Analysis of the legislative and regulatory framework of CO_2 capture, transport and storage systems in targeted European countries

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Abstract. The installation and operation of infrastructures for carbon capture, transport and storage of CO_2 to reduce CO_2 emissions from power plants and carbon-intensive industries, is of major importance to fulfil the targets for the mitigation of greenhouse gas emissions. The industrial sector is considered a major contributor to CO_2 emissions. Carbon dioxide Capture and geological Storage (CCS) is currently 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. Although CCS technologies contribute to climate change mitigation, the number of CCS installations constructed in Europe is weaker than expected, among others, due to several aspects of the CCS legal framework implementation and legal gaps. For this purpose, the MOF4AIR European project performed an overall assessment of the legislative and regulatory framework in the EU on the capture, transport and storage systems of CO_2. This paper presents the results of the assessment; an analysis of the legislative and regulatory conditions in MOF4AIR participating countries; a comparison between the examined countries on the legislative framework and a set of recommendations for the improvement of the legal framework.

1. Introduction

Today, tackling climate change is a significant issue. Carbon dioxide (CO_2) 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 CO_2 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 to become climate-neutral by 2050. Intermediate goals include the reduction of greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels [2,3].

CCS is expected to play a critical role in the European Union in meeting emissions reduction goals at the lowest possible cost [4]. CCS includes three steps: capture, transport and storage of CO_2 from electricity production, industries, or other sources [5].

Investing in large-scale CO_2 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. Taking into account that some large-scale CO_2 capture projects are almost ready, a CO_2 transportation network and storage infrastructure would link CO_2 emitters in industrial clusters and power plants to storage sites, allowing the broad decarbonization required to fulfill the net-zero goals [6]. The CO_2 transportation from the CO_2 capture sites to the storage sites will also require the development of a CO_2 pipeline network.

In Europe, a small number of CO_2 transportation and storage projects are in operation. These projects show that CO_2 transportation and storage are crucial technologies in the CCS chain and are mature enough to be deployed at a commercial scale [6].

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 [4]. The best choice is defined by the quantity of CO_2 to be transported, the distance between the CO_2 source and the storage site and also 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 [5].

The enhancement of CCS technology, in order to achieve the ambitious goals of the EU, is one of the main objectives of the MOF4AIR project. MOF4AIR “Metal Organic Frameworks for carbon dioxide Adsorption processes in power production and energy Intensive industRies” is being funded by the European Horizon 2020, Research and Innovation Action (RIA) programme involving 14 organizations from 8 countries (Belgium, France, Greece, Italy, Norway, the United Kingdom, Turkey and Korea). The project duration is 4 years and is coordinated by the University of Mons (UMONS). The project aims to develop and demonstrate the performances of MOF-based CO_2 capture technologies in power plants and energy intensive industries (www.mof4air.eu).

This study presents an analysis of the legislative and regulatory framework in the EU and in the MOF4AIR participating countries. Based on the analysis the barriers for the implementation of CCS projects are identified and a set of recommendations is proposed.

2. European Union regulatory framework

This section examines the legal and regulatory framework for CO_2 transportation in the EU, as well as the legislative and regulatory framework for CO_2 capture and storage.

2.1. EU regulatory framework for CO_2 transport

Three different routes can be considered to transport CO_2 captured from industrial emission sites to storage sites: (i) pipelines (ii) ships and (iii) trains or trucks. However, the only feasible ways are through pipelines and ships, due to the huge volumes of CO_2 emitted/captured.

Until now, specific EU legislation for the transport of CO_2 to storage sites does not exist. Document 52013DC0180 of the European Commission of 27 March 2013 [7], “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] provides a comprehensive legal framework for capturing, transporting and storing CCS.

Furthermore, there are two Directives on environmental issues that mention the transportation of CO_2 by pipelines and one Regulation, on shipments of waste that mentions the shipments of CO_2. The first one 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" [9]. The second one is "Directive 2011/92/EU 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" [10]. The third relative framework is "Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste" [11].

2.2. 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 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]. 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 (CO_2) to contribute to the mitigation of climate change.

This Directive includes the regulatory framework on the following topics:

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

3. The legislative and regulatory framework in MOF4AIR participating countries

This section includes the legislative and regulatory framework for the capture, transport and storage of CO_2 in the MOF4AIR European project participating countries (Belgium, France, Greece, Italy, Norway, the United Kingdom, and Turkey). Furthermore, a comparison between the participating countries on the legislative framework is performed.

3.1. Belgium

In the Walloon Region (Belgium) there is no specific legislation for CO_2 transport, with the constraints being the same as for other gases. Law on the transport of gaseous and other products by pipeline is including in the decree of 11 March 1999 relating to the environmental permit with regard to the protection of the environment for the establishments covered by decree (DRW 1999-03-11 [12]/ 39, art. 175; In force: 01-10-2002, amended with effect from an undetermined date by L 2014-05-08 [13] / 23, art. 23; 27; 28, 035).

The legislative framework of CCS in the Brussels-Capital region is defined by "Arrêté du Gouvernement de la Région de Bruxelles-Capitale du 8 Juin 2017" M.B. (Moniteur Belge) 14.06.2017 [14]. The geological storage of CO2 on the territory of the Brussels-Capital Region is completely prohibited.

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.

The legislative framework of CCS in the Walloon Region (Belgium) is defined by M.B. 03.09.2013 [15] Decree with respect to the EU Directive 2009/31/CE.

3.2. France

There is no specific legislative framework for CO_2 transport in France. However, some aspects are covered by the French Decree n°2011-1411 of 31.10.2011 [16]. The legislative framework of CCS in France is defined by the above-mentioned Decree with respect to the EU Directive 2009/31/CE.

3.3. Greece

Although, there is no specific legislative framework for CO2 transport in Greece, some aspects are covered by the Joint Ministerial Decision 48416/2037/E.103 of 2011 (GG 2516 B') [17]. Furthermore, one Joint Ministerial Decision mentions the transportation of CO_2 by pipelines. This is Joint Ministerial Decision 181478/965 of 26.10.2017 (GG 3763 B') [18] with 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 of 07.11.2011 (GG 2516 B') [17] with respect to the EU Directive 2009/31/EC.

3.4. Italy

In Italy, there is no specific legislative framework for CO2 transport. However, some aspects are covered by Legislative Decree 162 (11G0207) of 14.09.2011 [19]. Furthermore, two Legislative Decrees mention the transportation of CO_2 by pipelines. The first one is Legislative Decree 216 of 04.04.2006 [20] with respect to the EU Directive 2003/87/CE. The second one is Legislative Decree (17G00117)" of 16.06.2017 [21] with respect to the EU Directive 2011/92/CE. The legislative framework of CCS in Italy is defined by the Legislative Decree 162 (11G0207) of 14.09.2011 [19] with respect to the EU Directive 2009/31/CE.

3.5. Norway

The Norwegian government strongly emphasizes the capture and storage of CO_2. 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 CO_2, due to geological reasons [22]. The legislative framework of CO_2 transport in order to be stored in Norway is defined by the Storage Regulation FOR-2014-12-05-1517 of 05.12.2014 [23].

The legislative framework of CCS in Norway is defined by:

1. The Storage Regulation FOR-2014-12-05-1517 of 05.12.2014 [23].
2. Pollution law LOV-1981-03-13-6 of 13.03.198 [24].
3. The Pollution Regulation FOR-2004-06-01-931 of 01.06.2004 [25].
4. The Petroleum Regulation FOR-1997-06-27-653 of 27.06.1997 [26].
5. Safety and work environment for CO_2 transport and storage on the Norwegian continental shelf FOR-2020-02-25-186 of 26.02.2020 [27].

3.6. The United Kingdom

A legislative framework for CO_2 transport in the United Kingdom does not exist. The only reference found is "The Planning (Environmental Impact Assessment) Regulations" (Northern Ireland) 2017 No. 83 [28].

The legislative framework of CCS in the United Kingdom is defined by the "Energy Act 2008 (Chapter 3 Section 17)" [29]. Other regulations that make provisions for the implementation of the EU Directive for CCS are:

1. The Storage of Carbon Dioxide (Licensing etc.) Regulations 2010 No. 2221 [30].
2. The Storage of Carbon Dioxide (Licensing etc.) Regulations (Northern Ireland) 2015 No. 387 [31].
3. The Storage of Carbon Dioxide (Licensing etc.) (Scotland) Amendments Regulations 2011 No. 457 [32].
4. The Storage of Carbon Dioxide (Inspections etc.) Regulations 2012 No. 461 [33].

3.7. Turkey

Currently, there is no legislation regarding CCS in Turkey. Critical developments at national level were encountered in 2021 and 2022. Turkey has ratified the Paris Agreement in 2021 and announced its 2053 net-zero emission target. The first Climate Council with the purpose of developing a roadmap for achieving the 2053 net-zero emission target and developing a basis for the Climate Law assembled in 2022. The Ministry of Environment, Urban Planning and Climate Change has announced 217 decisions made in the Climate Council under the released final declaration. Carbon capture, use and storage was included among other alternative emission reduction methods in the final declaration.

3.8. Comparison of the legislative and regulatory framework in MOF4AIR participating countries

An analysis of the legislative and regulatory conditions for the capture, transport and storage of CO_2 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 1 provides a summary of the legislative and regulatory framework that is in force in the MOF4AIR participating countries.

Table 1. Summary of the legislative and regulatory framework in MOF4AIR participating countries

Legislation/ Regulation	Wallon Region (BE)	FR	GR	IT	NO	UK	TR
Transport of CO_2	Not specific	Not specific	Not specific	Not specific	√[a]	x[b]	x
CCS							
CCS defined in Legislation as per the EU Directive	√	√	√	√	x	x	x
Primary legislation for CCS in place at Country/National Level	√	√	√	√	√	√	x
Secondary Local/Administration specific Legislation	x	x	x	x	x	√	x
Selection of storage sites and exploration permits							
Restrictions (limitations) in place for the selection of storage sites	x	√	√	√	Only on the continental shelf	√	x
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.	x

Permit required for exploration	√	√	√	√	√	√	x
Duration of the exploration permit	x	Defined in the exploitation authorization	Defined in the exploitation authorization	3 years	3 years	x	x
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	x
Storage permits							
Permit required for storage	√	√	Priority: holder of the exploration permit	√	√	√	x
Duration of the storage permit	x	x	25 years	x	Given in the permit	x	x
Typical time for submission and approval	1-1.5 years	Not available	Not available	180 days	Varies from case to case	>6 months	x
Name of the authority /administration responsible for the permit/registration	Walloon Region government	Ministry of Ecological Transition and Solidarity, General Directorate of Energy and Climate	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, Trade and Investment. Scotland: Scottish Ministers	x
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 environmental protection in relation to CCS	√ Environmental permit	√ Environmental permit	√ Environmental permit	√	√	√	x

Note: [a]√ = exist
[b]x = does not exist

After the analysis of the legislative and regulatory framework on capture, transport and storage of CO_2 in MOF4AIR participating countries, a comparison between these countries has been undertaken. According to this comparison:

- 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 with 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 defined 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, addresses the key barrier issues to CCS.
  Norway and the MOF4AIR EU Member States 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 identified between Norway and the MOF4AIR EU Member States:
  - The existence of a specific legal framework for the transportation of CO_2 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 MOF4AIR EU Member States and Norway, is the absence of a legal framework for the transportation of CO_2 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 a CCS Directive in the future, which means that the legal framework regarding CCS will be possibly also inspired from the MOF4AIR EU Member States, as well as from Norway and the UK.

4. Barriers

The installation and operation of infrastructures for carbon capture, transport, and storage of CO_2 in order to reduce CO_2 emissions from power plants and carbon-intensive industries, is of major importance to fulfil the targets for the mitigation of greenhouse gas emissions [34]. Actually, CCS is currently the only technology considered to be able to directly decarbonise industrial facilities at large scale such as cement, petrochemical and steel industries, without requiring a complete rethinking of the industrial sectors [35].

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, CO_2 transportation network, financial aspects of the CCS legal framework implementation and legal gaps.

One of the main barriers to 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 [34]. Public reaction to the deployment of these technologies is still uncertain, and opposition may result in the cancellations or delays of the projects [36].

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 the EU and at the 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 4 years ago (below 8 €/tCO_2 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 in the 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 [37].

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 [4].

Even though studies and projects are estimating CO_2 storage capacity per country, a European storage atlas that uses a common methodology for mapping and calculating storage capacity is still lacking [38].

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-stages process including capture, transport and storage stage, which involve a variety of different technologies, maturity stages and commercial interests. Potential breakthrough technologies mostly focus in the capture stage;

transportation technologies are mature and commercial, while storage technologies are generally nearing or already commercial [39].

Besides, the EU and national legislation on CCS set a number of financial requirements for CCS installations. In addition to the exploration, construction and operating costs, operators must submit a monitoring plan, describing the 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 storage site to the 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 have created financial uncertainty for the investors to carry out a CCS project [38]. The legal and economic framework must be guaranteed for a long time (20 or 25 years).

Another legal barrier to the CCS enhancement is the unclearness of legal aspects for CO_2 transport. The transportation of CO_2 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 CO_2 to storage sites are not harmonised into a single EU legislation. 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 [37], regarding the environmental risks of CO_2 transport, the Commission considers "that there is no need at this stage for further regulation of CO_2 transport. The risks entailed in the transport of CO_2 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".

5. Conclusions and recommendations

The paper aims to assess the regulatory framework for the implementation of carbon capture, transport and storage systems of CO_2 and to provide recommendations.

Initially, the legislative and regulatory framework on the EU level, concerning the capture, transport and storage of CO_2 systems, was investigated and analysed. Until now, specific EU legislation for the transport of CO_2 to storage sites does not exist. According to the European Commission, Directive 2009/31/of the European Parliament and of the Council, of the 23rd of April 2009, provides a comprehensive legal framework for capturing, transporting and storing CCS. Furthermore, there are two Directives, on environmental issues, that refer to the transportation of CO_2 by pipelines and one Regulation, on shipments of waste that mentions the shipments of CO_2. The regulatory framework that defines the capture and geological storage of CO_2 in the EU is Directive 2009/31/EC. The CCS Directive established the key legislation for the environmentally safe geological storage of CO_2 to contribute to the mitigation of climate change.

Besides, an analysis of the legislative and regulatory conditions in MOF4AIR participating countries (Belgium, France, Greece, Italy, Norway, the United Kingdom, and Turkey) was conducted. 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 MOF4AIR EU Member States is almost the same, based on the implementation of the EU Directive 2009/31/EC.
- The CCS legal framework in Norway and in the UK present many similarities in comparison to the one of the MOF4AIR EU Member States.
- Turkey as an associated EU Member State will adopt and implement a CCS Directive in the future, which means that the legal framework will be possibly also inspired from the EU Member States, as well as from Norway and the UK.

Furthermore, the barriers leading to delays in 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.

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

- One of the most promising driving forces for CCS implementation in this direction is to combine it with the utilization of CO_2, as well as Enhanced Oil Recovery-CCS, mineral carbonation options and geothermal-CCS. This is expected to create more trust among Green Non-Governmental Organizations (NGOs) and the general public.
- A European map including all the existing storage sites and their capacities is suggested to be created.
- 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 CCS costs should be covered by national or regional funds.
- Regarding the transportation of CCS, it is suggested that a new EU legislation, specified on the transportation of captured CO_2 to storage sites, should be established.
    - This legislation should create the regulatory framework for each of the three different routes for transporting captured CO_2 from industrial emission sites to storage sites: (i) pipelines (ii) ships and (iii) trains or trucks. Considering the huge volumes of CO_2 emitted/captured alone on an industrial scale, the regulation should focus on 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 CO_2 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 a negligible contribution to the investment of infrastructure.
    - 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 CO_2 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.

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