containing monitoring and other information given in Article 14.

The competent authority shall carry out routine and non-routine inspections of all storage complexes to ensure that the requirements of this Directive are met and to monitor the effect on the environment and human health. The routine inspections shall be carried out every year until three years after closure and every five years until the transfer of responsibility to the competent authority has been realized. The non-routine inspections shall be carried out in cases that the competent authority is notified or considers appropriate to check whether there is a problem, such as leakages, in the storage complex. Following each inspection, a report shall be prepared and published by the competent authority within two months of the inspection.

In case of leakages or significant irregularities, the operator is obliged to notify the competent authority and to take the necessary corrective measures. The measures shall at minimum follow the corrective measures plan, which the operator has submitted to and approved by the competent authority. Further actions to this plan may be required. In the case that the operator fails to take the necessary corrective measures, the competent authority shall take the necessary corrective measures itself. In this case, the competent authority shall recover the costs incurred in relation to the measures from the operator (Article 16).

In the first paragraph of Article 17, entitled “Closure and post-closure obligations”, of the CCS Directive, the three cases for closing a storage site are given:

- (a) If the relevant conditions stated in the permit have been met;
- (b) At the substantiated request of the operator, after authorization of the competent authority; or
- (c) If the competent authority so decides after the withdrawal of a storage permit pursuant to Article 11(3).

After a storage site is closed - in cases that the conditions stated in the permit have been met or there is a justified request by the operator – the operator remains responsible for monitoring, reporting and corrective measures, according to the requirements included in the CCS Directive. The operator shall also be responsible for sealing the storage site and removing the injection facilities. In these cases, the legal obligations and responsibility for the storage complex are transferred to the competent authority on its initiative or upon request from the operator. In the second case, upon request, the operator shall prepare and submit a report for approval to the competent authority. The report shall prove that the required conditions given in Article 18 (paragraph 1) are met. The competent authority shall make the report and the draft decision of approval available to the Commission within a month after the receipt. The Commission may issue a non-binding opinion on the report within four months after receipt of the draft decision of approval. When the competent authority is satisfied, the responsibility is transferred from the operator to the competent authority and the Commission is notified for the transfer.

In the case that the competent authority decides a permit withdrawal, after a storage site is closed, the competent authority is responsible for all the above-mentioned actions. The competent authority shall recover the costs incurred in relation to the actions and measures from the operator, using among others the financial security pursuant that the operator has submitted. In this case, transfer of responsibility shall take place when all available evidence indicates that the stored CO₂ will be completely and permanently contained, and after the site has been sealed and the injection facilities have been removed.

After the transfer of responsibility to the competent authority, routine inspections shall cease, and monitoring may be reduced to a level that allows for the detection of leakages or significant irregularities.

The operator is obliged to submit financial security that shall be valid and effective before the commencement of injection. The financial security shall be periodically adjusted to cover all the estimated costs of all obligations arising by the CCS Directive.

The operator shall make a financial contribution to the competent authority before the transfer of responsibility to it. This financial contribution may be used to cover the costs borne by the competent authority after the transfer of responsibility to ensure the permanent and safe isolation of CO₂ in geological storage sites after the transfer of responsibility.

- Third parties access and general provisions

In Chapter 5 of the CCS Directive, access to the transport network storage sites is defined (Article 21). Dispute settlement arrangements are given in Article 22, of the same chapter.

In Chapter 6, general provisions of the directive are given. It is worth to mention that the CCS Directive has foreseen the establishment of Registers (Article 25). The competent authority shall establish and maintain two registers. One register of the storage permits granted and a second permanent register of all closed storage sites and surrounding storage complexes. In Article 27 of the same chapter, the guidelines for reporting by Member states are given. The Member States shall submit every four years a report to the

Commission on the implementation of the CCS Directive. The Commission shall ensure that it will communicate the implementation information among the competent authorities of the Member States.

- Amendments

In Chapter 7 of the CCS Directive, the amendments of certain relative to CCS Directives are given. Most of the amendments include CCS aspects in existing Directives. In the following paragraphs, these Directives, together with the amendments made by CCS Directive, are presented.

Council Directive 85/337/EEC replaced by Directive 2011/92/EEC (on the assessment of the effects of certain public and private projects on the environment)

The first amendment made by the CCS Directive is the amendment of Council Directive 85/337/EEC of 27 June 1985. This Directive has been replaced by Directive 2011/92/EU [13, 14] (see Chapter 2.1.1). It should be mentioned that this amendment is not included in the consolidated text of the CCS Directive. Annex I and Annex II of the Directive (2011/92/EU) include information about the capture of CO₂ in the following points:

- Annex I (Projects referred to in article 4 (1))

Point 22 mentions “Storage sites pursuant to Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide”.

Point 23 “Installations for the capture of CO₂ streams for the purposes of geological storage pursuant to Directive 2009/31/EC from installations covered by this Annex, or where the total yearly capture of CO₂ is 1.5 megatons or more”.

- Annex II (Projects referred to in article 4 (2))

Point (j) (3) (“Energy industry”) mentions “Installations for the capture of CO₂ streams for the purposes of geological storage pursuant to Directive 2009/31/EC from installations not covered by Annex I to this Directive.

Directive 2000/60/EC

The second amendment made by the CCS Directive is the amendment of Directive 2000/60/EC of 23 October 2000. The full title of the document is “*Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy*”⁹ [20]. The Directive is in force as amended last time on the 20th of November 2014. The consolidated text is entitled “*Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy*”¹⁰ [21].

The subject of the Directive is “to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater”.

CCS Directive amends Article 11 (3)(j) of Directive 2000/60/EC. Article 11 refers to “Programme of measures”. In paragraph 3(j), states that “Member States may authorise specifying the conditions for injection of carbon dioxide streams for storage purposes into geological formations which for natural reasons are permanently unsuitable for other purposes, provided that such injection is made in accordance with Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological

⁹ Directive 2000/60/EC. <https://eur-lex.europa.eu/eli/dir/2000/60/oj>

¹⁰ Consolidated text: Directive 2000/60/EC. <http://data.europa.eu/eli/dir/2000/60/2014-11-20>

storage of carbon dioxide or excluded from the scope of that Directive pursuant to its Article 2 (paragraph 2)”.

Directive 2001/80/EC replaced by Directive 2010/75/EU

CCS Directive includes also an amendment of Directive 2001/80/EC of the 23rd of October 2001. The full title of the document is “*Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants*”¹¹ [22]. This Directive is no longer in force and has been replaced by Directive 2010/75/EU of 24 November 2010, that was published on the 17th of December 2010. The full title is “*Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (Text with EEA relevance)*”¹² [23]. The Directive is in force as amended last time on the 6th of January 2011. The consolidated text is entitled “*Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) [Text with EEA relevance]*”¹³ [24].

The subject of Directive 2010/75/EU is “to lay down rules on integrated prevention and control of pollution arising from industrial activities. It also lays down rules designed to prevent or, where that is not practicable, to reduce emissions into air, water and land and to prevent the generation of waste, in order to achieve a high level of protection of the environment taken as a whole”.

According to Article 36, entitled “Geological storage of carbon dioxide”, of the Directive 2010/75/EU:

1. “Member States shall ensure that operators of all combustion plants with a rated electrical output of 300 megawatts or more for which the original construction licence or, in the absence of such a procedure, the original operating licence is granted after the entry into force of Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide, have assessed whether the following conditions are met:
 - (a) Suitable storage sites are available;
 - (b) Transport facilities are technically and economically feasible;
 - (c) It is technically and economically feasible to retrofit for carbon dioxide capture.
2. If the conditions laid down in paragraph 1 are met, the competent authority shall ensure that suitable space on the installation site for the equipment necessary to capture and compress carbon dioxide is set aside. The competent authority shall determine whether the conditions are met based on the assessment referred to in paragraph 1 and other available information, particularly concerning the protection of the environment and human health.”

Directive 2004/35/EC

One more amendment by the CCS Directive is the one of Directive 2004/35/EC of the European Parliament and of the Council of 21 April 2004, that was published on the 30th of April 2004. The full title of the document is “*Directive 2004/35/CE of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage*”¹⁴ [25]. The Directive is in force as amended last time on the 26th of June 2019. The consolidated text is entitled

¹¹ Directive 2001/80/EC. <http://data.europa.eu/eli/dir/2001/80/oj>

¹² Directive 2010/75/EU. <http://data.europa.eu/eli/dir/2010/75/oj>

¹³ Consolidated text of Directive 2010/75/EU. <http://data.europa.eu/eli/dir/2010/75/2011-01-06>

¹⁴ Directive 2004/35/EC. <http://data.europa.eu/eli/dir/2004/35/oj>

“Directive 2004/35/CE of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage”¹⁵ [26].

The subject of this Directive is “to establish a framework of environmental liability based on the ‘polluter-pays’ principle, to prevent and remedy environmental damage”. The scope of the Directive is to apply to:

“a) environmental damage caused by any of the occupational activities listed in Annex III, and to any imminent threat of such damage occurring by reason of any of those activities, and b) damage to protected species and natural habitats caused by any occupational activities other than those listed in Annex III, and to any imminent threat of such damage occurring by reason of any of those activities, whenever the operator has been at fault or negligent”.

One of the occupational activities listed in Annex III (paragraph 14) is “the operation of storage sites pursuant to Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide”.

Directive 2006/12/EC replaced by Directive 2008/98/EC

Another amendment made by the CCS EU Directive is the amendment of Directive 2006/12/EC of 5 April 2001. The full title of the document is *“Directive 2006/12/EC of the European Parliament and of the Council of 5 April 2006 on waste (Text with EEA relevance)”¹⁶ [27].* The Directive was amended last time on the 25th of June 2009. The consolidated text is entitled *“Directive 2006/12/EC of the European Parliament and of the Council of 5 April 2006 on waste (Text with EEA relevance)”¹⁷ [28].*

This Directive is no longer in force and has been replaced by Directive 2008/98/EC of 19 November 2008, that was published on the 22nd of November 2008. The full title is *“Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Text with EEA relevance)”¹⁸ [29].* The Directive is in force as amended last time on the 5th of July 2018. The consolidated text is entitled *“Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Text with EEA relevance)”¹⁹ [30].*

The scope of the Directive 2006/12/EC is to list the categories of waste and to set the disposal and recovery operation for the listed waste.

There is no reference to CCS in the Directive 2008/98/EU, which replaced the Directive 2006/12/EC. However, in the consolidated text of Directive 2006/12/EC (no longer in force), in Article 2(1)(a), it is stated that the following category shall be excluded from the scope of the Directive 2008/98/EU:

“(a) gaseous effluents emitted into the atmosphere and carbon dioxide captured and transported for the purposes of geological storage and geologically stored in accordance with Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide or excluded from the scope of that Directive pursuant to its Article 2 (paragraph 2)”.

¹⁵ Consolidated text of Directive 2004/35/EC. <http://data.europa.eu/eli/dir/2004/35/2019-06-26>

¹⁶ Directive 2006/12/EC. <http://data.europa.eu/eli/dir/2006/12/oj>

¹⁷ Consolidated text of Directive 2006/12/EC. <http://data.europa.eu/eli/dir/2006/12/2009-06-25>

¹⁸ Directive 2008/98/EC. <http://data.europa.eu/eli/dir/2008/98/oj>

¹⁹ Consolidated text of Directive 2008/98/EC. <http://data.europa.eu/eli/dir/2008/98/2018-07-05>

It should be mentioned that the above category is not excluded in the Directive 2008/98/EU, which replaced the Directive 2006/12/EC. In the corresponding Article of the Consolidated text of Directive 2008/98/EU, Article 2(1)(a), it is stated that the following CO₂ emissions **shall be excluded** from the scope of the Directive 2008/98/EU as:

“(a) gaseous effluents emitted into the atmosphere”.

This was also the case before the amendment of Article 2(1)(a) of the Directive 2006/12/EC by CCS Directive.

Directive 2008/1/EC replaced by Directive 2010/75/EU

The final amendment made by the CCS Directive is the amendment of Directive 2008/1/EC of the 15th of January 2008. The full title of the document is “*Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control (Codified version) (Text with EEA relevance)*”²⁰ [31]. This Directive is no longer in force and has been replaced by Directive 2010/75/EU of 24 November 2010 that was published on the 17th of December 2010. The full title is “*Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) Text with EEA relevance*” [23]. The Directive is in force as amended last time on the 6th of January 2011. The consolidated text is entitled “*Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (Recast) (Text with EEA relevance)*” [24].

The subject of Directive 2010/75/EU is “to lay down rules on integrated prevention and control of pollution arising from industrial activities. It also lays down rules designed to prevent or, where that is not practicable, to reduce emissions into air, water and land and to prevent the generation of waste, in order to achieve a high level of protection of the environment taken as a whole”.

According to Article 10 of Chapter II, entitled “Provisions for Activities Listed in Annex I”, of the Directive 2010/75/EU, “Capture of CO₂ streams from installations covered by this Directive for the purposes of geological storage pursuant to Directive 2009/31/EC” is included in the “Annex I -Categories of activities referred to in Article 10” (Annex I, paragraph 6.9).

2.2. LEGISLATIVE AND REGULATORY FRAMEWORK IN MOF4AIR PARTICIPATING COUNTRIES

Chapter 2.2. includes the legislative and regulatory framework of capture, transport, and storage of CO₂ in the MOF4AIR participating countries. Special attention is given in the sense of licensing and permitting procedures. Furthermore, a comparison between the participating countries on the legislative framework is performed. As discussed in Chapter 2.1, regulations and decisions become automatically binding throughout the EU on the date they take effect. As a result, Regulation (EC) No 1313/2006 is in force in the EU Member States [17].

2.2.1. BELGIUM

Belgium is a federal constitutional monarchy in which the king is the head of state, and the prime minister is the head of government in a multi-party system. Decision-making powers are not centralised but divided between 3 levels of government: the federal government, 3 language-based communities (Flemish, French,

²⁰ Directive 2008/1/EC. <http://data.europa.eu/eli/dir/2008/1/oj>

and German-speaking) and 3 regions (Flanders, Brussels Capital and Wallonia). Legally they all are equal, but have powers and responsibilities for different fields. Belgium is a member of the EU since 1st January 1958 [32]. The CO₂ transport and sequestration policy is the responsibility of the regions.

The legislative framework of CO₂ transport in the Walloon Region (Belgium) is not a specific legislation for the transport of CO₂, the constraints are the same as for other gases (see law on the transport of gaseous and other products by pipeline). (replaced for the Walloon Region by DRW 1999-03-11 “ Décret relatif au permis d'environnement”²¹ [33]/ 39, art. 175; In force: 01-10-2002, with regard to the protection of the environment for the establishments covered by the decree of 11 March 1999 related to the environmental permit) (Note: Art 9; 13; 15/1 amended with effect from an undetermined date by L 2014-05-08 “Ordonnance modifiant l'ordonnance du 25 mars 1999 relative à la recherche, la constatation, la poursuite et la répression des infractions en matière d'environnement, d'autres législations en matière d'environnement et instituant un Code de l'inspection, la prévention, la constatation et la répression des infractions en matière d'environnement et de la responsabilité environnementale”²² [34] / 23, art. 23; 27; 28, 035);

The legislative framework of CCS in Brussels-Capital region is defined by “Arrêté du Gouvernement de la Région de Bruxelles-Capitale du 8 juin 2017” M.B. (Moniteur Belge) 14.06.2017²³ [35]. This document modified “l'arrêté du Gouvernement de la Région de Bruxelles-Capitale du 2 février 2012” dedicated to the CO₂ capture and its transportation on the Brussel-Capital area for final sequestration. The geological storage of CO₂ on the territory of the Brussels-Capital Region is totally prohibited. This “arrêté” defines the criteria and procedures to obtain permit for CO₂ capture (delivery by “l'Institut bruxellois pour la Gestion de l'Environnement”, public organism created by the government of Brussels-Capital Region in 1989), the rules of survey and the inspections and the non-discriminatory access to transport networks in the region and cooperation with other regions as well as cross-border.

The legislative framework of CCS in the Flemish Region is defined by the Decree of the Flemish Government of 6 June 2014 (M.B.). This Decree provides, in addition to and in implementation of the provisions of the Decree of 8 May 2009 (M.B 15.07.2011) on the deep subsoil, for the transposition of Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC and 2008/1/EC and Regulation (EC) No 1013/2006 of the European Parliament and the Council.

The legislative framework of CCS in the Walloon Region (Belgium) is defined by M.B. 03.09.2013 “*Décret relatif au stockage géologique du dioxyde de carbone*”²⁴ [36] Decree in respect to the EU Directive 2009/31/CE. The decree was revised in 2019 for environmental delinquency (a new version will be applicable during 2021). The main aspects of this legislation are shown in **Table 1**.

²¹ DRW 1999-03-11 (Walloon Region).

https://www.ejustice.just.fgov.be/cgi_loi/change_lg_2.pl?language=fr&nm=1999027439&la=F

²² L 2014-05-08 (Walloon Region).

https://www.ejustice.just.fgov.be/cgi_loi/change_lg.pl?language=fr&la=F&table_name=loi&cn=2014050854

²³ M.B. 14.06.2017 (Brussels Region). http://www.ejustice.just.fgov.be/mopdf/2017/06/14_1.pdf#Page376

²⁴ M.B. 03.09.2013 Decree (Walloon Region - Belgium). <http://environnement.wallonie.be/legis/solsoussol/gaz005.htm>

Table 1 also includes the legislative framework with predictions for environmental protection in relation to CCS.

Table 1: Legislative framework in Walloon Region (Belgium)

Legislation/Regulation	
CCS	
CCS defined in Legislation as per the EU Directive	In the Walloon Region, there is a definition of "geological storage" in the M.B. 03.09.2013 Decree relative to the EU Directive 2009/31/CE.
CCS Definition	In the Walloon Region, the definition of "geological storage of CO ₂ " in the M.B. 03.09.2013 Decree relative to the EU Directive 2009/31/CE is "Injection along with storage of CO ₂ flux into underground geological formations".
Primary legislation for CCS in place at Country/National Level	In the Walloon Region, it is defined in the M.B. 03.09.2013 Decree relative to the EU Directive 2009/31/CE.
Secondary Local/Administration specific Legislation	No.
SELECTION OF STORAGE SITES AND EXPLORATION PERMITS	
Restrictions (limitations) in place for the selection of storage sites	There is no a priori restriction . The Walloon government decides on the permission, based on storage capacity and risk assessment of the area targeted by the permit application.
Name of the authority/administration responsible for the permit/registration	The responsible authority is the Walloon Region government.
Permit required for exploration	Yes.
Duration of the exploration permit	In the Walloon Region it is not fixed by the regulation. The applicant must provide the duration.
Typical time for submission and approval	30 days for the admissibility of the application (with 6 months to complete it if incomplete) + 250 days for a final decision by the government.
STORAGE PERMITS	
Permit required for storage	Yes.
Duration of the storage permit	There is no duration in the Walloon Region.
Typical time for submission and approval	30 days for the admissibility of the application + 5 days for setting up the public inquiry + X days of public inquiry + 10 days for completing the public inquiry + 150 days for administrative inquiry (local administration, etc.) + 200 days for final decision + 4 months for EU feedback → rough estimate of the total duration: between 1 and 1.5 year .
Name of the authority/administration responsible for the permit/registration	Walloon Region government.
Conditions for storage permits	There are no a priori conditions but a list of items to be provided in the application. The applicant must demonstrate that he is technically and financially able to undertake the project.
OPERATION, CLOSURE AND POST-CLOSURE OBLIGATIONS	
CO ₂ stream acceptance criteria and procedure	Only trace amounts of natural foreign compounds or compounds introduced accidentally during the process (e.g., capture) or intentionally

	for monitoring purposes are allowed in compliance with EU Directive on CCS. CO ₂ fluxes must be analysed to check compliance.
Monitoring	Monitoring using the best current technologies available during operation and post-closure. The monitoring plan established for permit application must be updated every 5 years during operation.
Reporting by the operator	Reporting periodicity is imposed by the Walloon Region government (at least annually) .
System of routine or non - routine inspections	There is routine inspection at least once a year until 3 years after closure and every 5 years until the transfer of responsibility to the Walloon Region has occurred. Non-routine inspection when the government deems it is necessary (irregularity, claims, etc.).
Measures in case of leakages or significant irregularities	The operator immediately informs the authorities at all levels (“Region”, “Province” and “Commune”) and undertakes remedial action as a minimum on the basis of the remedial action plan that was submitted along with the permit application.
Closure and post - closure obligations	Upon closure, the operator is responsible for the sealing of the site. After closure, the operator remains responsible for the monitoring, reporting, remedial actions, etc. as before until the transfer of responsibility to the Walloon Region has occurred (after a minimum of 20 years and when the demonstration that the site is stable and safe has been made by the operator and approved by the Walloon government).
Financial security	The potential operator, in the context of his application for a storage permit, must presents proof that appropriate arrangements in the form of a financial guarantee or any other equivalent arrangement have been taken to ensure that all the obligations arising from the permit, including the closure and post-closure requirements and the preventive and remedial actions. The operator must maintain a financial guarantee in the Walloon Region. The financial guarantee is periodically adjusted to take into account the evolution of the assessed risk of leakage and the estimated costs of all the obligations arising from the permit issue.
Financial mechanism	The operator must support all costs linked to the storage, closure, and monitoring.
Existence of register	The Government of Walloon region or its delegate sets up and maintains: a register of storage permits granted and a permanent register of all closed storage sites and surrounding storage complexes, including maps and sections showing their extent, the available information making it possible to establish that the stored CO ₂ will remain perfectly and permanently contained, as well as all technical archives concerning this site. For the administrative police which concerns it, each competent authority takes both registers into consideration in the relevant planning procedures and when authorizing activities likely to have an impact on the geological storage of CO ₂ in registered storage sites, or to be disturbed by it.
ENVIRONMENT	
Legislative framework with predictions for the	An "Environmental permit" must be granted along with the storage permit. The environmental permit is based on the decree of the Walloon Government of 11.03.1999 “Décret relatif au permis d’environnement” (M.B. 08.06.1999 - err. 22.12.1999) amended for CO ₂ sequestration by

environmental protection in relation to CCS	Walloon Government decree of 10.07.2013 “stockage géologique du dioxyde de carbone” (M.B. 03.09.2013).
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2.2.2. FRANCE

France is a semi-presidential republic with a head of government - the prime minister - appointed by the president who is the directly elected head of state. France’s territory consists of 18 administrative regions - 13 metropolitan (i.e. European France) and 5 overseas regions. France is a member of the EU since the 1st of January 1958 [32].

The legislative framework of CO₂ transport in France is defined by the French Decree n°2011-1411.

The legislative framework of CCS in France is defined by the French Decree n°2011-1411 “Décret n. 2011-1411 du 31 octobre 2011 relatif au stockage géologique de dioxyde de carbone afin de lutter contre le réchauffement climatique” of 31.10.2011²⁵ [37] in respect to the EU Directive 2009/31/CE. The main aspects of this legislation are shown in **Table 2**.

Table 2 also includes the legislative framework with predictions for environmental protection in relation to CCS.

Table 2: Legislative framework in France

Legislation/Regulation	
CCS	
CCS defined in Legislation as per the EU Directive	The definition of "geological storage" has been adapted in the French Decree n°2011-1411 of 31.10.2011 in respect to the EU Directive 2009/31/CE.
CCS Definition	The definition of geological storage of CO ₂ is “Injection along with storage of CO ₂ flux into underground geological formations”.
Primary legislation for CCS in place at Country/National Level	It is defined in the French Decree n°2011-1411 of 31.10.2011 in respect to the EU Directive 2009/31/CE.
Secondary Local/Administration specific Legislation	No.
SELECTION OF STORAGE SITES AND EXPLORATION PERMITS	
Restrictions (limitations) in place for the selection of storage sites	In France, the regulatory framework for CO ₂ storage is based both on the regulation of classified installations to regulate their operation (authorisation regime subject to public inquiry) and on the procedures provided in the mining code for the supervision of exploration activities and the allocation of economic rights. A 30-year monitoring period is also required before the site is transferred to the State. A mining title is required to seek training suitable for storage and to carry out economic exploitation. For site search: Need to obtain an "exclusive permit to search for formations suitable for the geological storage of carbon dioxide”.
Name of the authority/administration	Prefect.

²⁵ French Decree n°2011-1411. <https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000024738062/>

responsible for the permit/registration	File under examination transmitted to the Ministry and the European Commission: The Prefect may only take its decision after four months following transmission of the draft decision to the European Commission or to the Minister responsible for mines unless both inform that they decide not to give an opinion.
Permit required for exploration	<p>Yes. The injection of gas requires a prefectural authorization request file. The operating permit sets out the conditions for the development and operation of the site and in particular:</p> <p>a) In application of article L. 512-4, the duration of validity of the authorization within the limit of that of the concession for the geological storage of carbon dioxide;</p> <p>(b) The precise location and delimitation of the storage site and complex, as well as of the information regarding the hydraulic system;</p> <p>(c) The maximum quantity of carbon dioxide for which storage is permitted and the distribution of this quantity over the operating life;</p> <p>(d) Reservoir pressure limits and maximum injection rates and pressures;</p> <p>(e) The carbon dioxide flow acceptance criteria and the means implemented to ensure that they are respected;</p> <p>(f) Preventive measures to be applied to avoid any risk of leakage or risk to the environment or to the human health;</p> <p>(g) Any other requirements for injection and storage aimed, in particular, at preventing risk of leakage, a leakage or a risk to the environment or to the human health.</p>
Duration of the exploration permit	Defined in the exploitation authorization.
Typical time for submission and approval	Not Available.
STORAGE PERMITS	
Permit required for storage	Yes. Storage sites should not be operated without a storage permit.
Duration of the storage permit	No.
Typical time for submission and approval	Not Available.
Name of the authority /administration responsible for the permit/registration	Ministry of Ecological Transition and Solidarity, General Directorate of Energy and Climate. (Ministère de la transition écologique et solidaire, Direction Générale de l'Energie et du Climat (DGEC)).
Conditions for storage permits	<p>The competent authority shall issue a storage permit only if the following conditions are met:</p> <p>1. The competent authority, on the basis of the application submitted pursuant to Article 7 and of any other relevant information, is satisfied that:</p> <p>(a) all relevant requirements of this Directive and other relevant Community legislation are met;</p> <p>(b) the operator is financially sound and technically competent and reliable to operate and control the site and that professional and technical development and training of the operator and all staff are provided;</p> <p>(c) in the case of more than one storage site in the same hydraulic unit, the potential pressure interactions are such that both sites can simultaneously meet the requirements of this Directive;</p>

	2. The competent authority has considered any opinion of the Commission on the draft permit issued pursuant to Article 10.
OPERATION, CLOSURE AND POST -CLOSURE OBLIGATIONS	
CO ₂ stream acceptance criteria and procedure	<p>Order of 31 October 2012 - art. 3 - Three categories:</p> <p>"Minor streams" means a group of streams whose combined emissions do not exceed 5 kilotons of fossil CO₂ per year or whose total contribution is less than 10% (up to a maximum of 100 kilotons of fossil CO₂ per year) of the total annual emissions of fossil CO₂ from that installation before deduction of the CO₂ transferred, whichever is the higher in terms of absolute emissions;</p> <p>"Marginal streams" means a group of minor streams whose combined emissions do not exceed 1 kiloton of fossil CO₂ per year, or whose total contribution is less than 2% (up to a maximum of 20 kilotons of fossil CO₂ per year) of the total annual fossil CO₂ emissions of that installation before deduction of the CO₂ transferred, whichever is the greater in terms of absolute emissions;</p> <p>"Major source streams" means a group of source streams that do not belong to the group of "minor source streams" [38].</p>
Monitoring	Yes.
Reporting by the operator	Art. R. 229-77-The operator sends the annual report provided for in article L. 229-38 to the prefect. The operator shall send a copy to the site monitoring commission created in the application of Article L. 229-40. The operator shall also make a copy of this report available to the public. The Prefect shall send a copy of it, for information, to the departments concerned, to the regional health agency as well as to the mayors of the municipalities on whose territory the operating license is granted in whole or in part.
System of routine or non - routine inspections	<p>Decree n° 2011-1411 (31/10/2011), Article 2, Sous-section 6</p> <p>Art. R. 229-80-The operating permit is subject to review at the intervals provided for in Article L. 229-42. This review shall be carried out in the light of the information mentioned in Article L. 229-42 or in subsection 5. It may also be initiated on the basis of the latest scientific findings, the latest technological developments or when the operator anticipates that the quantities of carbon dioxide flows injected over a given period will exceed the values set by the operating permit order.</p>
Measures in case of leakages or significant irregularities	Art. R. 229-99-In the event of withdrawal of the authorisation in accordance with Article L. 229-42 and if no new authorisation is issued, the site is permanently shut down on the basis of the provisional post-closure plan, updated if necessary.
Closure and post - closure obligations	The decree n° 2011-1411 (31/10/2011) provides for a "post-closure plan" including, in particular, the definitive shutdown of the site and its monitoring for at least 30 years after its definitive shutdown. This amount corresponds at least to the provided amount of the cash payment.
Financial security	<p>The justification of the technical and financial capacities of the operator is in accordance with 5° of article R. 512-3. This justification may be based on the documents, updated, submitted in support of the application for a concession for the geological storage of carbon dioxide referred in Article R. 229-69.</p> <p>The procedures for periodically updating the amount of the financial guarantees, as set by the authorization order, shall take into account</p>

	changes in the assessed risk of leakage and the estimated costs of all the obligations arising from the granting of the operating permit as well as those arising from the inclusion of geological carbon dioxide storage sites in the system of greenhouse gas emission quotas. In the event of withdrawal of the operating permit, the financial guarantees shall be maintained until a new operating permit is issued or until the transfer of responsibility referred to in Article R. 229-100.
Financial mechanism	Geological storage, combined with CO ₂ recovery, is eligible for "future investments".
Existence of register	Not exactly, but there is the ADEME Club CO ₂ , with many projects about CCUS [39].
ENVIRONMENT	
Legislative framework with predictions for the environmental protection in relation to CCS	The French Order n° 2010-1232 (DISPOSITIONS RELATIVES AUX DOMAINES DES ESPACES NATURELS, DE L'AIR, DE L'ATMOSPHERE ET DE LA PREVENTION DES POLLUTIONS ET DES RISQUES) of 21-10-2010 aims to adapt divers adaptation of the EU Environmental rights. Besides, the French Decree n°2011-1411 of 31.10.2011 includes amendment of the EU Directive 2009/31/CE related to Environmental aspects. For instance, the Art. R 229-101 clearly states about "leaking issues" that should lead to intensification of the supervision of storage sites and, if needed, preventive or corrective actions must be taken". It should be mentioned that for any CO ₂ geological storage and exploitation a permit should be delivered. The elements of this permit rely on the French Decree n°2011-1411 of 31.10.2011.

2.2.3. GREECE

Greece is a parliamentary republic with a head of government - the prime minister - who has the most political power, and the head of state - the president - whose duties are largely ceremonial. The executive power is exercised by the government. Greece is a member of the EU since the 1st of January 1981 [32].

The legislative framework of CO₂ transport in Greece is defined by the Joint Ministerial Decision 48416/2037/E.103 of 2011. Furthermore, one Joint Ministerial Decision mentions the transportation of CO₂ by pipelines. This is Joint Ministerial Decision 181478/965 "Τροποποίηση και κωδικοποίηση της υπ' αριθμ. Η.Π. 54409/2632/2004 κοινής υπουργικής απόφασης «Σύστημα εμπορίας δικαιωμάτων εκπομπής αερίων θερμοκηπίου σε συμμόρφωση με τις διατάξεις της οδηγίας 2003/87/EK "σχετικά με τη θέσπιση συστήματος εμπορίας δικαιωμάτων εκπομπής αερίων θερμοκηπίου εντός της Κοινότητας και την τροποποίηση της οδηγίας 96/61/EK του Συμβουλίου" του Συμβουλίου της 13ης Οκτωβρίου 2003 και άλλες διατάξεις», (B' 1931) όπως αυτή έχει τροποποιηθεί και ισχύει" of 26.10.2017²⁶ (GG 3763 B') [40] in respect to the EU Directive 2003/87/EC.

The legislative framework of CCS in Greece is defined by the Joint Ministerial Decision 48416/2037/E.103 "Μέτρα και όροι για την αποθήκευση διοξειδίου του άνθρακα σε γεωλογικούς σχηματισμούς-Τροποποίηση της υπ' αριθμ. 29457/1511/2005 (B' 992) κοινής υπουργικής απόφασης, του

²⁶ Greek Joint Ministerial Decision 181478/965 http://www.et.gr/idocs-nph/search/pdfViewerForm.html?args=5C7QrtC22wEsriP0JAlxBXdvtvSoClrL8RQNGuy-8PDm4ndCieBbLVuJInJ48_97uHrMts-zFzeyCiBSQOpYnTy36MacmUFCx2ppFvBej56Mmc8Qdb8ZfRjQZnsIAdk8Lv_e6czmhEmbNmZCMxLMtYhpgkZCI OuDJPsgcSDSbKfEb8fnmnd1PTeeoqciqxUD

Π.Δ. 51/2007 (Α' 54) και του Π.Δ. 148/2009 (Α' 190), σε συμμόρφωση προς τις διατάξεις της οδηγίας 2009/31/ΕΚ του Ευρωπαϊκού Κοινοβουλίου και του Συμβουλίου της 23ης Απριλίου 2009 «σχετικά με την αποθήκευση διοξειδίου του άνθρακα σε γεωλογικούς σχηματισμούς και για την τροποποίηση της οδηγίας 85/337/ΕΟΚ του Συμβουλίου, των οδηγιών του Ευρωπαϊκού Κοινοβουλίου και του Συμβουλίου 200/60/ΕΚ, 2001/80/ΕΚ, 2004/35/ΕΚ και 2008/1/ΕΚ και του Κανονισμού (ΕΚ) αριθ. 1013/2006»²⁷ of 07.11.2011²⁷ (GG 2516 Β') [41] in respect to the EU Directive 2009/31/EC. The main aspects of this legislation are shown in **Table 3**.

Table 3 also includes the legislative framework with predictions for environmental protection in relation to CCS.

Table 3: Legislative framework in Greece

Legislation/Regulation	
CCS	
CCS defined in Legislation as per the EU Directive	It is defined in Joint Ministerial Decision 48416/2037/E.103 of 07.11.2011 (GG 2516 Β') in respect to the EU Directive 2009/31/CE.
CCS Definition	The definition of geological storage of CO ₂ is "Injection accompanied by storage of CO ₂ streams in an underground geological formation".
Primary legislation for CCS in place at Country/National Level	It is defined in Joint Ministerial Decision 48416/2037/E.103 of 07.11.2011 (GG 2516 Β') in respect to the EU Directive 2009/31/CE.
Secondary Local/Administration specific Legislation	No.
SELECTION OF STORAGE SITES AND EXPLORATION PERMITS	
Restrictions (limitations) in place for the selection of storage sites	A geological formation shall only be selected as a storage site, if under the proposed conditions of use there is no significant risk of leakage, nor significant environmental or health risks exist.
Name of the authority/administration responsible for the permit/registration	Ministry of Environment and Energy.
Permit required for exploration	Yes.
Duration of the exploration permit	Defined by the exploitation authorization . The duration of a permit shall not exceed the period necessary to carry out the exploration and may be extended when the specified duration is not sufficient/enough for completion of exploration.
Typical time for submission and approval	Not available.
STORAGE PERMITS	
Permit required for storage	Yes. Priority for the granting of a storage permit for a particular site shall be given to the holder of the exploration permit for that site, provided that the exploration of that site is completed, that any condition set in

²⁷ Greek Joint Ministerial Decision 48416/2037/E.103. http://www.et.gr/idocs-nph/search/pdfViewerForm.html?args=5C7QrtC22wFYAFdDx4L2G3dtvSoClrL8O_i9IGUdzi8fP1Rf9veiteJInJ48_9_7uHrMts-zFzeyCiBSQOpYnTy36MacmUFCx2ppFvBej56Mmc8Qdb8ZfRjQZnsIAdk8Lv_e6czmhEmbNmZCMxLMtdoP2rqW_eqiFFKELYg4gpwovMyjRtza2uDgJemYK7ZZf

	the exploration permit has been complied with, and that the application for a storage permit is made during the period of validity of the exploration permit.
Duration of the storage permit	25 years maximum, which can be renewed every 5 years .
Typical time for submission and approval	Not available.
Name of the authority /administration responsible for the permit/registration	Ministry of Environment and Energy.
Conditions for storage permits	<p>a) all relevant requirements of Joint Ministerial Decision 48416/2037/E.103 and other relevant National and European Community legislation are met;</p> <p>b) the operator is financially sound and technically competent and reliable to operate and control the site and that professional and technical development and training of the operator and all staff are provided;</p> <p>c) in the case of more than one storage site in the same hydraulic unit, the potential pressure interactions are such that both sites can simultaneously meet the requirements of Joint Ministerial Decision 48416/2037/E.103.</p>
OPERATION, CLOSURE AND POST-CLOSURE OBLIGATIONS	
CO ₂ stream acceptance criteria and procedure	<p>1. A CO₂ stream shall consist overwhelmingly of carbon dioxide. To this end, no waste or other matter may be added for the purpose of disposing of that waste or other matter. However, a CO₂ stream may contain incidental associated substances from the source, capture or injection process and trace substances added to assist in monitoring and verifying CO₂ migration. Concentrations of all incidental and added substances shall be below levels that would:</p> <p>a) adversely affect the integrity of the storage site or the relevant transport infrastructure;</p> <p>b) pose a significant risk to the environment or human health; or</p> <p>c) breach the requirements of applicable National and European Community legislation.</p> <p>2. The operator is obliged to:</p> <p>a) accept and inject CO₂ streams only if an analysis of the composition, including corrosive substances, of the streams and a risk assessment have been carried out, and if the risk assessment has shown that the contamination levels are in line with the conditions referred to in paragraph 1;</p> <p>b) keep a register of the quantities and properties of the CO₂ streams delivered and injected, including the composition of those streams.</p>
Monitoring	The operator carries out monitoring of the injection facilities, the storage complex (including where possible the CO ₂ plume), and where appropriate the surrounding environment. The monitoring shall be based on a monitoring plan that shall be updated every 5 years.
Reporting by the operator	The frequency is determined in the storage permit and in any case at least once a year.
System of routine or non - routine inspections	A routine inspection shall be carried out at least once a year until 3 years after closure and every 5 years until the transfer of responsibility to the Ministry of Environment and Energy (competent authority).

	Non-routine inspections shall be carried out in case of leakages or significant irregularities, insufficient compliance with the permit conditions, etc.
Measures in case of leakages or significant irregularities	The operator has to immediately inform the Ministry of Environment and Energy (competent authority), and to take the necessary corrective measures on the basis of a corrective measures plan, including measures related to the protection of human health. If the operator fails to take the necessary corrective measures, the competent authority shall take the necessary corrective measures itself.
Closure and post -closure obligations	After closure, the operator remains responsible for monitoring, reporting, remedial actions, etc. The Ministry of Environment and Energy (competent authority) is responsible for the monitoring and other actions/measures after the withdrawal of a storage permit.
Financial security	The potential operator is obliged to submit a financial guarantee. The financial guarantee is determined in the storage permit and is adjusted every five years.
Financial mechanism	The operator makes a financial contribution every year, available to the Ministry of Environment and Energy (competent authority) before the transfer of responsibility has taken place.
Existence of register	Yes. The Ministry of Environment and Energy (competent authority) establishes and maintains: 1. A register of the storage permits granted; and 2. A permanent register of all closed storage sites and surrounding storage complexes, including maps and sections of their spatial extent and available information relevant for assessing that the stored CO ₂ will be completely and permanently contained.
ENVIRONMENT	
Legislative framework with predictions for the environmental protection in relation to CCS	According to Joint Ministerial Decision 48416/2037/E.103., the approval of an Environmental Impact Assessment is required to submit an application for storage permit. Furthermore, in the event of leakages or significant irregularities, the operator immediately notifies the Ministry of Environment and Energy, and takes the necessary corrective measures, including measures related to the protection of human health. In cases of leakages and significant irregularities which imply the risk of leakage, the operator shall also notify the Ministry of Environment and Energy pursuant to Joint Ministerial Decision 54409/2632/2004 (GG 1931 B'), as amended by Joint Ministerial Decisions 9267/468/2007 (GG 286 B') and 57495/2959/2010 (GG 2030 B').

2.2.4. ITALY

Italy is a parliamentary republic with a head of government - the prime minister - appointed by the president and a head of state - the president. The country is subdivided into 20 regions, with 5 of them having a special autonomous status, enabling them to pass legislation on some local matters. Italy is a member of the EU since the 1st of January 1958 [32].

The legislative framework of CO₂ transport in Italy is defined by the Legislative Decree 162. Furthermore, two Legislative Decrees mention the transportation of CO₂ by pipelines. The first one is Legislative Decree 216 "Attuazione delle direttive 2003/87 e 2004/101/CE in materia di scambio di quote di emissioni dei gas

a effetto serra nella Comunità, con riferimento ai meccanismi di progetto del Protocollo di Kyoto” of 04.04.2006²⁸ [42] in respect to the EU Directive 2003/87/CE. The second one is Legislative Decree 104 “Attuazione della direttiva 2014/52/UE del Parlamento europeo e del Consiglio, del 16 aprile 2014, che modifica la direttiva 2011/92/UE, concernente la valutazione dell’impatto ambientale di determinati progetti pubblici e privati, ai sensi degli articoli 1 e 14 della legge 9 luglio 2015, n. 114. (17G00117)” of 16.06.2017²⁹ [43] in respect to the EU Directive 2011/92/CE.

The legislative framework of CCS in Italy is defined by the Legislative Decree 162 “Attuazione della direttiva 2009/31/CE in materia di stoccaggio geologico del biossido di carbonio, nonche' modifica delle direttive 85/337/CEE, 2000/60/CE, 2001/80/CE, 2004/35/CE, 2006/12/CE, 2008/1/CE e del Regolamento (CE) n. 1013/2006. (11G0207)” of 14.09.2011³⁰ [44] in respect to the EU Directive 2009/31/CE. The main aspects of this legislation are shown in Table 4.

Table 4 also includes the legislative framework with predictions for environmental protection in relation to CCS.

Table 4: Legislative framework in Italy

Legislation/Regulation	
CCS	
CCS defined in Legislation as per the EU Directive	It is defined in the Legislative Decree 162 of 14 September 2011.
CCS Definition	Geological sequestration is defined as the injection and confinement of CO ₂ streams in underground geological formations without exchanges of fluids with other formations.
Primary legislation for CCS in place at Country/National Level	It is defined in the Legislative Decree 162 of 14 September 2011.
Secondary Local/Administration specific Legislation	No.
SELECTION OF STORAGE SITES AND EXPLORATION PERMITS	
Restrictions (limitations) in place for the selection of storage sites	Aquifers with usable water (drinkable or for irrigation) and aquifers in highly seismic places cannot be used. Moreover, data on rock layers composition, the composition of water in the rock layers, assessment of pressure differences that can arise and environmental impact assessment must be provided to apply for the permit.
Name of the authority/administration responsible for the permit/registration	Ministry of Environment and Ministry of Economy with the support of the “National Committee for the management of the directive 2003/87/CE and for the support in the management of the project activities of the Kyoto Protocol” (“Comitato nazionale per la gestione della direttiva 2003/87/CE e per il supporto nella gestione delle attività di progetto del Protocollo di Kyoto di cui all'articolo 3-bis del decreto legislativo 4 aprile 2006, n. 216).

²⁸ Italian Legislative Decree 216. <https://www.camera.it/parlam/leggi/deleghe/testi/06216dl.htm>

²⁹ Italian Legislative Decree 104. <https://www.gazzettaufficiale.it/eli/id/2017/07/06/17G00117/sg>

³⁰ Italian Legislative Decree 162.

https://www.gazzettaufficiale.it/atto/serie_generale/caricaDettaglioAtto/originario?atto.dataPubblicazioneGazzetta=2011-10-04&atto.codiceRedazionale=011G0207

Permit required for exploration	Yes. The permit must be granted by the Ministry of Economy and the Ministry of Environment, on the basis of the judgement of the technical committee, and in agreement with the "Region" where the site is located.
Duration of the exploration permit	3 years , which can be renewed for 2 additional years .
Typical time for submission and approval	Permit granted or not in 180 days .
STORAGE PERMITS	
Permit required for storage	Yes. It is granted by the Ministry of Economy, the Ministry of Environment (on the basis of the technical committee opinion), and the Region of the storage site.
Duration of the storage permit	It is not specified although it can be set by the authority and the permit can be suspended, updated, modified during the years of operation.
Typical time for submission and approval	Maximum time 180 days.
Name of the authority /administration responsible for the permit/registration	Granted by the Ministry of Economy, the Ministry of Environment (on the basis of the technical committee opinion) and the Region of the storage site.
Conditions for storage permits	<ul style="list-style-type: none"> a) subjects must possess management, technical and economic capability set by the law (allegato III); b) construction and operation of the storage site does not affect the collectivity and the major interests of the local people; c) no negative effects on close mines/extraction sites; d) guarantee on the long-term safety of the storage site; e) measures are planned to avoid damages to collectivity..
OPERATION, CLOSURE AND POST -CLOSURE OBLIGATIONS	
CO ₂ stream acceptance criteria and procedure	Minimum CO ₂ purity, which is indicated in the permit, concentrations of other substances below safety values.
Monitoring	The operator has to monitor the injected stream composition and provide certificates to the committee every 6 months (at minimum) indicating the origin of the injected CO ₂ (companies that captured CO ₂).
Reporting by the operator	The operator has to record the injected amounts.
System of routine or non - routine inspections	Non-regular inspections by the technical committee.
Measures in case of leakages or significant irregularities	<p>The operator has to:</p> <ul style="list-style-type: none"> a) implement safety measures planned for the issue b) inform the Ministry of Economy, the Ministry of Environment, the technical committee, the Region and all the monitoring authorities c) if the operator cannot fulfil the safety measures/actions asked by the authority, the authority will implement such measures.
Closure and post - closure obligations	The operator has to get the closure permit from the Ministry of Economy and Environment. The operator has to seal the storage site and remove the injection facilities. After the closure, the Ministry of Economy is responsible for the monitoring and other actions/measures.
Financial security	The storage site operator must guarantee all economic obligations from the permit to the post-closure steps. The amount of the guarantee can be updated on the basis of the risks.

Financial mechanism	The guarantee covers the costs of monitoring for 30 years, the costs required to keep confinement of CO ₂ , possible damages to the environment and human health.
Existence of register	Yes.
ENVIRONMENT	
Legislative framework with predictions for the environmental protection in relation to CCS	The Ministry of the Economic Development ("Ministero dello Sviluppo Economico") should have a database of the data collected during the activities of exploration and storage.

2.2.5. NORWAY

Norway is a constitutional monarchy. Executive power is exercised by the Council of State (the cabinet) led by the Prime Minister. Legislative power is vested in both the government and the legislature (the Storting) [45]. Norway is not a European Union member, but through its membership of the European Economic Area (EEA), Norway is closely linked to the activities of the EU. Norway transposed the CCS Directive into Norwegian law and entered into force on the 1st of June 2013 [46].

The Norwegian government strongly emphasizes the capture and storage of CO₂. At present, transportation by pipeline for permanent storage in a subsea geological formation on the continental shelf is the only solution for the storage of CO₂, due to geological reasons [47]. The legislative framework of CO₂ transport in order to be stored in Norway is defined by the Storage Regulation FOR-2014-12-05-1517 "Forskrift om utnyttelse av undersjøiske reservoarer på kontinentalsokkelen til lagring av CO₂ og om transport av CO₂ på kontinentalsokkelen Lagringsforskriften" of 05.12.2014³¹ [48].

The legislative framework of CCS in Norway is defined by:

1. The Storage Regulation FOR-2014-12-05-1517 "Forskrift om utnyttelse av undersjøiske reservoarer på kontinentalsokkelen til lagring av CO₂ og om transport av CO₂ på kontinentalsokkelen Lagringsforskriften" of 05.12.2014.
2. Pollution law LOV-1981-03-13-6 "Lov om vern mot forurensninger og om avfall (Forurensningsloven)" of 13.03.1981³² [49].
3. The Pollution Regulation FOR-2004-06-01-931 "Forskrift om begrenning av forurensning (forurensningsforskriften)" of 01.06.2004³³ [50].
4. The Petroleum Regulation FOR-1997-06-27-653 "Forskrift til lov om petroleumsvirksomhet" of 27.06.1997³⁴ [51].

³¹ Storage Regulation FOR-2014-12-05-1517 (Norway).

<https://lovdata.no/dokument/SF/forskrift/2014-12-05-1517>

³² Pollution Law LOV-1981-03-13-6 (Norway). <https://lovdata.no/dokument/NL/lov/1981-03-13-6>

³³ Pollution Regulation FOR-2004-06-01-931 (Norway). https://lovdata.no/dokument/SF/forskrift/2004-06-01-931/KAPITTEL_9#KAPITTEL_9

³⁴ Petroleum Regulation FOR-1997-06-27-653 (Norway). https://lovdata.no/dokument/SF/forskrift/1997-06-27-653/KAPITTEL_6#KAPITTEL_6

5. Safety and work environment for CO₂ transport and storage on the Norwegian continental shelf FOR-2020-02-25-186 “Forskrift om sikkerhet og arbeidsmiljø ved transport og injeksjon av CO₂ på kontinentalsokkelen» of 26.02.2020³⁵ [52].

The main aspects of the legislations are shown in **Table 5**. This table also includes the legislative framework with predictions for environmental protection in relation to CCS.

Table 5: Legislative framework in Norway

Legislation/Regulation	
TRANSPORT OF CO₂	
	<p>Transportation of CO₂ to be stored in geological formations is regulated in the Storage Regulation chapter 6. The regulation establishes a licensing scheme for the operation of transport facilities, primarily pipelines for the transportation of CO₂. The license is granted by the Ministry of Petroleum and Energy.</p> <p>A license application must contain information regarding the geographical placement of the pipeline, its dimensions and capacity. Furthermore, it must provide information about the ownership of the facility and a description of technical solutions; governing systems; maintenance; financial circumstances and necessary permits. It must also contain information about technical measures for safety.</p> <p>The Ministry may grant a permit under certain conditions; the ownership of the facility, the destination of the pipeline, in addition to the route, dimension, and transport capacity of the pipeline. The Ministry may also order that the facility shall be connected to other facilities, that the capacity is to be increased or that the facility shall be rebuilt to be used for other CO₂ than what it was initially built for.</p> <p>As mentioned above, the Storage Regulation is primarily focused on transportation through a pipeline. Other types of transportation, such as by ships or trucks, are not specified in the Storage Regulation. However, the rules in the regulation apply to these transportation types as well.</p>
CCS	
CCS defined in Legislation as per the EU Directive	CCS is not directly defined, but the main stages/elements of the process are defined in the Storage regulation (e.g. geological storage, injection, exploration, etc).
CCS Definition	No.
Primary legislation for CCS in place at Country/National Level	The CCS Directive is implemented through the Storage Regulation and additions and amendments to the Petroleum Regulation and the Pollution Regulation.
Secondary Local/Administration specific Legislation	No
SELECTION OF STORAGE SITES AND EXPLORATION PERMITS	
Restrictions (limitations) in place for the selection of storage sites	The Storage regulation limits the selection of storage sites to the Norwegian continental shelf. This restriction is based on geological circumstances.

³⁵ Safety and work environment for CO₂ transport and storage on the Norwegian continental shelf FOR-2020-02-25-186 (Norway). <https://lovdata.no/dokument/LTI/forskrift/2020-02-25-186>

Name of the authority/administration responsible for the permit/registration	Ministry of Petroleum and Energy.
Permit required for exploration	Yes. A permit requires that the licensee has the financial strength, technical competence, and sufficient reliability to operate exploration activity.
Duration of the exploration permit	3 years , unless otherwise agreed.
Typical time for submission and approval	Typical time varies from case to case. The general regulation in the Public Administration Act applies.
STORAGE PERMITS	
Permit required for storage	Yes. A permit is required from the Environment Agency before the injection and storage of CO ₂ in geological formations. This is regulated in the Pollution Regulation.
Duration of the storage permit	The duration is given in the permit.
Typical time for submission and approval	This varies from case to case. The general regulations in the Public Administration Act apply.
Name of the authority/administration responsible for the permit/registration	Environment Agency
Conditions for storage permits	The geological formation must be suitable for storage; the applying activity must not represent a significant risk; the operator must be financially solid and reliable with the necessary competence; potential reciprocal pressure effects between storage sites in the same hydraulic unit must be of such a nature that the sites at the same time can meet the requirements of the Pollution regulation.
OPERATION, CLOSURE AND POST-CLOSURE OBLIGATIONS	
CO ₂ stream acceptance criteria and procedure	In accordance with the Pollution Regulation, the permit for storage shall include specific demands for the composition of the CO ₂ stream.
Monitoring	In accordance with the Storage Regulation, the Ministry of Petroleum and Energy or the one it authorizes, is obliged to supervise at least once a year until three years after the operation is closed.
Reporting by the operator	In accordance with the Pollution regulation, the operator is obliged to report to the Environment Agency at least once a year about; the results of the monitoring, information about the CO ₂ streams, documentation of establishment and continuation of collateral and information that is relevant for the authorities to assess if the operator acts in accordance with the permit.
System of routine or non - routine inspections	In accordance with the Pollution regulation, the Environment Agency shall at least once a year inspect the operations. If the Agency has information about leakage or other irregularities, it shall also do a non-routine inspection.
Measures in case of leakages or significant irregularities	See comment above. In case of leakage, the operator is, according to the Pollution Regulation, obliged to inform the Environment Agency immediately.
Closure and post - closure obligations	The operator must inform the Ministry of Petroleum and Energy of a closure plan and the date of closure. Based on this information the Ministry shall decide on disposal.

Financial security	Permits to explore and store are only given to operators with sufficient financial strength and requires payment of a processing fee. The operator has to provide collateral.
Financial mechanism	In cases of leakage and where the responsibility for the operation is transferred to the government, the operator shall provide the government with a financial contribution that can cover monitoring for 30 years. This is regulated in the Petroleum Regulation.
Existence of register	Yes.
ENVIRONMENT	
Legislative framework with predictions for the environmental protection in relation to CCS	The Pollution Regulation provides a general framework for the environmental protection. The Environmental Agency commissioned the Institute of Public Health (Folkehelseinstituttet) to assess the health impact of amines and their derivatives associated with amine-based carbon capture. This report is used by the regulators in assessing amine-based carbon capture and gives the Norwegian limits on amine-based carbon capture and the associated process degradation products like nitramines and nitrosamines emitted by the industry [53].

2.2.6. UNITED KINGDOM

The United Kingdom is a parliamentary democracy under a constitutional monarchy. The head of state is the monarch, and the head of the government is the prime minister. The UK consists of England, Wales, Scotland, and Northern Ireland. Wales, Scotland, and Northern Ireland have their government and a devolved unicameral legislature. The central government has given responsibilities in matters such as education, transport, and the environment [54]. UK is not a EU member since the midnight of 31st of January 2020.

A legislative framework for CO₂ transport in the United Kingdom does not exist. The only reference found is “The Planning (Environmental Impact Assessment) Regulations” (Northern Ireland) 2017 No. 83³⁶ [55].

The legislative framework of CCS in the United Kingdom is defined by the “*Energy Act 2008 (Chapter 3 Section 17)*”³⁷ [56]. Other regulations that make provision for the implementation of the EU Directive for CCS are:

1. *The Storage of Carbon Dioxide (Licensing etc.) Regulations 2010 No. 2221*³⁸ [57].
2. *The Storage of Carbon Dioxide (Licensing etc.) Regulations (Northern Ireland) 2015 No. 387*³⁹ [58].

³⁶ The Planning (Environmental Impact Assessment) Regulations (Northern Ireland) 2017 No. 83 <https://www.legislation.gov.uk/nisr/2017/83/made>

³⁷ Energy Act 2008. <https://www.legislation.gov.uk/ukpga/2008/32/part/1/chapter/3>

³⁸ The Storage of Carbon Dioxide (Licensing etc.) Regulations 2010 No. 2221. <https://www.legislation.gov.uk/uksi/2010/2221>

³⁹ The Storage of Carbon Dioxide (Licensing etc.) Regulations (Northern Ireland) 2015 No. 387. <https://www.legislation.gov.uk/nisr/2015/387/made>

3. *The Storage of Carbon Dioxide (Licensing etc.) (Scotland) Amendments Regulations 2011 No. 457*⁴⁰ [59].
4. *The Storage of Carbon Dioxide (Inspections etc.) Regulations 2012 No. 461*⁴¹ [60].

The main aspects of the legislation are shown in **Table 6**. This table also includes the legislative framework with predictions for environmental protection in relation to CCS.

Table 6: Legislative framework in the United Kingdom

Legislation/Regulation	
CCS	
CCS defined in Legislation as per the EU Directive	CCS is not directly defined, but the main stages/elements of the process are defined in the Storage regulation (e.g. geological storage, injection, exploration, etc).
CCS Definition	No.
Primary legislation for CCS in place at Country/National Level	Applies to England, Wales, Northern Ireland, Scotland, the territorial sea and the waters in a Gas Importation and Storage Zone (The Energy Act 2008).
Secondary Local/Administration specific Legislation	Other regulations make provision for the implementation of the EU Directive for CCS, which have to do with licensing, inspections, access to infrastructure, and termination of licenses. There are also regulations with the same provisions but specific for Northern Ireland and Scotland. There is one more regulation to allow the amendment of the regulations in relation to the withdrawal of the UK from the EU.
SELECTION OF STORAGE SITES AND EXPLORATION PERMITS	
Restrictions (limitations) in place for the selection of storage sites	The storage site must have been sufficiently characterised and assessed, no part of the storage complex can extend beyond the territories of the member states, and there must be no significant risk of leakage or harm to the environment or human health under the proposed conditions of use of the storage site.
Name of the authority/administration responsible for the permit/registration	The Secretary of State. For Northern Ireland, it is the Department of Enterprise, Trade, and Investment. For Scotland, it is the Scottish Ministers.
Permit required for exploration	Yes. No person may carry out an exploration of a controlled place with a view to, or in connection with, the storage of carbon dioxide, except under a license.
Duration of the exploration permit	The appraisal term may not exceed the period necessary to generate the information necessary to select a storage site and to prepare the documents required for an application.
Typical time for submission and approval	~6 months.
STORAGE PERMITS	

⁴⁰ The Storage of Carbon Dioxide (Licensing etc.) (Scotland) Amendments Regulations 2011 No. 457. <https://www.legislation.gov.uk/ssi/2011/457/made>

⁴¹ The Storage of Carbon Dioxide (Inspections etc.) Regulations 2012 No 461. <https://www.legislation.gov.uk/uksi/2012/461/made>

Permit required for storage	Yes. No person may use a controlled place for the storage of carbon dioxide except under a license.
Duration of the storage permit	If the authority becomes aware of any (or any risk of) leakage or significant irregularities, any breaches of the terms and conditions of the storage permit, or any scientific finding or technological development which appears to have a bearing on the conduct of operations, or in any event on the date of the fifth anniversary of the grant of the permit, and subsequently on every tenth anniversary, they must consider whether to modify or revoke the permit. The operator may close the storage site if given consent by the authority and any conditions attached to the consent have been met.
Typical time for submission and approval	Likely > 6 months
Name of the authority /administration responsible for the permit/registration	The Secretary of State. For Northern Ireland, it is the Department of Enterprise, Trade and Investment. For Scotland, it is the Scottish Ministers.
Conditions for storage permits	The storage site must have been sufficiently characterised and assessed, no part of the storage complex can extend beyond the territories of the member states, and there must be no significant risk of leakage or harm to the environment or human health under the proposed conditions of use of the storage site. The proposed operator must be technically competent, financially sound, can be relied upon to carry out the functions of an operator, and has in place an appropriate programme of professional and technical development and training.
OPERATION, CLOSURE AND POST-CLOSURE OBLIGATIONS	
CO ₂ stream acceptance criteria and procedure	The stream must consist overwhelmingly of carbon dioxide. It must not contain other matter added for the purposes of disposal. It may contain incidental and trace substances if the concentrations of such substances are low enough to not adversely affect the integrity of the storage site or transport infrastructure or pose a significant risk to the environment or human health. See notes for CO ₂ extraction.
Monitoring	The operator must carry out a programme of monitoring of the storage complex and injection facilities. Such monitoring must include the monitoring of the carbon dioxide plume, and the surrounding environment.
Reporting by the operator	The operator must send to the authority a report in respect of each reporting period. It must be sent no later than four weeks after the end of the relevant reporting period. Unless the authority specifies otherwise, the reporting periods are one year beginning with the commencement of injection, and each subsequently yearly period.
System of routine or non - routine inspections	The authority must carry out an inspection not later than one to five years from the date that the initial or post-closure periods commence respectively, and subsequently not later than one to five years from the date of the previous inspection during the respective period. An inspection must be carried out if the authority becomes aware of significant irregularities or a breach of the terms and conditions of the permit, or a complaint is made about the effects of the activities. The authority may also carry out an inspection other than when required as the authority considers appropriate.

Measures in case of leakages or significant irregularities	The authority may direct the operator to take any corrective measures that the authority, after consulting the operator, considers necessary. If the operator fails to take the measures so directed, the authority may at any time take such measures itself, with the costs to be paid by the operator. The measures may be additional to, or different from, those set out in the corrective measures plan.
Closure and post - closure obligations	The operator must close the storage site where the conditions are met. After the storage site has been closed and until the license is terminated, the operator must continue to monitor the storage site, comply with its reporting and notification obligations, and comply with its obligations to take corrective measures. The operator must also seal the storage site and remove the injection facilities in accordance with its obligations under Part 4 of the Petroleum Act 1998.
Financial security	<p>The operator must maintain financial security that is of an amount sufficient to ensure that the obligations specified can be met, that is in force before the commencement of injection, and that remains in force until the license is terminated. However, if the storage permit is revoked, the security must remain in force until a new storage permit is granted or if the storage site is closed following such revocation, until the license is terminated.</p> <p>All obligations of the operator arising under the storage permit, including those arising in respect of the closure of the storage site and during the period between such closure and the termination of the license, the obligation to pay the authority's costs under regulation 10(4)(b) or 12(6), and any obligations of the operator arising in respect of the storage site under legislation implementing Directive 2003/87/EC.</p>
Financial mechanism	<p>Following each report made by the operator, the authority is to assess whether the secured amount is appropriate in the light of the assessed risk of leakage, and the estimated costs of meeting the obligations specified. If following that assessment, the authority decides that the secured amount is to be adjusted, the authority must notify the operator of the new amount that is required and where the secured amount is less than that of the new amount, the operator must ensure that it is increased to the new amount within three months of receiving that notification.</p> <p>All obligations of the operator arising under the storage permit, including those arising in respect of the closure of the storage site and during the period between such closure and the termination of the license, the obligation to pay the authority's costs under regulation 10(4)(b) or 12(6), and any obligations of the operator arising in respect of the storage site under legislation implementing Directive 2003/87/EC.</p>
Existence of register	<p>Yes. There is a public register containing information about the storage licenses and storage permits, and also about storage sites both before and after the closure of the site.</p> <p>The information includes the particulars of each license and storage permit granted and the particulars of each storage site, including a storage site that has been closed. In addition, the Secretary of State may include on the register any other information that the authority that granted the storage permit considers relevant for assessing whether the CO₂ will be completely and permanently contained in the storage site and</p>

	an estimate by that authority of the total storage capacity of the storage site.
ENVIRONMENT	
Legislative framework with predictions for the environmental protection in relation to CCS	The Environmental Liability Directive establishes a framework of environmental liability, based on the "polluter-pays" principle, to prevent and remedy environmental damage. Where environmental damage has not yet occurred but there is an imminent threat of such damage occurring, the operator shall, without delay, take the necessary preventive measures and, in certain cases, inform the competent authority of all relevant aspects of the situation, as soon as possible.

2.2.7. TURKEY

Turkey's political system is based on a separation of powers according to the Constitution. The Constitution states that the legislative power is vested in the Parliament of Turkey, the executive power is carried out by the President of Turkey and that the judicial power is exercised by independent and impartial courts.

The Government of Turkey is a unitary government established by the Constitution of Turkey as a constituted governing authority of a parliamentary democratic republic, constitutionally called the Republic of Turkey. The politics of Turkey take place in the framework of a presidential republic as defined by the Constitution of Turkey. The President of Turkey is elected via presidential elections which are conducted every 5 years. The President is both the head of state and head of government.

In Turkey, municipality administrations are elected via local elections which are carried out in every 5 years. The mayors of cities and districts are capable of performing the municipal functions independently [61,62].

Currently, there is no legislation regarding CCS in Turkey. Despite this fact, **Table 7** includes the main aspects of the future legislation; taking into account the assumptions provided by the Turkish project partners TUPRAS and TCMA.

Table 7: Future legislative framework in Turkey

Legislation/Regulation	
CCS	
CCS defined in Legislation as per the EU Directive	No.
CCS Definition	Carbon capture and storage is the process of capturing CO ₂ caused by electricity generation and industrial production and storing it in distinct impermeable layers of ground under high pressure. There is also another definition for CCS by the Ministry of Energy and Natural Resources [63]. <i>The definition is given in the EU-supported 'Low-Carbon Turkey' Project with its full title as "Technical Assistance for Developed Analytical Basis for Formulating Strategies and Actions towards Low Carbon Development", which aims to decrease the carbon print in Turkey - mainly from the 4 main sectors of building, transportation, agriculture and waste, led by the Ministry of Environment and Urbanization and partnered with ministries such as the Ministry of Transport and Infrastructure, Ministry of Agriculture and Forestry, Ministry of Energy and Natural Resources and local administrations, academic institutions, sectoral experts and non-governmental organisations. Regulatory Impact Analysis for the</i>

	<i>adaptation of national legislation in Turkey is carried out for 4 EU Directives including EU Carbon Capture and Storage Directive within the scope of this project [64, 65].</i>
Primary legislation for CCS in place at Country/National Level	No. CCS technologies are evaluated as preliminary technologies at these upfront studies in Turkey, where there is no legal legislation. These evaluations aim to serve the policy makers the benefits of the use of CCS and CCU technologies. CCS technologies constitute a major part of the agenda of these studies, which facilitates the determination of the carbon emissions in Turkey.
Secondary Local/Administration specific Legislation	No.
SELECTION OF STORAGE SITES AND EXPLORATION PERMITS	
Restrictions (limitations) in place for the selection of storage sites	There is no legislation about storage sites. Yet, Turkey is evaluating the possible areas for carbon storage such as Enhanced Oil Recovery (EOR) and depleted oil wells. Petroleum and gas reserves, deep salty aquifers, coal beds for enhanced extraction and ocean beds are referred to the definition article of CCS by the Ministry of Energy and Natural Resources [66, 67].
Name of the authority/administration responsible for the permit/registration	Authority/administration responsible for the permit/registration is not available. If yes, those would be: the General Directorate of Mining and Petroleum Affairs (Ministry of Energy and Natural Resources), the Ministry of Environment and Urbanization and the Energy Market Regulatory Authority.
Permit required for exploration	In the scope of adaptation and implementation strategy of EU CCS Directives to Turkey, the permit and exploration procedures would be very close to the EU's. CO ₂ storage is considered a mining operation in Turkey, since it requires a natural reservoir; therefore, it requires a mining license. A mining license for ordinary mining activities can be taken in roughly 2 months. Yet, CO ₂ storage is a unique operation and licensing process might take longer.
Duration of the exploration permit	No estimation can be made.
Typical time for submission and approval	In the scope of adaptation and implementation strategy of EU CCS Directives to Turkey, the submission and approval procedures would be very close to the EU's. No estimation can be made.
STORAGE PERMITS	
Permit required for storage	In the scope of adaptation and implementation strategy of EU CCS Directives to Turkey, the permit procedures would be very close to EU's.
Duration of the storage permit	No estimation can be made.
Typical time for submission and approval	No estimation can be made.
Name of the authority/administration responsible for the permit/registration	Authority/administration responsible for the permit/registration is not available. If there was an authority responsible for the permits, those would be: General Directorate of Mining and Petroleum Affairs (Ministry of Energy and Natural Resources), the Ministry of Environment and Urbanization and the Energy Market Regulatory Authority.
Conditions for storage permits	An Environmental Impact Assessment (EIA) will be required by the authorities for site-specific planning taking into account the effects on

	<p>biodiversity, proximity to a residential area and ground structure. If the EIA is approved, geological research (such as exploration, geological mapping, technical studies of the ground layers, permeability, distance to the groundwater, effect on natural balance, etc.) is required for a license as official storage permission.</p> <p>Mining regulation includes natural gas storage but not CO₂. So the permission and conditions depend on the General Directorate of Mining and Petroleum Affairs (Ministry of Energy and Natural Resources).</p>
OPERATION, CLOSURE AND POST -CLOSURE OBLIGATIONS	
CO ₂ stream acceptance criteria and procedure	There would be limitations on the type and amount of the impurities within the CO ₂ stream. The interaction of the impurities with humidity, storage area, etc. would be taken into account on the impact of environment.
Monitoring	-
Reporting by the operator	-
System of routine or non - routine inspections	There are informed/uninformed inspections conducted by related ministries in the scope of 'General Environmental Inspections'. The inspections cover the waste site, GHG emissions monitoring, wastewater treatment sites, etc.
Measures in case of leakages or significant irregularities	-
Closure and post - closure obligations	The obligations will include storage site dimensions, piping depth, storage/reservoir conditions, etc. After storing CO ₂ and sealing the natural reservoir, the storage site must be regenerated in the scope of 'Mining Law' to protect the environment and natural balance [68].
Financial security	Turkey requests to be categorized as a developing country to get international funding and benefit from CCS and CCU technologies as the criterion to ratify the Paris Agreement. Turkey is already receiving significant international climate finance from several multilateral development banks and bilateral channels, as well as money for technology and capacity building from several financial institutions to fight climate change.
Financial mechanism	There would be different mechanisms from related government, ministries, EU funding programs such as the H2020 Research and Innovation program, self-investment by the companies, etc.
Existence of register	Annual greenhouse gas emissions including CO ₂ of each company are monitored, reported and verified since 2015. The Ministry of Environment and Urbanization owns the database for emissions and the verifications are conducted by the institutions authorized by the Ministry. Also, the Turkish Statistical Institute gathers the fuel consumptions from the industrial companies and the Ministry of Energy and Natural Resources, calculates and shares total annual GHG emissions based on the industrial sectors, such as waste, transport, etc.
ENVIRONMENT	
Legislative framework with predictions for the environmental protection in relation to CCS	<p>The main legal framework is set out in Environment Law No. 2872 which came into force on 11 August 1983 [69].</p> <p>Existing environmental regulations don't include the CCS subject. There are several on-going studies among ministries, governmental institutions, academic institutions, sectoral experts and non-governmental organizations for CCS EU Directive adaptations in the near future.</p>

	Emission Trading System and Carbon Tax are under consideration as the Carbon Pricing Instruments.
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2.2.8. COMPARISON OF THE LEGISLATIVE AND REGULATORY FRAMEWORK IN MOF4AIR PARTICIPATING COUNTRIES

An analysis of the legislative and regulatory conditions on capture, transport, and storage of CO₂ in the participating countries of the MOF4AIR project has been undertaken. To this analysis special attention was given in the sense of licensing and permitting procedures.

Table 8 provides a summary of the legislative and regulatory framework that is in place in the MOF4AIR participating countries. This table also includes Turkey, even though no legislation regarding CCS exists.

Table 8: Summary of legislative and regulatory framework in MOF4AIR participating countries

Legislation/Regulation	Walloon Region (Belgium)	France	Greece	Italy	Norway	UK	Turkey
TRANSPORT OF CO₂	Not specific	Not specific	Not specific	Not specific	✓	✗	✗
CCS							
CCS defined in Legislation as per the EU Directive	✓	✓	✓	✓	✗	✗	✗
Primary legislation for CCS in place at Country/National Level	✓	✓	✓	✓	✓	✓	✗
Secondary Local/Administration specific Legislation	✗	✗	✗	✗	✗	✓	✗
SELECTION OF STORAGE SITES AND EXPLORATION PERMITS							
Restrictions (limitations) in place for the selection of storage sites	✗	✓	✓	✓	✓ Only on the continental shelf	✓	✗
Name of the authority/administration responsible for the permit/registration	Walloon Region government	Prefect	Ministry of Environment and Energy	Ministry of Environment and Ministry of Economy	Ministry of Petroleum and Energy	The Secretary of State. Northern Ireland: Department of Enterprise, Trade and Investment. Scotland: Scottish Ministers.	✗

Legislation/Regulation	Walloon Region (Belgium)	France	Greece	Italy	Norway	UK	Turkey
Permit required for exploration	✓	✓	✓	✓	✓	✓	✗
Duration of the exploration permit	✗	Defined in the exploitation authorization	Defined in the exploitation authorization	3 years	3 years	✗	✗
Typical time for submission and approval	30 days admissibility + 250 days final decision	Not available	Not available	180 days	✓ Varies from case to case	✓ ~6 months	✗
STORAGE PERMITS							
Permit required for storage	✓	✓	✓ Priority is given to the holder of the exploration permit	✓	✓	✓	✗
Duration of the storage permit	✗	✗	25 years	✗	✓ Given in the permit	✗	✗
Typical time for submission and approval	1-1.5 years	Not available	Not available	180 days	✓ Varies from case to case	✓ >6 months	✗
Name of the authority /administration responsible for the permit/registration	Walloon Region government	Ministry of Ecological Transition and Solidarity, General Directorate of	Ministry of Environment and Energy	Ministry of Economy, Ministry of Environment and Region of the storage site	Environment Agency	The Secretary of State. Northern Ireland: Department of Enterprise,	✗

Legislation/Regulation	Wallon Region (Belgium)	France	Greece	Italy	Norway	UK	Turkey
		Energy and Climate				Trade and Investment. Scotland: Scottish Ministers	
Conditions for storage permits	x	√	√	√	√	√	x
OPERATION, CLOSURE AND POST-CLOSURE OBLIGATIONS							
CO ₂ stream acceptance criteria and procedure	√	√	√	√	√	√	x
Monitoring	√	√	√	√	√	√	x
Reporting by the operator	√	√	√		√	√	x
System of routine or non - routine inspections	√	√	√	√	√	√	x
Measures in case of leakages or significant irregularities	√	√	√	√	√	√	x
Closure and post - closure obligations	√	√	√	√	√	√	x
Financial security	√	√	√	√	√	√	x
Financial mechanism	√	√	√	√	√	√	x
Existence of register	√	x	√	√	√	√	x
ENVIRONMENT							
Legislative framework with predictions for the environmental protection in relation to CCS	√ Environmental permit	√ Environmental permit	√ Environmental permit	√	√	√	x

Note: √ = exist, x = does not exist

After the analysis of the legislative and regulatory framework on capture, transport, and storage of CO₂ in MOF4AIR participating countries, a comparison between these countries has been undertaken. According to this analysis:

- The legislative framework of CCS in the EU Member States [Belgium (Walloon Region), France, Greece, and Italy] is connected with the transposition of CCS Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide, into national laws. This means that Member States ratified the CCS Directive by creating a CCS framework for their countries, without proceeding in any further legal reforms. As a result, CCS's legal framework for these States is almost the same. Minor differences exist in some parts. Indicatively, such differences are:
 - In the restrictions in place for the selection of storage sites [Walloon Region (Belgium), France & Greece: no restrictions and Italy: specific restrictions].
 - In the duration of exploration permits [Walloon region (Belgium): not defined, France & Greece: defined in the exploitation authorization and Italy: 3 years].
 - In the duration of storage permits [Walloon region (Belgium), France & Italy: not defined and Greece: 25 years].
 - In the typical time for submission and approval of exploration permits [Walloon Region (Belgium): 30 days for the admissibility of the application+ 250 days for a final decision, France and Greece: not available and Italy: 180 days].
 - In the typical time for submission and approval of storage permits [Walloon Region (Belgium): 30 days for the admissibility of the application+ 250 days for a final decision, France and Greece: not available and Italy: 180 days].
 - In the conditions for storage permits [Walloon Region (Belgium): no, France, Greece and Italy: yes].
- Norway has a comprehensive legislation and regulatory framework regarding CCS. Norway as a European Economic Area country transposed the CCS Directive into Norwegian law. The CCS Directive is implemented through the Storage Regulation and additions and amendments to the Petroleum Regulation and the Pollution Regulation. Transportation by pipelines for permanent storage in a subsea geological formation on the continental shelf (exclusively) is defining by the Storage Regulation. As it is mentioned, Norway regulates taking into account EU Directives. As a result, Norway has a CCS framework that aligns with EU requirements, as a result, addresses the key barrier issues to CCS.

Norway and the EU Member States (MOF4AIR participating countries) present many similarities in their CCS legal framework, especially in terms of exploration and storage permits, as well as in operation, closure, and post-closure obligations.

The main differences that identified between Norway and the EU Member States:

- The existence of a specific legal framework for the transportation of CO₂ in order to be stored in Norway;
- The restrictions in the selection of storage sites only to the Norwegian continental shelf for geological reasons.

- The legislative framework of CCS in the United Kingdom is defined by the Energy Act 2008. Other regulations that make the same provision for the implementation of the CCS Directive specifically for Northern Ireland and Scotland.

The UK, as a former Member State of the EU, transposed the CCS Directive into national law. As a result, the CCS framework presents many similarities with those of EU Member States (MOF4AIR participating countries), as well as with Norway.

The most important difference for the UK, in comparison to the EU Member States and Norway, is the absence of a legal framework for the transportation of CO₂ in order to be stored.

- Currently, there is no legal framework regarding CCS in Turkey. Turkey as an associated EU Member State will adopt and implement CCS Directive in the future, which means that the legal framework regarding CCS will be close to the EU Member States, as well as to Norway and UK.

3. BARRIERS AND RECOMMENDATIONS

Chapter 3 includes the existing barriers for the development and implementation of the CCS technology and recommendations for overcoming them.

Specifically, an overview of cement sector - status and CCUS potential - is provided in Annex I.

3.1. BARRIERS

The installation and operation of infrastructures for carbon capture, transport, and storage of CO₂ in order to reduce CO₂ emissions from power plants and carbon-intensive industries, is of major importance to fulfil the targets for the mitigation of greenhouse gas emissions [70]. Actually, CCS is the only technology considered to be able to directly decarbonise industrial facilities such as cement, petrochemical and steel industries, without requiring a complete rethinking of the industrial sectors [71].

There are several barriers that influence the political decisions in the countries, the process, and the implementation of CCS projects. These include social acceptance issues, the maturity of the CCS technology, CCS storage capacity determination possibilities, CO₂ transportation network, financial aspects of the CCS legal framework implementation and legal gaps.

One of the main barriers in the development and implementation of CCS projects in Europe and worldwide is social acceptance and public support. Public opposition has influenced CCS projects either directly through local action groups, or indirectly by making the political climate for CCS unfavorable. The problem that social science researchers face when they examine public perception of CCS is that in most countries, the public is rather unfamiliar with it [70]. Public reaction to the deployment of these technologies is still uncertain, and opposition may result the cancellations or delays of the projects [72]. The factors that affect social acceptance, as well as measures to mitigate them will be described analytically in the Deliverable 8.1 “Report on social surveys and public engagement scenarios” of WP8 of the current project.

A substantial number of CCS installations established under the existing legal framework is required to evaluate the effectiveness and efficiency of the present regulatory framework in EU and at national level. However, due to the lack of commercial cases for the technology, mainly because of the worldwide economic crisis in 2008 and low carbon pricing in Europe until 3 years ago (below 8 €/tCO₂ in January 2018), the number of CCS installations constructed is much lower than expected. The limited number of CCS projects and the lack of practical experience of implementation of EU and national CCS legal framework lead to the creation of legal uncertainty, difficulty in the determination of legal framework efficiency through evaluation of administrative costs or regulatory burden and also environmental safety issues [73].

So far, European funding has mostly concentrated on capital grants for the construction of CCS infrastructures. However, support is required during the project's operational phase to be financially successful [7].

Even though studies and projects are estimating CO₂ storage capacity per country, a European storage atlas that uses a common methodology for mapping and calculating storage capacity is still lacking [46].

Another important barrier to the enhancement of CCS technology is financial issues. For once, as a new and innovative technology, CCS has a high investment cost. CCS is a multi-stage process including capture, transport, and storage stage, which involve a variety of different technologies, maturity stages and commercial interests. Potential breakthrough technologies are mostly in the capture stage; transportation

technologies are mature and commercial, while storage technologies are generally nearing or already commercial [74].

Besides, the EU and national legislation on CCS set a number of financial requirements for the CCS installations. In addition to the exploration, construction and operating costs, operators must submit a monitoring plan, describing monitoring of the injection facilities, the storage complex and the surrounding environment. After the closure of the storage sites the operator remains responsible for monitoring, reporting and corrective measures in case of leakages until transferring of the storage site to competent authority. The required monitoring period is at least 20 years for most EU Member States. Moreover, financial guarantees are required from operators. All these financial aspects created financial uncertainty to the investors to carry out a CCS project [46]. The legal and economic framework must be guaranteed for long time (20 or 25 years).

Another legal barrier for the CCS enhancement is the unclearness of legal aspects for CO₂ transport. The transportation of CO₂ to storage sites is a critical parameter in the development of CCS technologies. However, the existing EU and national regulatory frameworks on the transportation of CO₂ to storage sites are not harmonized into a single EU legislation. As discussed in chapter 2.1.1, certain aspects of CCS transport are included in several EU legislations and regulations, but they are difficult to be identified and to be examined in a consistent manner.

According to the Review report of the European Commission [73], regarding the environmental risks of CO₂ transport, the Commission considers “that there is no need at this stage for further regulation of CO₂ transport. The risks entailed in the transport of CO₂ are no higher than those of the transport of natural gas or oil and there have been no events or suggestions to warrant any change in current regulations”.

3.2. RECOMMENDATIONS

One of the main targets of European Union is the reduction of greenhouse gas emission by 80% to 95% by 2050, compared to 1990 levels. Until then, the power production industries will have to be nearly carbon-free. The industrial sector will also have to contribute considerably, reducing emissions by more than 80%, compared to 2015 levels [7].

In order to overcome the existing barriers and to succeed the targets the following recommendations are proposed:

- Recommendations towards the increase of social acceptance of the CO₂ technology will be analysed in Deliverable 8.1 “Report on social surveys and public engagement scenarios” of WP8 of the current project.
- One of the most promising driving forces for CCS implementation in this direction is to combine it with the utilization of CO₂ (CCU), as well as Enhanced Oil Recovery-CCS, mineral carbonation options or geothermal-CCS. This is expected to create more trust among Green Non-Governmental Organizations (NGOs) and the general public.
- A European atlas matching all storage sites and capacities is suggested to be created. This should be designed using a common methodology to map and calculate storage potential per European country [46].
- Since the CCS technology is new, innovative and expensive, it is suggested that the number of EU and national financial instruments supporting CCS projects should be increased. Furthermore, European Commission should enhance the Research and Development of CCS projects.

- Rapid deployment of CCS technologies in the capture stage will be achieved through the increase of the commercialization of such technologies. This will enable technology cost reduction. Additionally, it is recommended to focus on more technical goals, such as efficiency improvements and reducing environmental risks.
- Financial support mechanisms should take into account the actual costs. A part of CCUS costs should be covered by country or region funds.
- Regarding the transportation of CCS, it is suggested that a new EU legislation, specified on the transportation of captured CO₂ to storage sites, should be established.
 - This legislation should create the regulatory framework on each of the three different routes for transporting captured CO₂ from industrial emission sites to storage sites: (i) pipelines (ii) ships and (iii) trains or trucks. Considering the huge volumes of CO₂ emitted/captured alone on an industrial scale, the regulation should focus on the transportation through pipelines and ships.
 - Alternatively, references to the specific regulation for the transport of natural gas or oil, also applicable to CCS transport, should be included in the revision of EU “*Directive 2009/31/EC*”.
 - The development of a cross-border European pipeline network for the transportation of captured CO₂ to storage sites, allowing all European countries and industries to connect to this infrastructure. The construction of this cross-border network is suggested to be co-financed by European Commission and Member States. As a result, the private sector will have negligible contribution to the investment of infrastructures.
 - The legislation should clarify trans-boundary transportation issues with pipelines and ships.
- Suggestions for the improvement of Directive 2009/31/EC:
 - For safety reasons specific limits of the physical and chemical properties of the injected fluid should be included.
 - Creation of an open access database with completed and ongoing CCS projects.
 - Mandatory enforcement of CO₂ capture and storage for all new power plants and carbon intensive industries after 2030.
- Development of a certification mechanism (system) for the power plants and carbon intensive industries that have implemented CCS technologies. This certificate will be regarded as added value.
- Development of a European Union Strategic roadmap for the development and deployment of CCS. This roadmap should focus on the vision, goals and actions required to promote the implementation of CCS systems. The roadmap should include short term (5 to 10 years) and long term (10 to 30 years) targets.

4. CONCLUSIONS

Aim of Deliverable 7.1 is to assess the regulatory framework for the implementation of carbon capture, transport, and storage systems of CO₂ and to provide recommendations. With this in mind, the deliverable includes a) legislative and regulatory framework at the EU level, b) legislative and regulatory framework in MOF4AIR participating countries and c) barriers and recommendations.

Initially, the legislative and regulatory framework on the EU level, concerning capture, transport, and storage of CO₂ systems, was investigated and analysed. Until now, a specific EU legislation for the transport of CO₂ to storage sites does not exist. According to the European Commission, Directive 2009/31/EC (CCS Directive) with full the title “Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006 (Text with EEA relevance)”, provides a comprehensive legal framework for capturing, transporting and storing CCS. Furthermore, there are two Directives, on environmental issues, that refers to the transportation of CO₂ by pipelines and one Regulation, on shipments of waste that mentions the shipments of CO₂. The regulatory framework that defines the capture and geological storage of CO₂ in EU is Directive 2009/31/EC of the European Parliament and of the Council, of the 23rd of April 2009. The Directive 2009/31/EC (CCS Directive) established the key legislation for the environmentally safe geological storage of carbon dioxide (CO₂) to contribute to the mitigation of climate change.

Besides, an analysis on the legislative and regulatory conditions in MOF4AIR participating countries (Belgium, France, Greece, Italy, Norway, United Kingdom, and Turkey) was conducted. Special attention was given in the sense of licensing and permitting procedures. In addition, a comparison between the participating countries on the legislative framework was comprised. According to the analysis:

- The legislative framework of CCS in the EU Member States [Belgium (Walloon Region), France, Greece, and Italy] is connected with the transposition of CCS Directive 2009/31/EC, into national laws. This means that Member States ratified the CCS Directive by creating a CCS framework, for their countries, without proceeding in any further legal reforms. As a result, CCS’s legal framework for these States is almost the same. Minor differences exist in some parts.
- Norway has a comprehensive legislation and regulatory framework regarding CCS. Norway as a member of the European Economic Area has a framework that aligns with EU requirements, as a result, addresses the key barrier issues to CCS.

Norway and EU Member States (MOF4AIR participating countries) present many similarities in their CCS legal framework.

The major differences identified between Norway and the EU Member States regulation include a) the existence of a specific legal framework in Norway for the transportation of CO₂ in order to be stored and b) the restrictions in the selection of storage sites only to the Norwegian continental shelf.

- The UK as a former Member State of the EU transposed the CCS Directive into national law. As a result, the CCS framework presents many similarities with those of EU Member States (MOF4AIR participating countries), as well as with Norway.

The most important difference for the UK, in comparison to the EU Member States and Norway, is the absence of a legal framework for the transportation of CO₂ in order to be stored.

- There is no legal framework regarding CCS in Turkey. Turkey as an associated EU Member State will adopt and implement CCS Directive in the future. This means that the legal framework regarding CCS will be close to the EU Member States, as well as to Norway and UK.

Furthermore, the barriers leading to delays of the proposed installations of CCS projects were investigated. Several barriers influence the political decisions in the countries, the process and the implementation of CCS projects. These include social acceptance issues, the maturity of the CCS technology, CCS storage capacity determination possibilities, financial aspects of the CCS legal framework implementation and legal gaps.

Finally, a set of recommendations to enhance CCS technologies were proposed. These include:

- The creation of a European atlas matching all storage sites and capacities.
- The increase of EU and national instruments supporting CCS projects.
- The establishment of a new EU legislation, specified on the transportation of captured CO₂ to storage sites.
- Suggestions for the improvement of Directive 2009/31/EC.
- Development of a certification mechanism (system) for the power plants and carbon intensive industries that have implemented CCS technologies.
- Development of a European Union Strategic roadmap for the development and deployment of CCS.

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ANNEX I

Cement sector: Status and CCUS potential

Cement industry is one of the leading contributors of greenhouse gases after power plant industries [1]. Responsible for 5 to 7% of the global anthropogenic CO₂ emissions, cement manufacturing is expected to grow with industrialization and increased urbanization in all parts of the world. Responsible for 5 to 7% of the global anthropogenic CO₂ emissions, cement manufacturing is expected to grow with industrialization and increased urbanization in all parts of the world [2].

Although the cement manufacturing process has already been optimized with regards to economic and environmental considerations, these improvements being summarized in the Best Available Techniques (BAT) to be used for the production of cement [3, 4], two-thirds of the CO₂ emissions are related to the decarbonation reaction of limestone (CaCO₃, MgCO₃ and FeCO₃) occurring in the clinker manufacturing process leading to the production of lime, while the remaining is mainly due to combustion for providing necessary heat. To this extent, the cement sector must implement CCUS technology. Other mitigation strategies such as alternative resource use, recycling, electrification, and efficiency increases can be used only for reduction of CO₂ coming from fuel combustion.

The primary sources of CO₂ emissions are focused on the production process, and they mostly stem from the fuel combustion connected with the raw material's heating process and subsequent thermal degradation into metal oxides. Emissions are mostly determined by the nature of the raw materials, the fuel used, and the process efficiency. As a result, the cement industry's carbon footprint varies greatly from plant to plant [5].

Different studies are ongoing to reduce CO₂ emissions. In order to regulate the carbon level in the atmosphere, research studies are being carried out on the CO₂ capture, utilization and storage (CCUS). The current technologies are generally very expensive and significant developments are needed to develop a more affordable CCUS.

In the application of carbon capture, use and storage technology, revisions or renewals may be required in the rotary kiln system where clinker is produced to capture CO₂ from the flue gas. In the cement production process, the CO₂ originating from the raw material and the CO₂ originating from the fuel are released from a single source.

It is known that in the post-capture CO₂, valuable chemicals and fuels can be produced with green hydrogen.

After determining the separation systems to be used in cement plants transportation energy requirements largely depend on the choice of the storage site; the average pressure of transportation; the distance between the CO₂ production site and the storage site; and the details of the overall design characteristics of the CO₂ pipeline.

The possible geologic sites for carbon storage are abandoned or mature oil and gas fields, deep aquifers, soda mine salt caverns and possibly coal bed methane sites and natural CO₂ fields [6].

In case of dissemination of technologies emerging from promising projects, government incentives are important in terms of high cost.

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