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Carbon Capture and Storage's Relevance to Achieve Net Zero. An Analysis of CCS EU Law Framework and a Focus on CCS in the Italian National Energy and Climate Plan.

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List of abbreviations

ACCC	Aarhus Convention Compliance Committee
BECCS	Bioenergy with Carbon Capture and Storage
CALLISTO	Carbon Liquefaction Transportation Storage
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Usage
CCUS	Carbon Capture Usage and Storage
CDR	Carbon Dioxide Removals
CEF	Connecting Europe Facility Fund
CO_2	Carbon Dioxide
DACCS	Direct Air Capture with Carbon Storage
EEA	European Economic Area
EGD	European Green Deal
EOR	Enhanced Oil Recovery
ESR	Effort Sharing Regulation
EU	European Union
GHG	Greenhouse Gas
GVA	Gross Value Added
IEA	International Energy Agency
IEG	Information Exchange Group
ILC	International Law Commission
IMO	International Maritime Organisation
IPCC	Intergovernmental Panel on Climate Change
IWG	Implementation Working Group
LC	London Convention
LP	London Protocol
MoU	Memorandum of Understanding
Mtpa	Million tonnes per year
NDC	Nationally Determined Contribution
NECP	National Energy and Climate Plan
NGO	Non-governmental Organisation

NRRP	National Recovery and Resilience Plan
NZIA	Net Zero Industry Act
PCI	Project of Common Interest
SDGs	Sustainable Development Goals
SETIS	SET Plan Information System
SET Plan	Strategic Energy Technology Plan
SME	Small and Medium Enterprise
TFEU	Treaty on the Functioning of the EU
TRL	Technological Readiness Level
UNCLOS	United Nations Convention on the Law of Sea

Introduction

The overarching goal of this thesis is to argue in favour of the need for a more robust and clearer legal framework for Carbon Capture and Storage (CCS), both at the international and EU law levels, to facilitate the successful deployment of CCS projects, particularly transnational ones. The legal and regulatory landscape for CCS is currently marked by significant uncertainties and gaps, which pose barriers to the large-scale implementation of this technology. Specifically, the lack of ratification of the London Protocol by certain countries, including Greece, introduces legal and commercial challenges that could impede the progress of CCS projects like the Prinos CO_2 project operated by Energean in the Greek side of the Mediterranean Sea. Furthermore, a focus on the Italian case and on its National Energy and Climate Plan (NECP) underscoring the importance of this document in defining what should be a clear roadmap to CCS implementation in Italy especially in light of the most recent announcement by Eni and Snam dated September 3, 2024, of the launch of the Phase 1 of the CCS Ravenna Hub, which functioning will be analysed in the conclusive chapter. The thesis is structured in three chapters as described hereunder.

The first chapter provides an in-depth introduction to CCS as a groundbreaking technology for decarbonization. Recognized by the Intergovernmental Panel on Climate Change (IPCC) and receiving renewed attention at the EU level, CCS is seen as a crucial component in achieving significant reductions in greenhouse gas emissions by 2050. This chapter will also provide a broader context by discussing other relevant technologies, such as Direct Air Capture and Storage (DACCS) and Bioenergy with Carbon Capture and Storage (BECCS), to offer a comprehensive view of advancements in CO_2 capture and storage methods. Additionally, the European Green Deal (EGD) and its role as an atypical source of EU environmental law are analysed. Indeed, despite its non-binding nature, the EGD has played a crucial role in catalysing the development of binding regulations, including the recent Net-Zero Industry Act (NZIA), which entered into force on June 29, 2024. The chapter will also discuss the Strategic Energy Technology (SET) Plan, highlighting its role as a “push policy” pillar within the EU’s research and development framework. The SET Plan emphasizes the link between technological innovation and economic competitiveness, underscoring the strategic importance of CCS for EU’s decarbonization.

Then, the second chapter addresses the regulatory challenges associated with CCS, both at the international and EU levels. It identifies key regulatory gaps and the issues stemming from the high level of uncertainty in existing regulations. This chapter will explore the excessive degree of autonomy granted to EU Member States according to the provisions of Directive 31/2009/EC (CCS Directive), which complicates the regulatory environment for CCS. A significant focus of this chapter is the proposal for applying the strict liability principle to CCS operators as a mean to mitigate risks associated with CO_2 leakage during transport and storage. The analysis reveals that a solid international legal framework for state liability in cases of environmental damage caused by lawful activities is currently lacking. While the insurance industry is attempting to remedy to this lack with the most recent insurance CCS products arguably this is not sufficient, to the aim of creating a certain framework of action for operators. The chapter will also examine the supply chain of CCS, with a particular focus on the legal implications of CO_2 transport and storage. This includes a detailed analysis of international treaties such as the Basel Convention, the London Convention and its Protocol, and the United Nations Convention on the Law of the Sea (UNCLOS) and a conclusive analysis of the implications of EU's ratification status of these treaties. It highlights that while the EU has ratified UNCLOS and the Basel Convention, their state-centred nature poses challenges for direct applicability within the EU legal framework. The lack of ratification of the London Protocol by the EU and certain Member States is particularly relevant for transnational CCS projects and constitutes a significant barrier to the implementation of CCS.

Lastly, the third chapter provides a case study of Italy's efforts to relaunch CCS implementation, focusing on the Ravenna CCS project and the broader CCS Mediterranean Plan. This chapter critically assesses Italy's approach following the 2011 Brindisi-Cortemaggiore project, highlighting both progress and ongoing challenges. The lack of accessible information regarding the Brindisi-Cortemaggiore project and the transparency issues related to Italy's National Energy and Climate Plan (NECP) are discussed, including potential violations of the CCS Directive and the Aarhus Convention. The chapter further explores the role of the Ravenna CCS Hub in the CCS Mediterranean Plan, emphasizing its importance in enhancing the competitiveness of the South Mediterranean region. The legal framework established by the London Protocol is scrutinized, noting that while France and Italy have ratified it, Greece has not, noting that this discrepancy poses a potential commercial barrier to the Prinos CO2 project, operated by Energean in the framework of the

Mediterranean CCS Plan and the joint effort to decarbonise the Southern Mediterranean basin.

Chapter I

The Net Zero Target: CO_2 Capture and its Potential to Mitigate Climate Change in Europe

1.1. Capturing CO_2: An Evaluation of the Different Techniques of Climate Engineering Under Deployment

Carbon Capture Usage and Storage (CCUS) indicates a group of technologies used to extract carbon dioxide (CO_2) from large point sources, such as factories or power plants that run on biomass or fossil fuels[1]. In addition to this, it is possible to extract CO_2 directly from the atmosphere. When not needed immediately, the compressed CO_2 is either injected into deep geological formations (such as saline formations or depleted oil and gas reservoirs) to trap the gas for long-term storage, or it is transported by pipeline, ship, rail, or truck for use in a variety of applications. The schematic graphic representation of CCUS here enclosed aims to help in better grasping the technicalities behind its functioning[2].

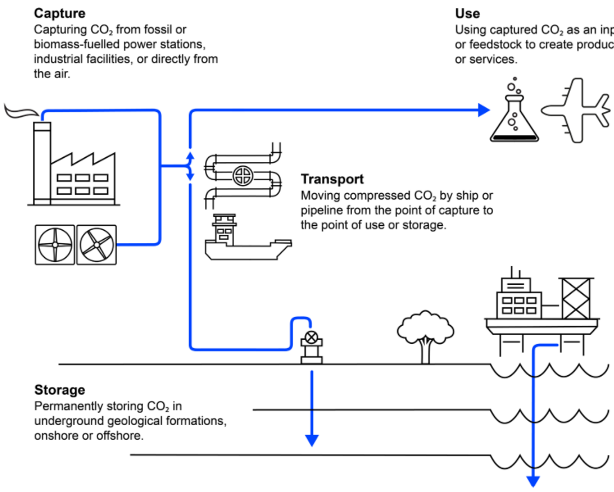

Figure 1: Schematic of CCUS[3].

[1] Extracting CO_2 from factories or power plants running from fossil fuels, makes CCUS a 'clean energy technology'. This term defines those innovations that produce little to no emissions of pollutants and CO_2. Report, International Energy Agency (IEA), 2023, *Energy Technology Perspective 2023.*
[2] Report, International Energy Agency (IEA), 2020, *Energy Technology Perspective 2020. Special Report on Carbon Capture Utilisation and Storage. CCUS in clean energy transition.*
[3] Report, *Energy Technology Perspective 2020. Special Report on Carbon Capture Utilisation and Storage. CCUS in clean energy transition*

The amount of CO_2 that is captured from the point source, as well as whether and how the CO_2 is used, determine how much CO_2 emissions are reduced net. Its technical relevance derives from the fact that, in the so-called 'hard-to-abate industries'[4], Carbon Capture Usage and Storage technologies can offer a way to remove CO_2 from the atmosphere, or 'negative emissions'[5].

Concerning these technologies' relevance to mitigate climate change[6], this has been recognised by the Intergovernmental Panel on Climate Change (IPCC) worryingly acknowledging the undeniable impact of emissions of greenhouse gases (GHG) related to human activities on climate change through global warming. Indeed, human activity has unquestionably caused global warming, with the global surface temperature rising by 1.1°C between 2011 and 2020, primarily due to greenhouse gas emissions. Indeed, alarmingly between 2010 and 2019, there has been a persistent rise in greenhouse gas emissions worldwide. This can be attributed to various factors such as unsustainable energy use, land use and land-use change, and variations in consumption and production patterns across different regions, countries, and individuals. Numerous weather extremes and climate change caused by humans are already being felt in every part of the world. This has resulted in numerous negative effects on the security of food and water, human health, economies, and society, as well as losses and damages[7] to both people and the environment. Disproportionately impacted are vulnerable communities that have traditionally made the least contribution to the current climate change[8]. Furthermore, the IPCC clearly explains the interplay between the increase in GHG emissions related to human activities, their concentrations increase in the atmosphere and the rising global surface temperature. As shown in figure 2 in panel (a), over the past few decades, emissions of CO_2 have rapidly increased, reaching the level of highest concentration in the atmosphere in 2019 with the value of 410 Parts

[4] 'Hard-to-abate industries' are those where it may not be economically or technically possible to achieve zero emissions. Those include petrochemicals, steel, and cement. Since carbon is used in every one of their operations, this industry as a whole is responsible for around 30% of global greenhouse gas emissions. Report, Anne-Laure de Chammard (Siemens Energy), 10 November 2022, *The road to a sustainable industrial revolution.*

[5] Report, *Energy Technology Perspective 2020. Special Report on Carbon Capture Utilisation and Storage. CCUS in clean energy transition.*

[6] Climate change mitigation is defined as reducing the flow of heat-trapping greenhouse gases into the atmosphere. It aims to stabilise greenhouse gas levels in a timeframe sufficient to allow ecosystems to adapt naturally to climate change. Report, Intergovernmental Panel on Climate Change (IPCC), 2014, *IPCC 2014 Report. Summary for Policymakers.*

[7] 'Losses and damages' refer to adverse observed impacts and/or projected risks and can be economic and/or non-economic. Report, Intergovernmental Panel on Climate Change (IPCC), 2023, *AR6 Synthesis Report. Climate Change 2023.*

[8] Report, *AR6 Synthesis Report. Climate Change 2023.*

per million (ppm) depicted in panel (b). Consequently, panel (c) shows an increase of the temperature of the earth's surface of about 1.1°C compared to the baseline scenario of the period 1850-1900. Therefore, the best estimate following these figures is that human activity is the cause of the warming seen between 1850 and 1900 and 2010 and 2019 (panel (d))[9].

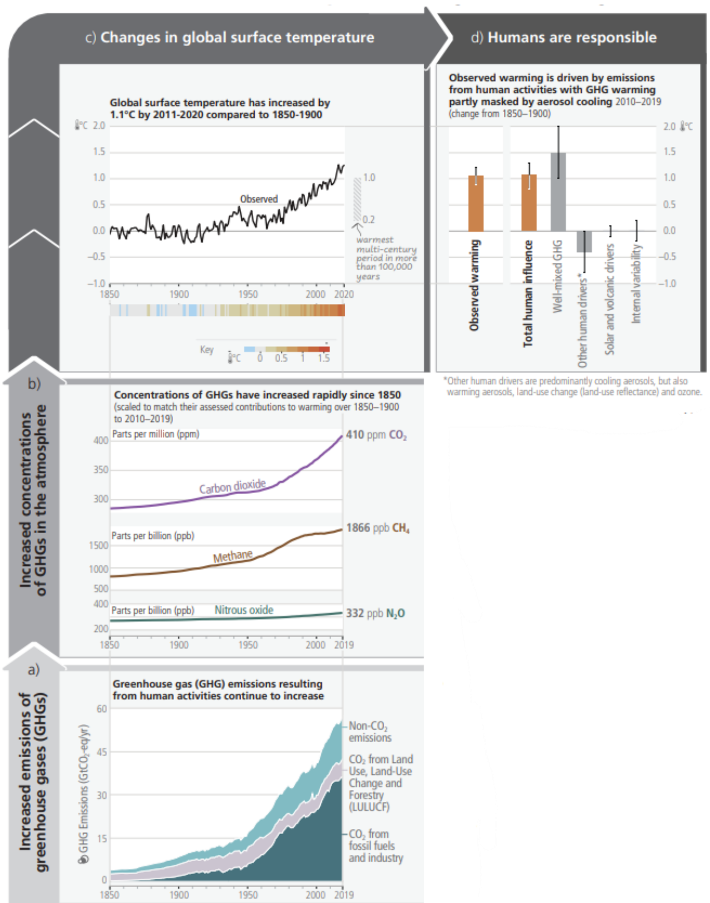

Figure 2: The causal chain from emissions to resulting warming of the climate system[10].

Considering the above, it is crucial to stress that the IPCC already in 2014 considered CCUS technologies as an essential tool for climate change mitigation. Indeed, it estimated the opportunity cost of not implementing CCUS as leading to an increase of the 138% in the total discount mitigation costs for

[9] Ibid.
[10] Ibid. p. 43.

the period 2015-2100[11]. Therefore, the analysis of the IPCC and of the International Energy Agency (IEA) support the implementation at a rapid pace of CCUS technologies to mitigate the adverse consequences of climate change, being these technologies an instrument to counteract the negative consequences of human activities in terms of CO_2 emissions, especially considering industrial plants or power plants relying on fossil fuels. This status of art seems to be currently relaunched as always more compelling for the international community by the European Commission. CCUS technologies are described as crucial climate engineering means to meet the most recent target envisaged in the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions, 6 February 2024, 2024/63/EU, *Securing our future. Europe's 2040 climate target and path to climate neutrality by 2050 building a sustainable, just and prosperous society.* Indeed, this document presents the so-called '2040 target', which is a 90% net GHG emissions reduction compared to 1990 levels[12]. The need to drastically abate CO_2 emissions through CCUS technologies comes from the diffuse fear within the international community that it could be already too late to achieve what is envisaged in the Paris Agreement[13]. Indeed, to keep the increase in global average temperature to no more than 1.5°C, with reference to the pre-industrial levels' emissions, current emissions need to be reduced by 45% by 2030 and reach Net Zero by 2050, meaning that global greenhouse gas emissions from human activity are in balance with emissions reductions. At Net Zero, CO_2 emissions are still generated, but an equal amount of CO_2 is removed from the atmosphere as is released into it, resulting in zero increase in net emissions[14].

Currently, the main CCUS limitation is the need of significantly higher investments in R&D so to proceed to its large-scale implementation in the short term. However, 2023 has seen a growing momentum for collective global action on Carbon Capture and Storage (CCS), the most developed CCUS technology according to the Global CCS Institute. Indeed, 2023 has been the year with the highest annual growth rate in capture capacity of CCS projects in construction and development, with an increase of the 57% compared to 2022.

[11] Report, *IPCC 2014 Report. Summary for Policymakers.*
[12] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions, 6 February 2024, 2024/63/EU, *Securing our future. Europe's 2040 climate target and path to climate neutrality by 2050 building a sustainable, just and prosperous society.* This document will be detailly analised in Chapter II (*infra* pp. 52-57).
[13] Conference of the Parties, Adoption of the Paris Agreement, 12 December 2015, UN Doc. FCCC/CP/2015/L.9/Rev/1 (12 December 2015).
[14] SMITH (2023: 68-71).

As of the 31st of July 2023, 312 Mtpa[15] of CO_2 were captured in CCS projects, compared to the 199 Mtpa of CO_2 captured in 2022, as shown below in figure 3[16].

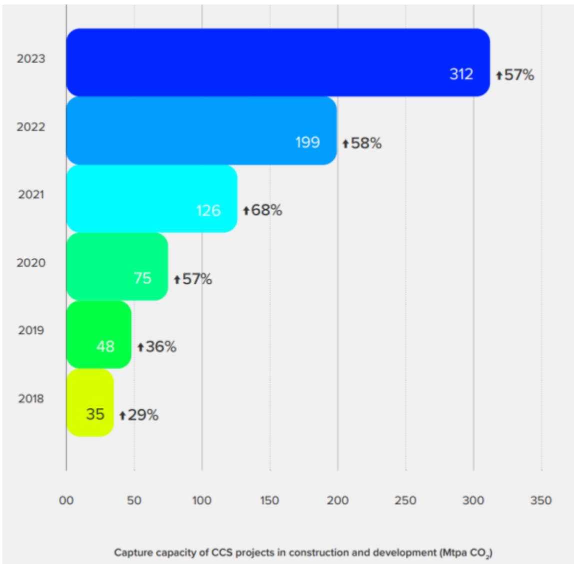

Figure 3: Year-on-year growth in capture capacity of CCS projects in construction and development (excludes capacity in operation)[17].

Despite these significative advancements, considering the goal of having no CO_2 emissions by 2050, 10 billion tonnes of CO_2 must be captured, which would necessitate the construction of about 2000 carbon capture plants[18]. In virtue of the status of the art of CCS implementation depicted above, the first chapter of this thesis will describe the technical functioning and feasibility of the main CCUS technologies. Then, it will analyse the commitments undertaken by the European Union (EU) to achieve Net Zero and climate neutrality; together with the efforts made through investments in strategic technologies, including CCS and carbon dioxide removals technologies (CDR technologies).

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[15] Mtpa stands for Million tonnes per year of CO_2 captured in CCS projects.
[16] Report, Global CCS Institute, 2023, *Global Status of CCS 2023 Scaling up through 2030*.
[17] Report, *Global Status of CCS 2023 Scaling up through 2030.*
[18] ANIKA ET AL. (2022).

1.1.1. Carbon Capture and Storage (CCS)

CCS is characterised of four components: i) the integration of CO_2 capture, ii) the CO_2 compression from a gas to a liquid or denser gas, iii) the pressurised CO_2 transportation from the point of capture to the storage location, and iv) storage-based isolation from the atmosphere. All of these can be accomplished with existing technologies, but presently, the implementation of CCS is difficult due to high capture costs, a lack of large-scale demonstrations of CCS integration with electricity production or industrial processes, and the need for greater assurance that storage can remain safe and efficient for at least a millennium[19].

As seen, CO_2 storage is preceded by the capture phase, in which the carbon dioxide is captured directly from the flues of large industrial plants and separated from the other gases with which it is mixed. Once captured, the CO_2 is compressed so that it can be transported more easily, usually through pipelines or by sea or land. At this point, concentrated CO_2 free of impurities is obtained and it can be reused as raw material in other production processes or stored deep underground. In the first case the technology is denominated Carbon Capture and Usage (CCU), and in the second CCS[20]. In the latter CO_2 is injected into deep geological formations such as depleted hydrocarbon deposits or saline aquifers, selected based on rigorous geological and technical investigations. The reuse of depleted reservoirs is particularly advantageous because it makes it possible to use geological formations that are well known and thus to predict with high accuracy the diffusion of carbon dioxide within the structures. In addition, the reuse of part of the existing infrastructure allows for quick and competitive projects, applying the principles of the circular economy to decarbonisation[21].

Furthermore, up to date there are three technology families for CO_2 capture namely i) post-combustion, ii) pre-combustion and iii) oxyfuel. Except for the polymer membrane[22], which is a technology validated in the laboratory, all methodologies have an intermediate/high level of technological development (TRL)[23]. Relevantly the average capture efficiency demonstrated is around 90-

[19] BENSON (2012 : 1004-1005).
[20] Online web page, ENI, *Cos'è la CCS*, available online.
[21] BANKES (2020: 400-403).
[22] A detailed analysis of membrane separation technology in carbon capture is provided by Guozhao Ji and Ming Zhao. JI AND ZHAO (2016: 59-90).
[23] Technology maturity during a program's acquisition phase can be estimated using technology readiness levels, or TRLs. TRLs make it possible to have uniform and consistent conversations

98% and CCS achieves a TRL of 9 in three out of four CCS technologies in the family of pre combustion[24]. Significantly, using CCS on an individual facility can reduce approximately 65–85% of CO_2 emissions from fossil fuels when considering full life cycle emissions. The trade-offs between the amount of emission reduction and the cost of capture and age of the facility on which it is deployed will ultimately determine the ideal degree of emission reduction[25].

Therefore, the figures described above confirm that CCS is essential to meet Net Zero climate targets. Remarkably, according to the IEA, it will be nearly impossible to achieve Net Zero goals without CCS[26]. Moreover, CCS' implementation in the EU would furnish not only a mean to face global warming, but also a window of economic opportunities. For example, in the UK it has been shown that deploying CCS in the industry and the power sector can significantly increase Gross Value Added (GVA) economic productivity compared against moving production offshore and not deploying CCS. Under all scenarios the expansion of renewable energy sources and the decrease of coal- and gas-fired power result in significant reductions in power emissions in 2025 and 2030[27]. In this regard, economic benefits of implementing CCS have been stressed by the Global CCS Institute, which demonstrated a positive correlation between the $GtCO_2$ stored and the cost savings of the whole economic system, expressed in US$ trillions. Considering a temporal horizon extending until 2065, the continue process of deploying this technology and increasing the amount of CO_2 captured until reaching 700 $GtCO_2$ will lead to save almost 200 US$ trillions in 2065[28].

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about technical maturity across various technology categories. A technology readiness assessment (TRA) that looks at programme concepts, technology requirements, and proven technology capabilities determines TRL. TRLs are derived from a scale of 1 to 9, where 9 represents the most advanced technology. HÉDER (2017: 4-6).

[24] Report, The European House Ambrosetti, 2023, *Zero Carbon Technology Roadmap. Carbon Capture & Storage: a strategic lever for decarbonisation and competitiveness of Italy.*

[25] BENSON (2012: 997).

[26] Report, *Energy Technology Perspective 2020. Special Report on Carbon Capture Utilisation and Storage. CCUS in clean energy transition.*

[27] GANZER & MAC DOWELL (2022: 5-6).

[28] Further information can be retrieved consulting the Global Economic Net Zero Optimisation Model (GENZO)'s 2023 report. GENZO considers 23 regions and provides a detailed representation of the global energy system with a full suite of zero and low-carbon technology options, such as Direct Air Capture with Carbon Storage (DACCS) and Bioenergy Carbon Capture and Storage (BECCS). Report, *Global Status of CCS 2023 Scaling up through 2030.*

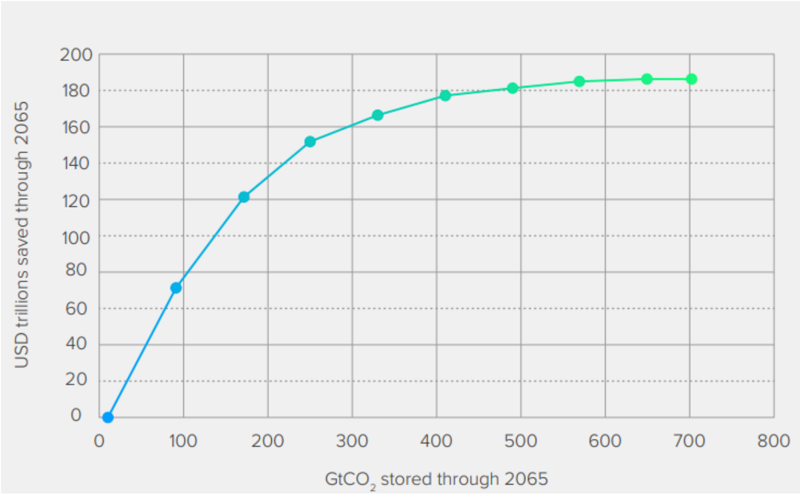

Figure 4: Total undiscounted energy system cost savings with cumulative GtCO2 stored through 2065[29].

In particular, the captured $GtCO_2$ considered in figure 3 includes a variety of capturing technologies, such as Direct Air Capture with Carbon Storage (DACCS) which appears to be the most profitable carbon capture technology to be deployed in the medium run, with the lowest startup costs. According to economic modelling by the Global CCS Institute, the deployment of DACCS could begin as early as 2043 with low-cost assumptions, such as US$ 137 per tonne of CO_2[30]. DACCS, which is a negative emission technology, is particularly relevant because it represents the only way to capture dispersed emissions, like those from transportation. Achieving Net Zero CO_2 emissions by 2050 will necessitate the use of DACCS technologies in addition to emission capture from point sources[31]. Therefore, the lower the cost of implementation of DACCS and CCS projects in general, the more rapid its deployment will be, resulting in lower CO_2 prices and reducing the overall cost of the transition to Net Zero[32].

[29] Report, *Global Status of CCS 2023 Scaling up through 2030.*
[30] WILLIAMS (2023).
[31] DACCS was first proposed in 1999 to lessen the consequences of rising CO_2 emissions. The technology is dependent on the use of chemisorbing materials for CO_2 capture because DACCS processes must function at very low CO_2 concentration levels. BUCKINGHAM ET AL (2022: 2)
[32] Ibid.

1.1.2. Direct Air Carbon Capture and Storage (DACCS)

Using chemical sponges, called sorbents, DACCS remove carbon dioxide directly from the air. When it comes to offshore geological storage, carbon dioxide is compressed and injected underground for storage. It can be stored as a liquid in saline aquifers found in sedimentary basins, or as a supercritical state in reactive mineral reservoirs, where it turns into carbonate rock, which geologists predict will be stored for tens of thousands of years. DACCS is not the same as CCS, which stores CO_2 emissions from point sources that are released during the processing of oil and gas or from other industrial sources of abiotic carbon[33] .

Indeed, the fundamental idea behind DACCS is that, even though CO_2 is not highly concentrated in the atmosphere it is still feasible to remove a sizable amount of it annually by exposing vast amounts of air to substances called sorbents. The sorbents function primarily through two processes. The first is called absorption, in which the sorbent material dissolves the CO_2. The second is adsorption, in which CO_2 molecules stick to the sorbent material's surface. Both times, the sorbents are processed to release the CO_2 so that it can be stored in geological repositories or used to make other chemicals and fuels based on carbon[34].

Since it is more difficult to capture CO_2 from ambient air, where it is between 100 and 300 times more diffuse than when concentrated in the flue gases of power plants burning coal and gas, DACCS is more energy and material intensive than conventional CCS processes. This implies that, in comparison to the areas or volumes of sorbents in contact with flue gases, DACCS plants must have a substantially larger surface area of CO_2-absorbing chemicals in contact with ambient air. As a result, for every tonne of ambient CO_2 removed, DACCS uses roughly three times as much energy as CCS[35].

However, there are some clear advantages that DACCS has over conventional CCS, which may help with the technology's large-scale deployment. For instance, DACCS plants offer suitable CO_2 storage, low-carbon energy inputs, the ability to be installed anywhere, and/or transportation services to suitable storage locations are offered. Unlike conventional CCS, they do not require colocation with fossil fuel power generation plants or industrial manufacturing plants; in fact, they may be based offshore.

[33] NAWAZ AND SATTERFIELD (2024: 2).
[34] GAMBHIR AND TAVONI (2019: 1-5).
[35] Ibid.

This means that, in theory, DACCS can capture the CO_2 emissions from widely dispersed sources, which together account for approximately 35% of global man-made CO_2 emissions, unable to be captured by CCS. These sources include transportation, buildings, and land use for forestry and agriculture[36].

1.1.3. Bioenergy with Carbon Capture and Storage (BECCS)

Several different carbon capture technologies are included under the umbrella term BECCS. The most widely used system involves capturing carbon dioxide emissions from burning biomass to produce electricity and heat. A different method collects carbon dioxide from fermentation processes, like those that make ethanol from crops like sugarcane, wheat, or maize. The benefit of this is that it produces a simpler-to-process stream of carbon dioxide that is purer. As with conventional CCS projects, the captured carbon dioxide can then be transported to geological storage locations like saline aquifers or abandoned oil wells. Alternatively, some of the carbon can be produced as biochar (solid carbon), depending on the feedstock and process parameters. There are many applications for biochar, most of which are connected to enhancing soil quality and raising agricultural productivity[37].

Remarkably, in its Fourth Assessment Report published in 2007, the IPCC for the first time mentioned BECCS as a possible means of stabilising greenhouse gas emissions or as a quick fix to prevent abrupt climate change. However, the IPCC stressed the lack of in-depth research done on large-scale biomass conversion with CO_2 capture and storage up until now. Indeed, it underlined the need for further research to fully understand the opportunity costs and long-term mitigation potential of biomass[38].

However, the attention towards BECCS continued to rise in the 2018 special report on Global Warming of 1.5°C (SR1.5)[39] and in the 2019 special report

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[36] Ibid.

[37] BRACK AND KING (2020: 3).

[38] Report, Intergovernmental Panel on Climate Change (IPCC), 2007, *Climate Change 2007: Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.*

[39] Report, Intergovernmental Panel on Climate Change (IPCC), 2018, *Global Warming of 1.5°C.* This IPCC publication is a Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.

on Climate Change and Land (SRCCL)[40]. Indeed, both contain critical assessments of the viability, costs, and benefits of extensive use of BECCS in meeting 1.5–2°C warming limitation targets. Contributions from different CDR methods, primarily BECCS and afforestation and reforestation, are included in all the four pathways sticking to limit global warming to 1.5°C, envisaged in the aforementioned reports:

• P1 (concentrate on lowering energy demand): BECCS makes no contribution.

• P2 (broad focus on sustainability): cumulative 151 $GtCO_2$ captured by BECCS to 2100.

• P3 (middle-of-the-road scenario, largely following historical patterns): cumulative 414 $GtCO_2$ captured by BECCS to 2100.

• P4 (resource- and energy-intensive overshoot scenario in which emissions reductions are mainly achieved through BECCS): cumulative 1.191 $GtCO_2$ captured by BECCS to 2100.

In all of these 1.5°C scenarios, generation of negative emissions must start in the first half of the century. In the most obstinate case (P4), 7.2 million km^2 of land would be needed for bioenergy crops for BECCS, and it would be more than twice the size of India or roughly half of the total area of croplands on Earth today[41]. Therefore, the highly ambitious European goal of reaching Net Zero emissions by 2050 necessitates quick action to cut greenhouse gas emissions and mitigate leftover ones. Although the geological storage resources of CO_2 in Europe are more than adequate to meet the requirements of CCS under Net Zero emission scenarios, the creation of CO_2 transport networks throughout Europe continues to be a technical, social, political, and financial challenge. The BECCS potential could reduce, through carbon dioxide removal technologies, greenhouse gas emissions in Europe by 5% (or 200 million tonnes CO_2 annually)[42].

To conclude, technologies such as DACCS, BECCS and CCS should be seen as a complementary set of instruments to reduce CO_2 emissions at a faster

[40] Report, Intergovernmental Panel on Climate Change (IPCC) (2019), *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.*
[41] BRACK AND KING (2020: 7).
[42] ROSA ET AL. (2021: 3094).

pace to ease the process of carbon dioxide emissions' reduction in the so-called hard-to-abate industries and to comply and so to comply with what is envisaged in the Paris Agreement. Considering the analysis presented, it is reasonable to auspicate further investments and a clear regulatory framework for these technologies, as supported by key international actors such as the IPCC and the IEA. Therefore, the next sections of this chapter will analyse the efforts made by the EU not only to tackle climate change but also to reach Net Zero investing in strategic technologies of CO_2 capture, and primarily in CCS.

1.2. The European Commitment to Become the First Climate Neutral Continent by 2050

1.2.1. The European Green Deal: Communication 2019/640

When in late 2019 the Commission presided over Ursula von der Leyen took office her political priorities clearly voiced the need for a stronger action to tackle climate change, not only by achieving the 2030 target posed by the Paris Agreement but also in a long-term view aiming at creating a roadmap for a decarbonized Europe in 2050. She committed to strive for more to make Europe the first climate-neutral continent, by presenting a European Green Deal in her first 100 days of office and by enshrining into law the 2050 climate-neutrality target[43]. The international legal obligation to comply with the Paris Agreement, with the United Nations's 2030 Agenda and the Sustainable Development Goals and more widely with obligations deriving from binding legal sources of international environmental law, is the focal point of the multi-level governance in EU Climate Law. Furthermore, the EU in such a complex domain cannot be seen as a unitary actor because according to art. 4 TFEU environment and energy both constitute shared competences[44].

In this context, the European Green Deal (EGD) can be seen as an attempt to provide a clear definition of sustainable development in secondary EU law legislation[45]. Over the past few decades, environmental law in the EU has developed from a technical policy specific to a guiding element of the EU's political and legal framework founded on the ideas of sustainable development and integration, combined with the idea of strong environmental protection ingrained in EU treaties[46]. The EGD is intended to be an integral part of the

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[43] Report, Ursula von der Leyen, 2019, *Political Guidelines for the European Commission 2019-2024. A Union that Strives for More.*
[44] WOERDMAN ET AL. (2021: 238-243).
[45] JENDROŚKA ET AL. (2021: 93-94).
[46] SIKORA (2020: 685).

strategy to implement the United Nations 2030 Agenda and the Sustainable Development Goals (SDGs), as the European Commission states explicitly in its communication about the Green Deal, with the goal of placing SDGs at the heart of the EU's policymaking and action[47].

Despite the ambitious goals set, the EGD remains a soft law instrument, posing faith in its implementation through the principle of sincere cooperation between the EU and the Member States[48]. Nevertheless, the soft law character of the EGD did not hamper its authoritative nature which led to the establishment of binding targets for Member States. Within the last five years, it can be argued that the EGD boosted the establishment of a binding regulatory framework currently in place, which is setting targets at the EU and at the national level not only for reaching Net-Zero but also for the development of strategic technologies aimed at capturing CO_2 emissions, such as CCS. Indeed, in the following chapters the Net Zero Industry Act (NZIA) will be presented as a milestone in setting the most ambitious target of CO_2 storage for the EU. It is of utmost importance to stress that the NZIA being a regulation directly binds Member States and it is automatically into force in their national legal frameworks, since the 29th of June 2024[49]. This exemplifies how soft law instruments pertaining to the field of environmental law have a high degree of authoritativeness and can effectively influence the establishing of binding targets.

In addition to this, traditional sources of EU environmental law should be considered when evaluating the EGD as a response to climate change and a tool for change within the Union. Indeed, the EGD differentiates itself both from the environmental action programmes and from the environmental principles in the meaning of art. 191.2 TFEU, with particular reference to the precautionary principle[50]. Firstly, environmental action programmes which have been the cornerstone of the EU's environmental policy since its inception, have a specific role and legal standing[51]. On the one hand, the general action programmes are adopted through the regular legislative procedure in

[47] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions, 11 December 2019, 2019/640/EU, *The European Green Deal.*
[48] SIKORA (2020: 688).
[49] See chapter II and III (*infra* pp. 57-59; pp. 71-72).
[50] Art. 191.2 TFEU clearly mentions the precautionary principle aimed at protecting the environment and human health, preserving scarce natural resources. Furthermore, the principle of international cooperation to the aim of mitigate and combating climate change is there envisaged.
[51] SIKORA (2020: 688).

accordance with art. 192.3 TFEU, and consequently they are legally binding[52]. On the other hand, the above-mentioned environmental principles seem to have a more uncertain impact on the EU acquis, but their relevance is well recognised on multi-dimensional environmental problems, especially when the precautionary principle is at stake involving prevention, climate change's mitigation measures and the so-called polluter-pays principle[53].

The EGD can be considered as an atypical source of EU environmental law, because it is neither an environmental action programme nor does it involve environmental principles. Only the concept of sustainability has garnered significant attention, primarily due to its potential economic benefits. This shows a critical dissonance between the EGD as an ambitious policy measure and the legacy and applicability of EU environmental law for the purposes of its implementation[54]. However, it has been argued that the EGD has importantly affected EU's industrial policy. By introducing the no-harm to the environment principle, the EGD is much more than just adjusting to shifting societal demands. Accordingly, it would not be possible to adopt new environmental legislation going beyond the sustainability rationale, for example legislation asserting that the EU should avoid doing any harm to the environment when acting in fields such as mobility and CO_2 emission performance standards for industrial plants or for products' production[55]. In this regard, the EGD mentions CCS in two crucial occasions. Firstly, it is considered as a strategic technology which deployment at a large scale should be fostered through a renovated framework of smart infrastructures. Secondly, the EGD calls for an improved access to critical raw materials as strategic tools to avoid interdependencies. Furthermore, the EGD calls for 'climate and resource frontrunners' able to develop the first commercially viable applications of breakthrough technologies, classifying CCS in this category, in key industrial sectors, with a focus on the so-called hard-to-abate industries[56].

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[52] The Parliament and Council adopt the general action programmes outlining the priority goals to be achieved in accordance with art. 192.3 TFEU. Following that, actions required to carry out the environmental action plan must be taken based on either art. 192.1 TFEU and art. 192.2 TFEU or on a distinct pertinent legal foundation found in the TFEU. Specifically, since environmental factors are transversal, actions pertaining to environmental policy might be included in other policies.
[53] DE SADELEER (2020).
[54] SIKORA (2020: 689).
[55] CHITI (2022: 36).
[56] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions, *The European Green Deal*, pp. 6-8.

Concerning CCS as a technology to be fostered by strategic infrastructure, the EGD acknowledges the important role that it could play in facilitating the production of low-carbon hydrogen[57] for use across the energy system, so to facilitate decarbonisation[58]. Indeed, to fulfil the goals of the EGD, modernising Europe's cross-border energy infrastructure is supported by the TEN-E Regulation[59]. Europe needs to upgrade its infrastructure to accommodate new technologies if it is to move towards a clean energy economy that is climate neutral. Through projects of common interest (PCIs)[60], which must help the EU meet its 2030 emission reduction targets and achieve climate neutrality by 2050, the TEN-E policy facilitates this transition.

Indeed, in May 2022, the TEN-E Regulation was revised to conform to the EU's 2050 climate neutrality goals. Three key thematic areas are included in the revision: cross-border CO_2 networks, smart gas, and electricity grids. Remarkably, the infrastructure for transporting and storing CO_2 between EU members and neighbouring third-country states is included in the CO_2 networks area. Pipelines, CO_2 storage facilities connected to cross-border CO_2 transport (which was not included before the update), and fixed facilities for buffer storage and liquefaction connected to additional transportation are examples of eligible infrastructure that could become PCIs and fostering decarbonization through CCS deployment and low-carbon hydrogen production[61]. Furthermore, the final TEN-E Regulation permits the PCI status for CO_2 surface and injection facilities connected to infrastructure inside a geological formation that is employed to store carbon dioxide permanently. Since surface and injection facilities are the primary elements required for storage (the geological formation already exists as an exhausted oil or gas field or a salt cavern), their inclusion implies that EU funding could cover a significant portion

[57] Low-carbon hydrogen is defined as hydrogen the energy content of which is derived from non-renewable sources, which meets a greenhouse gas emission reduction threshold of 70% irrespective of whether it is produced within the EU or imported. Proposal for a Directive of the European Parliament and of the Council, 15 December 2021, COM/2021/83, *on common rules for the internal markets in renewable and natural gases and in hydrogen.*

[58] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions, *The European Green Deal*, p. 6.

[59] Regulation of the European Parliament and of the Council, 30 May 2022, 2022/869/EU, *on guidelines for trans-European energy infrastructure.*

[60] The European Commission defines projects of common interest (PCIs) as key cross border infrastructure projects that link the energy systems of EU countries. They are intended to help the EU achieve its energy policy and climate objectives: affordable, secure, and sustainable energy for all citizens, and the long-term decarbonisation of the economy in accordance with the Paris Agreement. Proposal for a Directive of the European Parliament and of the Council, *on common rules for the internal markets in renewable and natural gases and in hydrogen.*

[61] Report, International Energy Agency (IEA), 2022, *TEN-E (Trans-European Networks for Energy): CCUS.*

of the cost of CCS. Lastly, the regulatory treatment of onshore and offshore cross-border CO_2 transportation was also covered by the Final TEN-E Regulation; even if it's still unclear if pipelines used to avoid CO_2 onshore storage would be granted PCI status and the related fundings. Indeed, having this warrantee could be crucial to assure the large-scale deployment of CCS, having it the necessary facilities for CO_2 storage, and so its consequent increased contribution to decarbonising the energy mix through low-carbon hydrogen production[62].

To conclude this section, it is important to stress how through the last five years the nature of the EGD has evolved ranging from being firstly a soft law instrument although ambitious, to then acquiring an influential and authoritative character contributing to setting the most ambitious EU and national law binding targets pertaining decarbonization through strategic technologies.

1.3. Decarbonising the EU through Investments in Strategic Technologies

1.3.1. The European Strategic Energy Technology Plan (SET Plan)

In order to accelerate clean energy technology research and innovation (R&I) towards Net Zero emissions, efficient public spending of limited resources is crucial. By concentrating resources on a few promising low-carbon technologies, the EU's Strategic Energy Technology Plan (SET Plan), which was adopted in 2008, sought to increase and integrate disparate and fragmented R&I funding programmes at different levels. Concerning the governance of the SET Plan, the 14 Implementation Working Groups (IWGs), the Bureau of the SET Plan Steering Group, and the Steering Group comprise it. The SET Plan's decision-making body is the Steering Group. It is made up of delegates from the EU Member States, Iceland, Norway, and Turkey, as well as other SET Plan nations. The Bureau prepares internal meetings and discussions to support its operations. The scientific data required for decision-making is provided by the SET Plan Information System (SETIS), which supports the SET Plan's operations. The 14 working groups monitors the SET Plan targets, and the R&I initiatives being carried out at the national and European levels, and they report to SETIS on their progress. The implementation plans of the working groups identify the activities and targets in collaboration with national governments and industry and research bodies. Lastly, the working groups are comprised of national and regional authorities responsible for research,

[62] Report, The Oxford Institute for Energy Studies, 2022, *The TEN-E Regulation: allowing a role for decarbonised gas.*

education, energy, innovation, and climate action, along with representatives from industry, research institutes, and non-governmental organisations (NGOs)[63].

The SET Plan provided a supplementary technology 'push' pillar aimed at accelerating innovation through the development and demonstration of technology. By lowering the costs and risks for private investors, 'push' policies aim to increase the impact of their investments, which make up over 70% of clean energy research and development spending in Europe[64]. Interestingly, already at its launch time in 2008, proving CCS viability and fostering its development was a key priority of the SET Plan. The aim was to prove the viability of zero-emission fossil-fuel power plants at industrial scale. Therefore, the SET Plan accorded highest priority to promoting low-carbon electricity generation technologies[65]. In this sense, the SET Plan served as a mirror to inspire efforts conducted by the international community at a larger scale within the framework of the Paris Agreement. Indeed, at the margin of COP 21 in Paris on the 30th of November 2015 the leaders of 24 countries and the EU, representing about 80% of global public spending in clean energy R&I, launched 'Mission Initiative' a global collaboration aimed at accelerating the clean energy revolution. It focuses on reinvigorating and accelerating public and private global clean energy innovation with the objective to make clean energy widely affordable as an indispensable part of an effective, long-term global response to shared climate challenge[66]. Mission Innovation's objectives echoed the goals of the SET Plan, which were to reduce costs by accelerating clean energy innovation. More in detail the objectives envisaged by 2021 were: i) to raise the amount spent on clean energy research and development, ii) to promote investment from the private sector, and iii) to include early-stage and technology demonstration projects[67]. In particular, Mission Innovation's Action Plan for the Net Zero Industries showcases the technologies that are needed to decarbonise the hard-to-abate industries, giving relevance to CCS stressing the importance of capturing CO_2 as an essential mitigation instrument. However, industry's current investments levels are not keeping up with their needed rate to meet the 2030, let alone 2050, global emissions'

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[63] Report, SETIS-SET Plan Information System, *Implementing the actions (Governance),* available online.
[64] SKJÆRSETH AND EIKELAND (2023: 259-262).
[65] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions, 22 November 2007, 2007/723/EC, *A European Strategic Energy Technology Plan (SET-PLAN).'Towards a low carbon future'.*
[66] MISSION INNOVATION (2020).
[67] SKJÆRSETH AND EIKELAND (2023: 267).

reduction targets. Posing the goal of making a positive change in the industry understanding of CCS in time for 2030; quick and relevant action is needed. Consequently, the Action Plan delivers a roadmap to achieve this target entailing a multi-level and collaborative approach to R&I between industries and Member States to foster low-carbon technologies such as CCS, so following the strategy delineated in the 2008 SET Plan and revised in the 2015 Integrated SET Plan[68].

Despite the SET Plan being a model of international cooperation based on fostering R&I through a mixture of private and public fundings, its failure to provide successful results in terms of CCS implementation has been widely acknowledged. In this regard, the multi-level governance of EU climate law and energy law has effectively hampered CCS' large-scale deployment, also due to a lack of sufficient industrial demonstrations of the viability of such an innovative technology. Indeed, most of large-scale demonstration projects were unable to secure enough funding from industry to reach financial closure, in part due to the difficulties in concentrating, bolstering, and streamlining public programmes at the EU and national level. If CCS received inadequate support, instead, funding mechanisms were more successful in encouraging industry investments in some of the more developed SET-Plan technologies (mass-burned biomass, onshore wind power, and solar photovoltaics)[69]. As shown by a 2016 European Commission's report, it should come as no surprise that all Banks and nearly all General Investors limited themselves to opportunities involving SET Plan projects at TRL 9, primarily involving wind energy, biomass conversion, and solar photovoltaics, given their general adverse attitude towards unproven technology in general. The most popular sectors among the four groups of market participants (enclosed in the four categories of producers, specialised investors, general investors, and banks) are wind energy and biomass conversion, with at least 50% of individual market participants active in each; then advanced electricity networks, concentrated solar power, geothermal, and large-scale energy storage, with approximately 25% of individual market participants active in each. Significantly, the least popular sectors are ocean energy and CCS, with less than 10% of individual market participants active in each. In particular, the report confirms that in the framework of the SET Plan, funding is a major problem for CCS deployment because of a lack of warranty against storage leakage of CO_2, meaning very high levels of contingency. Consequently, this high level of uncertainty hampers investments also through the related difficulties of obtaining permits for

[68] Report, Mission Innovation, 2023, *Action Plan for the Net-Zero Industries Mission.*
[69] EIKELAND AND SKJÆRSETH (2021).

CCS installation, creating a vicious circle to be broken only through strong and coordinated R&I efforts at public and private levels, ensuring the maximum level of coordination between Member States' actions and between the EU and Member States. Thus, support on this sector is necessary to overcome failures and give this first-of-a-kind technology a real boost[70].

1.3.2. The Communication on the Revision of the SET Plan COM (2023)634

To promote the achievement of the priorities of the Research, Innovation and Competitiveness dimension of the Energy Union the SET Plan has been revised and it conducts an analysis of the identifiable achievements in this context[71]. It is of particular interest that priority n. 5 of the 2023 revised SET Plan has been devoted to 'Driving ambition in carbon capture, utilisation and storage'. Indeed, to maximise its impact, the revised SET Plan must encourage concerted efforts by the public and private sectors to develop business cases and cooperative models for the developing carbon capture, storage, or use value chains. This includes evaluating storage options at the regional and national levels before they become competitive to support the economically viable operation of at least 50 million tonnes of annual CO_2 injection capacity by 2030 in both EU depleted hydrocarbon fields and saline aquifers[72].

The revision process of the CCS related aspects of the SET Plan started with the 2017 Declaration of intent summarising the positions of research and industry stakeholders together with those of the SET Plan countries[73] that chose to take part in the definition of strategic R&I targets for CCS[74]. As a first key argument, the Declaration of intent states that, as for 2017, CCS had not yet

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[70] Report, European Commission 2016, *Innovative financial instruments for First-of-a-Kind, commercial-scale demonstration projects in the field of energy,* available online.

[71] The Energy Union supports the clean energy transition as it unites all aspects of energy policy under a coherent, integrated approach. The Energy Union is based on five dimensions: i) security, solidarity and trust; ii) a fully integrated internal energy market; iii) energy efficiency; iv) climate action and decarbonising the economy; and v) research, innovation and competitiveness. Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, 24 October 2023, COM 2023/650/EU, *State of the Energy Union Report 2023.*

[72] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions, 20 October 2023, 2023/634/EC, *on the revision of the Strategic Energy Technology (SET) Plan.*

[73] These countries are Belgium, Denmark, Spain, Finland, France, Italy, Netherlands, Norway, Romania, and the United Kingdom.

[74] Report, CCUS-SET Plan, 2017, *SET-Plan Declaration of Intent on strategic targets in the context of Action 9 'Renewing efforts to demonstrate carbon capture and storage (CCS) in the EU and developing sustainable solutions for carbon capture and use (CCU)',* available online.

taken off in Europe. The primary cause is the absence of a viable business plan for running a CCS installation, but other obstacles have included issues with public support for CO_2 storage on land, a lack of transportation infrastructure, and worries about long-term liability. However, as a prerequisite for its commercialization and deployment, large-scale demonstration is still required, if not more urgently now. Therefore, to support future research and validate CCS's technical and financial feasibility as an affordable way to reduce CO_2 emissions in the electricity and industrial sectors, commercial-scale demonstration projects[75] are required. Indeed, significantly without CCS in Europe, meeting the agreed-upon climate targets could prove to be extremely expensive and challenging. The EU would also lose out on economic opportunities and technological leadership in this field, which could eventually force European industry to import CCS technology from non-EU nations[76].

The content of this 2017 Declaration of intent, then led to the elaboration of the Implementation Plan on Action 9 related to CCS deployment in the context of the activities of IWG n. 9[77]; which serves as fundamental document in understanding the meaning of priority n. 5 of the Communication on the revision of the Strategic Energy Technology (SET) Plan. The key insights from the 2017 SET Plan Implementation Plan for CCS and CCU are firstly related to the realization of at least one commercial-scale CCS project in the power and industrial sectors. Secondly, the focus in the short/medium term will be on granting EU PCI status to infrastructure's network in the North Sea basin, with the aim to link CO_2 emissions transport between Norway and the UK[78]. However, these two objectives involving CO_2 capture and CO_2 transport and/or storage, entails significantly different business models and liability clauses. Therefore, decoupling capture from transport and storage is favoured by several stakeholders as a necessary step toward the commercial adoption of CCS. To address the liabilities, the market will need to establish new insurance

[75] According to the Global CCS Institute, commercial-scale projects are defined as projects involving the capture, transport, and storage of CO_2 at a scale of at least 800,000 tonnes of CO_2 annually for a coal–based power plant, or at least 400,000 tonnes of CO_2 annually for natural gas–based power generation and emissions–intensive industrial facilities.
[76] Report, *SET-Plan Declaration of Intent on strategic targets in the context of Action 9 'Renewing efforts to demonstrate carbon capture and storage (CCS) in the EU and developing sustainable solutions for carbon capture and use (CCU)'.*
[77] In 2017, the IWG n. 9 was composed of 11 SET-Plan countries (the Czech Republic, France, Germany, Hungary, Italy, Norway, the Netherlands, Turkey, Spain, Sweden and the UK), industrial stakeholders, NGOs and research institutions. The IWG9 is chaired by the Netherlands, Norway, and the Zero Emissions Platform. Report, CCUS-SET Plan, *About SET Plan*, available online.
[78] Report, CCUS-SET Plan, 2017, *SET-PLAN TWG9 CCS and CCU Implementation Plan*, available online.

products, which can only happen when there is enough proof that, when geological storage of CO_2 is carried out in compliance with the CCS Directive's standards, the chance of leakage is negligible[79].

In summary, the 2023 revised SET Plan outlines an ambitious agenda to advance CCS, its related infrastructures, and to promote a stronger policy support in Europe by 2030 to enable deep decarbonization across industrial sectors. Significant investments and collaboration between industry, governments and researchers will be required to achieve the Net Zero target by 2050 through the capture and store of between 300 and 640 million tonnes of CO_2 per year by 2050[80]. Having this in mind, this chapter provided a general understanding of CCS functioning and of the implications of its implementation, so the next will delve into the legal challenges currently encountered by CCS in the EU and international law legal frameworks, providing an overview of the most recent 2024 European Commission's strategy for decarbonisation.

[79] The legal challenges related to CO_2 capture and transportation will be more detailly analysed in the following chapter, covering the CCS Directive (pp.) and the London Protocol (pp.). Report, *SET-Plan Declaration of Intent on strategic targets in the context of Action 9 'Renewing efforts to demonstrate carbon capture and storage (CCS) in the EU and developing sustainable solutions for carbon capture and use (CCU)'.*

[80] These figures are provided by the 2023 SET Plan Progress Report. Additional insights can be retrieved in its section dedicated to CCS. Report, European Commission, *2023, SET Plan. PROGRESS REPORT 2023 Coordinated energy research and innovation for a competitive Europe*, available online.

Chapter II

Going beyond the CCS Directive: The Most Recent Efforts for EU''s Decarbonization

2.1. The Legal Challenges Hampering CCS'' Deployment at a Large Scale in Europe

This chapter moves from the assumption that there are still regulatory gaps needing to be closed to provide better regulation and a faster deployment for CCS, considering the international law and EU law frameworks. Crucially, to achieve a full transition to climate neutrality, it is vital to identify the industries that require intervention to become climate neutral. For this reason, CCUS technologies are at the same time beneficial and essential. Although there have been environmental criticisms of CCUS technologies because they concentrate on climate change mitigation rather than prevention, it is becoming more and more clear that all forms of carbon mitigation are required to avert a global environmental catastrophe[81]. A significant aspect of offshore CCS is international law, which influences most country regulations pertaining to energy. The body of regulations known as international energy law is non-uniform[82]. The area is broad, intricate, and deals with several hard law and international legal issues that relate to many kinds of energy resources. In many structural ways, domestic energy law and international energy law are interwoven. Energy and the environment are two examples of cross cutting issues that lead to international responsibilities for states: considering domains such as oil and gas, renewable energy initiatives, and CCS[83].

For a considerable amount of time, international environmental legislation has neither specifically forbidden nor permitted the transportation or storage of CO_2. Due to this, parties who want to start CCS projects, which entail moving CO_2 from one state to another, are unsure of their legal position under

[81] NOUSSIA ET AL. (2022: 385).
[82] The best way to understand international energy law is to look at the legal frameworks that govern the distribution of obligations and rights pertaining to the exploitation of all energy resources among states, governments, and private citizens. International energy law is an amalgam of customary law, treaties, national and regional laws, and the tenets of non-governmental and intergovernmental international organizations. These elements collectively govern the different aspects of energy production, supply, consumption, and commerce. Every energy resource will have a unique interface with the law when it is exploited. Laws pertaining to R&D, exploration, production/generation, transportation, investment and financing, business and contractual arrangements, market access, subsidies and taxation, trade, dispute resolution, environmental and safety issues, to name a few, are among the many legal topics covered by energy law. WAWRYK (2014: 226-228).
[83] BRANCO DE ALMEIDA (2022: 11).

international law, since it has taken a long time to implement changes to existing conventions, and in certain cases, those issues are still unresolved[84]. It should be also noted that the current international legal framework lacks a precise definition of CO_2 as a component of the energy cycle in CCS. When transported offshore, CO_2 collection is put through a transit mode of operation where it is kept and could "loose" its identity as a stock that is thought of as flow. The intricacy of a CCS project intended for an offshore stage implies that CO_2 has numerous contradictory nuances in energy law, and it is contradictory to identify it as a ''resource'' or an ''activity'' to witness to the current situation[85]. This can be explained since energy can take on various conceptual forms, such as that of i) a product, ii) a resource, iii) a technology, or iv) an activity. It should be noted that to determine the regulations and framework supporting the investment, an evaluation of the "energy object" (in this case CO_2 and the related technologies aimed at its capture and storage) under international law is required prior to the start of any energy project. Interestingly, until the twenty-first century, international accords did not foresee provision in CCS. As a result, it is not obvious if a CCS initiative belongs in the category of technology, product, resource, or activity. This is why a modernization of such instruments is necessary given the importance of having a legal framework regarding CCS technologies in the energy sector[86].

Furthermore, because of the peculiarities of unusually dangerous operations, the strict liability principle is suited for the functioning of CCS, especially since there's the chance of carbon leaks and related incidents during the capture, transit, and storage phases of CCS[87]. In addition to this, information asymmetry is another factor in favour of the strict liability principle. One of the most important theories in economics and law, rational choice theory, contends that people behave in a way that maximizes their expected utility. Nevertheless, maximizing expected utility requires having access to adequate knowledge, being reasonable, and having the ability to make independent decisions. The market is still uncertain due to the lack of public information on

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84 NOUSSIA ET AL. (2022: 385).
85 BRANCO DE ALMEIDA (2022: 19).
86 BRANCO DE ALMEIDA (2022: 11).
87 Strict liability is defined as liability incurred without requiring proof of purpose or negligence for causing harm or damage to life, limb, or property. People or entities (such as a construction company, or manufacturing company) who engage in abnormally dangerous activities, often referred to as "ultrahazardous activities", may be held strictly liable for injuries caused to others by the activity. Since many states' national laws contain strict liability provisions for ultrahazardous acts, this legal theory may be regarded as universal. The concept of strict liability for hazardous activities, such as nuclear operations, the transportation of hazardous waste, the shipping of oil by sea, and dangerous activities in general, is also embraced by many civil liability treaties. SANDS ET AL. (2012: 712).

CCS, but the owners and operators of CCS projects have a significant informational advantage because, as potential liability holders, they can generally understand the risks that are likely to occur and the steps that can be taken to reduce any potential harm that may result from those risks. The strict liability principle, which raises the standard of environmental information disclosure and somewhat lessens information asymmetry, mandates that CCS operators notify the public of all information on transit and storage at every stage. Additionally, the strict liability principle encourages the advancement of CCS by making information more readily available and helping investors and consumers comprehend CCS projects. Furthermore, the distinct qualities of every storage site, the ever-present risk of harm, the advantages and disadvantages of the legal framework, and the special features of CCS all contribute to the conclusion that the strict liability principle is a more appropriate framework for regulating CCS projects than the fault liability principle[88].

Considering the framework depicted above, this chapter will proceed by analysing two legal challenges such as CO_2 ship transport and CO_2 storage, this last linked with the use of sub-seabed transboundary geological formations for the disposal of CO_2. The legal analysis will highlight the main provisions involved deriving from the international law and the EU law frameworks. Then, regulatory gaps will be addressed together with their implications on the conduction of CCS large scale deployment in Europe. Lastly, the second part of the chapter will focus on the most recent developments in EU law regarding CCS and namely European Commission's efforts to relaunch CO_2 emissions abatement through CCS

2.1.1. CO_2 Transport

Any CCS project comprises three phases: i) capturing CO_2 at large final emitters, ii) the compression and transportation of the CO_2 to a storage destination and iii) its injection under pressure on an oil/gas field well into the pore space of suitable geological formations[89]. Concerning CO_2 transportation, the IPCC states that CO_2 can be transported as a gas, liquid or solid and that the most viable modes of doing so would be via pipeline or ship. For both ship and pipeline transport, the principal risks in CO_2 transportation are leakage and unintended release, which could cause damage to human and animal health,

[88] Fault liability is a type of liability in which the plaintiff must prove that the defendant's conduct was either negligent or intentional; fault-based liability is the opposite of strict liability. ZHANG ET AL. (2023: 513-514).
[89] NOUSSIA ET AL. (2022: 385).

property and ecosystems[90]. Depending on how the CO_2 is transported, there is also a potential climate change impact if CO_2 is released back into the atmosphere[91]. The key challenge in this context remains the transportation of large amounts of CO_2, since small quantities of it are daily transported by different industrial sectors' supply chains. Indeed, mostly for the food and beverage sector the majority of CO_2 shipping is centred on containers that can be moved by truck, train, and ships, making them appropriate for modest movements. Conversely large-scale CO_2 transportation such as that which will be necessary in the future to satisfy climate goals requires the construction of new transportation infrastructure, with a CO_2 pipeline network modelled after the current natural gas grid being the most effective solution[92].

This said, the second phase of the functioning of a CCS project is particularly interesting from an international law standpoint. Indeed, not only CO_2 transport is crucial to ensure the correct deployment of a CCS facility, leading to the building of the necessary infrastructures such as pipelines for offshore transportation for example, but it also raises legal concerns due to the classification of CO_2 as a legal object[93]. However, it should be noted that the fact that all the international treaties on CO_2 transportation were drafted before CCS technology were developed presents a unique interpretation challenge because none of them addressed CO_2's proper classification in the international legal framework. Another legal challenge is represented by the so-called "proximity principle" in international environmental law. According to this, hazardous waste should be dealt with at source rather than being transferred to another state for disposal. So, exporting CO_2 for storage in another state could theoretically result in legal requirements for regulations and, in certain situations, prohibitions[94]. Therefore, the purpose of the following legal analysis is to shed light on how the current legal frameworks both at the international and at the EU law levels regulate this phenomenon, highlighting the consequences on CCS technology's deployment of these legal choices.

The first relevant international treaty is the Basel Convention which entered in force in 1992 with the intention of creating a worldwide framework to regulate the international traffic of hazardous waste. There are currently 53

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90 Report, Intergovernmental Panel on Climate Change (IPCC), 2005, *Special Report on Carbon Dioxide Capture and Storage*.
91 Report, Intergovernmental Panel on Climate Change (IPCC), 2006, *Guidelines for National Greenhouse Gas Inventories.*
92 FRATTINI ET AL. (2024: 1).
93 NOUSSIA ET AL. (2022: 385).
94 RAINE (2008: 357).

signatories to the Convention, although the US has not accepted the convention's provisions. Despite this lack, the Basel Convention has among its parties the EU which implemented it through the most recent Regulation 2024/1157/EU[95]. In virtue of its highly technical nature and because of its state-centred character the Convention does not belong to those international treaties directly applicable within the EU acquis. Pertaining the position of this Convention in the legal hierarchy, it is coherent with the legal doctrine affirming the superiority of international law treaties to secondary EU legislation, but not to primary EU law. Indeed, it is remarkable that international treaty at stake, namely the Basel Convention, has been implemented through regulations periodically amended or repealed[96].

Pertaining the content of the Basel Convention some key points should be highlighted. Annexes I through III of the Convention include substances and the qualities that make them ''hazardous waste''. Parties are subject to certain general duties regarding the handling of waste, including under art. 4.2, if the substance in question is classified as a ''hazardous waste'' under the Convention. ''Hazardous waste'' is defined in art. 1 which states, *inter alia*, that the following wastes that are subject to transboundary movement shall be ''hazardous wastes'': (i) wastes that belong to any category contained in Annex I (categories of wastes to be controlled), unless they do not possess any of the characteristics contained in Annex III (list of hazardous characteristics); and (ii) wastes that are not covered under paragraph (a) but are defined as, or are considered to be, hazardous wastes by the domestic legislation of the party of export, import or transit. Even while CO_2 is not specifically listed as a hazardous material covered by the Convention, under some conditions it does have some of the harmful properties listed in Annex III of the Convention. This Annex enumerates fourteen distinct attributes of compounds that may be considered hazardous. CO_2 would be included in groups like toxicity and corrosiveness, if containing in its stream the harmful properties enlisted in Annex III[97]. Additionally, it is feasible that Annex IV of the Convention, which

[95] Regulation of the European Parliament and of the Council, 11 April 2024, 2024/1157/EU, *on shipments of waste, amending Regulations (EU) No 1257/2013 and (EU) 2020/1056 and repealing Regulation (EC) No 1013/2006.*

[96] It is important to stress that conventionally, EU courts have granted international treaties immediate effect in the EU acquis. In particular, international treaties have the potential to have direct effect, provided that three requirements are met: first, the treaty must bind the EU; second, the relevant provision of the treaty must be sufficiently explicit, unconditional, and clear to allow for direct application; and third, the treaty's "nature and structure" or "broad logic" cannot prohibit direct effect. So, considering this premise the case of the Basel Convention represents an exception in this context. ZIEGLER (2013).

[97] Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, 22 March 1989, 1673 UNTS 126, Basel Convention.

addresses waste injection and storage, includes CCS in its purview. The IPCC suggested that CO_2 would only be covered by the Basel Convention if it were combined with another material that the Convention considered harmful (such as some heavy metals making CO_2 impure), but no one has agreed upon or verified this interpretation[98]. This area of law demonstrates that the Convention has a legislative void regarding CCS that has to be clarified further.

Should CO_2 be deemed an "hazardous waste" by the Basel Convention, both the contracting parties desiring to export the CO_2 and those desiring to move garbage transboundarily may need to comply with the Convention's regulatory requirements and restrictions. These are extensive and may consist of the following: (i) prohibiting the export and import of CO_2 to and from non-parties[99]; (ii) an obligation to export CO_2 only in the event that the exporting state lacks the requisite capacity for disposal[100]; (iii) the transit states' possible refusal to consent, which gives them the authority to forbid transit passage[101]; (iv) a ban on exports to countries to whom the exporting party has good grounds to suspect that the CO_2 will not be managed sustainably[102]; (v) a duty to work with stakeholders to enhance and accomplish environmentally sound management of the stored CO_2[103]; (vi) standards for documentation, notice, and consent; and (vii) states that import and transit and are parties to the agreement may demand that the CO_2 be guaranteed by insurance or another means[104]. Regarding the last criterion, this could lead the insurance industry to consider potential insurance products for CCS[105]. Overall, it must be stressed that all the aforementioned provisions from the Basel Convention, if applicable to CO_2 as an "hazardous waste", could hamper not only its transportation but also a crucial phase of CCS' supply chain together with this technology's deployment at a large scale, having as an obstacle burdensome legal obligation. Remarkably, following art. 2 of Regulation 2024/1157/EU, currently implementing the Basel Convention into the EU acquis, the shipments of carbon dioxide for the purposes of geological storage in accordance with Directive 2009/31/EC would be out of the scope of application of the Regulation itself. Acknowledging this means to recognize that the Basel Convention

98 Report, *Carbon Dioxide Capture and Storage*.
99 Basel Convention, art. 4.5.
100 Basel Convention, art. 4.9.
101 Basel Convention, art. 6.4.
102 Basel Convention, art. 4.2e.
103 Basel Convention, art. 4.2h.
104 Basel Convention, art. 6.11.
105 RAINE (2008: 359).

does not constitute a barrier to CCS implementation among EU Member States and nations of the European Economic Area (EEA)[106].

Not more helpful in solving the controversy of whether CO_2 can be transported as a not "hazardous waste" is the United Nations Convention on the Law of the Sea (UNCLOS). Even in this case the EU ratified UNCLOS and this convention represents the most famous exception to the direct applicability of international treaties in EU law[107]. Indeed, UNCLOS was not given direct effect by the European Court of Justice. The problem came from a challenge to the EU lawfulness of Directive 2005/35/EC (the Ship-Source Pollution Directive), which imposed criteria that were incompatible with UNCLOS, among other arguments. Firstly, the Court cited the UNCLOS's "nature and structure" as an exception, stating that it is essentially state-centred, in order to deny its direct effect. Secondly, it narrowed down the definition of the need for direct effect, which is that a norm must be unambiguous, explicit, and unconditional. Lastly, the Court mandated that a provision must bestow a genuinely subjective or individual right in order to qualify for direct effect[108]. Arguably, this last criterion sets a high threshold for individuals who want to rely on provisions of international law within the EU legal order since true individual rights are still rare in international law.

Then, with regards to UNCLOS' provisions, the following key points are worth mentioning. Part XII of the Convention contains the primary environmental protection provisions. UNCLOS codified important norms for preventing pollution in specific regions of the seabed as well as a collection of laws and regulations for those areas[109]. States are generally required by art. 192 to protect and preserve the marine environment[110]. Similarly, art. 195 stipulates that States shall act so as not to transfer, directly or indirectly, damage or hazards from one area to another or transform one type of pollution into another when taking action to prevent, reduce, and control pollution of the marine environment[111]. Therefore, art. 195 institutionalises the prohibition of transfers

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[106] Regulation 2024/1157/EU, art. 2h.

[107] ZIEGLER (2013: 11-12).

[108] Judgement of the European Court of Justice, 3 June 2008, Case 308/06, *Intertanko et al. v. Secretary of State for Transport.* This judgement represented a milestone in EU's jurisprudence since with it UNCLOS joined the General Agreement on Tariffs and Trade (GATT) and the World Trate Organization agreement as non-directly applicable international treaties. A detailed analysis on the evolution of the jurisprudence on this matter can be found in the here mentioned chapter. ECKHOUT (2011), *The legal effects of international law*, in ECKHOUT (ed.), *EU External Relations Law,* Oxford, II ed., pp. 324-436.

[109] United Nations Convention on the Law of the Sea, 1982, 1833 UNTS 3, UNCLOS.

[110] UNCLOS, art. 192.

[111] UNCLOS, art. 195.

or exports of hazardous materials, underlying the rationale that the producer of waste should deal with and neutralise it at the source rather than transporting it to other areas. This reflects the "proximity principle" which was further developed in transboundary movement of waste instruments[112]. It is unclear if CO_2 is classified as a pollutant or dangerous material under UNCLOS, but it is also evident that this Convention does not prohibit its transportation. Depending on the ocean zone the CO_2 is being transported through, UNCLOS does impose various restrictions on the transportation of CO_2 by ship and pipeline.

Governments may object to the laying of pipes in their exclusive economic zone and continental shelf, but permission from all governments whose territorial seas the pipeline crosses is necessary for pipelines to be installed in territorial seas. Pipelines can be installed anywhere on the high seas without a permit since they are not governed by any one state. All of the ocean's designated regions are open to ship transportation of CO_2, but caution must be used to make sure that the rules governing each area are followed when a ship passes through. In general, it can be said that CCS is not forbidden by UNCLOS. Nevertheless, stakeholders must take care to ensure they abide by the Convention's provisions when transporting CO_2[113]. Remarkably, UNCLOS is merely a framework law that leaves it up to other, more specific laws, like the London Convention (LC) and its 1996 Protocol (LP), to elucidate specific rules. In reality, if a state wants to get rid of CO_2 transported to its soil and is a party to both UNCLOS and the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention and/or its Protocol), for instance, it will be accountable for adhering to the stricter treaty first and will rarely mention the general requirements imposed by UNCLOS[114]. It is the London Convention and its Protocol, in particular, that could hamper CO_2 ship transportation, constituting a significant barrier to CCS deployment at a large scale in Europe. To better understand this constraint, the next section will explore specifically the issue of CO_2 transportation by ship and what are the legal implications of the currently in force international law framework

2.1.1.1. CO_2 Ship Transport

[112] Raine (2008: 361).
[113] Noussia et al. (2022: 386).
[114] Purdy and Macrory (2004: 18).

Transboundary CO_2 shipping is currently deemed to be necessary because of the worrying rise in greenhouse gas (GHG) emissions on a worldwide scale, together with proved CCS contribution to reduce GHG emissions through CO_2 capture. Since shipping can be used to match sources and sinks with flexibility, it could be a viable way to achieve major decarbonization in sectors that are difficult to address[115].
To contextualise the issue at stake, it is crucial to state that unequivocally CO_2 ship transport is regulated having in mind the protection of the marine environment from dumping of hazardous waste, one of the most prominent forms of intentional marine pollution. Indeed, according to UNCLOS art. 210, state parties should avoid, lessen, and regulate pollution of the maritime environment by dumping[116].

However, being UNCLOS a wider framework convention it is necessary to define the legal scope of more sectoral treaties in the framework of the International Maritime Organization (IMO), namely the London Convention and of its Protocol[117]. In force since 1975, the London Convention is among the first international agreements to safeguard the maritime environment from human activity. Its goal is to encourage the efficient control of all marine pollution sources and to take all reasonable precautions to avoid polluting the sea by disposing of waste and other materials[118]. To further modernize the Convention and eventually replace it, the London Protocol was agreed upon in 1996, and then entered into force in 2006[119]. Notably, neither CCS nor the transboundary movement of CO_2 were covered by these major legal mechanisms. This omission can be attributed to the fact that the draft was written with less understanding and advancement in the field of CCS and the potential ramifications of transboundary CO_2 transfer than at present[120]. The London Protocol prohibits all dumping, apart from wastes that may be allowed listed on the so-called "reverse list"; which significantly now includes CO_2 streams for CCS. Indeed, in the framework of the London Protocol, efforts are being

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115 Mittler (2023: 1).
116 UNCLOS, art. 210.
117 The EU did not ratify the London Convention and the London Protocol, instead some Member States did. This aspect is particularly interesting for the analysis conducted since the lack of ratification of these instruments could constitute a barrier for the deployment of CCS transnational projects, as it will be shown in chapter III (*infra* pp. 74-77).
118 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 29 December 1972, 1046 UNTS 120, London Convention.
119 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 7 November 1996, 36 ILM 7, London Protocol.
120 Mittler (2023: 4).

made to capture and permanently store carbon dioxide in submerged geological formations to help prevent the oceans from becoming more acidic[121].

Nevertheless, the classification of CO_2 (whether it is an “hazardous waste”, which transportation constitutes dumping or not) remains a crucial issue to be addressed. In this regard, the London Convention and its recently amended Protocol offer more openness to conduct this activity offshore, if compared to the provisions of the Basel Convention. Indeed, as of right now, the London Protocol is the most sophisticated worldwide regulatory framework for CCS in submerged geological marine and formations. To govern CCS in sub-seabed geological formations for permanent isolation, the London Protocol contracting parties enacted changes in 2006 due to the eminent opinion of the IPCC; that views CCS as one of the near-term technological solutions for lowering net CO_2 emissions to the atmosphere[122]. Indeed, Annex I of the Protocol was amended in 2006 by the contracting parties to regulate CCS in sub-seabed geological formations, giving it a legal foundation under international environmental law. Specifically, although dumping is generally forbidden under the London Protocol, eight wastes may be allowed to be dumped at sea after a rigorous license and assessment procedure and CO_2 streams from CCS are among them. Large point sources of CO_2 emissions, such as cement factories and power plants, have the potential to sequester and store CO_2 for long-term isolation in submerged geological formations. However, even though there are numerous R&D and demonstration projects underway, no permits under the London Protocol have been granted yet[123]. Furthermore, to allow parties to exchange transboundary sub-seabed geological formations for CO_2 sequestration projects, in 2009 the parties changed art. 6 of the London Protocol, regarding the export of wastes for dumping purposes. Indeed, art. 6 used to prohibit the international movement of waste for the purposes of dumping or incineration[124]. Once that amendment comes into effect, CO_2 exports for geological sequestration will be permitted.

This exception from art. 6 for CO_2 streams for CCS purposes would be given if the participating nations have developed an “agreement” or an “arrangement”, with particulars specified in the revised art. 6.2 and art. 6.3[125].

[121] Report, International Maritime Organization (IMO), *The London Convention and Protocol. Their Role and Contribution to Protection of the Marine Environment.*
[122] For a more detailed analysis on IPCC consideration of CCS see Chapter I (*supra* pp. 7-8).
[123] Report, International Maritime Organization (IMO), 2016, *The London Protocol What It Is and Why It Is Needed.*
[124] London Protocol, art. 6.
[125] An “arrangement” is a non-binding understanding between governments, such as a

However, since the 2009 amendment requires the parties to the London Protocol to ratify it by a two-thirds majority, it has not yet come into effect[126].

This provision would constitute a vital component of the puzzle that would allow cooperative operations for the subsea disposal of captured emissions of CO_2 from industrial sites that are not in the coastal state that oversees the disposal location[127]. Indeed, the centrality of offshore CCS installations is deemed crucial for this technology's deployment, and it presents a wide range of benefits. Firstly, near-offshore capacity holds great worldwide importance, and data from oil and gas development and production, when accessible, provide a solid understanding of the offshore geology. Secondly, the management and ownership of both surface and mineral rights are held by a single entity, namely a state. Thirdly, freshwater aquifer risks are comparatively low. Furthermore, the development of CO_2 pipeline infrastructure could be facilitated by the rights-of-way for existing pipelines used for oil and gas production[128].

So, to foster the process of CCS large scale deployment, due to its recognized necessity to mitigate climate change, the contracting parties to the London Protocol in 2019 allowed to permit the temporary application of this art. 6 amendment, consenting the export of CO_2 for storage in submerged geological formations[129]. Therefore, currently, exporting CO_2 for geological storage can be agreed upon by two or more nations. However, it should be noted that this resolution is only a provisional solution allowing CO_2 export for CCS purposes, and that parties are urged to formally accept art. 6 amendment[130]. Indeed, according to the IEA, the simplest and possibly fastest course of action would have been for the contracting parties to adopt an interpretative resolution at a meeting suggesting the 2009 amendment to be applied provisionally while its amendment is ratified following the rules stated in art. 21 of the London Protocol. Indeed, it appears doubtful that the contracting parties would have objected to the 2009 amendment's provisional application, as they agreed that art. 6 should not operate as a barrier to CCS. Perhaps a quicker way to clarify the application of art. 6 would have been to pass a resolution at

memorandum of understanding, whereas an "agreement" is a legally binding commitment between states, such as a treaty or memorandum of agreement. Report, IEA Greenhouse Gases R&D Programme, 2021, *Exporting CO_2 for Offshore Storage – The London Protocol's Export Amendment and Associated Guidelines and Guidance.*

126 London Protocol, art. 21.

127 BANKES (2019: 1).

128 Report, Offshore Storage Technologies Task Force, 2015, *Technical Barriers and R&D Opportunities for Offshore, Sub-Seabed Geologic Storage of Carbon Dioxide.*

129 Resolution IMO LP.5(14), LC 41/17/Add.1, 29 October 2019.

130 Report, International Maritime Organization (IMO), 2016, *The London Protocol What It Is and Why It Is Needed.*

a meeting of contracting parties stating that art. 6 of the London Protocol should not be interpreted as operating to prevent the transboundary movement of CO_2 from contracting parties. Nonetheless, the contracting parties hesitated to deviate from the formal procedure and to accept such a resolution since they acknowledged that art. 6 could be understood to forbid the export of CO_2 and have already started a formal amendment process on this basis. As for possible alternatives, contracting parties desiring to participate in transboundary export may enter into a second agreement (bilateral or multilateral) if they are unable to come to an agreement as for the terms established by the amended art. 6.2 and art. 6.3. They might also have changed or halted art. 6 to the point where it appears to forbid the export of CO_2 across international borders. All three of these choices, meanwhile, would have probably taken more time and energy than a contractual parties'' resolution. Lastly, contractual parties viewed art. 6 suspension as less desirable from a political standpoint[131].

Relevantly, the amendments to the London Protocol, and of its art. 6 caught the attention of the European Commission which elaborated a detailed legal analysis on the matter, linking the London Protocol with the EU law CCS Directive[132]. The Information Exchange Group of the CO_2 Storage Directive 2009/31/EC received an analysis paper from the European Commission on September 30, 2022, titled "The EU legal framework for cross-border CO_2 transport and storage in the context of the requirements of the London Protocol". According to the European Commission, there exists a substantive congruence between the legislative framework of the EEA nations and the requirements of the London Protocol for the safe geological storage, cross-border movement, and capture of CO_2. It is suggested that the CCS Directive, the EU ETS Directive, and their incorporation into the EEA legal regime can act as a relevant "arrangement" needed for CO_2 export under the London Protocol for all EEA countries, regardless of whether or not they are Contracting Parties to the London Protocol, since art. 6.2 of the London Protocol requires the concerned countries to enter into an arrangement for the export of carbon dioxide streams for disposal. Thus, for the European Commission EEA nations that have ratified the London Protocol would be exempted from the requirement to establish the bilateral agreement stipulated in the 2019 Resolution to the

[131] Report, International Energy Agency (IEA), 2011, *Carbon Capture and Storage and the London Protocol Options for Enabling Transboundary CO_2 Transfer*.
[132] CCS Directive 2009/31/EC will be analysed more in depth in this chapter (*infra* pp. 47-52).

2009 amendment to art. 6[133]. Rather, they should inform IMO that any new bilateral agreements the Parties desire to reach on matters not covered by EU law are part of the applicable arrangements for these exchanges. In this regard, the Memorandum of Understanding (MoU) between Denmark and Belgium on cross-border CO_2 transit for geological storage, which was reached on September 13, 2022, serves as an example and it contains clauses about agreements between the parties and amendment procedures[134]. The European Commission position paper appears to suggest that EU legislation should govern the export of carbon dioxide streams for disposal among EEA nations, superseding the obligations of the London Protocol. However, it is still unclear where the London Protocol Contracting Parties and IMO stand. It is noteworthy that the interpretation put forth by the EU is not legally enforceable under the London Protocol, since laws and regulatory frameworks can only be formally developed by Contracting Parties[135].

To conclude, it can be argued that the legal framework currently in force evolved in a way favourable to CO_2 ship transport large scale deployment, even though the above-mentioned provisions still did not significantly reduce the level of legal uncertainty surrounding CCS supply chain and its security issues related to CO_2 transport through ships. In understating the bigger picture, it is of primary importance also to consider that the state of CCS is going through a major change, characterized by increased interest and investment from public and private sectors, but also by residual scepticism and disappointments from the past. To fully realize the potential of CCS projects as the demand for them in the battle against climate change grows, it will be essential to promote global cooperation and consensus-building. Only through increasing investments and large-scale projects building stakeholders will be incentivized to revise the current legal framework at the international level to ensure legal certainty in CCS supply chain and in CO_2 transport

2.1.2. CO_2 Storage

[133] Commission services analysis paper for the Information Exchange Group (IEG) under Directive 2009/31/EC, 30 September 2022, *The EU legal framework for cross border CO_2 transport and storage in the context of the requirements of the London Protocol.*
[134] Memorandum of Understanding (MoU), 13 September 2022, *MoU between the Minister for Environment of the Flemish Region and the Federal Minister for the North Sea of Belgium and the Minister for Climate, Energy and Utilities of Denmark on Cross Border Transportation of CO_2 with the Purpose of Permanent Geological Storage.*
[135] Frattini et al. (2024: 4).

Exporting carbon dioxide allows for the implementation of business in close collaboration with neighbouring or transboundary nations. Relevantly, in a negative scenario, carbon dioxide leakage can happen to inadvertently harm neighbouring countries, even if a CCS regime is correctly established in each nation. Furthermore, also global consequences should be given attention in the analysis when considering risks related to CO_2 storage, ranging from disruptive effects for human and environmental safety. However, being the focus of the section on the legal framework regulating CO_2 storage, this typology of risk will not be considered.

The issue surrounding transboundary CCS projects stems from the scarcity of suitable storage locations and the possibility of transboundary CCS damages, both of which are inadequately addressed under current international law. Three types of reservoirs (saline aquifers, depleted oil and gas reservoirs, and unmineable coal seams) are currently being investigated as potential geological sequestration repositories for CO_2. These three different reservoirs would be found deeply within the earth, isolated at least a kilometre below the surface. Furthermore, these existing sequestration mechanisms might exist deep below the ocean's surface, beneath the seafloor, and on land. As a result, there are two different types of geological sequestration techniques: onshore sequestration and offshore sequestration.

The feature that sets CCS apart from other storage technologies is its ability to store CO_2 for an extended period, hundreds or even thousands of years, in the future. For almost 40 years, the oil and gas producing industry has been using technology for the capture, transportation, and storage of carbon dioxide in conjunction with enhanced oil recovery (EOR) technology. While EOR technology uses CO_2 injection into oil fields for temporary storage to boost oil production, CCS technology has permanent sequestration and necessitates a larger pipeline system than that used by the current EOR network. Indeed, CCS typically involves transporting CO_2 from larger point sources than EOR, such as power plants and industrial facilities, where it is captured in significant quantities. This requires pipelines that can handle higher flow rates to efficiently transport the captured CO_2 to storage sites. Therefore, the design of CCS pipelines must accommodate the need for high-pressure transport over potentially long distances to geological storage sites. This often necessitates larger diameters to minimize pressure losses and accommodate the dense phase of CO_2, which is crucial for efficient transport. [136].

[136] Extraction of crude oil from an oil field that cannot be extracted in any other way is known as enhanced oil recovery (EOR), or tertiary recovery. EOR works by changing the chemical

Concerns have been raised over the possibility of carbon dioxide leakage and the vulnerability of deep saline aquifers to this trapping mechanism when it comes to sequestration, as opposed to depleted oil and gas reserves[137]. Therefore, it will be crucial to look for geologically suitable locations to store carbon dioxide. The storage locations must provide an enough amount of reservoir rocks for suitable storage capacity in addition to an adequate supply of cap rocks for safe confinement. To do this, evaluation criteria for site selection must be established since every step of the last sequestration process, namely installing wells, injecting carbon dioxide, and shutting wells, carries a possible danger of carbon dioxide leakage[138]. Furthermore, the potential risk of leakage is related to some elements called "parameter sensibility" (e.g., pressure, temperature, and permeability). Therefore, to prevent any negative effects on the cap rock, legislative regulations pertaining to injection pressure and rate must be established. Additionally, earthquakes are another possible source of leakage, and in particular induced earthquake, occurring because of anthropogenic activity. Lastly, even once injection wells are closed, their careful control is crucial. Indeed, when wells are aged and closed, human neglect or carelessness could result in erosion of cement where an injection well plug is sealed, consequently causing CO_2 leakage[139].

2.1.2.1. Advocating for an international liability regime for CCS

Considering the features of CO_2 storage and the related risks mentioned above, it is argued that large-scale CO_2 storage and the widespread deployment of CCS technologies are contingent upon the establishment of a strong

makeup of the oil itself to facilitate extraction. The US Department of Energy states that one of three EOR techniques, thermal, gas, or chemical injection, is injected simultaneously with carbon dioxide and water. The EOR technique that is attracting the newest market interest is CO_2-EOR. First tried in 1972 in Scurry County, Texas, CO_2 injection has been used successfully throughout the Permian Basin of West Texas and eastern New Mexico and is now being pursued to a limited extent in Kansas, Mississippi, Wyoming, Oklahoma, Colorado, Utah, Montana, Alaska, and Pennsylvania. More information on CO_2 - EOR and its implementation status in the US can be retrieved here. Report, US Office of Fossil Energy and Carbon Management, *Enhanced Oil Recovery*, available online.

137 PARK (2020: 46-48).

138 The shape of the aquifer's top determines how CO_2 trapped in deep, saline aquifers migrates. Elevated ridges may offer paths that allow CO_2 to migrate farther from the injector, or topographical highs like anticlines may trap CO_2 and limit the amount moved. The overall structure of the aquifer has an impact on the outcomes (CO_2 dissolution and plume migration), not only the shape of the caprock. Additionally, it has been shown that the transition zone improves CO_2 storage. SHARIATIPOUR ET AL. (2014: 5545, 5554).

139 PARK (2020: 49).

international liability regime that provides adequate coverage of long-term liability and establishes a stable, transparent, and accountable regulatory framework that is applicable beyond national borders[140]. In this context, a review of the various CCS-specific legal regimes developed to-date, reveals three largely distinct forms of liability applicable to CCS operations. Liability may refer to civil liabilities where another party seeks compensation for damage caused by CCS operations, administrative liability where an operator may be subject to specific requirements imposed by a regulator, and GHG emissions/climate change liability where any subsequent leakage may require an operator to account for any credits previously gained for GHG storage[141].

This said, insurance products under certain conditions could serve as a temporary solution until the international community implements a strong regulatory framework for CCS technology, in the absence of a unified domestic or worldwide legal liability and regulatory regime[142]. This lack significantly hampers the large-scale deployment of CCS due to the transboundary nature of its projects often involving multiple countries, so envisaging the possibility of damages provoked by one country in another country's territory or even contemplating, although low, a risk of environmental harms to shared resources such as aquifers. Indeed, examples of harm to a neighbouring country resulting from the implementation of CCS in one country include situations in which CO_2 in sequestration leaks into the neighbouring country's territory over an extended period of time, contaminating underground water, or where an accident occurs in an offshore geological sequestration facility in one country, harming the marine environment of another country[143].

The most diriment legal issue pertains the involvement of state's liability for environmental damages caused by lawful activities related to CCS facilities and its supply chain (in particular, CO_2 transport and storage). Above it has been argued that a regime of strict liability resting on the private operators would stimulate innovation and information disclosure related to CCS plants' facilities[144]. However, due consideration should be given to state's liability, considering also the entity of the damage and its related economic, social and environmental implications. Under current international law, a clear responsibility framework for environmental harm brought on by lawful actions is still lacking. Indeed, referring to the Draft Principles on the Allocation of Loss in

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140 GOLA AND NOUSSIA (2022: 6).
141 Report, Global CCC Institute, 2019, *Lessons and Perceptions: Adopting a Commercial Approach to CCS Liability*.
142 GOLA AND NOUSSIA (2022: 6).
143 PARK (2020: 60).
144 *Supra* (pp. 28-29).

the Case of Transboundary Harm Arising Out of Hazardous Activities several difficulties related to states' responsibility for damages caused by lawful activities under international law emerge[145].

The idea of placing strict liability on states has been the main challenge the International Law Commission (ILC) has faced regarding the liability issue. States' persistent resistance to such a proposal has limited the ILC's capacity to recommend a liability scheme based on the idea of strict obligation on the part of States for transboundary harm caused by hazardous activities. Indeed, states generally held two views: either an activity was illegal, and no international legal responsibility or liability could attach to the effects produced by the activity, or an activity was not illegal and the law on state responsibility would govern any reparations to be made in respect of its consequences. Therefore, states would not accept the idea of establishing a type of international legal liability for the results of actions that were not themselves forbidden by international law, according to the ILC's conclusion. Ultimately, by creating a plan based on a "privatized" approach to risk, advancement has been made. Operating companies, not the source states, will bear the primary responsibility for making up for transboundary harm brought about by hazardous activities. The model that the ILC has created ought to promote the internalization of expenses related to the risks involved in these kinds of operations by business organizations and guarantee that appropriate insurance is obtained by them. Furthermore, through a broader interpretation of the polluter pays approach, the 2006 Draft Principles increment states' incentives to control and prohibit activities with potentially serious consequences for populations of other states. These Principles should be interpreted in the sense that the state that approved the activity as well as the operator can be deemed the "polluters" who must "pay". Therefore, the proposed Principles can be viewed as a means of resolving the conflict between the requirement that the source State ensure the compensation of innocent victims, and the polluter pays principle, encouraging a vision according to which the operator should take liability primarily and, if this compensation is less than enough, the state should become liable secondarily[146].

However, it should be noted that the outdated nature of the Draft Principles and the lack of any specific reference to CCS, does not make this UN Document sufficient to ensure a proper international liability framework for operators and states involved in transboundary CCS projects involving CO_2

[145] Draft Principles on the Allocation of Loss in the Case of Transboundary Harm Arising out of Hazardous Activities, U.N. Doc. A/61/1, 2006.
[146] FOSTER (2005: 265-266).

transport and storage. Therefore, *ad hoc* insurance products should be seen as desirable tools to be utilized to lessen the impact and likelihood of an injury, given the ambiguity surrounding the precise nature and hazards involved with CCS activities and its anticipated effect. Currently, the present marine insurance solutions on the market can pay for the short-term obligations associated with CO_2 transportation. However, the insurers may limit the coverage, add more exclusions, or request a higher premium because of the vast quantities of CO_2 that must be shipped, and the unknown risk associated with it, adding complexity and uncertainty to this type of insurance protection[147]. Then, considering long-term responsibility for environmental contamination caused by CO_2 transportation or storage improved and expanded insurance products should be taken into account[148]. This need is exacerbated by the fact that CCS projects have several risks that could lead to accountability for damages, including expenditures associated with crisis management, clean-up, restoration, and environmental degradation[149].

Therefore, it is crucial to manage this potential liability to forward future CCS initiatives. Covering long-term liability risks would need long-tail policies for risks that run hundreds of years into the future, which the insurance industry is now hesitant to underwrite, and the existing liability policies for CCS projects do not extend coverage to long-term liability risks. The paradox is that currently there is no regulatory framework that could accurately determine the level of liability; rather, it is these long-term risks resulting from CCS operations that necessitate proper coverage. Essentially, this regulatory gap is hampering insurance companies' ability to create policies that meet the requirements of CCS projects because regulations typically drive the evolution of the insurance market. Indeed, CCS measures will not be implemented until additional regulatory advice is available to direct and guide the insurance industry to purchase more insurance products[150]. However, leading the way in this regard, Zurich has created several specialized products, such as the ''Carbon Capture and Sequestration Liability Insurance Policy'', which is targeted directly at CCS project operators, to help them capture the risks involved in CCS operations. With coverage ranging from 30 to 50 years, this insurance product provides geo-mechanical liability, transmission liability, well control

[147] GOLA AND NOUSSIA (2022: 6).
[148] Improved and expanded insurance generally refers to efforts to enhance and broaden the scope of insurance coverage. This can include: i) offering more comprehensive benefits, ii) making insurance more accessible and affordable, iii) improving the quality of services provided under the insurance plan, iv) streamlining administrative processes to reduce overhead costs and improve the overall efficiency of the insurance system.
[149] GOLA AND NOUSSIA (2022: 6).
[150] GOLA AND NOUSSIA (2022: 7).

coverage, pollution event liability, and business interruption coverage. Zurich has also formed a task group to create an insurance plan that will address the legal and physical risks related to CCS[151].

In this context, it is crucial to highlight that 2024 has been an important year for the development of new insurance products aimed at balancing the impellent need for CCS' implementation with all the risks and uncertainties explained above. So, it can be argued that this year represented a momentum of increased interest in developing this strategic technology also for insurers, aiming to provide operators with products allowing them to attempt compliance with and implementation of the updated ambitions of the European Commission pertaining to CCS' deployment at a large scale in Europe[152]. Indeed, leading insurance company such as Aon, Marsh, and Howden have recently launched innovative insurance products specifically designed for CCS projects.

Firstly, Aon has introduced a comprehensive insurance solution aimed at international transport and storage companies involved in CCS. This product covers various risk exposures, including physical risks, loss of revenue, general liabilities, and indemnity for tax credits related to CO_2 leakage. Developed in collaboration with Eni UK, Aon's product is positioned to enhance the financial viability of CCS projects, thereby facilitating access to capital and changing perceptions about insurability in this sector[153]. Then, also Howden has unveiled a pioneering insurance facility that provides coverage for the sudden or gradual leakage of CO_2 from commercial-scale CCS facilities and the ultimate goal is to de-risk projects essential for decarbonisation and is part of a broader strategy to develop a commercial insurance market for CCS[154]. Lastly, Marsh is developing insurance programs that tackle various risks associated with CCS, including delivery, permanence, and invalidation of carbon credits. Their initiatives aim to bolster investor confidence and

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[151] Geologic Sequestration Financial Assurance and CCS Liability Insurance are offered by Zurich Financial Services Group. From the planning and development stages of CCS projects to the closure and post-closure events at the geologic storage sites, these products aim to satisfy insurance requirements for CCS. Pollution event liability, business disruption, well control, transmission liability, and geo-mechanical liability are all covered under the Carbon Capture and Sequestration Liability Insurance Policy. Report, Carbon Capture Journal, 2009, *Zurich launches CCS insurance products*, available online.
[152] *Infra*, (pp. 52-59).
[153] Report, Aon, 2024, *Aon launches the first fully comprehensive carbon capture and storage insurance solution to support energy transition*, available online.
[154] Report, Howden, 2024, *Howden launches first-of-its-kind carbon capture and storage insurance facility*, available online.

support the growth of the carbon market, reflecting a growing recognition of the importance of insurance in facilitating sustainable environmental practices[155].

Therefore, developments in CCS insurance will encourage the establishment of a legal and regulatory framework for the CCS sector, which will ultimately result in a reduction in the cost of CCS liability insurance, overall reducing the costs for CCS transboundary projects set-up and implementation. However, for global deployment and public acceptance of CCS technology, a long-term responsibility framework for transboundary shipping and storage of captured CO_2 is essential. At present, there are still concerns about the long-term risks and effects of CCS on biological diversity, the environment (including marine life and ecosystems), human health, society, and culture, which calls for more scientific research and knowledge sharing. This is true even though CCS is becoming more and more accepted as climate mitigation technologies in the international legal arena. Therefore, to boost CCS deployment at a large scale it is necessary to ensure a complementary development of innovative insurance products aimed at protecting from the abovementioned risks deriving from such an innovative technology, and of support by the public sector through financial state-aid schemes. This would ensure the fruitful application of the strict liability principle to operators, but also the liability of states involved in transboundary CCS projects when the operators from the private sector would need state's support, especially in the case of high due economic compensations. So, the ultimate goal should be to strengthen overall the transboundary liability regime for CCS projects, creating a flexible insurance market supported by the involved states so to guarantee the maximum coverage from unexpected hazards deriving from CCS related activities, which are lawful conducts under domestic and international law.

Considering the international legal challenges related to CO_2 transport and storage, the next section will investigate the provisions in place in the European Union to regulate and foster the large-scale deployment of this technology.

[155] Report, Carbon Capture Journal, 2024, *Marsh launches first-of-its-kind insurance solution for CCS projects*, available online.

2.1.2.2. The Provisions of the EU CCS Directive 2009/31/EC: a Focus on Liability

A legal framework for the environmentally safe geological storage of CO_2 was established in 2009 by the European Commission through the issuance of the CCS Directive[156]. Its main goal is to ensure that the long-term geological storage of CO_2 is carried out in a way that minimizes and prevents threats to the environment and public health. Indeed, a permanent confinement of CO_2 in a manner that prevents and, where this is not possible, eliminates as far as feasible the negative effects and any risk to the environment and human health and combats climate change is the stated goal of safe geological storage of CO_2[157]. Furthermore, the CCS Directive outlines requirements for the selection of storage sites and the issuance of storage permits. It also places operational and closure obligations and post-closure requirements, including reporting and monitoring, as well as the need to take corrective action in the event of leaks or other notable irregularities[158]. When assessing any CO_2 storage project this must be divided into three phases: i) pre storage, ii) operation and iii) closure and post-closure.

Concerning the pre-storage phase, art. 4.4 of the CCS Directive establishes that a storage site may be selected if there are no significant risks[159] of CO_2 leakage, nor environmental or health risks[160]. These conditions have to be previously ensured through a geological characterization, a three-dimensional computer modelling used to project the behaviour of CO_2 when injected into the soil or into an offshore aquifer reservoir, which is currently deemed to be the most time-consuming and expensive operation in this phase[161]. Then, after the necessary exploration activities conducted under the relative permit[162], obtaining a storage permit by the competent national authority is crucial to

[156] Directive of the European Parliament and of the Council, 23 April 2009, 2009/31/EC, *on the geological storage of carbon dioxide*.
[157] Directive 2009/31/EC, art. 1.
[158] FRATTINI ET AL. (2024: 4).
[159] Significant risk under the CCS Directive refers to a combination of a likelihood of damage occurring and a degree of damage that cannot be ignored without undermining the Directive's intended outcome for the storage site in issue. The magnitude of damage that can result from different leakage risk scenarios varies depending on the site and considers both the potential volume of leaking associated with the risk scenario and the potential impact of that leakage on the environment or human health. Report, European Commission, 2024, *Guidance document 3 Criteria for transfer of responsibility to the competent authority.*
[160] Directive 2009/31/EC, art. 4.4.
[161] WOERDMAN ET AL. (2021: 174).
[162] Directive 2009/31/EC, art. 5.1.

ensure the environmentally safe storage of CO_2[163]. In this process the involvement of the European Commission is not secondary to that of Member States since it may issue non-binding opinions on the storage permits issued by the Member States'' competent authorities[164]. They cannot depart from these opinions without stating valid reasons, since these documents are based on scientific analysis carried out by a panel of experts. Indeed, involving high-level experts in the process is a mean to enhance public confidence towards CCS and also a mean to exchange best practices with and between Member States[165].

Secondly, regarding the operation phase it should be stressed the importance of the monitoring requirements of the CO_2 injection facilities imposed to operators[166]; together with the duty resting on competent national authority to conduct regular inspections of all the storage facilities covered by the CCS Directive[167]. After these inspections an evaluation report of compliance with the conditions required for the storage permit is drafted, and in case of non-compliance the competent national authority has the power to withdraw the permit[168]. Indeed, in the eventuality of leakages[169] or significant irregularities[170] it rests on the national competent authority or to rely on the operator to enact corrective measures or to do it autonomously[171]. Enforcing operator's obligation, the competent authority will rely on the financial security of the operator, a mandatory requirement to be achieved by the operator before the issuance of a storage permit, meaning that the latter can comply with the obligations related to monitoring and enforcing corrective measures, dealing with closure and post-closure obligations and remedial measures in case of leakage[172]. Furthermore, the storage operator is bound to make a financial contribution (financial mechanism) to the competent national authority before the transfer of responsibility for the storage site to the latter[173]. However, it should be noted that the CCS Directive does not define the financial security principle

[163] Ibid., art. 6.1.
[164] Ibid., art. 10.
[165] WOERDMAN ET AL. (2021: 175).
[166] Directive 2009/31/EC, art. 13.
[167] Ibid., art. 15.
[168] Ibid., art. 11.3.
[169] Leakages are defined as any release of CO_2 from the storage complex. Ibid., art. 3.5.
[170] A significant irregularity is any irregularity in the injection or storage operations, implying the risk of leakage, environmental or health risks. Ibid., art. 3.17.
[171] Ibid., art. 16.
[172] Ibid., art. 19.
[173] Ibid., art. 20.

or the financial mechanism in quantitative terms, creating operational uncertainty for both the storage operator and the competent national authorities[174].

Concerning the liability related provisions, the CCS Directive in its artt. 16 and 17 defines three forms of liability. Firstly, the operator[175] is liable under the CCS Directive for corrective measures in the event of leakage and significant irregularities. In a similar vein, the operator is required by Directive 2004/35/CE (Environmental Liability Directive) to take preventative and remedial actions if there is an actual or imminent threat of environmental damage, so applying the principle of strict liability. Indeed, the operator can be deemed financially liable for the environmental damage caused by CO_2 storage activities[176]. In that circumstance the operator must take preventive and remedial measures[177]. Furthermore, any leakage of carbon dioxide emissions is required by the EU ETS Directive to be made up for by forfeiting the corresponding EU ETS credits, and this is referred to as liability for climate damage or climate liability. Indeed, after the 2009 amendment of the ETS Directive storage operators are required to give up on emissions allowances for any leaked GHG emissions, and in this specific case of CO_2. Currently, CO_2 geological storage, capture and transport are remarkably included in this category as per Annex I of the Directive 2009/29/EC[178]. This obligation to surrender emissions allowances in case of CO_2 leakages has been perceived by the industry as a significative financial burden related to climate liability. The compliance with this requirement constitutes a barrier to CCS deployment due to the uncertainty connected to the size of the compensation needed, caused by the unpredictability of the EU ETS allowances prices[179].

Then, the procedure "transfer of responsibility" is used to move these three categories of liability from the storage operator to the Member State's competent authority, as for the conditions envisaged by art. 18 of the CCS Directive. After that, the Member State bears long-term responsibility for remedial actions, environmental harm, and climate change resulting from leaks. A transfer

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[174] WOERDMAN ET AL. (2021: 180).
[175] The operator is defined as "any natural or legal, private or public person who operates or controls the storage site or to whom decisive economic power over the technical functioning of the storage site has been delegated according to national legislation". Directive 2009/31/EC, art. 3.10.
[176] Directive of the European Parliament and of the Council, 21 April 2004, 2004/35/CE, *on environmental liability with regard to the prevention and remedying of environmental damage*.
[177] Ibid., art. 5.1; Ibid., art. 6.1.
[178] Directive of the European Parliament and of the Council, 23 April 2009, 2009/29/EC, *amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community.*
[179] WOERDMAN ET AL. (2021 : 176).

of this kind may occur if all of the following conditions are satisfied: i) the CO_2 storage will be entirely and permanently confined; and ii) a minimum amount of time, to be decided by the competent authority, has passed. Unless the competent authority is persuaded that the requirement mentioned in item i) is met before the end of that term, this minimum duration cannot be shorter than 20 years. The other two conditions are that iii) the post-transfer financial responsibilities are fulfilled and that iv) the injection facilities are removed, and the storage site is shut[180].

However, it should be underlined that the transfer of responsibility does not involve civil liability, which is not regulated by the CCS Directive. Civil liability arises when CO_2 storage damages individuals or properties, for example causing earthquakes or underground movements. This type of liability, which is not covered by the CCS Directive, the Environmental Liability Directive or the EU ETS Directive is dealt only at national level and solely regulated by national law[181]. All things considered, the nature of permanent subterranean storage of CO_2 is long-term, which makes managing long-term responsibilities difficult. Legislators must balance the need to regulate all potential risks that could arise during CO_2 storage, such as potential leaks, warfare attacks on vital infrastructure, and unforeseen climate events, with the careful avoidance of imposing too many regulations that could impede the development of a technology that has not yet been widely adopted. This is because CO_2 will be confined in geological storage sites for a very long time, estimated at thousands of years[182]. However, even in case of the transfer of responsibility, the storage operator is still entitled to face post-closure costs, especially if there is a fault on its side (deficiency of data, concealment of relevant information, negligence, wilful deceit or failure to exercise due diligence). In these circumstances, the competent authority has to recover incurred costs from the former storage operator[183]. This is feasible since under art. 20 of the CCS Directive the storage operator has to make a financial contribution (financial mechanism) to the competent authority before the happening of the transfer of responsibility for the storage site[184].

However, from this overview it emerges a lack of clarity and of precision in the text of the CCS Directive especially concerning the provisions related to financial matters. For example, the just mentioned financial mechanism

[180] Directive 2009/31/EC, art. 18.
[181] Ibid., recital 34.
[182] FRATTINI ET AL. (2024: 5).
[183] Directive 2009/31/EC, art. 18.7.
[184] Ibid., art. 20.

should cover at least the anticipated costs of monitoring for 30 years[185], without quantitatively defining this amount and leaving a broad margin of discretion to Member States and storage operators. On the one hand, this can help in setting specific standards for each storage projects, diminishing unnecessary administrative burdens. On the other hand, it generates uncertainty raising transactional costs for CCS market players[186]. Furthermore, another weak point of this directive challenging the implementation of CCS at a large scale is the lack of a collective approach to storage site selection and development.

So, an individual national approach is favoured where Member States can select the area adequate for the CO_2 storage site, including the faculty for them to not allow CO_2 storage[187]. Indeed, the absence of a common EU approach in this sense hampers Member States with only little storage capacity to have their captured CO_2 stored. Lastly, the CCS Directive does not significantly encourage the establishment of solidarity mechanisms between Member States and does not favour any form of transboundary cooperation, dealing rudimentarily with these issues[188]. It can be argued that the CCS Directive neglects to address the establishment of CCUS hubs, networks, and clusters, which could potentially foster CCS, that should be carried out as a collaborative project to reduce expenses and improve deployment efficiency. To create these clusters, hubs, and networks, extra site selection requirements must be met, including the selection of multiple potential storage sites in reasonable proximity to each other and the establishment of a dominant party or third party to act as the sole permit holder to comply with the current CCS Directive. Similarly, regarding CCS hub, cluster, and network formation, a comprehensive regulatory framework may aim to guarantee a continuous supply of CO_2 if a partner emitter suspends collection operation. Using common transportation infrastructure, a CCS hub and cluster network connects several CO_2 emitters and/or multiple storage locations. When compared to individual initiatives, hub and cluster networks provide network users with several clear benefits. For many, the hub and cluster method lower risks and expenses. It also

[185] Ibid.
[186] Transactional costs refer to the costs of transacting through the market (e.g., search, information, contract, monitoring costs). MARNEFFE ET AL. (2019: 2084-2089).
[187] Directive 2009/31/EC, art. 4.1.
[188] The provisions of art. 22.2 and art. 24 only invite Member States respectively to consult each other in case of a cross-border dispute over transboundary access to a CO_2 storage or transport facility; and to cooperate in case of transboundary transport or storage complexes of CO_2. Ibid., art. 22.2; Ibid., art. 24.

makes it possible to capture CO_2 from small-scale industrial facilities for possible CCS projects[189].

Lastly, since the third implementation report of the CCS Directive (May 2019 - April 2023), the following changes have been reported by various Member States regarding their implementation of the Directive through national legislation. Iceland has allowed industrial-scale geological storage of CO_2 on its territory since 2021, after permitting exploration and research projects since 2015. Hungary has laid down detailed rules for geological structures suitable for storing carbon dioxide. Denmark has established legislation to open certain areas to continuous granting of permits for exploration and storage of CO_2, designated the national permitting authority, and enabled state participation in every storage permit. Greece has designated the competent authority and established permitting procedures for economic operators with existing rights for hydrocarbon exploration and production in relevant areas. France has specified and simplified the procedures for necessary environmental impact assessments in the context of exploration or storage permits. Bulgaria and Sweden have clarified the implementation of post-closure requirements set out in the Directive. Overall, geological storage of carbon dioxide is now allowed in all Member States, Iceland, and Norway, except in Germany, Estonia, Ireland, Cyprus, Latvia, Austria, Finland, Slovenia, and Lithuania, where geological storage has been prohibited since July 2020[190].

Considering the legal framework put in place by the CCS Directive and its implementation by Member States, the next section will analyse the most recent efforts by the European Commission to relaunch CO_2 emissions abatement through strategic technologies, and in particular through CCS.

2.2. European Commission's Efforts to Relaunch CO_2 Emissions Abatement

2.2.1. Commission's Communication on Europe's 2040 Climate Target: COM (2024) 63

[189] Report, Global CCS Institute, 2016, *Global Status of CCS Special Report. Understanding Industrial CCS Hubs and Clusters*.
[190] Report from the Commission to the European Parliament and the Council, 24 October 2023, COM 2023/657/EU, *on Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide.*

The European Commission made its assessment of the EU''s 2040 climate target public in February 2024. The Commission suggested a 90% reduction in the EU''s net GHG emissions by 2040 over 1990 levels[191]. The EU''s resolve to combat climate change is reaffirmed by the 2040 climate target, which will also direct our course after 2030 to guarantee that the EU achieves carbon neutrality by 2050. The centrepiece of the European Green Deal is the legally required carbon neutrality goal by 2050, which is outlined in the European Climate Law. In addition, the European Climate Law establishes an intermediate goal of lowering net greenhouse gas emissions from 1990 levels by at least 55% by 2030. Achieving Net Zero GHG emissions for the EU by 2050 entails reducing emissions, investing into green technology, and safeguarding the environment, involving every economic society and the European civil society at large[192].

The Communication 2024/63/EU set the ambitious 2040 target relying on estimates and projections accounting for GHG emissions in the EU in the period 2015-2050.

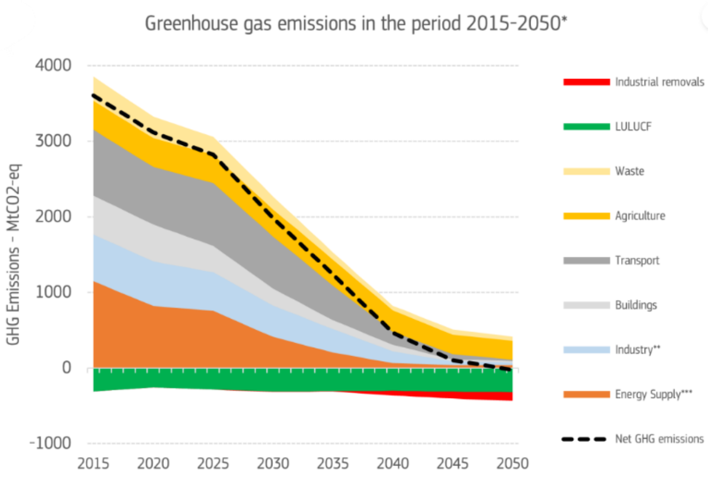

Figure 5: GHG emissions in the period 2015-2050[193].

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[191] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions, 6 February 2024, 2024/63/EU, *Securing our future. Europe's 2040 climate target and path to climate neutrality by 2050 building a sustainable, just and prosperous society.*

[192] Regulation of the European Parliament and of the Council, 30 June 2021, 2021/1119/EU, *establishing the framework for achieving climate neutrality.*

[193] Commission Staff Working Document, 6 February 2024, SWD/2024/63, *Impact Assessment*

This image is a multi-coloured, intricate line graph that shows the expected trends for different industries regarding GHG emissions. The graph's y-axis shows the GHG emissions in metric tons of CO_2 equivalent, while the x-axis shows time, running from 2015 to 2050. Land use, Land-Use Change and Forestry (LULUCF), Waste, Agriculture, Buildings, Transport, Industry, Energy Supply, and Net GHG emissions are among the sectors that are covered. Every section is symbolized by a line that is coloured differently. As time goes on, the graph shows a notable decrease in GHG emissions across several sectors, with some even achieving zero emissions. Noteworthy, BECCS-free industrial removals are excluded from the "Industry" line, while BECCS-free bioenergy with carbon capture and storage is excluded from the "Energy Supply" line. Therefore, this graph provides a thorough representation of the anticipated patterns in greenhouse gas emissions over a 35-year period for a variety of businesses. By 2040, reducing our net emissions by 90% will:

i) set us on the path to achieving climate neutrality by 2050 and constructing a safer and healthier future for Europeans; ii) make sure that resources invested today and in the future decades are compatible with the EU''s pathway to climate neutrality, preventing wasteful investments in the fossil fuel economy, in order to maintain stability for citizens, enterprises, and investors; iii) increase the competitiveness of European companies, generate steady, long-term employment, and provide the EU the ability to take the lead in creating the future clean technology markets and iv) enhance Europe's resilience and fortify its strategic independence[194].

To account for the whole range of potential net GHG emission levels, the European Commission's Impact Assessment examines mainly three scenarios for the ''2040 target''. Then, a thorough analysis of the actions required to achieve climate neutrality by 2050 are broken down by sector, presenting the three alternatives. The 2040 target could be set to cut emissions:

- by up to 80% (Option 1), in keeping with the ''linear'' trend of net GHG gas emissions between the years 2030 and 2050 mentioned in art. 8 of the European Climate Law[195];

Report Part 1, Accompanying the document Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions, Securing our future. Europe's 2040 climate target and path to climate neutrality by 2050 building a sustainable, just and prosperous society.

[194] Ibid. p. 23.

[195] Regulation 2021/1119/EU, art. 8.

- adopting one of the two choices that align with the spectrum of plausible scientific scenarios achieving the 1.5 °C temperature increase target set forth in the Paris Agreement:
    - reducing GHG emissions by at least 85% (Option 2) corresponding to a range of 85-90% reduction. Option 2 is identified as the baseline scenario, reflecting the total net GHG emissions that would be reached with a continuation of the current policy framework.
    - reducing GHG emissions by at least 90% (Option 3) corresponding to a range of 90-95% reduction.

Utilizing economic modelling research, three representative scenarios (S1, S2, S3) are used to quantitatively examine the target options. These scenarios all achieve climate neutrality by 2050, but at varying net greenhouse gas levels in 2040. These scenarios make it possible to evaluate how much GHG is reduced across industries and how much various technologies are used to this aim, such as carbon capture, to the various target levels by 2040. Every one of these scenarios line up with the three evaluated target options, i.e. target option 1, 2, and 3, in that order. They are employed in the process of selecting the favoured target option and comparing the effects of the three target alternatives evaluated.

- S1: this scenario primarily depends on Fit-for-55 energy trends[196] up until 2040, which enables it to produce a target in 2040 that represents the linear reduction path of net GHG emissions between 2030 and 2050. It makes no specific assumptions about mitigating non-CO_2 emissions above the existing framework's preset evolution. However, by 2040, every industry must significantly cut GHG emissions in considering achieving climate neutrality by 2050 and utilizing all available technologies.
- S2: it combines the energy trends reflected in S1 with additional carbon capture and e-fuel deployment, as well as significant reductions of GHG emissions in the land sector, including non-CO_2 emissions in the agriculture sector and carbon removals in the LULUCF sector, to reach a reduction of at least 85% of GHG emissions by 2040.
- S3: Building on S2, this scenario aims to achieve a reduction of at least 90% of the GHG emissions by 2040. It does this by assuming a fully developed carbon management industry by that time, with carbon capture

[196] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions, 14 July 2021, 2021/550/EU, *"Fit for 55": delivering the EU's 2030 Climate Target on the way to climate neutrality.*

providing significant carbon removals from all industrial process emissions and higher production and consumption of e-fuels than in S2 to further decarbonize the energy mix.

Figure 5 presented hereunder presents the paths for GHG emissions reduction until 2050, according to the three different scenarios presented above and corresponding each to a target option. In particular, the graph shows that the only option able to ensure a GHG emissions'' reduction of the 90% of the 1990 levels, is the target option 3 (which would permit to reduce GHG emissions between 90% and 95%)[197].

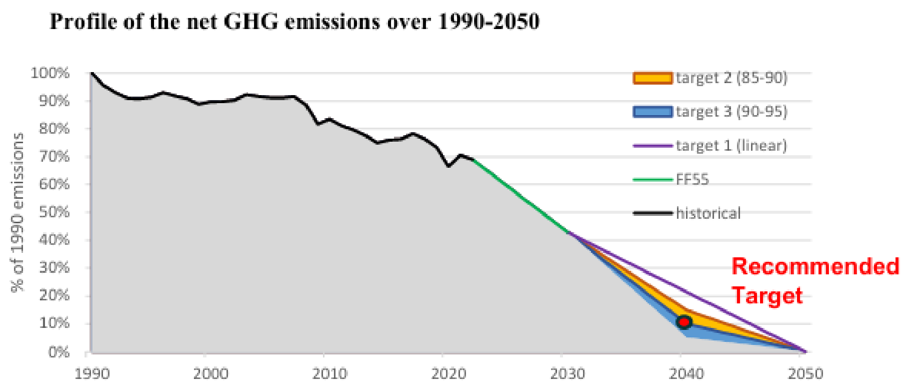

Figure 6: Profile of the net GHG emissions over 1990-2050[198].

With a larger decrease in net GHG emissions before 2040, option 3 is the most effective in getting the EU to climate neutrality by 2050. Therefore, it will suggest fewer additional measure to be taken after 2040, to achieve Net Zero emission by 2050. The target option 3 is anticipated to have the greatest influence on lowering global emissions and raising the likelihood of maintaining 1.5 °C of warming within reach to minimize the disruptions to all economies, including the possibility of reaching irreversible climate tipping points. This is because it encourages early action. Regarding the significance of novel technologies, there is a discernible distinction between the target options. Between 2031 and 2040, Option 3 has a quicker implementation of low-carbon technologies than Option 2, including electrolysis to produce hydrogen, carbon capture, and industrial carbon removals. The introduction of these technologies is mostly delayed by Option 1 until the final decade, 2041–2050. Compared to Options 1 and 2, Option 3 calls for larger yearly investment

[197] Commission Staff Working Document, SWD/2024/63, p. 28.
[198] Ibid.

requirements in 2031–2040 and relatively smaller investment requirements in 2041–2050. Innovative technologies, among which we find CCS, only very slightly alter GDP, the overall cost of the energy system, and export competitiveness worldwide, but target option 3 offers the most advantages in terms of energy independence and improved defence against fluctuations in the price of fossil fuels[199].

To decarbonize the energy system by 2040, all zero and low carbon energy solutions, such as geothermal and hydroelectric power, nuclear energy, CCS, CCU, CDR technologies, and all other present and upcoming Net-Zero energy technologies, are required. A deployment path for CCS is outlined in the Communication on Industrial Carbon Management, since this technology is deemed to be essential for hard-to-abate industries. Hard-to-abate industries will require adequate support to initiate a fair green transition and the same is true for small and medium enterprises (SMEs), which will require specialized assistance to comply with applicable EU laws and obtain funding for sustainable initiatives. If the transition is successful, the EU will be able to maintain its sustainable industrial competitiveness, enhancing a differentiate use of the energy mix to avoid any strategic dependence from third countries. To do so innovative technologies such as CCU/CCS, must be deployed easing permitting procedures and reducing the risks and uncertainties associated with offshore CO_2 storage. Therefore, the "2040 target" calls for the implementation of CCS at a large scale in Europe to ease the achievement of the target option 3, together with the Net-Zero goal by 2050. However, it should be noted that the although successful implementation at a large scale of CCS in Europe does not constitute an alternative to the necessary effort of the industrial sector to reduce drastically their emissions, so to be able to achieve decarbonization thanks to a more sustainable and differentiated use of the energy mix at current disposal, avoiding strategic dependencies from third countries and including CCS as a powerful tool to eliminate hard-to-abate industries' emissions.

2.2.2. Commission's Communication on EU's Industrial Carbon Management Strategy: COM (2024) 62

The array of methods used to remove CO_2 from the atmosphere and to collect, store, transport, and use CO_2 emissions from industrial and energy production facilities is known as industrial carbon management[200]. The three technology

[199] Ibid.
[200] The term "Industrial Carbon Management" was first defined by David W. Keith in the early

paths that industrial carbon management focuses on are: CCS, CCU and the removal of CO_2 from the atmosphere. The Strategy from the European Commission refers to twenty Member States that have already incorporated industrial carbon management strategies into their national energy and climate plans (NECPs). Additionally, Member States give CCS priority in generating electricity, particularly from biomass, and in the low-carbon hydrogen production. Moreover, the refining industry, garbage incineration, and thermal heat production are further uses for carbon capture that are represented as priorities for Member States[201]. The Industrial Carbon Management Strategy aims to create an enabling environment by addressing challenges such as building viable business cases, establishing a comprehensive regulatory framework, and providing incentives for private and public investment. Achieving the 2030 and 2040 targets will require significant scaling up of efforts and investments in industrial carbon management technologies across the EU. Indeed, the goals set are highly ambitious and involve the achievement of negative emissions by 2050 through the following steps: i) the capture and storage of 280 million tonnes of CO_2 by 2040 and 450 million tonnes by 2050, ii) the deployment of a CO_2 storage capacity of at least 50 million tonnes per year by 2030, along with the related transport infrastructure and iii) the using of captured CO_2 in synthetic products, chemicals or fuels production[202].

However, this European Commission's Communication must be red in the light of the already in force Net Zero Industry Act (NZIA) regulation, having immediately binding effects on the Member States. Indeed, the Act proposes a target for the EU to have available capacity to annually store 50 million tonnes of CO_2 by 2030, a key target that will drive the scale-up of CO2 storage infrastructure across the EU[203]. Significantly, the NZIA includes regulatory measures such as accelerated permitting procedures for CO_2 storage projects, streamlining the deployment of storage capacity to meet the 2030 target. This

2000s. In his 2001 paper "Industrial Carbon Management: A Review of International Approaches", Keith defined industrial carbon management as the linked processes of capturing the carbon content of fossil fuels while generating carbon-free energy products, such as electricity and hydrogen, and sequestering the resulting carbon dioxide away from the atmosphere. KEITH (2000).

[201] Member States have different priorities, Germany, Hungary, Lithuania, Portugal (CCS & CCU), Cyprus, Czechia, Denmark, Estonia, Greece, Spain, France, Croatia, Italy, Netherlands, Romania, Sweden, Slovenia, Slovakia (CCS), Finland, Luxembourg (CCU).

[202] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions, 6 February 2024, 2024/62/EU, *Towards an ambitious Industrial Carbon Management for the EU.*

[203] Regulation of the European Parliament and of the Council, 13 June 2024, 2024/1735/EU, *on establishing a framework of measures for strengthening Europe's net-zero technology manufacturing ecosystem,* art. 20.

regulatory acceleration is critical to ensuring timely progress towards the established CO_2 storage goals. Furthermore, the Act facilitates investments in CO_2 infrastructure hubs by enabling EU-wide CO_2 transport infrastructure interoperability rules[204]. These rules include minimum CO_2 quality standards to ensure the free flow of CO_2 across the EEA for storage. Remarkably, the importance of easing CO_2 transport, posing less burdensome obligations to operator is a key priority of the Industrial Carbon Management Strategy, which poses emphasis on the need to a closer cooperation with IMO to elaborate appropriate guidelines[205]. By establishing clear CO_2 storage targets, mandating investments from key industries, streamlining permitting, and enabling cross-border transport, the Net Zero Industry Act is poised to be a critical driver in scaling up CO_2 storage capacity in the EU to meet its climate goals.

Everything considered, achieving the NZIA goals, coherently with the framework set up in the Industrial Carbon Management Strategy, will require a comprehensive enabling framework with more ambitious and well-coordinated policies at the national level, strategic infrastructure planning at the EU level, and close cooperation between governments, industry, and other stakeholders. Having explored the legal framework regulating CCS at the international and European level, the analysis will move at the national level shedding light on the Italian case for CCS implementation. In particular, the goal of the next and conclusive chapter is to analyse the final updated version of the Italian National Energy and Climate Plan (NECP) and how much it has been influenced by the EU Industrial Carbon Management Strategy and by the so-called "2040 target". Lastly, the practical implications of the Italian CCS project in Ravenna will be analysed, providing an international outlook on the role of Italy in CCS implementation by means of an overview of the Mediterranean CCS Plan.

[204] Ibid., art. 22.
[205] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions, *Towards an ambitious Industrial Carbon Management for the EU*, p. 10.

Chapter III

CCS in the Italian National Energy and Climate Plan (NECP)

3.1. Explaining the Lack of a Clear Roadmap for CCS Implementation in the Italian NECP

Considering the long-term nature of the required adjustments, the EU attempted to look further forward after the Paris Agreement in December 2015. The EU adopted the Clean Energy Package for All Europeans package in 2019, which included binding energy and climate targets for 2030 along with a comprehensive reform of EU energy policy. Relevantly to the analysis here conducted the second chapter of the 'Clean energy for all Europeans' report confirms the nexus between technological innovation, economy's modernization and improved benefits for the public at large. Indeed, the shift to sustainable energy has several advantages beyond lowering GHG emissions. In addition to creating jobs and growth prospects, the massive investments needed for this economic revolution will also boost industrial competitiveness in Europe and promoting innovation and research. Meanwhile, more intelligent and greener energy will imply better health, a higher standard of living, and the freedom for people to adopt the most tailored energy mix for their consumption, ensuring a just and equitable transition. To this aim 180 billion euros were estimated to be dedicated to investments in strategic technologies among which there is CCS and to improve energy efficiency and increase the production and deployment of renewables[206].

To coordinate national efforts to these purposes, EU Member States created a revolutionary structure as part of this process: a plan detailing each nation's efforts to meet its climate targets for the next ten years, beginning in 2021 and named National Energy and Climate Plan (NECP), defined under the Regulation on the Governance of the Energy Union[207]. Remarkably this regulation complements Directive 2009/31/EC, highlighting the priority to foster CCS and CDR technologies in the context of the Energy Union and within NECPs[208]. However, in terms of efforts and relevance dedicated to CCS Member States' NECPs demonstrate a general low level of ambition and the lack of a strategy for this technology's deployment, not following European Commission's recommendations on NECP's content[209]. Indeed, already in 2022,

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[206] Report, European Commission, 2019, *Clean energy for all Europeans*.

[207] Regulation of the European Parliament and of the Council, 11 December 2018, 2018/1999/EU, *on the Governance of the Energy Union and Climate Action*.

[208] Ibid., recital 70.

[209] Report, Bellona Europa, 2024, *Carbon Capture and Storage in the Draft National Energy and Climate Plans. Bellona Europa's Assessment of the Draft NECPs' Inclusion of the European Commission's Recommendation on Carbon Capture and Storage.*

the European Commission advised Member States on incorporating into their updated NECPs the measures intended to allow their companies to permanently collect and store their inherent process emissions in geological storage sites. The European Commission underlined that to meet the climate-neutrality goal, the EU must attain negative emissions after 2050 and balance its residual GHG emissions throughout the EU by 2050, including removals from hard-to-abate sectors[210]. In light of the cruciality of CCS to these purposes, the European Commission specified that NECPs must provide detailed and specific strategies for the deployment of CCS. This includes establishing strong financial backing, fostering cross-border cooperation, and clearly understanding the climate benefits to guide informed policymaking. Indeed, effective planning, reporting, and regulatory support are critical to overcoming obstacles and ensuring the timely and successful development of CCS. The NECPs should not only recognize the importance of CCS but also clearly outline strategies for the deployment of capture, transport, and storage infrastructure. It's fundamental for these Plans to set precise targets for capturing CO_2 from industrial process emissions, distinctly separating them from emissions that can be reduced through other methods. Additionally, the Plans should identify the potential for CO_2 storage that needs to be developed, ensuring a comprehensive approach across the entire CCS value chain. This level of detail is essential for effective climate change mitigation and the successful implementation of CCS technologies.

As for its last version issued on the 1st of July 2024, the Italian NECP undeniably recognizes the importance of CCS as a climate change mitigation tool but fails to provide a detailed implementation plan to effectively deploy the technology in the country[211]. Indeed, the alignment with the NZIA results to be ambitious but is not followed by a coherent strategy[212]. Remarkably, the NZIA being an already into force regulation directly binds Member States and the generic reference in the Italian NECP to implement all the available technologies to mitigate climate change, among which there is CCS, is not sufficient and consequently not aligned with European Commission's indications[213].

[210] Commission Notice, 29 December 2022, 2022/C 495/02, *on the Guidance to Member States for the update of the 2021-2030 national energy and climate plans.*
[211] Regulation of the European Parliament and of the Council, 2018/1999/EU, art. 14.
[212] Regulation of the European Parliament and of the Council, 2024/1735/EU.
[213] Report, Italian Ministry of the Environment and Energy Security, 1st of July 2024, *Integrated National Plan for Energy and Climate.*

However, considering the date of entry into force of the NZIA being the 29th of June 2024, and the last version of the Italian NECP being released on the 1st of July alignment efforts to provide Italy with a more structured strategy for CCS implementation will happen in the incoming years, and this area should be object of further research to verify the compliance of the Italian NECP with NZIA's provisions. These drawbacks do not favour Italy's alignment with the most recent updated climate target set by the EU for Member States' efforts to reduce GHG emissions, in the framework of the Nationally Determined Contributions (NDCs) within the Paris Agreement. Indeed, the level of EU's ambition for Italian NDCs has significantly increased, if it is considered that Regulation 2018/42/EU determined a goal of a GHG emissions reduction of the 33% to be achieved by 2030 in comparison with 2005 national levels[214], while currently with the same timeline and baseline conditions Italy is expected to reduce its GHG emissions of the 43.7%[215]. In particular, Regulation 2023/857/EU, known also as the Effort Sharing Regulation (ESR), set an overall target of GHG emissions reduction for each Member State plus Norway and Iceland. Then freedom of means to achieve the goal is left to the single nations pursuing the principle of common but differentiated responsibilities. Furthermore, the decision to establish an overall target for each Member State in the ESR rather than specific targets for particular sectors is supported by economic reasoning. The rationale being that Member States ought to prudently make use of the resources they have, according to a cost benefit analysis previously carried out. So, the flexibility provided by ESR enables nations to choose the combination of market and non-market tools that are most appropriate for their financial, social and political situation[216].

Nevertheless, currently it must be stressed that the lack of such an implementation plan for CCS in the Italian NECP is due mainly to the concern of the Italian civil society and by the failure of previous attempts to launch CCS pilot projects in Italy. This said, the Italian NECP positively accounts for the regulatory framework allowing CCS and provides insights on the evolution of the regulatory landscape on the issue at the national level, interestingly covering dynamics related to the interplay between CCS EU law and its implementation

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[214] Regulation of the European Parliament and of the Council, 30 May 2018, 2018/842/EU, *on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement. and amending Regulation 525/2013/EU*.
[215] Regulation of the European Parliament and of the Council, 19 April 2023, 2023/857/EU, amending *Regulation 2018/842/EU on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement, and Regulation 2018/1999/EU.*
[216] HARRIS (2023: 2-3).

at the national level. Therefore, this section will proceed by analysing the Italian NECP shedding light on the reasons behind the lack of a detailed strategy to implement CCS in Italy and of specific financial measures in the National Recovery and Resilience Plan (NRRP).

The Italian NECP, apart from stressing the cruciality of CCS implementation, provides a status of the art linked to the current CCS situation in Italy. Indeed, moving from the non-well-defined advantage that the Italian territory has due to depleted reservoirs used as hydrocarbons deposit, the NECP illustrates the CO_2 storage potential divided into offshore and onshore hubs and accounting in total for 750 Mt between the Ravenna area and Sicily. Furthermore, also saline aquifers are indicated as suitable sites for CO_2 storage, but the reference studies used to defend this thesis are dated back to more than 10 years ago and should be duly updated since arguing that the storage potential of Italian saline aquifers is not yet fully known is not appropriate for the purposes of the NECP[217]. The only specific indication provided is the reference to the release in 2023 of a permit authorisation for an experimental project in the ENI hub of Casal Borsetti gas power plant, in proximity of Ravenna. It is expected to permanently store 25.000 tonnes of CO_2 per year, launching its industrial phase from 2027 raising its storage capacity to 4 Mt per year by 2030, although no exact indications are provided on how this CO_2 storage facility would achieve this goal defined as having a programmatic indicative nature and not that of a biding target neither by the NECP nor by Eni. In addition to this, the NECP provides a general overview on the sectors to be targeted by CCS and reveals the still ongoing uncertainty on the Italian market's demand for CCS[218]. Remarkably, from a financial viewpoint the NECP fails to address the resources needed to CCS deployment, only vaguely referring to the EU Innovation Fund as an instrument to sponsor high-level mature strategic technologies' development, among which there is CCS[219]. To shed light on the resources mobilised by Italy for the green transition and for investing in strategic technologies such as CCS it is useful to analyse the recently updated Italian NRRP divided into 6 missions with one specifically dedicated to these issues and denominated 'Green Revolution and Ecological Transition' (Mission n.

[217] Report, *Integrated National Plan for Energy and Climate,* p. 85.
[218] Ibid., pp. 86-89. An accurate description of Italian hard-to-abate industries emissions can be retrieved at pp. 86-89 of the Italian NECP. Interestingly, at the moment of writing a co-sponsored market survey by Eni and Snam on the potential market for the transport and storage of CO_2 at the Ravenna CCS site addressed to entities with missile sites on Italian territory, is now concluded and results are awaited to be published. The results of this survey may be of utmost importance to address the next key steps in launching a comprehensive Italian CCS strategy.
[219] Ibid., p. 180.

2)[220]. In the framework of this mission the component denominated M2C2 specifically targets the energetic transition and sustainable mobility and interestingly for the analysis conducted includes investment 7 and sub investment 1, ultimately aiming to the creation of a Public Fund supporting the development of the technologies aimed at reaching Net Zero. Specifically sub investment 1 dedicated 3.6 billion euros to these purposes, out of the 23.78 billion of euros dedicated to Mission 2, so arguably not a significant share of the resources estimated. Furthermore, within the resources allocated for sub investment 1 it is not specified which percentage would be dedicated to CCS' deployment, adding additional uncertainty on public support for market players[221].

This degree of uncertainty does not favour the successful large-scale deployment of CCS in Italy, but this is due also to the lack of updated scientific evidence fully supporting the adequacy of CO_2 selected storage sites; that maybe requires further investigation. Moreover, the absence of an assessment of historical CCS experience in Italy is hampering the future of this technology in the country. According to a 2021 report by WWF and ECCO[222], the creation of a detailed Italian CCS implementation strategy should rely on an analysis of previous attempts made in our country to develop this technology. Only after critically assessing these attempts and the failure behind them it could be possible to build a more certain CCS market sustained by increased public funding and a regulatory framework accounting for updated scientific evidence. Indeed, 2011 seemed to represent a promising start for CCS implementation, through a pilot project by Eni and Enel inaugurated in the south of Italy precising in Enel's coal central in the proximity of Brindisi. Of the 13 Mt of CO_2 emitted the CCS demonstrative facility was able to capture only 8.000 tonnes of CO_2, making so its contribution marginal. The CO_2 was then supposed to be liquefied and stored in Cortemaggiore a locality in the Emilia-Romagna region and significantly far from Brindisi, posing challenges related to CO_2 transportation[223]. The Brindisi-Cortemaggiore CCS pilot project was implemented for 3 years, after which tracks of its results were lost and

220 Law, 29 April 2024, 2024/56, *Conversion into law, with amendments, of Decree-Law No. 19 of 2 March 2024, containing additional urgent provisions for the implementation of the National Recovery and Resilience Plan (NRRP).*
221 Interinstitutional file, 2 May 2024, 2024/0103(NLE), *Annex to the Council's Decision of execution amending the implementing decision of July 13, 2021, on the approval of the assessment of the plan for the recovery and resilience of Italy.*
222 ECCO is an Italian, independent, nonprofit think tank dedicated to energy transition and climate change with a national, European and global focus.
223 Report, WWF and ECCO, 2021, *Ambiguità, rischi e illusioni della CCS-CCUS. Criticità connesse allo sviluppo in Italia di una tecnologia più rischiosa che utile.*

criticisms from the public were raised in particular due to the use of national and EU public funding to kickstart a project at the time judged as ineffective. This experiment sheds light on the necessity to develop a more transparent approach on the result of experimental pilot projects aimed at implementing innovative strategic technologies. Remarkably, the absence of information on the Brindisi-Cortemaggiore CCS pilot project constitutes a case of noncompliance with the art. 26 of the previously detailly analysed CCS directive[224]. This provision, indeed, requires Member States to make available to the public all the environmental information relating to the geological storage of CO_2[225]. Furthermore, this noncompliance is made more severe by the fact that art. 26 of the CCS Directive has been transposed into national law with a provision having the exact formulation and being already in force at the time. So, the interplay between the art. 26 of the CCS Directive and the art. 31 of the Legislative Decree 2011/162 confirms the gravity of this lack of information available to assess the effectiveness of the project and its economic viability.

More broadly, the lack of transparency and the difficulties in accessing information are highlighted to constitute not only a barrier to the deployment of an effective CCS strategy at the Italian national level, but also a sever obstacle in the formulation of the NECP through an effectively transparent deliberative process result of the involvement of stakeholders[226]. Arguably, this is particularly relevant in the case of CCS implementation since private companies such as Eni and Snam together with environmental think thanks and NGOs such as ECCO or WWF could really provide a unique source of expertise to boost the deliberative process providing unique insights and the necessary know-how to elaborate detailed NECP's provisions. Not allowing a transparent access to information and a just deliberative process in environmental and climate law matters constitute a violation of the obligations envisaged by the Aarhus Convention, the only legally binding instrument protecting environmental democracy[227]. Indeed, the respect of its provisions has been recognized to be of utmost importance by the European Commission in its document 'Guidance to Member States for the update of the 2021-2030 national energy and climate plans'. In its paragraph 3.2 the document underlines the necessity and obligation to involve stakeholders from the civil society in the deliberative process prior NECP drafting, and that they should be updated about every step taken

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[224] *Supra* (pp. 47-52).
[225] Directive 2009/31/EC, art. 26.
[226] GARELLI (2024: 235-236).
[227] Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters, 25 June 1998, 2161 UNTS 477, Aarhus Convention.

within the decision-making process, while at the same time granted access to the related information[228]. Being Italy and the EU parties to this Convention the respect of its artt. 6 and 7 becomes of utmost relevance, since noncompliance with these norms could be reported to the Aarhus Convention Compliance Committee (ACCC)[229].

From this perspective the Italian case results of particular interest since the interplay between national, EU and international law confirms the country's noncompliance with the obligation to guarantee involvement and environmental information during the decision-making process. Furthermore, the same obligations are binding also in the case of the conduct of an experimental project aiming at storing CO_2 as for Annex I of the Aarhus Convention[230]. Therefore, the lack of transparency and of detailed information pertaining firstly the process behind the starting and authorization of the Brindisi-Cortemaggiore CCS pilot project could be reported as a violation of the Aarhus Convention, taking into account also post-closure obligations related to the necessity to report on the status of the facility. In this regard, joint efforts by the Italian government and private stakeholders in ensuring transparency and effective participation by stakeholders should be seen as an opportunity to foster a more accountable strategy to pursue EU binding climate targets, not only in light of the NECP's drafting process, as for Regulation 2018/1999 EU, but also in consideration of the elaboration of a precise and accountable Italian CCS strategy. Indeed, the compliance with the Aarhus Convention arguably poses challenges not only in relation with the Energy Governance Regulation (Regulation 2018/1999/EU) and the subsequent NECP drafting process, but also in relation with the CCS Directive (Directive 2009/31/EC) and the relevant Italian legislation implementing it.

Despite what said above, it should be recalled that Italy is among the EU countries putting in place significant efforts to update its national regulatory framework related to CCS implementation and CO_2 geological storage and this clearly emerges from the Italian NECP[231]. Of particular interest is a preparatory study soon to be issued by the Italian Ministry of the Environment and of Energy Security in accordance with the Decree-Law 181/2023, then converted

[228] Commission Notice, 2022/C 495/02, para. 3.2. The European Commission analysis moves from artt. 9.4, 10 and 11 of Regulation 2018/1999 EU. Furthermore, in recitals 28 and 29 of the Regulation

[229] Further insights on the ACCC mode of work and on the evolution of its role can be found here. SAMVEL (2020).

[230] Aarhus Convention, Annex I para. 3b and para. 21.

[231] Report, *Integrated National Plan for Energy and Climate,* pp. 254-256.

into law with amendments by Law 2/2024. The preparatory study will *inter alia*: i) review of the existing legislation relating to the CCS supply chain, (ii) develop technical and economic regulation schemes for CO_2 transport and storage services, (iii) draw up technical rules for the design, construction, testing, operation and surveillance of CO_2 transport networks, (iv) define the arrangements for the remuneration of the various stages of the CCS supply chain. Hopefully this study will positively contribute to fostering R&I on CCS supply chain leading to more certainty for market players and increased public funding, also stimulated by a comprehensive risk assessment on which to base the further implementation and development of Italian CCS law, so to align it with EU's goal and ultimately pointing at the achievement of Net Zero by 2050.

It can be affirmed that a solid and certain regulatory framework is a precondition for easing CCS deployment at a large scale, but in the bigger picture of the Italian NECP a comprehensive strategy to obtain this goal remains absent[232]. Lastly, it can be argued that the lack of a comprehensive and effective strategy is due to a high level of uncertainty concerning CCS implementation in Italy which led to the approximative allocation of funding without detailing the destination of use for the resources in an adequate timeline aiming to achieve Net Zero by 2050 through strategic technologies. A long-term view on the Italian contribution to CCS deployment at a large scale in Europe appears to be lacking, together with realistic hypothesis on those scenarios, relying only on vague indications and on not updated studies. Having analysed the status of the art in relation with the Italian NECP and the failure in accountability for the previous attempts at CCS implementation, the next section moves on to provide an overview of the transnational efforts to relaunch CCS in Italy and in the Mediterranean basin.

3.2. Ravenna CCS: a Renewed Offshore Carbon-Storage Project

Moving from the experience of the joint CCS pilot project of Brindisi-Cortemaggiore by Eni and Enel, the time has come for Italy to relaunch investments in such a strategic technology. This new initiative is a joint venture by

[232] The most recent measure adopted up to date is Law, 2 February 2024, 2024/11, Conversion *into law, with amendments, of Decree-Law No. 181 of December 9, 2023, on urgent provisions for the energy security of the country, the promotion of the use of renewable energy sources, support for energy-intensive businesses, and on reconstruction in the territories affected by the. exceptional flood events that occurred on or after May 1, 2023.*

Eni and Snam and at completed deployment aims to absorb 90% of the CO_2 emissions of Ravennna's industrial district[233]. On the 19th of December 2022 at the time of signing the agreement launching agreement, both Claudio Descalzi, Eni's CEO, and Stefano Venier, Snam's CEO underlined how much CCS is currently crucial to combine decarbonization with the achievement of energy security and of industrial competitiveness, especially for the hard-to-abate industries. Furthermore, also in that occasion attention was given to CCS relevance in the fight against climate change, as recognised by both the IEA and the IPCC[234].

Leveraging the large capacity of the depleted gas fields in the Adriatic, the Ravenna hub will operate according to different phases. Indeed, the project includes an initial phase, set to begin in 2024, with the goal of capturing 25.000 tons of CO_2 from Eni's natural gas treatment plant in Casalborsetti, a locality close to Ravenna. Once captured, the CO_2 will be redirected to the Porto Corsini Mare Ovest platform and then injected into the namesake depleted gas field in the Ravenna offshore area. In the industrial phase, starting in 2027, the storage of 4 Mt of CO_2 is planned to contribute to the decarbonization of the industries of the hard-to-abate sectors from Ravenna's industrial district. Then, from 2030 onwards, the large capacity of the fields will allow the capacity to be increased to 16 million or more tons per year, depending on market demand. The functioning of the CCS plants above depicted, is illustrated in the figure hereunder to provide a visual representation of such a complex technology.

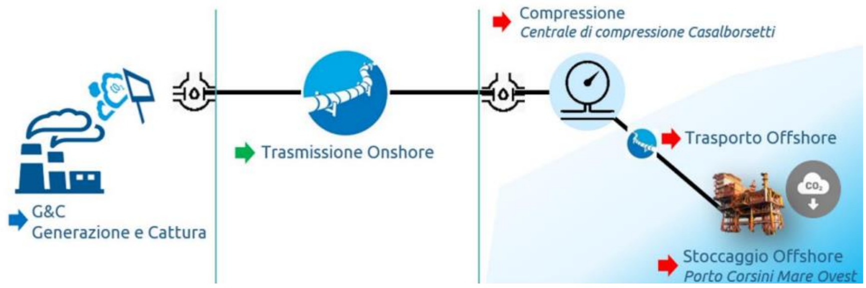

Figure 6: Industrial functioning of the CCS Ravenna Hub, from Capture, Transport

[233] A joint venture is a contract by which two or more enterprises agree to collaborate for the purpose of achieving a specific purpose or the execution of a project. The enterprises remain legally and financially independent, but they join forces and resources in a given area to carry out specific joint projects and achieve their intended goals. Enterprises cooperate only on joint projects, not on other autonomous activities, for which each remains responsible for itself.
[234] *Supra* (pp. 7-9).

and Offshore Storage of CO_2 in the facility of Porto Corsini Mare Ovest[235].

The timing of this initiative is crucial since CCS is enjoying a unique momentum with an international rediscovered motivation to foster this technology's deployment, as demonstrated by its relevance being recognised in particular by EU's unique efforts in fostering its large-scale implementation[236]. This section, therefore, in the light of this favourable context to CCS deployment will provide insights on the CCS Ravenna hub providing a critical assessment of it, considering the previous attempt by Eni and Enel to implement CCS in Italy in 2011. After one decade, significant evolutions of CCS technology at a global level have been taking place, and more specifically Eni and Snam are currently operators of CCS facilities in Europe and this will only facilitate positive externalities linked to know-how sharing that could only enrich and foster the functioning of the CCS Ravenna hub, as a leverage for Italian industrial competitiveness through the relaunch of the industrial district of the Po valley[237].

A key factor in promoting the development of new CCS projects is the emergence of the 'CCS Hub' concept. Historically, storage projects were vertically integrated, with a capture facility linked to a dedicated transportation and storage system. This setup required large-scale projects to be economically viable, which were not easily achievable. Recently, however, there has been a shift towards decoupling the emissions capture part from the transportation and storage infrastructure, which can now be shared by multiple capture facilities and various industrial entities. This approach allows even smaller capture projects to benefit from economies of scale, making them competitive. The concept of clusters in CCS leverages the fact that many emissions-intensive facilities, both industrial and power-related, are often concentrated in specific

[235] Report, Eni and Snam, 2022, *Eni e Snam formano una JV per il primo progetto di CCS in Italia*, available online.
[236] *Supra* (pp. 52-59).
[237] In this regard, to mention well-developed CCS projects, Eni is a partner in Norway's Sleipner project: the first CCS project in Europe and the first in the world dedicated exclusively to permanent geological storage. Operational since 1996, it has already injected over 20 million tons of carbon dioxide into a deep saline formation in the North Sea, establishing itself as an example of the technical and industrial feasibility of CCS. More detailed technical information asserting the technical relevance of the Sleipner project as a successful case study for CCS can be retrieved here. FURRE ET AL. (2024).

geographical areas. These clusters are typically located near energy sources, power plants, or ports. This geographical proximity allows CO_2 emitters in close vicinity to collaborate and create a ‘capture cluster’, which is then connected to a large-scale CO_2 storage site via shared infrastructure that is strategically ‘oversized’. In this context, ‘oversized’ infrastructure refers to facilities that are larger than necessary for a single user but appropriately scaled to meet the needs of multiple users. By sharing infrastructure such as pipelines and compression stations, the overall costs can be reduced on a per-user basis. This is because the expenses are shared among multiple users, or incurred only once, rather than repeatedly for each individual project.

The theoretical definition of CCS Hub fits the case of the Ravenna facility since it represents a unique cluster composed of plants from the chemical and petrochemical sectors, from the thermoelectrical sector, from the cement sector together with steel and agribusiness industries. Considering that CO_2 collection hubs will form a connective element among a constellation of capture sources, volumes of captured CO_2 will vary considerably depending on each individual emissions source within the cluster. Of economic relevance is the fact that collection and storage hubs provide point-to-point transportation for compressed CO_2, thereby reducing the cost of transport infrastructure between the individual point source emitters and individual points of injection into geological storage.

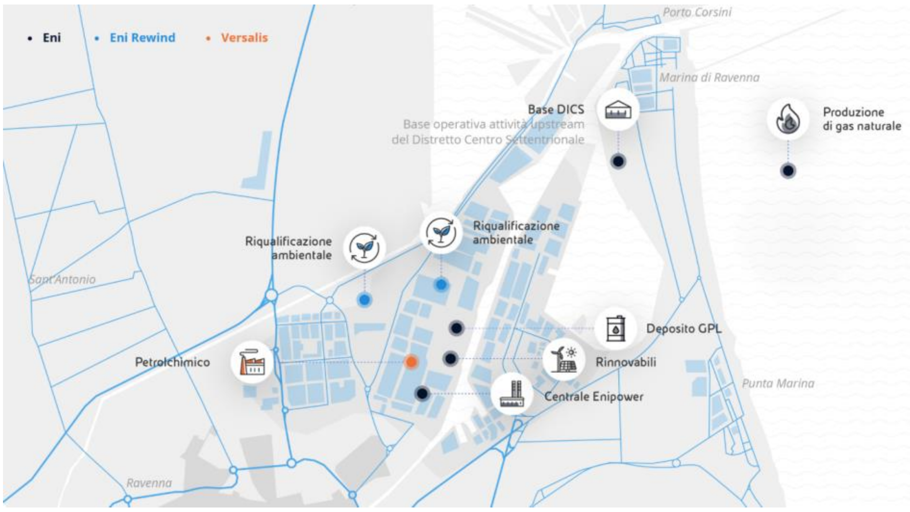

Figure 7: The presence of Eni in the Ravenna industrial district[238].

[238] Report, Ravenna CCS, *Progetto Ravenna CCS – Vantaggi per il territorio – Il rilancio del distretto ravennate*, available online.

A second point to be remarked, concerns the interplay between the more favourable regulatory landscape at the EU level and the increased EU public funds available for investments for strategic technologies and for CCS. Indeed, undoubtedly the CCS Ravenna Hub in Italy will benefit from the establishment of the Net-Zero Europe Platform as for the entered into force NZIA. This platform aims to monitor the implementation of the NZIA and of projects aiming to implement strategic decarbonization technologies providing guidance and support related to access to funding opportunities at the EU level[239]. This form of top-down strategic monitoring arguably constitutes an advantage for the CCS Ravenna Hub that would benefit of structure ensuring supranational support, something that lacked in such a structured form in the case of the 2011 Brindisi-Cortemaggiore CCS plant.

Furthermore, section III of the NZIA is dedicated to defining and regulating Net-Zero strategic projects, as means to foster decarbonization as a key priority for Member States through EU's support. In particular, art. 13 of the NZIA recalls that by the 1st of March 2025 the European Commission will adopt an implementing act to further specify the criteria defined in art. 13, so this document will be of particular relevance to delineate a bigger picture in support of the Ravenna CCS Hub. However, art. 13.3 already envisages that CO_2 capture and storage process together with their facilities for CO_2 transport can be awarded the status of Net-Zero strategic projects[240]. This condition guarantees priority status by Member States to those projects in the issue of storage permits and it is granted through an application provision defined by NZIA's art. 14[241]. Interestingly the launch of the application process for CCS projects to become Net-Zero strategic projects is foreseen to happen later this year[242]. The participation of the Ravenna CCS Hub to this call would be of strategic importance to foster the plants' deployment, and the application process will also be eased by the Ravenna CCS Hub PCI status acquired in 2023[243]. Among the related benefits enlisted in artt. 15, 16 and 19 of the NZIA it is interesting to recall the priority status at national level for all administrative processes, as well as for the permit-granting process, including for environmental assessments and spatial planning.

Lastly, another aspect of relevance is the PCI status acquired by the Ravenna

[239] Regulation of the European Parliament and of the Council, 2024/1735/EU, art. 38 and art. 19.
[240] Ibid., art. 13.
[241] Ibid., art. 14.
[242] Report, European Commission, 2024, *Strategic projects under the NZIA*, available online.
[243] For a definition of PCI status see *supra* (pp. 20-21).

CCS Hub in 2023[244], making it crucial for the development of a high-tech global value chain in the decarbonization industry. Indeed, on the 28th of November 2023, CALLISTO's integrated CCS project (Carbon Liquefaction transportation and Storage) was admitted to the European list of PCIs and its link with the Ravenna CCS Hub will generate positive externalities[245]. The CALLISTO project is part of the wider scope of the Italian Ravenna CCS project, which aims to provide large-scale open access infrastructure by offering industries and power plants located in both Italy and South Europe with CO_2 emissions that are difficult to reduce through a timely and economic decarbonisation solution. In this project, Italy is the country receiving CO_2 emissions from other countries, becoming the pivot of the sector through its geological storage site in the Adriatic Sea[246]. So, the admission to the PCI projects list will make the Ravenna CCS Hub eligible for funding from the Connecting Europe Facility Fund (CEF), which is intended to provide non-reimbursable funding to support research and development of infrastructure for the receipt, transportation, and storage of CO_2[247]. Notably, the Ravenna CCS Hub and the CALLISTO project must be analysed in the wider framework of the transnational cooperation between Italy, France and Greece establishing the Mediterranean CCS Plan in light of the Trans-European Networks for Energy Regulation (Regulation 2022/869/EU).

This section provided evidence for a renewed interest in CCS both at the Italian national level and at the international level. Indeed, the Ravenna CCS Hub is benefitting of a unique momentum for CCS' deployment, with definitely the most favourable context in Europe for technological innovation. Although the Italian NECP does not provide a detailed strategy for CCS implementation national efforts in this direction can be perceived and will hopefully boost the Ravenna CCS Hub as a transnational critical infrastructure for decarbonisation. Factors such as the presence of increased public resources in connection with EU funds, transnational cooperation and increased expertise and know-

[244] To ensure climate change mitigation, namely meeting the Union's 2030 energy and climate targets and its climate neutrality objective by 2050 at the latest, PCIs, key energy infrastructure projects, are essential to finishing the European internal energy market. They also ensure interconnections, energy security, market and system integration, competition that benefits all Member States, and affordability of energy prices. Commission Delegated Regulation, 28 November 2023, C (2023) 7930, *amending Regulation 2022/869/EU of the European Parliament and of the Council as regards the Union list of projects of common interest and projects of mutual interest.*
[245] Report, Eni, 2023, *Eni: Ravenna CCS Project joins European List of Projects of Common Interest*, available online.
[246] Report, *Integrated National Plan for Energy and Climate*, p. 49.
[247] Report, Global CCS Institute, 2024, *From Proposals to Reality: How EU Funds Can Help Jump-Start CCS Projects*, available online.

how would improve the chances of succeeding of the Ravenna CCS Hub, if compared with the critical experience of the 2011 Brindisi-Cortemaggiore CCS project. Furthermore, the incoming publication of the Snam's market survey on CCS demand in Italy and of the preparatory study on CCS supply chain by the Italian Ministry of Environment and of Energy Security will be crucial in assessing the chances of succeeding of the Ravenna CCS Hub, which already undeniably has the potential to boost decarbonization and to relaunch the industrial competitiveness of an important industrial district in the Adriatic Sea. Lastly, the next and conclusive section of this chapter will provide the implications related to one of those aspect benefiting the Ravenna CCS Hub, namely its involvement in the Mediterranean CCS Plan as a form of transnational cooperation.

3.3. A Transnational Approach to CCS: an Overview of the Mediterranean CCS Plan

The presentation in March 2023 of the Mediterranean CCS Plan represents a milestone in transnational cooperation for CCS deployment in the Mediterranean basin, involving Italy, France and Greece. In this regard, the Mediterranean CCS Plan aims at easing the cooperation to foster CCS large-scale deployment in the Mediterranean basin and it does not impose further burdens on the signatories and does not replace national CCS policies and strategies. On the contrary, it aims to support the application of the CALLISTO Mediterranean CO_2 Network, Prinos CO_2 storage project and Augusta CO_2 project, in accordance with the provisions of the TEN-E Regulation by providing a framework for discussions and cooperation between its signatories[248]. Italy enjoys a dual involvement in the Plan since it is both an exporter and an importer of CO_2. In particular, in the context of the PCI CALLISTO project Italy is the recipient of CO_2 emissions from other nations, acting as the project's core in the Adriatic Sea serving as a geological storage location. The primary plan of the candidate PCI CALLISTO project entails the collection and transportation of CO_2 from emitters in Italy and France, both onshore and offshore, via new or existing onshore pipelines. The CO_2 is then shipped to relevant hubs for CO_2 liquefaction and regasification, which are situated in Italy and France, before being stored in the Ravenna CCS Hub. With an anticipated start date of 2027, this project is being led by Air Liquide[249] and supported by

[248] Report, *Integrated National Plan for Energy and Climate,* p. 48.
[249] Air Liquide is a leading global provider of gases, technology, and services for business and healthcare is the French company.

eighteen firms, including Snam and Eni, the Ravenna CCS Hub's operators[250].

On the other hand, in Prinos CO_2 storage project, Italy is part of the process as an emitter country, as the storage of CO_2 is planned at the Prinos storage site in Greece. Energean[251]'s Prinos CO_2 Storage project, situated near Kavala in Northeast Greece, aims to support local and regional decarbonization efforts by storing captured CO_2 from various industrial sources. With an exploration permit secured in September 2022 and subsequent studies confirming the field's capacity to handle 1 million tons of CO_2 per annum in its first phase, the project is poised to expand to higher injection rates[252].

However, in the context of the analysis conducted it is of particular interest the reference to the application of the London Protocol in the context of the Mediterranean Plan within the Italian NECP, since it is recognised as an overarching legal framework at the international law level superseding relevant EU law and national law[253]. Referring to the London Protocol in this context is appropriate since it is the main legal instrument regulating CO_2 transport and allowing offshore CO_2 storage, but the status of the London Protocol consideration has not been taken into account. Indeed, it is important to recall that neither the EU nor Greece have ratified the London Protocol, with Greece only being a party of the less advanced London Convention. As argued, within the Prinos CO_2 project Greece is characterized as an importer of CO_2 which could circumvent the application of the London Protocol since it applies to CO_2 export and exporters. In this analysis, the degree of complexity is augmented by the fact that the London Protocol does not provide a definition of "export", but as previously argued CO_2 transport is allowed for CCS purposes when the CO_2 stream comply determined conditions[254]. The scenario that would arise from the Prinos CO_2 Project, operating in the framework of the Mediterranean CCS Plan, is the CO_2 transportation from Italy being a party of the London Protocol to Greece, which instead did not ratify it in the same way as the EU did not.

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[250] Report, Snam, 2023, *Snam: SoutH2 Corridor and Callisto Mediterranean CO_2 Network enter the 6th List of EU Projects of Common Interest (PCI), available online.*
[251] Established in 2007, Energean is an Exploration & Production (E&P) company with operations across the Mediterranean and UK North Sea. Energean has grown to become the leading independent, gas-focused E&P company in the Greater Mediterranean region. The company explores and invests in new ideas, concepts and solutions to produce and develop energy efficiently, at low cost and with a low carbon footprint.
[252] Report, Energean, 2024, *Prinos CO_2*, available online.
[253] Report, *Integrated National Plan for Energy and Climate*, p. 49.
[254] *Supra* (pp. 35-39).

Nevertheless, this circumstance was envisioned at the time of the 2019 Resolution by the London Protocol contracting parties allowing for the temporary application of art. 6 amendment consenting CO_2 transport for CCS purposes in submerged sea formations[255]. Indeed, this *ad interim* resolution also supports CO_2 export for offshore storage to non-contracting parties, as long as minimal provisions equivalent to those of the London Protocol are followed, including issue of permits and protection and preservation of the marine environment. So, in this foreseen case within the framework of the Mediterranean CCS Plan the CO_2 exporter contracting party (Italy) is responsible for compliance with the London Protocol and must establish an agreement with the non-contracting party importer (Greece) that, at a minimum, should provide the same protection of the Protocol. Stipulating such an agreement would be costly in terms of negotiation efforts due to the high degree of technicality involved in CO_2 transportation's regulations[256]. Furthermore, it should be investigated if Greece would be willing to stipulate such an agreement *de facto* binding itself to respect the London Protocol which did not ratify in the first place. Widening the scope of the analysis, it is also to be considered that to respect international law Greece is bound to sign a different agreement with every CO_2 exporter that has ratified the London Protocol, so multiplying technical binding agreements with sensitively high negotiation costs. This scenario appears to have been insufficiently investigated under the judicial literature and further research should be conducted to investigate the implications of this type of agreement. In particular, if they would constitute a legal barrier to strategic technologies implementation, such as the case described involving Greece and Italy.

In addition to this, the case of the Greek Prinos CO_2 project operated by Energean is of particular interest since it notably involves the EU acquis on CCS law and on CO_2 transport. Already in 2022, the European Commission highlighted a substantial overlap between the scope of the London Protocol and the EU CCS Directive and the relevant EU law acquis, arguing in favour of the possibility for EU's Member States to circumvent the obligation to sign separate agreements to regulate CO_2 exports, whether they are parties to the London Protocol or not. In particular, a notable degree of conformity between the London Protocol's requirements and the existing legal framework in the

[255] Resolution IMO LP.5(14), LC 41/17/Add.1, 29 October 2019.

[256] As discussed in the previous chapter, CO_2 transport is a key component of CCS' supply chain. Due to the numerous and diverse implications of this step an analysis of the main concerns has been provided, in particular in relation to environmental risks and operators' liability. *Supra* (pp. 28-29).

EEA has been underscored with respect to the capture, safe geological storage, and cross-border transportation of carbon dioxide among EU Member States and EEA nations[257]. So, the European Commission legal interpretation consists in an *ad hoc* status for EEA countries, already bound by relevant provisions aligned with the scope of the London Protocol[258]. However, this interpretation would be problematic because it would constitute a breach of international law for those EEA and EU countries that instead ratified the London Protocol and must comply with the obligations to sign relevant agreements with parties or non-parties to the Protocol to allow CO_2 exports as for the amended art. 6 of the Protocol, provisionally applying since 2019. This interpretation remains interesting since it confirms the relevance of the London Protocol as the most advanced legal instrument allowing CO_2 storage and transport at the international law level, even though the EU at the moment has not ratified it.

Lastly, it is important to recall that no advancement in international law has been undertaken, and Parties of the London Protocol remains bound to comply with its relevant provisions[259]. This would imply a rising number of agreements signing between parties and non-parties of the London Protocol to allow CO_2 export, as it will be the case to allow the Prinos CO_2 Project to consent CO_2 transboundary export between Italy and Greece. It is important to highlight that as currently envisaged the first operational phase of this project would allow it to receive CO_2 in a compressed form by the end of 2025, and in a liquefied form by mid-2027, although an agreement between Italy and Greece is currently lacking. This process could be eased by considering as a model the MoU signed by Denmark and Belgium in 2023 to allow CO_2 export, taking into account national specificities of Greece when applying the technical criteria required by the London Protocol[260].

To conclude, the analysis of the Italian NECP reveals a critical need for a comprehensive roadmap for CCS implementation, particularly in light of Italy's ambitious GHG reduction targets. While the NECP acknowledges the role of CCS as a vital tool for climate change mitigation, it falls short in

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[257] In particular reference is made to Directive 2009/31/EC (CCS Directive), to Directive 2009/29/EC (amended ETS Directive) and the EEA Treaty.
[258] Commission services analysis paper for the Information Exchange Group (IEG) under Directive 2009/31/EC, *The EU legal framework for cross border CO_2 transport and storage in the context of the requirements of the London Protocol.* See *supra* (pp. 38-39).
[259] ARLOTA ET AL. (2024).
[260] Earlier reference to the 2023 MoU between Denmark and Belgium has been made in the second chapter, as a first-of-a-kind leading agreement in the field of allowing CO_2 export in the framework of the London Protocol. *Supra* (p. 39).

providing a detailed strategy for its deployment. The recent updates to the NECP, particularly following the introduction of NZIA, highlight an urgent requirement for Italy to align its strategies with EU's targets. Despite recognizing the potential of CCS, the Italian NECP lacks specific targets and financial commitments, which are essential for fostering investment and public confidence in this technology. The historical context of the failed pilot project of Brindisi-Cortemaggiore initiative has contributed to public scepticism and a cautious approach towards CCS, further complicating its acceptance and implementation. However, the new Ravenna CCS project, set to capture and store significant CO_2 emissions from the industrial sector, represents a promising shift towards revitalizing CCS efforts in Italy. As this project progresses, it will be crucial for the Italian government to ensure transparency, engage stakeholders, and provide a clear regulatory framework that supports the development of CCS technologies. The forthcoming preparatory study by the Ministry of the Environment and Energy Security is expected to address existing legislative gaps and outline a more structured approach to CCS, which could ultimately facilitate Italy's compliance with EU climate targets and contribute to a sustainable energy future. Thus, while challenges remain, the potential for CCS in Italy is significant, and a strategic commitment to its development is essential for achieving long-term climate goals, also in virtue of the transnational approach of the Mediterranean CCS Plan. Indeed, further research should aim to investigate if uniformities to the legal framework put in place by the London Protocol would be beneficial and if the lack of ratification of the London Protocol could severely hamper CCS transnational projects' development in particular in the Mediterranean basin.

Conclusion

The year 2024 has emerged as a transformative period for CCS, marked by heightened international interest and significant developments. Italy, in particular, has embarked on an ambitious journey to advance CCS as a key component in its decarbonization strategy, focusing on the Ravenna industrial district, which hosts challenging hard-to-abate industries within the petrochemical sector. The recent announcement by Eni and Snam on September 3rd, 2024, regarding the initiation of CO_2 injection activities for Phase 1 of the Ravenna CCS project underscores Italy's renewed commitment and positions it prominently on the international CCS landscape.

This thesis has critically examined the intersection of CCS technology and legal frameworks, highlighting the crucial need for a more robust and clear legal structure to facilitate the successful deployment of CCS projects. The analysis demonstrates that both international and EU legal frameworks are currently insufficiently equipped to address the complexities associated with CCS, particularly with regard to transnational projects. This legal uncertainty hampers the broader adoption and implementation of CCS technology, a concern that is especially pertinent in the Mediterranean region.

One of the primary challenges identified is the lack of a comprehensive international liability regime for CCS operations. The potential risks associated with CCS, such as CO_2 leakage during transportation and storage, are significant and require a well-defined legal framework for state responsibility. Currently, the international legal instruments addressing these issues are inadequate, leading to a gap in liability coverage and regulatory certainty. This shortfall is exacerbated by the absence of ratification of the London Protocol by Greece, which could impede the progress of the Prinos CO_2 project operated by Energean. The need for a clearer legal framework is crucial to instil confidence among stakeholders and foster investment in CCS technologies.

Furthermore, the thesis has highlighted the impact of regulatory gaps and the lack of a unified approach within the EU. The CCS Directive, while comprehensive in certain aspects, still leaves significant room for uncertainty and variability in its implementation across Member States. The high degree of autonomy granted to individual states, coupled with the long-term nature of CO_2 storage risks, contributes to a regulatory environment that lacks cohesion and clarity. This situation creates a vicious cycle of uncertainty, hindering the large-scale deployment of CCS and stifling technological innovation.

Despite these challenges, 2024 offers a unique opportunity for CCS technology, driven by the European Commission's renewed focus on climate goals through its communications on the "2040 target" and Industrial Carbon Management. These communications emphasize the importance of transnational cooperation in deploying CCS technology and have been embraced by several EU Member States. Italy's renewed CCS efforts, particularly the Ravenna CCS Hub, are a testament to the potential of CCS as a strategic technology for achieving EU's decarbonization objectives.

However, the analysis has also revealed several areas requiring improvement. The Ravenna CCS project and other similar initiatives would benefit from enhanced transparency and a more detailed and accessible roadmap. The current lack of transparency, particularly in relation to the Brindisi-Cortemaggiore project and the drafting of Italy's NECP, raises concerns about potential violations of the CCS Directive and the Aarhus Convention, which mandate public involvement and information accessibility.

In conclusion, the future of CCS technology hampers the development of a supportive and comprehensive legal framework. Both international and EU legal instruments must evolve to address the regulatory gaps and uncertainties that currently impede the large-scale deployment of CCS. The ongoing efforts, such as Italy's Ravenna CCS project and the broader CCS Mediterranean Plan, are critical in advancing CCS technology and achieving global and European climate targets. Addressing the identified legal and regulatory challenges will be essential to realizing the full potential of CCS as a pivotal technology in mitigating climate change and transitioning towards a more sustainable future.

Abstract

The year 2024 and particularly the last months represented a unique momentum in the increased interest at the international level for CCS. In this timeframe Italy is currently launching its renewed attempt to implement CCS and to contribute to the decarbonization of the Ravenna's industrial district, comprising hard-to-abate industries from the petrochemical sector. Indeed, Eni and Snam announced on the 3rd of September the start of CO_2 injection activities relating to Phase 1 of Ravenna CCS. Furthermore, the Italian context projects itself as promising on the international panorama for CCS

It can be argued that the multidisciplinary analysis conducted shed light on the necessity to adopt a more certain legal framework for CCS law, both at the international and EU law levels, so to favour the prosperous deployment of transnational CCS projects and the deployment of this technology at a large scale in Europe. Furthermore, an invite is made to investigate how legal uncertainty and the lack of ratification of the London Protocol could hamper the deployment of transnational CCS projects constituting a legal and commercial barrier. At the moment, the case of the CCS Mediterranean Plan is to be kept under scrutiny since the lack of ratification of the London Protocol by Greece could hamper, or slower, the deployment of the Prinos CO_2 project operated in Greece by Energean. Indeed, at the time of writing a MoU between Italy and Greece necessary to comply with the London Protocol and to not breach international law has not been signed. So, when bearing in mind strategic technologies and their evolution the international and EU legal frameworks should be seen as starting points regulating the deployment of strategic transnational projects and also as powerful enablers of technological innovation through the degree of legal certainty provided to stakeholders.

This thesis started by presenting CCS as a first-of-its-kind technology for decarbonization, which relevance has been acknowledged at the international level by the IPCC and it is currently object of a relaunched interest at the EU level, namely for achieving the "2040 target" of a net reduction GHG emissions compared to 1990 levels. However, CCS is only one of the technologies currently being deployed to decarbonize industrial production and it should be seen as part of a wider and more complex energy mix to be used to achieve by 2050. Indeed, technologies such as DACCS and BECCS are presented to provide the reader with a descriptive overview of the technological advancements pertaining to CO_2 capture and storage through different methods. Then, the legal focus of this analysis was introduced firstly providing an overview of the

EGD presenting it as an atypical source of EU environmental law that although its soft law character boosted the entry into force of binding regulations currently setting the most ambitious EU target for decarbonization and CCS' implementation date, such as the most recent NZIA which entered into force on the 29th of June 2024. Furthermore, the first introductory chapter presented the SET Plan as the "push policy" pillar of EU's R&D framework, confirming the unequivocable nexus between research and technological evolution as a boost for economic competitiveness; in this case to be reached through CCS' deployment as a strategic technology for EU's decarbonization.

Moving forward, the second chapter presented the main challenges related to CCS law at the international law and at the EU law levels, being them, the regulatory gaps connected to the high level of uncertainty and the related lack of details in regulation and the excessive degree of autonomy delved in particular to EU's Member States. Arguably, the complexity of the domain of energy law, and in particular of CCS law, is increased by the undergoing process of technological evolution and application of CCS leading of a vicious circle of regulatory uncertainty for one of the most advanced technological climate change's mitigation tools. In this context, the application of the strict liability principle for operators is proposed as a solution to mitigate the uncertainty deriving CCS related risks and more worryingly CO_2 leakage during its transport or storage. As a first regulatory gap in this regard, it is highlighted that at the international law level a solid legal framework for state's responsibility for risks deriving from lawful acts is currently lacking. Then the supply chain of CCS is analysed focusing on CO_2 transport and on its storage. Firstly, CO_2 transport is deemed to be relevant from a legal viewpoint since the classification of CO_2 as an "hazardous waste" or not could really hamper or foster the thriving of CCS as a commercially viable technology. The legal analysis conducted examined the Basel Convention, the London Convention and its Protocol, and UNCLOS. These international treaties have been linked to the presence or lack of their ratification by the EU. In particular, it emerges that UNCLOS, and the Basel Convention have been ratified by the EU but are not directly applicable due to their state-centred nature. The direct applicability is generally the rule for international treaties applicable to the EU acquis, but this exception made for UNCLOS, and the Basel Convention indicates that sea and the deployment of innovative technologies through its use are a state's priority at the national law level where to retain states' sovereignty is extremely problematic. Furthermore, the London Convention and its Protocol have not been ratified by the EU and not by all its Member States, which is particularly relevant for the deployment of CCS transnational projects as explained in the conclusive chapter. In this regard, the fact that the EU did not ratify the London Protocol poses challenges to CCS implementation since this is the most advanced international instrument legalizing CO_2 storage for CCS purposes and its transport and export, even if through the provisional application of its amended art. 6.

Following this analysis pertaining international law, the chapter advocated in favour of an international liability regime for CCS, starting from the fact that due to its complexity CCS necessitates a legal framework for states' liability for environmental damages caused by lawful activities. Indeed, states should play a complementary role in supporting operators when fulfilling the strict liability principle. In particular, it can be argued that an enhanced role of states in this regard could also reduce the risks associated with CCS' deployment and also foster the thriving of renewed insurance products, as it is happening at the moment as discussed. The necessity of such regime is reaffirmed also in relation to the analysis of the CCS Directive, which is up to date the most comprehensive EU act regulating CCS and its supply chain. Despite it providing for environmental and administrative liability, in this context civil liability remains regulated only by Member States. Furthermore, the analysis conducted of the CCS Directive's main provisions reveals that it still has a high degree of uncertainty and lack of specific details while not sufficiently encouraging a common EU approach and the deployment of CCS transnational projects. However, it must be stressed that these difficulties derive from the long-term of the CO_2 storage envisaged by CCS which related risks are not well fully acknowledged, despite the TRL of this technology being around 9.

Nevertheless, 2024 represents a unique momentum for CCS deployment as proven by the two most recent European Commission's communications on the "2040 target" and on Industrial Carbon Management. Definitely, the encouragement presented in these communications on deploying CCS through transnational cooperation to decarbonize the EU has been seized by Member States. In particular, the third conclusive chapter has analysed the role of Italy in relaunching CCS implementation after the 2011 Eni and Enel's critical attempt to debut as CCS operators in the Brindisi-Cortemaggiore project. This initiative is particular useful to conduct a critical assessment of CCS' implementation in Italy even if this is made more difficult by the lack of accessible information on the facility and its criticalities. This lack of transparency constitutes a violation of art. 26 of the CCS Directive and of the relevant national legislation implementing it. Furthermore, also the lack of involvement of civil society and of transparency of information in the context of the NECP's drafting process could constitute a violation of the Aarhus Convention. So, the analysis of the Italian NECP showcased the urgence to accelerate the deployment of CCS in Italy through the Ravenna CCS Hub but also proved the necessity of a clearer and more detailed roadmap to this purpose.

Lastly, after having described the goal and functioning of the Ravenna CCS Hub its transnational involvement in the CCS Mediterranean Plan has been analysed as a key component in the process of relaunching South Mediterranean's competitiveness. In this context, the legal framework put in place by the London Protocol is of utmost importance since France and Italy ratified it, while Greece did not. This could arguably constitute a commercial barrier in the development of the Prinos CO_2 project operated by Energean. Since to comply with the London Protocol a MoU between Italy and Greece would be mandatory and while this has not been signed yet the complexity of the operations involved could slow the process of finding an agreement respecting the instructions of the London Protocol, which Greece did not ratify, while only having ratified the less advanced London Convention.

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