CARBON CAPTURE & STORAGE

Regulatory Framework & Overall Structure

HEREMA S.A. and
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Aristofanis Stefatos
CEO
HEREMA

Introduction to CCS Regulatory Framework and Overall Structure White Paper

Carbon Capture and Storage (CCS) is widely recognized as a critical technology for reducing carbon dioxide emissions in hard-to-abate industrial sectors and, hence, for reaching net zero targets and limiting the rise in average global temperatures.

Greece is currently in the process of updating its National Energy and Climate Plan (NECP). The updated NECP is expected to set even more ambitious targets for development of renewable energy sources and energy efficiency, and to recognize CCS as one of the main strategic axes for the achievement of the net zero goals by 2050. Besides its critical role in helping Greece achieve its net-zero objectives, the development of CCS is also very important in order to allow the hard-to-abate Greek industries to stay competitive in a European and global context.

HEREMA's role as the national competent authority for the geological storage of CO_2 is threefold: overall management of the rights of the Hellenic state for the storage of CO_2, issuance of exploration and storage permits for the geological storage of CO_2, as well as monitoring the safe operation of the respective projects. To further support the development of CCS applications in Greece, HEREMA initiated the White Paper in hand to cover three main pillars of CCS application, namely status and landscape of CCS activities/projects worldwide, CCS legal framework, and applicable business/revenue models. The objectives of this White Paper are to present the deployment status of CCS technology on a global and European level, as well as the current status of CCS regulation legislation at EU, member state and EEA level. In addition, to present, evaluate and assess the most common and widespread business/revenue models for CCS applications worldwide. In this direction, HEREMA considers the definition of the main prerequisites on both legal and economic level for the successful deployment of CCS, as the essential foundation for any further work. To further strengthen our initiative, a cooperation with KPMG led to the definition of a working group dedicated to addressing the aforementioned goals, and has resulted in the publication of the White Paper in hand.

With the implementation of both EU and national regulatory framework for underground storage, and in particular carbon storage, HEREMA does not simply seek to ensure the implementation of the respective regulations, but it additionally strives to facilitate the development of an efficient, dynamic, and safe CCS chain in the country, which will serve as a mitigation tool to climate change and will help Greece achieve its net-zero objectives. This dynamic was further strengthened in September 2022, with HEREMA granting the first exploration permit for geological storage in the Prinos Complex in northern Greece.

We envisage future CCS projects developing successfully in Greece, through an accelerated process based on the cross pollination of know-how and experience between the various stakeholders of the various CCS value chain elements. Based on our competence and experience, we hope to contribute to the successful implementation of the National Plan for Energy and Climate. Towards this vision, HEREMA shall serve as the principal authority and regulatory force on CCS activities, especially during a period where an active transition to environmentally friendlier energy sources creates a very dynamic environment for expedited investments. As we move further into the energy transition era, deployment of CCS technology will grow more and more, and so will the associated challenges, which we will face through the application of “best in class” practices.

To this end, HEREMA has already engaged in discussions with the EU commission, participating in the Implementation Exchange Group, establishing communications with other EU Member State Competent Authorities, the Global CCS Institute, the International Energy Agency as well as major Consultancy companies for direct and efficient exchange of expertise and information.

HEREMA as the representing state entity, can confirm that the industrial, energy and shipping sectors in Greece have the willingness, the foundations, and the technical capability needed, for the expedient deployment of a full CCS value chain. Projects of negative CO_2 footprint, such as the CCS, are critical as they have a direct effect on our ability to meet our net-zero targets and mitigate the climate changes effects. We are working diligently towards our new vision which, when achieved, will be a major contribution to ensuring the energy sustainability of Greece and improving the quality of life of its citizens.

Aristofanis Stefatos
CEO
HEREMA

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Executive Summary

In order to reduce the impacts and risks of climate change, parties of the Paris Agreement decided to enhance their efforts to limit the rise in average global temperatures to 1.5oC. To achieve this, governments focused on increasing the share of renewable energy in the global energy mix and developing energy efficiency incentives and policies. Significant greenhouse gas reductions have been achieved, but this is still not enough to meet the maximum temperature increase target. Governments must continue to strengthen their policies and apply technologies to accelerate overall emissions reductions, and they need to do it fast.

In this context, Carbon Capture and Storage (CCS) technologies are expected to play a crucial role. According to the International Energy Agency (IEA), in a path towards meeting international goals, CCS is the only technology that contributes both to reducing emissions in key sectors directly and to removing CO_2 in order to balance emissions that cannot be avoided. This is a critical part of reaching net zero targets. It could also play a key role in the supply chain for synthetic fuel production. CCS is the process of capturing the – otherwise emitted to the atmosphere – carbon dioxide and then transporting it through a transportation network (pipelines, ships, rails etc.) to storing complexes. Onshore and offshore saline aquifers as well as depleted oil and gas fields are the most common storage sites. CCS projects are divided into two main categories: commercial facilities and technology demonstration pilot projects.

Carbon Capture and Storage dates back to 1996, when Norway constructed the first CCS facility (Sleipner) to separate CO_2 from extracted natural gas. United States has leveraged CCS for Enhanced Oil Recovery for nearly 20 years. According to the Global status of CCS 2022 report published by the Global CCS Institute, as of September 2022, there were 30 commercial CCS facilities in operation worldwide (most of them in the US region), while 166 were in various stages (under construction, in advanced development, in early development etc.). However, there is still a long way to go before CCS facilities can be developed and operated to meet the global target of 1.5oC. Based on a study from ZEP "How much CCS and CCU will be needed in 2030? – Objective: for Europe to be on track to reach climate-neutrality by 2050" the projected median CO_2 abated in Europe to reach net-zero GHG emissions is 230-430 Mtpa in 2030, rising to 930-1200 Mtpa by 2050. Currently, only 42.6 Mtpa are captured and stored with CCS globally, with another 199.1 Mtpa under development.

According to the CCS Global Institute, a CCS readiness index has been established to actively monitor the progress of CCS deployment. The index tracks and combines a country's CCS requirements, policies, laws, regulations and storage resources development. Based on the CCS Readiness Indicator, the countries with the most progress in deploying CCS in Europe – currently – are Norway, the Netherlands, and the United Kingdom.

The European Commission's 2030 and 2050 roadmaps identify Carbon Capture and Storage as a key low-carbon technology for achieving the EU's 2050 greenhouse gas emission reduction targets, although much remains to be done to embed CCS in the future policy frameworks. The first EU Directive to set out the rules for granting exploration permits to determine the storage potential of CO_2, the actual storage operations and post-closure obligations is Directive 2009/31/EC. It sets criteria for the selection and characterization of storage sites, as well as criteria for the issuance of exploration and storage permits. The European Commission is also involved in the review of the application procedure, conditions, content and possible withdrawal of abovementioned permits. Some of the most important points of the Directive concern the selection of the geological site, which should only be done if there are no significant leakage, health and environmental risks. In addition, no storage activity is allowed without the appropriate storage permit. Monitoring and reporting requirements are established for both the competent authority and the operator of the transport & storage facilities. Special attention is given to the transfer of responsibility for the storage site and the operator's financial obligations for the operation period, closure and post-closure procedures. The operators' financial obligations also apply to the period after the transfer of responsibility. A financial security mechanism is established to ensure that all obligations, including closure and post-closure requirements, can be met. The financial mechanism must be valid and effective before CO_2 injection begins. Finally, access to infrastructure must be granted in a transparent and non-discriminatory manner.

To enhance the implementation of the Directive, an Information Exchange Group has been established to organize the exchange of information between the competent authorities of the Member States. To ensure knowledge sharing and exchange of practical information, the Commission organizes workshops and meetings with stakeholders and/or Member States.

The Directive was adopted on April 23rd, 2009, and entered into force on June 25th, 2009. Member States were required to comply with the Directive by June 25th, 2011. In Greece, the CCS Directive 2009/31/ EC was transposed into National law by Ministerial Decision 48416/2037/E.103/2011 (Official Gazette B' 2516/2011), as amended. The decision closely follows the CCS Directive. Additionally, recent developments in the legislation include provisions regarding the right of entities that already hold a license for exploration and exploitation of hydrocarbons to obtain an exploration license for CO_2 storage in the same area.

One of the most important provisions of Greek Law 4964/2022 designates the Hellenic Hydrocarbons and Energy Resources Management (HEREMA) as the competent authority for the licensing, monitoring and supervision of carbon storage projects. HEREMA is responsible for managing the rights of the Greek State in relation to the exploitation of geological formations for the storage of carbon dioxide. Monitoring the safe operation of the respective projects and making recommendations to the relevant ministries for the issuance of the regulatory/legal acts (secondary legislation) also falls under the responsibility of HEREMA. Within this framework, in September 2022 HEREMA granted the first exploration license for the Prinos and Epsilon fileds and the underlying Aquifer to Energean which has started assessing the carbon storage potential of the above-mentioned basin. According to preliminary estimates, around 50% of the total annual emissions of the Greek manufacturing sector could be stored there for 20 years.

The different phases of the CCS value chain will bring different requirements for financial support and policy frameworks. Choosing the right business/revenue models means finding the underlying structures for how a CCS project can create and deliver value to its investors while meeting specified environmental goals. Certain revenue models are applied to the various stages of the CCS value chain. Experience with CCS projects (in operation or under development) around the world indicates that the most common revenue models are the Contract for Difference for the capture phase, and the Cost-plus and Regulated Asset Base for the Transportation & Storage phase.

More specifically, a Contract for Difference (CfD) is a contract between a buyer and a seller stipulating that the buyer must pay the seller the difference between the current value of an asset and its value at contract time. CFDs offers traders and investors the opportunity to profit from price volatility. It is considered a revenue mechanism that allows governments to guarantee investors a fixed price that rewards CO_2 emission at a specific price. The PORTHOS project in the Netherlands is expected to operate under this business model.

Within the cost-plus open book model, the T&S operators must submit documentation of all hard costs to the government. The government makes direct operational payments to cover properly incurred costs on an annual basis, on an open-book basis, with the addition of an agreed-upon profit margin. This model is widely used for transportation and infrastructure projects. An example of the intended use of the cost-plus model in an industrial CCS project is the Longship in Norway.

In turn, a RAB model has traditionally been used to incentivize private investment in public projects by offering developers a secure payback and return on investment. Under this mechanism, investors operate the infrastructure project and take ownership of the assets and operating costs. In return, they can earn revenue, often through customer bills, and they can also receive government subsidies. This model is used primarily when the market has reached a certain level of maturity and the assets are to be privatized. An example of the application of the RAB model in a commercial CCS project is the HyNet in the United Kingdom.

To cover the costs of business models and ultimately contribute financially to CCS development, various funding sources could be considered.

Direct government funding could be one option, on the grounds that all members of society benefit from the greenhouse gases mitigation actions. Another option is to require taxation of national emitters (power industry and other emitters). This allocation is the "polluter pays" principle and a potential mechanism could be to increase allocation of tradeable certificates/allowances (e.g., under the Emissions Trading System) to emitters with installed carbon capture technologies, which are then sold to emitters without such technologies. Imposing a carbon tax on fossil fuel suppliers could be an additional instrument to finance the "green" transition. Another option is to introduce a price surcharge to be paid by end consumers based on the carbon intensity of each (end, "final") product.

Risks and liability issues, particularly related to transportation, injection, and storage have been identified as critical barriers to scale up CCS deployment. From a commercial point perspective, the potential closure of an industrial source of CO_2 means that the pipeline and storage operator might end up with no customers, and thus no revenue. In addition, potentially suitable storage sites could end up being utilized as natural gas storage facilities to enhance energy security, rather than being used for CO_2 storage. Finally, the insufficient information and low public awareness may lead to low or poor acceptance of CCS technology, mainly due to safety and environmental concerns.

The realization of large-scale CCS projects in Europe has proved challenging, as many projects have been slowed down or canceled due to financial constraints, public acceptance, but also lack of incentives. As the potential of CCS technology is increasingly recognized, government policies should continue to strengthen and incentivize greater private sector investments. According to the IEA, CCS is an essential component of the technology portfolio needed to significantly reduce greenhouse gas emissions globally in the most cost-effective manner. The scale of potential future deployment of CCS is significant, spanning industry, power generation, and hydrocarbon extraction worldwide. The OECD report on policy strategy for carbon capture and storage mentions that CCS policy must address new market creation, market barriers and failures, infrastructure support and regulation. In the early stages of development, policy will focus primarily on advancing CCS technology and establishing commercial arrangements between capture, networks, and storage. Over time, CCS technology is expected to mature, and as emissions reduction targets become more challenging, industries will recognize where the best opportunities lie. Policymakers can either propose emissions reductions where they appear most cost-effective or simply let the market self-regulate. Policy choices for support should mainly be focused on financing and funding through incentives provision for capital deployment or for operations. It is also important to focus on costs & risks allocation between public and private sector. Moreover, subsidizing abatement or penalizing emissions and targeting CCS-specific incentives or technology-neutral incentives, are expected to play a key role as policy instruments.

The lack of economic sustainability is a key factor that could delay planning and deployment of CCS projects. However, assuming that the provision of emission mitigation services evolves in the same direction as other markets, investment in CCS will continue to grow. According to the Global CCS Institute, demand will increase even more in the future, so, a rapidly growing industry is expected to meet that demand. At the same time, demand for energy and key materials and products such as fertilizers, steel, chemicals and cement, is increasing as emerging economies develop and their standard of living approach that of developed economies. This is leading to a continuous increase in CO_2 emissions that can only be offset by additional efforts.

The aim of this White Paper is initially to present the technology and global status of CCS. Additionally, to examine the current status of CCS regulation/legislation at EU level and evaluate its implementation in Greek legislation. Finally, the most common and widespread business/revenue models for such applications worldwide are examined and evaluated, so that the main prerequisites for the success of CCS in Greece in legal and economic terms can be determined.

In more detail, Chapter 1 defines the framework highlighting what CCS is and the ultimate purpose of applying such technologies. The global development status is presented – with special reference to the Greek status – listing all operational projects as well as the most important ones that are currently under development. Comprehensive details on selected projects are also presented as part of the corresponding appendix so as to give an all-around understanding of the key implementation parameters. Finally, a country readiness index assesses the progress made at the EU-level, taking into consideration the policy, law, regulation and storage resources development.

Chapter 2 presents regulatory and legislative development, starting with an analysis of the “holy grail” for EU Member States, the CCS Directive (2009/31/EC). The transposition of the CCS Directive into the Greek legislation is separately examined in detail and a gap analysis between Greece and other more (CCS) advanced countries such as Norway, the UK, the Netherlands, Spain and Italy is performed. Relevant details on selected areas of the regulation are also provided in the 2nd appendix for all the above countries.

In Chapter 3, the main challenges in deploying CCS technology and systems have been identified, while the most attractive business/ revenue models are explained with specific references to active or under development projects applicable to each of the models. Additionally, advantages and drawbacks of each model are also evaluated.

Finally, Chapter 4 presents the conclusions and summarizes the key areas to focus on in order for CCS to be successful in Greece. This chapter serves as a reminder of the key gaps and pre-requisites but also as a driver for the key actions that need to be taken for CCS systems to be successful in Greece and ensure economic sustainability for investors.

1. Introduction

In 2021, the EU made climate neutrality, the goal of zero net emissions by 2050, legally binding. This goal is enshrined in the climate legislation. Although renewable energy and energy efficiency measures seem to be the main priorities, carbon capture, utilization and storage (CCUS) will be necessary to achieve this 2050 target, especially during the transition. The cement industry is considered a good example of a sector with hard-to-abate GHG emissions. Up to 70% of CO_2 emitted in the cement production, comes from the chemical process of calcining calcium carbonate – which cannot be achieved by other methods. Therefore, CCS is seen as the only option for decarbonization.

1.1 The Paris Agreement and the other EU climate targets and policies

Following the Paris Agreement, signed in 2016, the parties involved have set the target of withholding the increase in the global average temperature below 2^{o}C above pre-industrial levels and more specifically pursuing efforts to limit the temperature increase to 1.5^{o}C above pre-industrial levels. The above action has been identified as an important measure to reduce the risks and impacts of climate change. Under the scope of this agreement, EU countries have engaged in developing directives, laws and strategies in order to reduce GHG emissions, which are directly related to the rise of the average global temperature.

Greece in its revised National Energy and Climate Plan (2019)[1] has set the target for reducing GHG emissions by almost 43% and 56% compared to 1990 and 2005 respectively. This goal is expected to be met by 2030, through focusing on three main objectives:

— **Reducing GHG emissions and achieving environmental objectives:**

1. Greek National Energy and Climate Plan -ec.europa.eu/energy/sites/ener/files/el_final_necp_main_en.pdf

the direct reduction of GHG is expected to be achieved by attaining emission reduction objectives in the individual sectors within and outside the emissions trading system which are equivalent to the respective core of EU objectives. Furthermore, quantitative targets have been set for reducing national emissions of specific air pollutants. Finally, the shutdown of all lignite power plants is expected to happen by 2028.

— **Increasing the RES share in energy consumption:** the RES share in gross final energy consumption is set to a minimum of 35%.

— **Enhancing energy efficiency:** by increasing overall energy efficiency, energy consumption will decrease in levels such that final energy consumption and primary energy consumption do not exceed 16.5 and 21 Mtoe in 2030, respectively.

Following the member states NECPs, the European Union adopted in 2021 a more aggressive approach on green transition, targeting net zero emissions by 2050. The "Fit for 55"[2] package was introduced among the member states, in which the first milestone was 55% reduction of CO_2 emissions, compared to 1990 level, by 2030. Some of the measures presented in the "Fit for 55" package include the increase of energy efficiency,

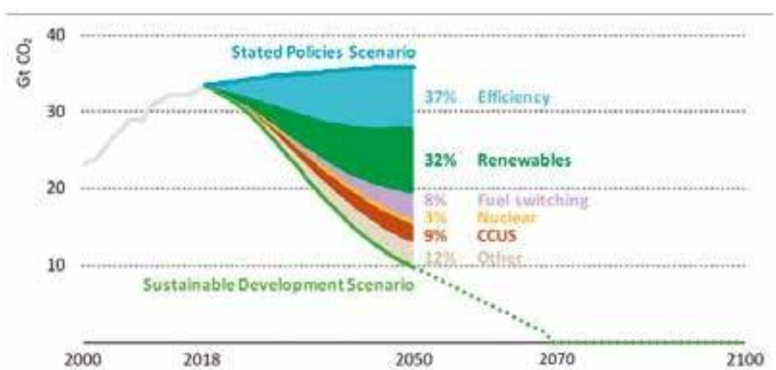

***Figure 1:** Energy-related CO_2 emissions and reductions by source in the Sustainable Development Scenario, (Source: International Energy Agency, (2019), world energy outlook 2019, Licence CC BY 4.0).*

2. Fit for 55- https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/

the greater penetration of renewable energy in the energy mix, enhanced research and development of alternative fuels, revision of the energy taxation, lowering of the CO_2 emission standards for cars, vans and more.

CCS might prove a useful method to acquire the above-mentioned targets. According to the International Energy Agency[3], the impact of CCS in reduction of CO_2 emission is at the levels of 9% of total policies' efforts.

CCS technologies contribute to clean energy transitions in several ways[4]:

— **Tackling emissions from existing energy infrastructure.** CCS can be retrofitted to existing power plants and industrial facilities that could otherwise emit 600 billion tons of CO_2 over the next five decades – almost 17 years' worth of current annual emissions.

— **A solution for some of the most challenging emissions.** Heavy industries account for almost 20% of global CO_2 emissions today. CCS is probably the main technical option for decarbonization of heavy emission industries such as cement production. Depending on the project location and available infrastructure, CCS could be one of the most cost-effective approaches to curb emissions in various industrial sectors (e.g., iron and steel and chemicals manufacturing).

— **A cost-effective pathway for low-carbon hydrogen production.** CCS option is applied in the natural gas reforming process in order to produce blue hydrogen. Blue hydrogen is considered to be a clean or low carbon hydrogen and in combination with the green hydrogen can support the development of a cost-effective hydrogen economy. An affordable and reliable hydrogen economy is required to meet short and long term demands in various sectors that are difficult to reduce emissions today, such as transport, industry and buildings.

— **Removing carbon from the atmosphere.** For emissions that cannot be avoided or reduced directly, CCS underpins an important techno-

3. IEA World Energy Outlook 2019, https://www.iea.org/reports/world-energy-outlook-2019

4. IEA, 2020, Energy Technology Perspectives: Special Report on CCUS – CCUS in clean energy transitions

logical approach for removing carbon directly from the atmosphere and delivering a net-zero energy system.

1.2 What is carbon capture and storage?

The Carbon Capture and Storage process consists of three main stages:

Stage 1: carbon dioxide is produced from various processes and captured using various technologies

Stage 2: the captured CO_2 is transported to a suitable geological location for storage

Stage 3: the transported CO_2 is the compressed and injected into a geo-logical location for permanent storage.

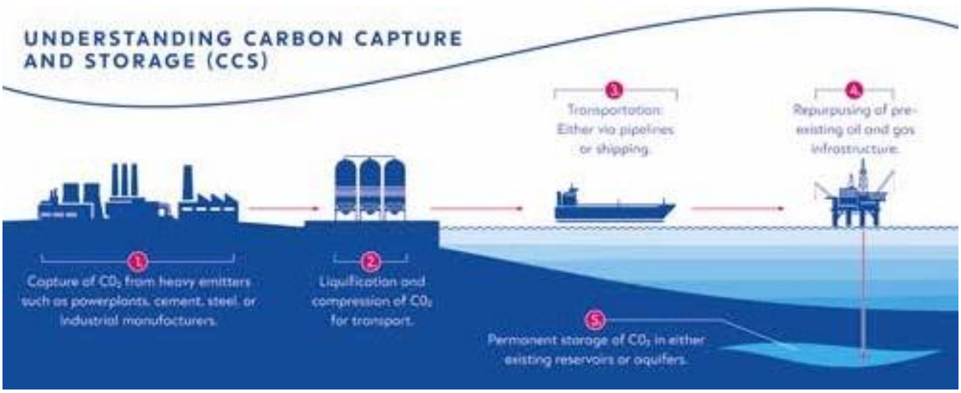

Figure 2: *What is CCS?*

Carbon dioxide is mainly produced by energy intense processes, such as power generation, cement production and generally from various industrial sectors. Carbon Capture technologies can capture carbon dioxide from process' emissions usually with an efficiency rate of 85-99%. The captured CO_2 is then, transported– and stored in viable underground geological formations.

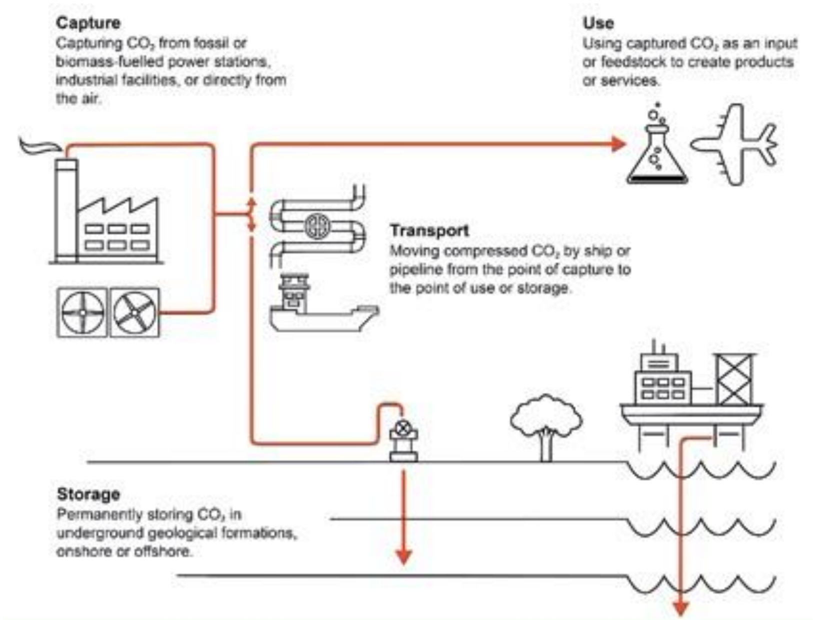

Figure 3: *CCUS value chain, (Source: International Energy Agency (2021), About CCUS, April 2021, Licence CC BY 4.).*

The most common CO_2 capture process that takes place in the emitters' site is based on the following three phases[5, 6]:

Pre-combustion: a gasification process in which the primary fuel (e.g., natural gas) is converted into a synthesis gas (syngas), from which the carbon dioxide is separated afterwards.

Oxy-fuel combustion: the primary fuel is combusted in oxygen instead of air, which produces a flue gas containing mainly water vapour and a high concentration of CO_2

Post-combustion: the separation of CO_2 from flue gases. Post-combus-tion is ideal for capturing CO_2 from energy generation sources, such as

5. Sílvio Vaz, Ana Paula Rodrigues de Souza, Bruno Eduardo Lobo Baeta –Technologies for carbon dioxide capture: A review applied to energy sectors

6. M. Mohammad, R.J. Isaifan, Y.W. Weldu, M.A. Rahman, S.G. Al-Ghamdi - Progress on carbon dioxide capture, storage and utilisation

thermal power plants and other plants that use waste to generate energy.

Transportation refers to the relocation of the CO_2 from the point of capture to the storage location. The most common method of CO_2 transportation is through pipelines, followed up by ships, trucks and rails (albeit at higher cost per ton of CO_2). Various parameters affect the economic viability of the selected transportation option, and it is considered that pipelines and ships could be the most cost-effective methods in transporting large quantities of CO_2, due to economies of scale[7].

The final stage of the CCS event chain is storage. Storage of CO_2 is envisaged either in deep geological formations, or in the form of mineral carbonates. The main options for storing CO_2 are onshore and offshore saline aquifers as well as depleted oil and gas fields.

1.3 Global as-is and development status of CCS

According to the Global CCS Institute database[8], there are 196 CCS facilities around the world in various stages (operating, in construction, under advanced development, early development etc.). The facilities are classified into two distinctive categories, Commercial CCS and Pilot & Demonstration facilities[9].

Commercial CCS facilities' basic characteristics:

— The generated CO_2 is captured and transported to the CCS facility for permanent storage as part of a continuous commercial operation

— Their economic lifetime is similar to the host facility (industry, power generation etc.) from which they capture CO_2

— These facilities should be economically viable while meeting existing regulatory requirements

7. Erin Smith, Jennifer Morris, Haroon Kheshgi, Gary Teletzke, Howard Herzog, Sergey Paltsev - The cost of CO_2 transport and storage in global integrated assessment modeling,

8. https:/co2re.co/FacilityData

9. Global Status of CCS 2020 - https://www.globalccsinstitute.com/wp-content/uploads/2021/03/Global-Status-of-CCS-Report-English.pdf

Pilot & Demonstration facilities:

— Capturing of CO_2 aims to test, develop or demonstrate new CCS technologies or processes

— The captured CO_2 is not necessarily permanently stored

— Their economic life is shorter compared to commercial facilities and depends on the duration of the testing and the development of new processes

These facilities do not provide a commercial return on investment.

As of September 2022, 30 commercial CCS facilities with a capture capacity of 42.6 Mtpa[10] were in operation worldwide, with the majority being in the US Region. The project pipeline capacity accounts for 199.1 Mtpa with additional 166 facilities in different stages of development (in construction, advanced development, early development, operation suspended).

Figure 4: *Map of commercial CCS facilities in operation.*

10. Global Status of CCS 2022 – https:/status22.globalccsinstitute.com/2022-status-report/global-status-of-ccs/

Table 1: Number of commercial CCS facilities in operation per region

Region	Commercial operational CCS facilities (n)	Storage capacity (Mtpa)
North and South America	19	32.3
Europe	4	1.5
Asia Pacific	4	5.1
Middle East	3	3.7
Total	**30**	**42.6**

(Source: Global CCS Institute, KPMG Analysis)

— **North America** is the most advanced region in the world in terms of CCS. In Texas, one of the world's largest CCS facilities, the Century Plant, has been in operation since 2010. This natural gas treatment facility with a capture capacity of around 5.0 Mtpa, accounts for more than 10% of the total global capture capacity. Captured CO_2 is transported via pipeline to a secure geologic storage in conjunction with oil

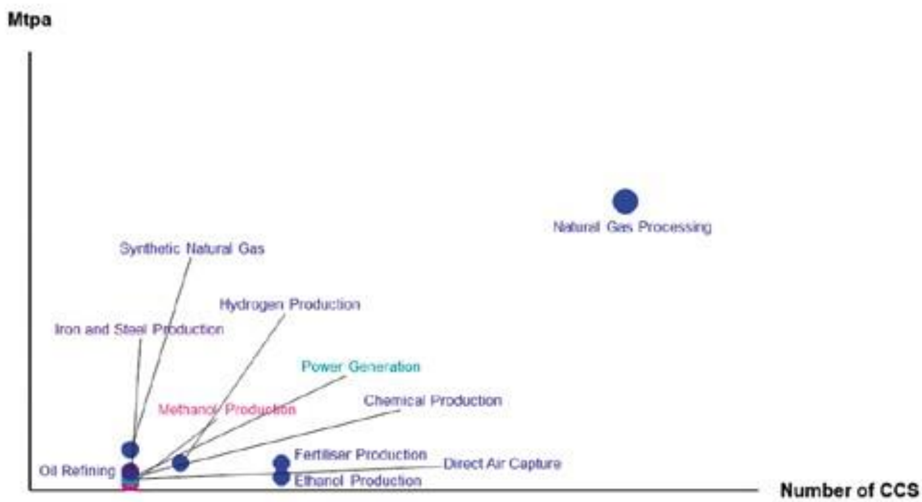

***Figure 5:** Number of operational commercial CCS facilities and Mtpa per usage (2022), (Source: Global CCS Institute, KPMG Analysis).*

and gas operations in the Permian Basin. Major policy and financial support for CCS took place during FY 2021 with the US congress of the appropriated USD 228.3 million for carbon capture, utilization, and storage. An additional USD 6 billion was authorized for CCS research, development, and demonstration programs for FY 2021-2025.

— **Europe** and neighboring regions lag behind North America in the number of CCS projects in operation. Currently, there are 106 CCS facilities and projects in various stages of development across Europe and the UK. Some of them include blue hydrogen production, one of the most common CCS applications (Europe's status with respect to CCS is analyzed in more detail in the next section).

Table 2: Number of CCS facilities in Europe

	Operational	In construction	Early development	Advanced development	Completed	Total
Commercial	4	5	45	23	0	77
Pilot	7	1	0	1	20	29

(Source: Global CCS Institute, KPMG Analysis)

— **Asia Pacific** region (China, Australia, Singapore, Malaysia etc.) achieved significant steps regarding the overall chain of CO_2 emissions, that could enhance the future state of CCS. Initially, China launches an emission trading system, covering 4,000 Mtpa from 2,225 power plants. China aims to achieve carbon neutrality before 2060; this ambition triggered significant interest for CCS technologies, leading in the inclusion, for the first time, of large-scale CCUS in China's Five-Year Plan. The Australian Government released in 2020 its *Technology Investment Roadmap: First Low Emissions Statement,* in which CCS is identified as one of the top priority technologies along with clean hydrogen and energy storage. In this respect, the Australian Government announced AU$263.7 million in new funding to support CCS/CCU projects and hubs. The Gorgon Carbon Dioxide Injection Project is part of the wider Gorgon Project in the Western Australia. The captured carbon dioxide is separated and compressed in facilities located on Barrow Island and then piped through a short distance to the CO_2 injection wells where it is injected in the subsurface. The operation of this project initiated in August 2019, the capture capacity ranges from 3.4 – 4 Mtpa, and the storage capacity is 120 Mt. The profitability scheme results from royalty and tax benefits.

— The last region presented is the **Middle East**, specifically the Gulf Cooperation Council states. Three existing facilities in the United Arab Emirates (UAB) and Saudi Arabia account for about 8.5% of the world's annual CO_2 captured (3.7 Mtpa), while Europe accounts for 3.5%. The largest commercial CCS facility in operation is that of Qatar Gas, with a capture capacity of 2.1 Mtpa of CO_2 from the Ras Laffan gas liquefication plant. Ras Laffan is developing an expansion plant, expecting to expand Qatar Gas' capture rate to 5.0 Mtpa by 2025. Despite the on-going projects, policy incentives in the GCC countries remain low, mainly due to the absence of climate policies.

Table 3: Indicative Global operating commercial CCS projects

Facility Name	Country	Starting year	Status	Industry	Storage capacity (Mtpa)
Century Plant	USA	2010	Operating	Natural Gas Processing	5
Gorgon Carbon Dioxide Injection	Australia	2019	Operating	Natural Gas Processing	3.4 - 4.0
Qatar LNG CCS	Qatar	2019	Operating	Natural Gas Processing	2.1

(Source: Global CCS Institute)

1.4 Existing and future status of CCS in Europe

Given the need to address the global climate crises, the EU has committed through the Paris Agreement and its green growth strategy (the EU "Green Deal") to significantly reduce its carbon footprint by 2030 and become a net-zero continent by 2050. One of the seven strategic pillars of the European Commission is the development of CCS, an instrument included in the EU's climate policy agenda.

Many countries within the EU consider the CCS as a key tool to achieve greenhouse gas neutrality by 2050. In the medium term, CCS could be a comparatively low-cost option for reducing otherwise unavoidable process-related emissions, mainly from industry. Many reduction strategies aiming at meeting global temperature targets also rely on negative emissions. In Europe, the pace of developments is accelerating with the first large-scale projects expected to be operational by 2024. Norway, the Netherlands, and the United Kingdom in Northern Europe are the most advanced countries, having established a regulatory framework, while announcing more than €5 billion in CCS funding[11]. Other projects are gradually being defined and developed in the rest of Europe.

Figure 6: *CCS readiness index of European countries, (Source: ©Global Carbon Capture and Storage Institute Ltd, Licence CC BY 4.0).*

The CCS Readiness Index, produced by the CCS Global Institute is used to actively monitor the progress of CCS deployment. The index tracks and combines a country's CCS requirements, policies, laws, regulations and storage resources development. Based on the CCS readiness indicator, the countries with the most/highest progress in terms of CCS deployment are Norway, the Netherlands and the UK, followed by Germany and Denmark.

11. Sylvie Cornot-Gandolphe, "CCUS in Europe: A New Role and Implications for France and Germany", Briefings de l'Ifri, Ifri, 2021

— **Norway** operates two commercial CCS facilities while additional 12 projects are in different stages of development. It is a fact that Norway showed an early engagement in CCS, by owning the first in the world CCS facility, the Sleipner CO_2 Storage facility. Sleipner started its operation in 1996 and has stored more than 20 MtCO_2 up to date. The source of the CO_2 is the extracted natural gas from Sleipner West field, from which the CO_2 is separated and injected into Utsira Sand formation, a shallow saline aquifer. Sleipner is a profitable project since the CO_2 separation makes the natural gas suitable (by achieving the maximum allowed concentration of CO_2) and because the cost of injection per ton is lower than the CO_2 tax (17 €/tn vs 70 €/tn).

Another CCS project in Norway is the Snohvit project. Like Sleipner, Snohvit separates CO_2 from liquified natural gas and injects it into a deep saline aquifer formation. The project has been in operation since 2008, with an injectivity capacity of 0.7 Mtpa.

Finally, an important upcoming CCS project in Norway is the Longship. Longship is expected to be operational by 2024, with an injection capacity of 1.5 Mtpa in the first phase and 5 Mtpa in the second phase. In the first phase, emissions of CO_2 will be captured from a cement factory and a waste-to-energy plant and stored in a saline aquifer formation. In the second phase, additional volumes of captured CO_2 from other projects will be transported and stored using Longship's transportation and storage infrastructure.

— **UK** has currently no commercial CCS facilities in operation. However, 36 projects (commercial and pilot) are in different stages of development, some of which have been completed (such as the Drax bioenergy carbon capture pilot plant) and others are still in the early stages of development. The Drax CO_2 pilot plant, commissioned in February 2019,

captures one ton of CO_2 per day from the Drax power unit, which is 100% biomass-fueled.

Major UK projects that are expected to be operational by 2030 include the HyNet, Acorn, and Teesside. HyNet will take advantage of existing pipelines to transport and store CO_2 in depleted hydrocarbon reservoirs located about 20 miles offshore in the Liverpool Bay. Captured CO_2 will be supplied by industry in the region. HyNet's injection capacity is expected to be 4.5 Mtpa in the first phase and 10 Mtpa in the second phase. The year 2025 is set to be the first year of operation.

The Acorn project will store captured CO_2, emitted from the industry and from the reforming of natural gas into hydrogen, in a saline aquifer. It is expected to be operational by 2026. The injectivity is also divided in two phases, with 0.3 and 12 Mtpa in the first and the second phase respectively.

Finally, Teesside, scheduled to come on stream in 2027, is estimated to inject 8.25 Mtpa into depleted oil fields and a saline aquifer.

— Although the **Netherlands** is among the countries with the highest readiness index, it lacks operational CCS facilities. By 2025, the Netherlands plan to deploy 6 CCS projects, mainly focused on hydrogen production and in CO_2 capturing from heavy industry. From these projects, PORTHOS is the most advanced and mature project in the country (and at the EU level along with the Norwegian Longship project) and has been classified as a Project of Common Interest (PCI). PORTHOS project comprises four distinctive smaller projects, a compressor station, an offshore pipeline, an onshore pipeline and a storage facility. The storage capacity is anticipated to be 37 Mt with an injection rate of 2.5 Mtpa. The state aid covers the difference between the capture and storage cost and the ETS price. This aid is expected to decrease year by year as the ETS price is expected to increase. The project is financed by the Dutch government and EU funds.

Table 4: Indicative European CCS Projects
(for more information please see Appendix A)

Facility Name	Country	Status	Starting year	Industry	Storage capacity (Mtpa)
Sleipner CO_2 Storage	Norway	Operational	1996	Natural Gas Processing	0.85
Snohvit	Norway	Operational	2008	LNG	0.7
Longship	Norway	Under development	2024	Cement & Waste to Energy	5
Drax BCC	UK	Operational	2019	Generation	Power
HyNet	UK	Under development	2025	Natural Gas Processing	10
Acorn	UK	Under development	2026	Hydrogen Production	12
Teesside	UK	Under development	2027	Variable	8.25
Porthos	Netherlands	Under development	2024	Chemical Refining	2.5

(Source: Global CCS Institute)

1.5 Current state of CCS in Greece

Greece is making rapid progress towards development of CCS projects compared to other more advanced economies in the EU. In April 2022, the Hellenic Hydrocarbons and Energy Resources Management Company (HEREMA) was appointed as Competent Authority for permitting and monitoring of carbon dioxide storage projects, as well as for storage projects for other gases and liquids. In particular, an amendment to the founding law of HEREMA, recently renamed to HEREMA, was submitted by the Ministry of Environment and Energy law (Chapter B, article 228), – as part of a bill by the Ministry of Finance (Law 4920/2022, Government Gazette A '74/ 15.04.2022) – which expands the scope of HEREMA.

Founded in 2011, with the Greek State as its sole shareholder, Hellenic

Hydrocarbon Resources Management S.A. (HHRM) manages the national interests related to the exploration and production of hydrocarbons, with a particular focus on natural gas. Since 2020, the company has initiated its transformation by strengthening its ESG standards and exploring synergies among various energy sectors towards a more sustainable future. From 2022, the company was renamed to Hellenic Hydrocarbons and Energy Resources Management (HEREMA) and expanded its mandate to include permitting of underground gas storage (including CO_2, natural gas, and hydrogen) and Offshore Wind Farms (OWF). As mentioned above, HEREMA is now the relevant competent authority for CO_2 storage applications and permits in Greece in accordance with EU Directive 2009/31/EC. In this capacity, HEREMA participates in the EU commission Information Exchange Group to promote the coherent implementation of the CCS Directive throughout the EU, and also cooperates with other competent authorities in the Member States.

Despite the early stage of CCS development in Greece, the first exploration license for the Prinos field was awarded by HEREMA to Energean, in late September 2022, with a term of 22 months. Energean contracted Halliburton (a well-known oilfield services company) to assess the carbon storage potential of the Prinos Basin. The scope of work includes long-term plume modeling, characterization of the storage complex, and a conceptual development plan with performance modeling. Energean estimates that the volume of the Prinos Basin is sufficient to store up to 100 million tonnes of CO_2, which is equivalent to about 50% of the total annual emissions of the Greek manufacturing sector over 20 years.[12]

12. https:/www.capital.gr/epixeiriseis/3624167/energean-sti-halliburton-i-meleti-gia-tin-apothikeusi-dioxeidiou-tou-anthraka-ston-prino

2. CCS Legal Framework

The scale-up of CCS technologies requires an effective legal and regulatory framework to ensure the effective management of CO_2 storage sites, the protection of public health and the environment, and the safety of CCS activities[1]. Regulatory frameworks are also required to clarify the rights, responsibilities and obligations of CCS stakeholders, including relevant authorities, operators, and the public, and to provide clarity and certainty to project developers and their investors.

While legal and regulatory frameworks should address all aspects of the CCS value chain (capture, transport, and storage), CO_2 storage is typically the primary focus, as it can present novel and complex issues for regulation. For example, ownership, responsibility and liability for CO_2 that is to be stored in perpetuity must be clarified. Regulations must also ensure appropriate site selection, safe operations, and mitigate and manage risks at all stages of site development, operation, and closure. In addition, they should provide a legal basis for CO_2 storage, allocating property rights and managing competition for resources.

Regulatory issues related to CO_2 capture, transport, and use often fall within the scope of existing regulatory frameworks for industrial activities, including oil and gas, minerals, waste management, health, safety, and environmental aspects for industrial sites, property rights, and transportation. Although these areas require little or no change to existing frameworks compared to CO_2 storage, it is important for governments to review existing national and international frameworks to remove potential barriers to CCS deployment.

As early as 2007, the European Commission offered political and financial support for CCS development. The New Entrant's Reserve (NER300) scheme – a funding mechanism linked to the EU Emissions Trading Scheme (ETS) – offered support for CCS alongside innovative renewable

1. IEA: Legal and Regulatory Frameworks for CCUS

energy projects, while the European Energy Programme for Recovery (EEPR) supported CCS projects in the context of post-economic crisis recovery and promotion of the energy transition[2]. In this context, the progress of CCS projects required an appropriate framework that would allow the expansion of such technology in all EU Member States. And so, the EU Directive (2009/31/EC) on the geological storage of carbon dioxide came into play.

2.1 Overview of EU Law – CCS Directive

The main objective of the EU Directive (2009/31/EC) on the geological storage of CO_2 is to regulate the safe and environmentally sound storage of captured CO_2. The Directive was adopted on April 23rd, 2009, and entered into force on June 25th, 2009. The Directive establishes a regulatory framework for permitting the exploration of potential CO_2 storage sites, the actual storage operation and post closure obligations. The CCS Directive focuses on the storage part of the CCS chain. Member States were required to comply with the Directive by June 25th, 2011.

The Directive sets out the criteria for the selection and characterization of storage sites and the issuance of exploration and storage permits. These criteria analyze the application process, conditions, content, as well as the requirement for the Commission to review permits, and modifications and withdrawal of permits.

2.1.1 Site selection, exploration permits and storage permits

2.1.1.1 Site selection and characterization

The Directive first establishes the right of national authorities to decide on areas for exploration. Member States that allow storage in their territory shall undertake an assessment of the storage capacity available in parts or the in the extend of their territory. Suitability for CO_2 storage is determined through the characterization and assessment of sites in three

2. DUTTON, JOSEPH, et al. EUROPEAN CCS: LEARNING FROM FAILURE OR FAILING TO LEARN? E3G, 2020. JSTOR, http://www.jstor.org/stable/resrep24948.

steps: (i) data collection, (ii) development of 3-D static geological model(s), and (iii) characterization of storage dynamic behavior.

A geologic storage site should be selected only if, there is no significant leakage risk and no significant health and environmental risks under the proposed conditions.

2.1.1.2 Exploration permit

Article 5 of the Directive sets out the provisions for an exploration permit which is necessary to hold for exploring potential carbon dioxide storage. In practice, it will (most probably) be always necessary to do some exploration of the site before the government is ensured that the requirements for characterizing a site as a storage site are met. This process is usually completed before any potential operator invests in the necessary infrastructure for the actual storage activity. Another important point to the exploration permit is that it provides to the holder of the permit exclusive rights to explore the potential CO_2 storage complex (Article 5(4)). The period for exploration should not exceed the period necessary to undertake the exploration it is granted for. However, an extension might be granted. The holder of a permit is the only party allowed to explore the specific (potential) storage area.

2.1.1.3 Storage permit

The geological CO_2 storage activity can take place only when a CO_2 storage permit is obtained, as it is presented in Chapter 3 of the CCS Directive. Specifically, Articles 6 to 11 go through the necessity of holding a storage permit. In more detail, the above-mentioned articles describe what information should be included in the application for obtaining a storage permit, the conditions for issuance and contents of such permit, the Commission's role as a reviewer of the draft permit and how to handle changes, reviews, updates and withdrawal of a storage permit.

Chapter 4 describes the storage operators' obligations throughout "Operations, closure and post-closure". Storage operator's obligations include, amongst others, monitoring and reporting, measurements and liability provisions. Specifically, according to Article 9, the storage operators are obliged to describe how they plan to monitor and report the CO_2 behavior and performance of the storage facility, what type of corrective measures are planned for implementation, what conditions will be considered for the storage site closure and what type of financial security mechanism will be applied at the time of the submission of a storage permit application. Generally, the requirements described in this chapter have a clear practical impact on securing an "environmentally safe geological storage of carbon dioxide to contribute to the fight against climate change" (Article 1).

2.1.1.4 *Operation, closure and post-closure obligations*

Regarding operational matters, Article 12 requires that CO_2 stream consists "*overwhelmingly of carbon dioxide*". In this lies an environmental security mechanism, as no operator holding a storage permit may store a CO_2 stream to which wastes, or other substances/matters have been added for the purpose of disposal (Article 12(1)). Article 12(1)(a) and (b) of the CCS Directive specifies where the threshold for any "*incidental associated substances*" lies and gives the Commission a mandate to "*adopt guidelines to help identify the conditions applicable on a case-by-case basis for respecting the criteria laid down in paragraph 1*", if appropriate. These guidelines can be found in the Commission Guidance Document 2 (2011) on *Characterization of the Storage Complex, CO_2 Stream Composition, Monitoring and Corrective Measures*[3].

Articles 13 and 14 set out monitoring and reporting obligations. Member States are required to ensure that the operator carries out monitoring in accordance with Article 13 and reports in accordance with Article 14. Article 16 sets out the operator's obligation to take corrective actions in the event of leakage or significant irregularities, and the right of the competent authority to intervene if the operator fails to take the necessary corrective measures. The competent authority shall recover the costs thereof from the operator, including the use of the financial security (Article 16(5)).

3. The wording on the CO_2 stream composition in the CCS Directive is the same as the one found in another legal framework bearing on CO_2 sequestration in geological formation below the seabed, namely the London Protocol.

Article 17 sets out the conditions and obligations for the closure of the storage site and the post closure period.

The last three articles of Chapter 4, (Articles 18, 19 and 20) address the transfer of responsibility for the storage site and the financial obligations of the operator throughout operation, closure and post-closure periods, and for a specified period of time after the transfer of liability. The financial security must already be presented and submitted as part of the application for the storage permit. According to Article 19, the financial mechanism must be "*valid and effective before commencement of injection*". Thus, the mechanism is in place from the start of injection, and it is intended to ensure that "*all obligations arising under the permit issued pursuant to this Directive, including closure and post-closure requirements, as well as any obligations arising from inclusion of the storage site under Directive 2003/87/EC, can be met*". The financial security shall remain valid and effective until the responsibility for the storage site has been transferred in accordance with Article 18 (Article 19(3)).

The following is a summary of the obligations under the permit that must be covered by a Financial Security or "Guarantee" in accordance with the Directive.

Table 5: Summary of obligations during operations and closure & post-closure period

Operations Period	*Closure and Post-Closure Period*
1. Monitoring, updates of monitoring plan, and required reports of monitoring results	1. Monitoring, updates of monitoring plan, and required reports of monitoring results
2. Updates of corrective measures plan, and implementing corrective measures, including measures related to the protection of human health	2. Updates of corrective measures plan, and implementing corrective measures, including measures related to the protection of human health
3. Surrender of allowances for any emissions from the site, including leakages, pursuant to ETS Directive	3. Surrender of allowances for any emissions from the site, including leakages, pursuant to ETS Directive
4. Update of provisional post closure plan	4. Sealing the storage site and removing injection facilities
5. Maintaining injection operations by the Competent Authority until new storage permit is issued, if storage permit is withdrawn, including CO_2 composition analysis, risk assessment and registration, and required reports of CO_2 streams delivered and injected	5. Making required financial contribution available to the CA

As noted above, Article 18 and the transfer of responsibility mark the "end" of the financial security according to Article 19(3). Several criteria must be met for the transfer of responsibility from the operator to the competent authority under Article 18. These include in particular:

— all legal obligations relating to monitoring and corrective measures

— the surrender of allowances in the event of leakages pursuant to Directive 2003/87/EC[4]

— preventive and remedial action pursuant to Articles 5(1) and 6(1) of Directive 2004/35/EC[5]

4. Liability for climate damage as a result of leakages is covered by the inclusion of storage sites in Directive 2003/87/EC, which requires surrender of emissions trading allowances for any leaked emissions.

5. Liability for environmental damage (damage to protected species and natural habitats, water and land) is regulated by Directive 2004/35/EC of the European Parlia-

shall be transferred to the competent authority on its own initiative or upon request from the operator, if the following conditions are met:

— all available evidence must indicate that the stored CO_2 will be completely and permanently contained (Article 18(1) paragraph (a))

— a minimum period of time following the closure of the storage site must have elapsed. This period of time shall be no shorter than 20 years, unless the competent authority is convinced that the criterion referred to in paragraph (a) is met before the end of that period (Article 18(1) paragraph (b))

— the financial obligation according to Article 20 must be fulfilled

— the site has been sealed and the injection facilities have been removed (Article 18(1) paragraphs (c) and (d)).

The Commission has adopted a Guidance document on this from 2011, entitled *Criteria for Transfer of Responsibility to the Competent Authority*. Article 18(3) to (5) sets out the formalities for the adoption of a final decision on the transfer of responsibility. Article 18(6) lays out the requirements for monitoring after the transfer of responsibility and paragraph 7 states the responsibility of the operator for any fault on his part.

The last remaining responsibility of the operator is the financial mechanism according to Article 20, which requires the operator to provide a *"financial contribution available to the competent authority before the transfer of responsibility pursuant to Article 18"*. The financial mechanism shall cover *"at least the anticipated cost of monitoring for a period of 30 years"*. It may be used to *"cover the costs borne by the competent authority after the transfer of responsibility to ensure that the CO_2 is completely and permanently contained in geological storage sites"*. One question of interest to both a potential operator and the competent authority is what should be the form of the financial security. The Guidance documents underline that the final decision rests with the national competent authority. It remains to be seen which mechanisms will be deemed the most appropriate.

ment and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage, which should be applied to the operation of storage sites pursuant to this Directive.

2.1.1.5 *Third-party access*

Chapter 5 of the Directive, "*third-party access*", is the chapter that clarifies the internal market and competition side of CO_2 transport and storage activities. Access to infrastructure put in place shall be provided in a "*transparent and non-discriminatory manner determined*", considering among other things, storage capacity, proportion of CO_2 reduction obligations, technical specifications, and other aspects based on duly justified reasonable needs of the operator (Article 21(2) paragraphs (a) – (d)).

2.1.2 Implementation of the CCS Directive

The European Commission works to ensure the coherent implementation of the CCS Directive throughout the EU. This includes reporting on the implementation, facilitating exchanges between the competent authorities, publishing guidance documents, and adopting Commission Opinions on draft storage permits.

2.1.2.1 *Reports on the implementation of the CCS Directive*

The CCS Directive includes reporting requirements for EU countries and the European Commission:

— Every 4 years, Member States report to the Commission on the implementation of the Directive

— The Commission then reports to the European Parliament and the Council on implementation across the EU.

The Commission has published 3 implementation reports:

— **1st implementation report[6] February 2014** – based on Member States' reports delivered between July 2011 and April 2013. This report covers implementation of all key provisions of the Directive, state of transposition of the Directive and Commission actions to improve implementation.

The report shows that by this point in time, all Member States notified transposition measures to the Commission. In this connection, most

6. http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52014DC0099

Member States opted for a combination of new specific legislation on the geological storage of CO_2 and amendments to existing legislation. Most of the Member States have assigned responsibilities to more than one competent authority. The assessment of potential CO_2 storage sites is ongoing, with several Member States issuing exploration permits and the Commission reviewing one submitted draft storage permit. The Member States which allow CO_2 storage on their territory have communicated implementation of the provisions on monitoring, reporting and inspections, leakages and significant irregularities, closure and post-closure obligations, as well as the two financial mechanisms established by the CCS Directive. As regards Member States which restrict or prohibit CO_2 storage on their territory, some transposed only the provisions of the Directive that deal with capture and transport aspects of CCS, while others transposed all the provisions of the Directive, including the storage related Articles.

— **2nd implementation report[7] February 2017** – covering the period from May 2013 to April 2016. This report focuses on the articles which have had practical application in the Member States.

The provisions of the CCS Directive have been consistently applied across the reporting period in the EU Member States. Some Member States have advanced in their assessments of storage capacity (Greece, Bulgaria, Germany, Hungary, Italy, the Netherlands, Sweden and the United Kingdom) but further and more detailed assessments will be needed should there be CCS projects starting. Despite the lack of positive assessment for technical and economic feasibility for CCS retrofitting, newly built power plants are generally going beyond the legal requirements and are setting aside land in case the conditions change in the future.

— **3rd implementation report[8] October 2019** – based on national reports covering the period from May 2016 to April 2019. This report focuses on the progress made by Member States since the second implementation report.

7. https://ec.europa.eu/clima/document/download/9b1548e7-d4d5-4e8d-aedc-6391f4f903bb_en?filename=com20017_37_ccs_directive_implementation_report_en.docx

8. https://ec.europa.eu/clima/document/download/311e9e47-49f5-48d5-870a-f816d4a2d5bb_en?filename=com_2019_566_en.pdf

The provisions of the CCS Directive have been correctly applied across the reporting period in the EU Member States, which have submitted reports to the Commission by 30 June 2019. A considerable number of Member States and Norway continue to support or plan to support in the near future, through their national programmes or funds, research and demonstration activities on CCS. Furthermore, many countries are involved in several European research and collaborative projects.

2.1.2.2 Information Exchange Group

An Information Exchange Group has been established to:

— organize an exchange of information between the competent authorities of the Member States, and

— promote a coherent implementation of the CCS Directive throughout the EU

As part of efforts to ensure knowledge sharing and exchange of practical information for the coherent implementation of the CCS Directive, the Commission services organize workshops and meetings with stakeholders and/or Member States.

2.1.2.3 Guidance Documents

Four guidance documents were published in 2011 to:

— provide an overall methodological approach for implementing the key provisions of the CCS Directive and

— help ensure environmentally safe geological storage of CO_2 across the EU.

The first guidance document[9] outlines a CO_2 storage life cycle risk management framework addressing different geological options for CO_2 storage as well as different storage risks (geological and manmade leakage pathways).

9. Available at: https://climate.ec.europa.eu/system/files/2016-11/gd1_en.pdf

The second guidance document[10] examines in more detail issues such as the characterization of the storage complex. Selecting the appropriate storage site ensures that the stored CO_2 will be completely and permanently contained. Also, CO_2 stream composition, monitoring and corrective measures are being examined.

The criteria for transfer of responsibility to the Member State are addressed by the third guidance document[11], putting emphasis on the minimum period for post-closure monitoring, site sealing and transfer of data.

Finally, the fourth guidance document[12] provides an overview of what is considered "financial security", which obligations are covered by it and in general, how to establish and maintain it. In respect of the amount of financial security, it discusses the basic principles, the obligations covered and lastly, the acceptable instruments for it.

The documents are mainly addressed to the competent authorities and relevant stakeholders.

They have been discussed with experts from Member States and key stakeholders, including industry, research community and NGO's.

Currently, the guidance documents are undergoing review process and an updated version will be issued by the end of the year.

2.1.2.4 Commission review of draft storage permits

Article 10 of the 2009/31/EC Directive describes the obligation of all Member States to make the permit applications available to the Commission within one month after receipt. They also have to make available other related material that are taken into account from the competent author-

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10. Guidance Document 2 "Characterization of the Storage Complex, CO_2 Stream Composition, Monitoring and Corrective Measures". Available at: https:/climate.ec.europa.eu/system/files/2016-11/gd2_en.pdf
Guidance Document 3 "Criteria for Transfer of Responsibility to the Competent Authority". Available at: https:/climate.ec.europa.eu/system/files/2016-11/gd3_en.pdf

11. Guidance Document 3 "Criteria for Transfer of Responsibility to the Competent Authority". Available at: https:/climate.ec.europa.eu/system/files/2016-11/gd3_en.pdf

12. Guidance Document 4 "Article 19 Financial Security and Article 20 Financial Mechanism". Available at: https:/climate.ec.europa.eu/system/files/2016-11/gd4_en.pdf

ity in the decision-making process of awarding a storage permit. Member States must inform the Commission of draft storage permits and any other material taken into consideration for the adoption of the draft decision. Within four months after receipt, the Commission may issue a non-binding opinion on it. If the Commission decides not to issue an opinion, it must inform the Member State within one month of submission of the draft permit and state its reasons.

The competent authority must notify the final decision to the Commission. In case there is a deviation from the Commissions' opinion, the reason must be stated.

2.1.3 Additional EU Policy measures

The EU plans to funnel significant funds through EU banks and markets to achieve its climate ambitions[13]. The EU Taxonomy clarifies which economic activities contribute to climate change mitigation and adaptation. This science-based tool recognizes CCS, thereby providing access to European Green Bonds.

Through the "Fit for 55" legislative proposals, changes relevant to CCS were introduced. Central to the package were modifications to the EU's emissions trading scheme (ETS) representing 40% of EU emissions. Changes would:

— increase the annual reduction rate of allowances to achieve the EU's new 2030 target

— recognize CO_2 is transported not only by pipelines, and cover all means of CO_2 transport

— double the size of the innovation fund

— add a new carbon border adjustment mechanism to put a carbon price on imports of targeted products, such as steel and cement, to avoid "carbon leakage"

Negotiations are ongoing, and the legislation should be finalized over the next few years.

13. Global CCS Institute - 2021

In the last year, the allowance price reached an all-time high. With greater national ambition and policy support, plus more awareness of climate risk amongst investors, hard to abate industries throughout Europe are increasingly exploring CCS.

2.2 Presentation of CCS legislation in Norway, UK, Spain, Netherlands and Italy

The CCS Directive has been transposed into national law by the majority of the Member States. A general overview shows that most of them simply adopt and incorporate the text of the Directive without significant changes. The Directive deliberately leaves room for initiatives by national legislators, taking into account the characteristics and specificities of each region. The countries that show the most interest in their regulatory framework are also the ones that have the most developed CCS projects.

In **Norway**, CCS has been part of climate policies for many years. As an EEA (European Economic Area) country, the CCS Directive entered into force on the June 1st, 2013. Until then, CCS activities were regulated under existing acts and regulations for petroleum activities, and two new sets of regulations on transport and storage of CO_2 on the continental shelf were introduced in 2014. Under the current regulations, exploration and storage of CO_2 is only allowed on the continental shelf. The resources belong to the state, and any CCS activity requires an exploration permit and an exploitation permit. Norway is the only country in Europe that has adopted specific provisions on leakage from CO_2 transport pipelines and considers the potential for force majeure. Norway has also included provisions for CO_2 transportation.

The **UK** began developing its CCS framework before the EU CCS Directive was finalized. The Energy Act 2008 establishes a regime for the regulation of CO_2 storage and introduced a licensing requirement for offshore CCS. In 2011, the Storage of Carbon Dioxide (Amendment of the Energy Act 2008) Regulations 2011 extended the licensing regime to include the onshore and the adjacent internal waters in the UK. The Crown Estate holds the territorial seabed rights for CO_2 transportation and storage within the UK Exclusive Economic Zone (excluding Scotland). CCS activities require an exploration and storage permit. There is a public registry for storage permits that have been granted. The UK also requires an environmental impact assessment for issuing storage permits and includes land protection and sustainable development into its environmental protection regime.

Spain incorporated the CCS Directive with the Act 40/2010, of 29 December 2010 (the CCS Act). The Act predominantly regulates the geological storage of CO_2, while capture and transportation are only marginally regulated. Geological storage of CO_2 is permitted in underground structures, including territorial sea, the exclusive economic zone, and the continental shelf. An exploration and a storage permit are required. In cases where the exploration permit is issued in areas already subject to other resource rights (e.g., mining or petroleum rights), the CCS Act allows exploration permits to be issued for storage sites, provided that storage is technically compatible with those resource activities. With respect to the transport of captured CO_2, the CCS Act only establishes general principles to ensure that access to the network of pipelines is open to third parties in a transparent and non-discriminatory manner.

In the **Netherlands**, the CCS Directive has been adopted in the Dutch Mining Act, the Dutch Mining Decree, and the Dutch Mining Regulation. Operators must obtain permits for the exploration of potential storage sites as well as for storage facilities. Once the minister has received an application for a permit, other parties will have the opportunity to also apply for the same area. The minister then decides to whom the permit will be granted based on the information provided in the applications. This means that an exploration permit, leading to the identification of a suitable site, does not guarantee a storage permit.

The **Italian** transposition of the CCS Directive was completed with the Decree No. 162/2011. Geological storage of CO_2 in the Italian territory is permitted in the exclusive economic zone and the continental shelf. An exploration permit and a storage permit are required. The exploration permit shall be subjected to the environmental impact assessment procedure.

The detailed regulatory aspects per country are presented in Appendix B.

2.3 Greek CCS Legislation

2.3.1 Subject matter and Purpose

In Greece, the Ministerial Decision 48416/2037/E.103/2011 (Government Gazette B' 2516/2011), as amended, transposed the CCS Directive 2009/31/EC into Greek law. The decision largely follows in the most part the philosophy of the CCS Directive. In detail:

— It intends and seeks to establish rules, measures and procedures for the environmentally safe storage of CO_2 in geological formations, as well as the necessary licensing framework, in order for Greece to contribute to the Community's efforts to combat climate change

— It adopts and establishes rules on licensing for the exploration and storage of CO_2, acceptance criteria, monitoring, reporting and inspection, operation, closure and post closure obligations, as well as issues of responsibility, financial security and penalties

— It is confirmed that the right to explore and store CO_2 in geological formations that fall within the scope of this Decision belongs exclusively to the State and its exercise always concerns the public interest

— The provisions of Law 3175/2003 (Government Official Gazette A' 207) and the Mining Law shall apply to issues that arise in the application of this Decision and that are not governed by the provisions of this Decision.

2.3.2 Scope

— This Decision applies to CO_2 storage in geological formations extending within the Greek Territory, including the seabed, continental shelf and subsoil up to the limits of the area in which the Hellenic State has sovereign rights, according to the United Nations Convention on the Law of the Sea (UNCLOS), ratified by Law 2321/1995 (Government Gazette A' 136)

— This decision does not apply to the geological storage of CO_2 with a total intended storage of less than 100 kt carried out for new research, development or testing products and processes

— CO_2 storage is not allowed/permitted:

• in a storage site with a storage complex that extends beyond the area of permitted scope

• in the water column and underground aquifers[14]

2.3.3 Competent Authority

HEREMA is determined as the competent authority for the implementation of the Ministerial Decision and is vested with the powers to:

— issue and grant permits for the exploration and storage of carbon dioxide in geological formations

— manage the rights of the Greek State in relation to the exploitation of geological formations for the storage of carbon dioxide, conclude, supervise and monitor the execution of the relevant contracts in accordance with the Joint Ministerial Decision 48416/2037/ E.103/7.11.2011

— monitor the safe operation of the respective projects, make recommendations to the relevant ministries for the issuance of the regulatory (secondary legislation) acts provided for in the current legislation to define the procedure and conditions for the use, development and exploitation of the geological formation

14. In comparison with the CCS Directive, which only prohibits storage in water columns, the Greek Ministerial Decision does not allow CO_2 storage also in underground aquifers. However, Article 32 of the CCS Directive introduces an amendment of the Directive 2000/60/EC regarding the field of water policy, which allows for injection of CO_2 into geological formations which for natural reasons are permanently unsuitable for other purposes. The preamble of the Directive states that "Directive 2000/60/EC establishing a framework for Community action in the field of water policy should be amended to allow for injection of CO_2 into saline aquifers for the purposes of geological storage". Therefore, the purpose of this amendment was to allow for CO_2 storage in saline aquifers. This conclusion is supported also by the Guidance documents of the Directive, which underline the importance of using saline aquifers as storage sites. The amendment in the Directive 2000/60/EC has been incorporated into Greek Law (through the Ministerial Decision 48416/2037/E.103/2011) in the Presidential Decree 51/2007, under article 12. Hence, in the same Ministerial Decision it seems that there are two contradictory provisions; one prohibiting storage in underground aquifers and one permitting storage in saline aquifers. No definition is provided for either term. To provide clarity as to what stands true, an amendment is required in the regulatory framework.

The Minister of Environment and Energy is also vested with the powers to:

— determine the areas from which storage sites can be selected

— to assess the suitability of a geological formation for use as a storage site for CCS

Other entities are also involved in the implementation of the Ministerial Decision:

— Special Secretariat for the Environment and Energy Inspectorate: Responsible for organizing and coordinating a system of routine and non-routine inspections of all storage complexes to verify and promote compliance with the requirements of the Ministerial Decision; additionally, monitoring the effects on the environment and human health.

— Settlement Committee for dispute resolution matters (refer below section 2.3.4.6).

2.3.4 CCS Licensing and Permitting Procedure

In accordance with the CCS Directive, the Greek CCS framework provides for the licensing procedure before the Competent Authority (HEREMA) the issuance of:

— an Exploration Permit

— a Storage Permit

2.3.4.1 Exploration Permit (Article 6)

The application for the permit shall include data and information demonstrating the necessary technical ability and competence of the exploration body concerned as well as a technical report containing at least the following elements:

— description of the exploration area and the wider area within a radius of at least 1 km

— time schedule of the works implementation

— landscape restoration schedule, in case exploitation of the storage site will not happen within a reasonable period of time

— measures for the safety and protection of workers

The Ministerial Decision does not address the issue of the duration of the exploration permit. It is provided that the Minister of Environment and Energy may issue a Decision specifying the conditions for the issuance of the exploration permit.

2.3.4.2 Storage Permit (Article 7)

The exploitation of a storage site requires a storage permit, only one operator for each storage site and lastly, the prohibition of conflicting uses of that site. Priority is given to the holder of an exploration permit for that site (under the condition that the exploration is complete, and the terms of the permit have been abided by).

In the context of the storage licensing, an environmental permit, namely the Approval of the Environmental Terms shall be obtained as well. For the issuance of the Approval, an Environmental Impact Assessment shall be conducted and submitted.

The duration of a storage permit shall not exceed 25 years and shall be renewed every 5 years after its expiration.

2.3.4.3 CO_2 storage by entities that hold a right or license to explore and exploit hydrocarbons

Entities that already hold a right or a license to explore and exploit hydrocarbons in a certain area, and who already have sufficient data that prove the eligibility of the area as a storage site, have (they or an associated entity) the right to apply for CO_2 storage license in that same area. It is noted that Spain has already adopted a similar provision.

The procedure for obtaining such a right is as follows:

— **Application for site eligibility:** in order for interested parties to activate their right, they must submit an application to HEREMA within one year of the enactment of the aforementioned law (i.e., by July 2023), demonstrating, based on geological, geophysical and drilling data, that the concession site is suitable in principle for the storage of CO_2

— **Application for activation of the storage right:** After confirmation of the suitability of the requested site, the interested party submits a new application to HEREMA. This involves first confirming the suitability of the geological formation as a storage site, then approving the environmental conditions, and finally approving the storage right. HEREMA's approval of the application constitutes a storage permit within the meaning of Article 6 of the CCS Directive

Notable is the fact that, if:

— the interested parties do not exercise within the abovementioned deadline (July 2023) their right, or

— waive it, or

— HEREMA's decision on the site eligibility or on the storage right's activation is revoked, then

— HEREMA may determine a particular geological formation within the concession area as suitable for CO_2 storage and grant an exploration and a storage permit pursuant to the provisions of the Ministerial Decision to any third party. In such case, it must be proved that the two activities can uninterruptedly coexist at the same site.

2.3.4.4 Withdrawal of Storage Permits (Article 12)

In line with the CCS Directive, withdrawal of a storage permit is foreseen only as a last resort if no other measure is effective. In particular, the competent authority shall review the storage permit and, if necessary, modify/amend it or revoke it:

— if it has been notified or made aware of any leakages or significant irregularities pursuant to Article 17(1)

— if the reports submitted pursuant to Article 15 or the environmental inspections carried out pursuant to Article 16 show non-compliance with permit conditions or risks of leakages or significant irregularities

— if it is aware of any other failure by the operator to meet the permit conditions

— if it appears necessary on the basis of the latest scientific findings and technological progress

— without prejudice to the previous points, five years after issuing the permit and every 10 years thereafter

2.3.4.5 Third-Party Access (Article 22)

Potential users may gain access to CO_2 transport networks and storage sites for the purpose of storing produced and sequestered CO_2 in geological formations. Access by the Competent Authority shall be provided in a transparent and non-discriminatory manner determined by taking into account:

— the storage capacity which is or can reasonably be made available within the areas determined, and the transport capacity which is or can reasonably be made available

— the proportion of its CO_2 reduction obligations pursuant to international legal instruments and to EU legislation that it intends to meet through capture and geological storage of CO_2

— the need to refuse access where there is an incompatibility of technical specifications which cannot be reasonably overcome

— the need to respect the duly substantiated reasonable needs of the owner or operator of the storage site or of the transport network and the interests of all other users of the storage or the network or relevant processing or handling facilities that may be affected

2.3.4.6 Dispute settlement (Article 23)

In accordance with the Directive's mandate to establish and have in place *"an authority independent of the parties with access to all relevant information, to enable disputes relating to access to transport networks and to storage sites to be settled expeditiously"*, the Ministerial Decision provides that a Settlement Committee for the Storage of Carbon Dioxide in Geological Formations is established as an out-of-court body for the rapid resolution of all disputes related to transport networks and storage sites.

The Settlement Committee is established by decision of the Minister of Environment and Energy, for a two-year term which can be renewed and is composed of three members:

— a Counselor, Senior Member or Judicial Representative, who serves in the Office of the Legal Advisor of the Ministry, as President

— a representative from the General Environment Directorate of the Ministry of Environment and Energy[15]

— a representative from the General Secretariat of Energy and Climate Change of the Ministry of Environment and Energy[16]

The Committee takes over the cases that fall under its competence following a signed report of at least one of the parties involved.

The Minister of Environment and Energy is competent to regulate the technical details of implementation of this provision, if necessary.

2.4 EU-GR Gap analysis

The resulting statute in Greece (as in most of the Member States) is a full, simple and uncomplicated transposition of the Directive. There is no "gold-plating", but slight divergences do occur.

A first gap identified in the Greek regulatory framework is that the procedure for issuing an exploration permit is not exhaustively defined in the Ministerial Decision. An example of what is not defined in the Greek text is the permit's duration; it is merely stated that the duration will be defined in the permit. The issue of the duration of the exploration permit is critical as it is associated with high research costs and proves the seriousness of the investor in carrying out and proceeding with the prospective project. Other countries have a stricter approach: in Italy the exploration permit is active for three years, and it can be extended for up to two (additional) years; it is important to note that the State can revoke the permit if no work has been commenced for a year. Likewise, in Spain its duration is for up to four years and it can be extended for additional two.

Another issue that is not addressed by the Greek Ministerial Decision or by the Directive and has significant implications for the economic viability of

15. Or the corresponding Directorate based on the Ministry's organization chart in force.
16. Or the corresponding Directorate based on the Ministry's organization chart in force.

CO_2 storage projects, is the transferability of the permits/licenses. Other regimes (Italy, Spain and the Netherlands) allow under certain conditions and authorizations the transfer of both the exploration and the storage permit. The opportunity to be able to transfer or acquire a permit is an important risk – mitigant and could, therefore, make the investment more attractive.

Additionally, the matter of saline aquifers creates uncertainty. Even though, the Greek Ministerial Decision has transposed the corresponding provision of the CCS Directive amending the Directive 2000/60/EC in order to allow for CO_2 injection in saline aquifers, the same Ministerial Decision also prohibits storage in underground aquifers. The result is that two opposing provisions coexist, and this leads to confusion. An amendment of the relevant framework is required in order to explicitly allow for CO_2 storage in saline aquifers.

In any case, the geographical constrains and the natural characteristics of each region (i.e., physical lack of CO_2 storage), may explain why the EU has established a more "general" framework and instead allowed Member States to develop their own frameworks and development strategies.

With respect to transportation matters, there has been some development; the 2009 amendment of the London Protocol[17] can go hand in hand with the CCS Directive and the EU framework in general. The provisional application of the 2009 amendment now means that two or more coun-

17. "*2 Notwithstanding paragraph 1, the export of carbon dioxide streams for disposal in accordance with Annex 1 may occur, provided that an agreement or arrangement has been entered into by the countries concerned. Such an agreement or arrangement shall include:*

.2.1 confirmation and allocation of permitting responsibilities between the exporting and receiving countries, consistent with the provisions of this Protocol and other applicable international law; and

.2.2 in the case of export to non-Contracting Parties, provisions at a minimum equivalent to those contained in this Protocol, including those relating to the issuance of permits and permit conditions for complying with the provisions of Annex 2, to ensure that the agreement or arrangement does not derogate from the obligations of Contracting Parties under this Protocol to protect and preserve the marine environment. A Contracting Party entering into such an agreement or arrangement shall notify it to the Organization."

tries can agree, through bilateral (or multilateral) agreements[18] to receive and export CO_2 for offshore geological storage. However, to do so they must first submit a formal declaration of provisional application with the Secretary-General of the International Maritime Organization (IMO), which provides the Secretariat for the London Convention and the London Protocol and is the depositary organization for the London Protocol. The countries/States concerned must also enter into an agreement or arrangement to confirm permitting responsibilities between the exporting and receiving countries consistent with the provisions of the Protocol[19].

Member States that are party to the London Protocol could enter into additional bilateral arrangements with other EU Member States and EEA partner countries only on issues that are not covered by the CCS Directive. These additional bilateral arrangements should be strictly limited to the residual issues not covered by EU law and they should not refer to the subject matters covered by EU rules. However, it must be highlighted that although most EU Member States and EEA countries are Contracting Parties to the London Protocol, Greece, Hungary, Malta, Poland and Portugal are party to the London Convention only. This means that in case of an exporting Contracting Party to the Protocol with a non-Contracting Party (e.g., Greece), the Contracting Party must establish an agreement or arrangement with the non-Contracting Party that, at a minimum, provides the same environmental protections as if the CO_2 were being stored by a Contracting Party. In the case of a breach of the agreement or arrangement by the non-Contracting Party, the Contracting Party should "engage in consultations to rectify". In the case of a "significant ongoing breach", the Contracting Party is required to "terminate the export".

18. Norway and the Netherlands are set to finalize a bilateral agreement in 2022.

19. Commission services analysis paper for the Information Exchange Group (IEG) under Directive 2009/31/EC – 30.09.2022

3. CCS Framework and Business/ Revenue Models

CCS technology is expected to play an important role in the transition to the net-zero emissions target, especially in reducing greenhouse gas emissions in heavy industry. For CCS to be successful, such projects require guaranteed, reliable access to safe and cost-effective CO_2 transport and storage. Building an infrastructure that enables the safe and efficient transport of captured CO_2 and its permanent underground storage, can be challenging. The different phases of CCS (Capture-Transport-Storage) bring different requirements for financial support and policy frameworks. Choosing the right business/ revenue models is about finding the underlying fundamental structures for how a CCS project will create value to its investors while meeting specified and predefined environmental goals (i.e., greenhouse gas reductions).

3.1 Challenges and Risks of CCS

Before identifying and evaluating business models, it is important to understand the risks and challenges that currently stand in the way of CCS expansion and deployment. In general, the main challenges associated with CCS are related to high and uncertain costs. For example, the cost of capturing a ton of CO_2 in a CCS system can range from USD 22 to 225[1] depending on the industry.

CO_2 capture from fossil fuel use and industrial processes will need to significantly increase and scale up to reach about 3.4 Gtpa of CO_2 by 2050 (currently 0.04 Gtpa). With more than 160 CCS projects at various stages of development, another 0.2 Gtpa of CO_2 capture capacity will be added. For CCS to reach the expected targets, CO_2 capture potential should be between 1Gtpa and 2Gtpa by 2030, according to IRENA reflecting an urgent need for CCS investments. There are many challenges to the de-

1. IRENA Reaching Zero With Renewables Capturing Carbon 2021.

ployment of CCS, however, these challenges can be successfully addressed to unlock the potential of CCS offering a cost-effective decarbonization pathway for energy infrastructure and heavy industry. Key challenges are identified as follows:

— In the **CO_2 capture phase**, challenges may arise depending on the origin of the greenhouse gas. The main sources of CO_2 are either the combustion of fossil fuels for heat and power generation, or direct production as a byproduct of industrial processes. To separate the CO_2, different chemical and physical techniques can be used, but their technological maturity varies, resulting in uncertainty regarding their performance. Additionally, when an entity has multiple sources of CO_2 emissions, a more intricate and expensive capture mechanism is required.

— For **CO_2 transportation**, scale is currently limited, and cost estimates are uncertain. The choice of transportation method is a key driver of costs in this phase. For transportation via pipelines, capital expenditures (CAPEX) account for almost 90% of the total transportation costs. On the other hand, for transportation by ship, the primary cost elements are operating costs (OPEX) for liquefaction, fuel, loading and unloading, and temporary storage. Additionally, for the case of the CO_2 transportation via ships, other challenges may arise on the size, haul and pressure and temperature for transporting liquid CO_2 in ships for scaling up liquid CO_2 carriers. Furthermore, the potential need for Floating CO_2 Storage Units enabling access to international markets and the storage and sale of CO_2 credits under certain carbon trading schemes.

— The development of **CO_2 storage** facilities has been slow. From 2012-2021, only 21.6 Mtpa of CO_2 storage capacity was added. Currently (September 2022), the storage capacity of facilities in operation worldwide account for 42.6 Mtpa, while the rest of the CCS projects in various stages of development account for 199.1 Mtpa. Geological storage of CO_2 has been carried out for many years without major issues, but the scale is small, and the costs are also uncertain. Security matters and long-term liability issues may arise with Gtpa-scale CO_2 storage, as the total CO_2 sequestered has not yet currently reached this scale.

The lack of liability and some societal reservations could lead to a lack of acceptance of CO_2 storage structures.

A classification of the main risks has been identified in the table below. For the detailed assessment, Appendix C describes each risk and challenge per cluster and separately for the State, the emitter/user and the T&S operator.

Table 6: Risk and Challenges Classification

Risk Clusters	Risks & Challenges Classification
Economic & Market	1. CO_2 Emissions Price (Weak and/or uncertain CO_2 price) 2. Investment cost & higher than anticipated construction cost 3. Operational cost and higher than expected 4. Value chain and market background
Technical & Operational	1. Failure to deliver CO_2 (emitter) 2. CO_2 Quality (fail to meet specifications) 3. Failure to receive CO_2 (T&S) 4. Leakage of CO_2 5. Delay in works completion 6. Underutilization of facilities 7. Terminal to ship interface (in case of transportation with ships)
Cross-chain	1. Force majeure 2. State instructed changes 3. Regulatory amendments (considered an additional operational cost) 4. Breach of contract 5. Transportation footprint

3.2 Presentation of the different business model options

To develop and select business models for CCS deployment in Greece, the potential mechanisms, instruments and risk management strategies were investigated through case studies and CCS projects both at EU and global level. The summary of the case study projects is presented in Appendix

A: Projects. In the meanwhile, each phase of CCS (capture, transport and storage) can be integrated through different and distinct business/ revenue models. To illustrate this, the following section presents some of the commonly known models for each phase of the CCS value chain. Combinations of these models are also possible. Figure 7 illustrates an overview on CCS Stakeholders and financial flows.

Figure 7: *CCS Stakeholders & financial flows.*

3.2.1 CO_2 Capture Phase

The key incentives in this phase are avoidance of costs associated with CO_2 emissions or benefits through the Emissions Trading System (ETS) and Results-based Climate Finance (RBCF). To expand the implementation of a CCS project, one option could be to establish an emissions performance standard or CCS mandate.

3.2.1.1 Tax Credits

Tax credits are reductions in the tax liability of a firm when it meets certain requirements[2]. The cost reduction (through taxes) that results from

2. University of Edinburgh Business School: A Review of Business Models for Carbon Capture, Utilization and Storage Technologies in the Steel Sector: A Qualitative Multi-Method Study (2019)

avoided environmental impacts and the simultaneous creation of value for customers and society as a whole is a “win-win” situation. This business model is prevalent in the U.S., but projects with this model can be found all over the world. Specifically, Section 45Q of the tax credits in the United States provides USD 50/tCO_2 for dedicated geological storage or USD 35 /tCO_2 for the use of CO_2 in enhanced oil recovery. In addition, the Section 48A tax credit applies to a certain percentage of capital expenditures for retrofitting coal-fired power plants with CO_2 capture technologies[3].

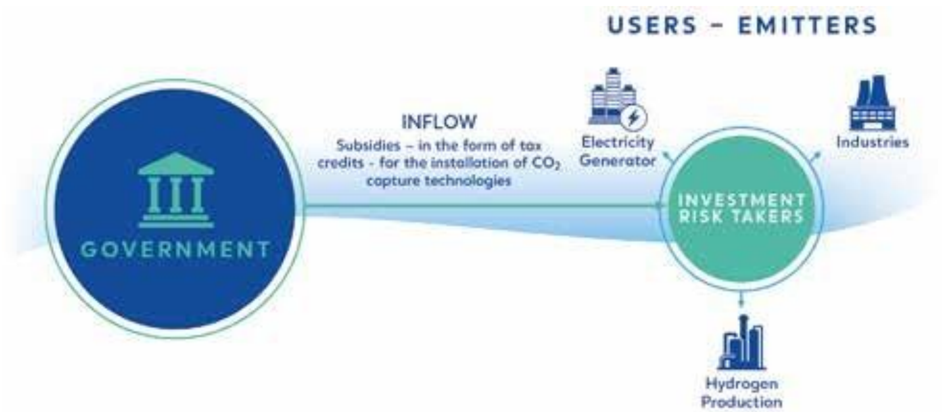


Figure 8: *Risk allocation and financial flow for the tax incentive mechanism.*

The level of tax credits, contractual certainty, capital availability and the ability to account for CO_2 prices are important determinants for the potential success of the policy. Tax credits for carbon sequestration already provide an incentive for capturing carbon and storing it underground in geologic or saline formations, underground through oil recovery and in products through CO_2 utilization. However, while this revenue model holds powerful potential to drive carbon capture, unlocking that potential requires making tax credit more accessible. It is also needed to ensure that tax credit provides an appropriate incentive to make carbon capture technologies (which currently have high costs) cost effective for developers.

3. IEA - The role of CCUS in low-carbon power systems – Actions for policy makers (2020)

Extending the credit and making it more directly available – regardless of the size of the tax burden an organization would be claiming it against – is a core tenet of providing a reliable and accessible credit around which developers can plan these multi-year projects.

A few examples of operating CCS facilities, under this revenue model are Sleipner and Snohvit in Norway. More information is presented in Annex A.

3.2.1.2 Emissions Trading System (ETS)

An **Emissions Trading System (ETS)** is a system in which emitters can trade emission units to meet their targets (see Figure 9). These systems have been widely adopted by the EU Member States. The EU ETS is a corner-stone of the EU's climate change policy and a very useful tool to reduce GHG significantly and cost-effectively. Emissions Trading Systems are applied worldwide; however, the EU ETS is the world's first and biggest carbon market.

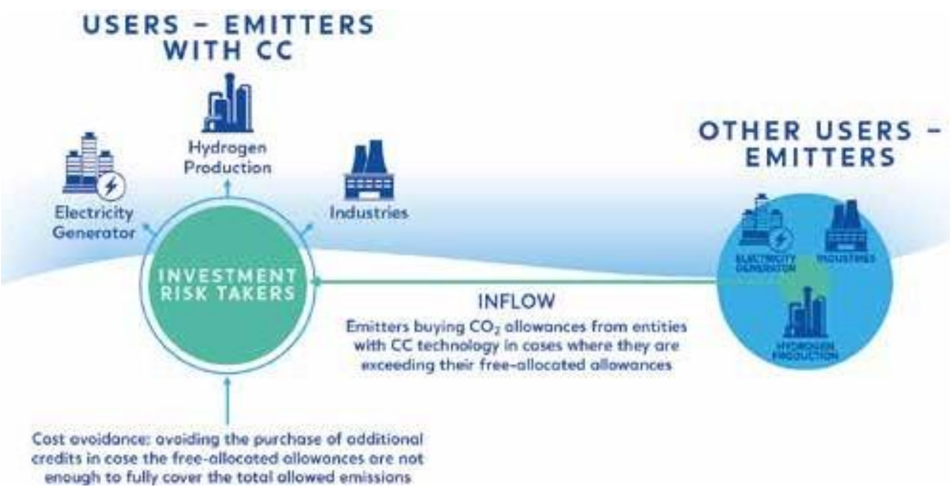


Figure 9: *Risk allocation and financial flow for the ETS mechanism.*

To comply with their emission targets at minimum cost, regulated entities can either implement internal mitigation measures or purchase emission units in the carbon market, depending on the cost of each option. By creating supply and demand for emissions units, an ETS establishes a market price for GHG emissions. The two main types of ETS are cap-and-trade and baseline-and-credit[4]:

- **Cap-and-trade systems:** Under the cap-and-trade system, a cap or absolute limit on the emissions within the ETS is set and then emissions allowances are distributed, usually for free or through auctions for the amount of emissions equivalent to the cap. The cap is reduced over time so that total emissions decrease
- **Baseline-and-credit systems:** baseline emission levels are defined for individual regulated entities, and credits are issued to entities that have reduced their emissions below this level. These credits can be sold to other entities exceeding their baseline emission levels

Figure 10 illustrates the EU ETS.

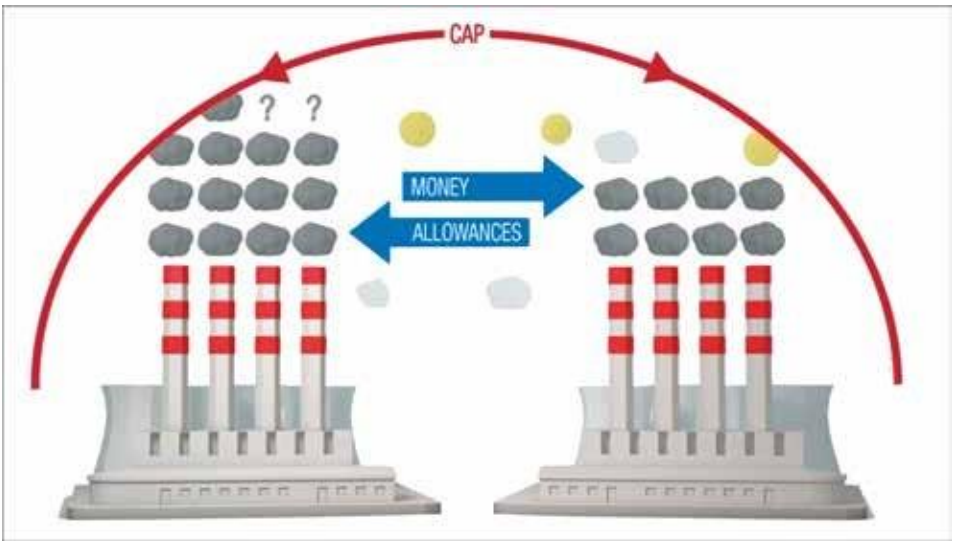


***Figure 10:** Cap-and-trade ETS, (Source: European Commission, Licence CC BY 4.0).*

4. European Commission (EC): EU Emissions Trading System https:/climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets_en

Through the ETS, entities that will limit their emissions by installing CO_2 capture systems will benefit by:

— selling their surplus allowances to other entities that are exceeding their emission levels

— avoiding the purchase of additional credits in case their allowances are not enough to fully cover the total emissions

3.2.1.3 Contract for Difference

Contract for Difference (CfD) is a contract between two parties (typically a buyer and seller), creating a guaranteed price for a product. This guaranteed price is called the "strike price" and one party must pay the other the difference between the strike price and the market price of the product. If the closing trade price is higher than the opening price, then the seller will pay the buyer the difference, and that will be the buyer's profit. The seller's profit is the difference that the buyer pays if the closing trade price is lower than the opening price. Figure 11 illustrates an example of CfD.

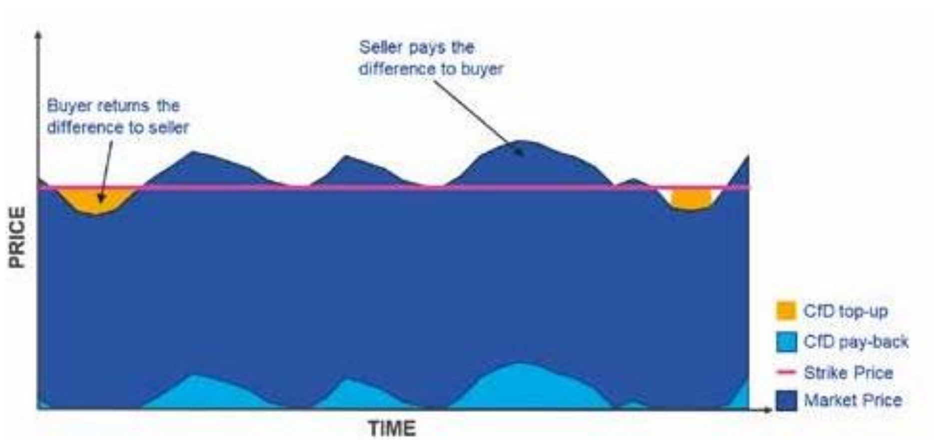


***Figure** 11: Example of CfD during fluctuating market prices.*

In a CCS project, a state aid could be dedicated to cover the difference of capture and storage cost compared to ETS credit. The strike price is the levelized cost per captured ton of CO_2. State aid is likely to be reduced year over year as ETS price is expected to increase.

It is expected that the PORTHOS project will follow this business model. The Dutch government will cover the cost difference between the purchase of carbon credits and the cost of CCS. However, this scheme makes the potential profitability of the PORTHOS project unlikely, as the state aid will only cover the additional costs compared to the ETS price; on the other hand, it means that no additional funds will be needed from investors, as the additional costs of implementing CCS technologies will have no impact on their finances due to the state aid mentioned above. Moreover, not investing in capture technologies may expose the industry to financial risks in an environment of increasing ETS prices and decreasing emission allowances. Finally, it is worth mentioning that the government's contribution will most likely decrease over time due to the expected increase in ETS prices. For more details on the PORTHOS project, see Appendix A.

3.2.1.4 Results-Based Climate Finance

The World Bank and other development finance institutions have increasingly used **Results-Based Climate Finance (RBCF)** in developing countries to incentivize climate actions and help countries achieve their Nationally Determined Contributions (NDCs) to the Paris Agreement. RBCF is a form of climate finance where funds are disbursed by the provider of climate finance to the recipient upon achievement of a pre-agreed set of climate-related results (see Figure 12). Results in RBCF can be defined as any milestone that indicates progress toward reducing GHG emissions. Payments are made once GHG emission reductions have been verified as real and additional – meaning they would not have occurred otherwise. These results are typically defined at the output or outcome level, which means that RBCF can support the development of specific low-emission technologies or the underlying climate outcomes. This business model is less appropriate for developed countries which are already members of a well-regulated emissions retention regime.

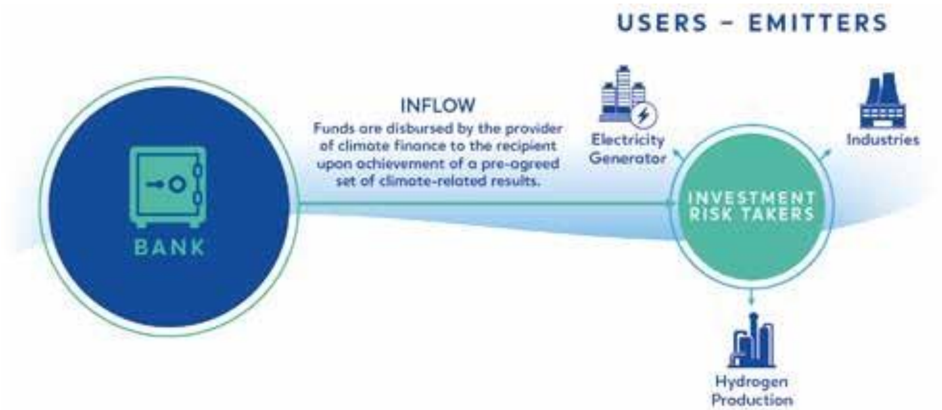


***Figure 12:** Financial flow for the RBCF mechanism.*

Various RBCF initiatives build on existing carbon market mechanisms and prepare for new instruments. Some RBCF programs purchase compliance emission reduction units, including CERs and ERUs, helping bridge the current lack of demand for these units. Some of these programs include the World Bank's Carbon Initiative for Development and the Pilot Auction Facility for Methane and Climate Change Mitigation[5]. Elements of the existing carbon market infrastructure, such as the CDM monitoring, reporting and verification (MRV) requirements, have been incorporated into these programs. Other programs not specifically designed for compliance markets use RBCF as a direct funding mechanism and were built from the ground up. Such programs include the Performance Based Climate Finance Facility in Latin America financed by the European Commission and the World Bank's Transformative Carbon Asset Facility. These programs focus on the implementation of large scale sectoral or policy-level emission reduction programs.

3.2.2 CO_2 Transportation & Storage Phase

In the Net Zero Emissions (NZE) by 2050 Scenario, the dynamic development of carbon capture facilities is supported by CO_2 transport and storage infrastructure. According to projections of the NZE scenario, around

5. International Bank for Reconstruction and Development (IBRD): What You Need to Know About Results-Based Climate Finance (2022)

1,200 Mt CO_2/year should be successfully captured and stored by 2030. With projects that are operational or under development, CO_2 storage capacity could reach only about 110 Mt CO_2/year by 2030[6]. CO_2 transport infrastructure needs to be expanded at least at the same rate as capture and storage capacity. To significantly increase T&S capacity, T&S investments must be made more attractive. Therefore, appropriate business and revenue models must be found to provide additional incentives for investors. The most common business models presented below, include the regulatory asset base (RAB), public private partnership (PPP) and cost-plus.

3.2.2.1 Regulatory Asset Base

The **Regulatory Asset Base (RAB)** concept emerged in the UK to provide assurance and certainty to the investors in privatized network utilities by setting out the principles for the calculation of price caps[7]. The RAB model was developed to value existing assets as part of the privatization process in the UK (rather than the delivery of stand-alone major investments). The model itself does not preclude any particular form of ownership for the infrastructure company – its assets can in principle be privatized or remain in public ownership. The RAB simply assesses the value of the assets used in the performance of a regulated function. In practice, it is an accounting number that reflects the value of past investments into the network infrastructure. It is calculated periodically by summarizing Regulated Assets (net of grants, user participations and recharges) plus regulated working capital and net new CAPEX.

RAB = Regulated Assets + Regulated Working Capital + Net New Capex

More specifically, **Regulated Assets** refer to the depreciated value of existing tangible and intangible assets, excluding grants used to finance

6. IEA, CO_2 Transport and Storage Analysis https:/www.iea.org/reports/co2-transport-and-storage

7. Duffield, Colin F. "Report on the performance of PPP projects in Australia when compared with a representative sample of traditionally procured infrastructure projects". *National PPP Forum – Benchmarking Study, Phase II*. 17 Dec. 2008, Melbourne. Web. 25 Feb. 2015.

the construction, recharges to end customers for these assets (e.g., connection fees) and any expenses incurred by the distribution company for the construction of projects (e.g., own labor cost) to the extent included in operating expenses. **Regulated Working Capital** is a percentage of Working Capital, which, over a financial period, is calculated as the difference between current assets minus current liabilities. **Net New Capex** is defined as the projected CAPEX (incl. work in progress) excluding grants, revenues and any other participation in cost paid up by the end customers.

The tariffs that the end users/ emitters will have to pay to the Transportation & Storage operator, are calculated periodically, based on estimates regarding the evolution of the Required Revenue and projected demand for CO_2 storage capacity. The Required Revenue is calculated usually on an annual basis as per below formula:

Required Revenue = RABxWACC + Depreciation charge + Operating expenses – Non-regulated income ± Recoverable difference

WACC stands for Weighted Average Cost of Capital and is the average rate that a company expects to pay to finance its assets. The **annual depreciation** of assets (tangible and intangible) included in RAB, is calculated based on the remaining lifetime of existing assets or useful lifetime for new assets included in RAB. Depreciation is estimated based on the accounting method established for each asset's category. **Operating expenses** are considered to be the reasonable expenses of the T&S Operator that relate to the activity of the CO_2 transportation and storage in a safe-efficient, cost-effective and reliable way. **Other income from non-regulated activities** comprises all other revenue streams, not relating to the basic T&S activity. Finally, as CAPEX is settled on actual figures, any variance (e.g., outperformance) is recovered through the **Recoverable Difference** mechanism.

The legal framework regulating the T&S network tariffs, should provide for regular tariff reviews to ensure there are no differences between the Required Revenue (using ex-post data available during the regular tariff review process) and actual distribution revenue attributable to the T&S Operator. A positive Recoverable Difference signifies an over-recovery of the Required Revenue by the T&S Operator, whereas a negative Recoverable Difference an under-recovery.

Periodical review of prices usually takes place every year or even more frequently (especially in the early years of operation). The regulator will need to review major expenditure such as network expansion to confirm consistency with specified objectives, and the network owner will need to submit long-term plans. The basic concern with the RAB model is that its application might lead to excessive capital expenditures, however it could be adapted to include the provision of financial support to decrease the upfront capital expenditure.

Figure 13: *Regulatory Asset Base structure example, (Source: ITF).*

An example of the application of the RAB model in a commercial CCS project is the HyNet in the UK, industrial site investments are valued, and costs are recovered from "consumers" under regulation. For more details on the Hynet Project, see Appendix A.

3.2.2.2 Cost plus

The **cost-plus open book** model is a process where the T&S should submit invoices to the government that include documentation of all hard costs. This would include invoices for materials and subcontractors as well as working hours and billing rates for direct labor supplied by the T&S company. This is a "Trust-but-Verify" process to ensure that the T&S company is keeping good records and billing responsibly.

Annually Payments to T&S Investors= Recorded Costs + Margin

Direct operational payments are made by the government to cover properly incurred costs annually, on an open-book basis, with an addition of agreed upon profit margins and return on investment. This model is widely used for transportation and infrastructure projects in other sectors and has traditionally (been an important component of network charges in the United States) formed an important part of network pricing in the USA[8].

Figure 14: *Risk allocation and financial flow for the Cost-plus mechanism.*

An example of the intended application of the cost-plus model to an industrial CCS project is the Longship in Norway. Government funding depends on the actual cost of the project and therefore increases if the project cost exceeds the agreed-upon cap. For more information on Longship Project, see Appendix A.

3.2.2.3 Public Private Partnership

In the **Public Private Partnership (PPP)** model of public infrastructure delivery, the government calls for tenders for a contract of a single infrastructure project. These contracts commonly take the form of a Design-Build-Finance-Maintain-Operate (DBFMO) contract. The contract gives the successful private consortium the responsibility for all aspects of project financing, delivery and operation for periods often spanning decades. The contract sets out how the consortium receives revenue:

8. Bellona Europa: Models for Transport and Storage of Captured CO_2: A review of some options (2021)

— **From the government** in the form of periodic “availability payments” and/or

— **Direct from users**: the efficiency gains in this approach are primarily determined at a single point in time, which is the competition between the bidders for the contract.

The efficiency gains in this approach are primarily determined at a single point in time: by competition between the bidders for the contract[9].

Figure 15: *Risk allocation and financial flow for the PPP mechanism.*

Ras Laffan CCS facility in Qatar is an example of a State-owned plant. More information is provided in Appendix A.

3.2.2.4 Government-owned model

The government sets up a regulated, publicly owned CO_2 T&S network that is responsible for delivering and operating the T&S infrastructure and implementing goals set by the government. In the UK, this would likely involve eventual privatization of the network as the CCS market matures, with a transition to a RAB model. However other jurisdictions, for example the Netherlands, may pursue continued State ownership.

9. International Transport Forum: The Regulatory Asset Base and Project Finance Models

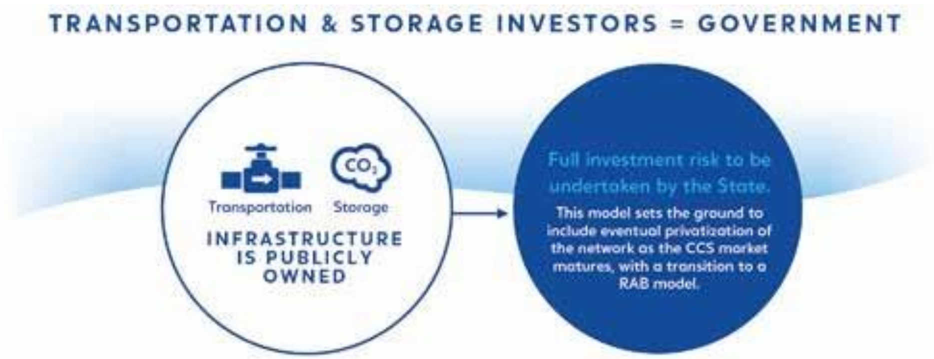


Figure 16: *Risk allocation and financial flow for the Government-owned mechanism.*

3.2.3 Comparison between models

In order to evaluate the different models, 9 selection criteria were chosen. The selection was driven by the risks and challenges section where some common areas were identified (evaluation justification is presented in Appendix D). The first 4 criteria are assessed in terms of risk allocation between the involved parties. Finally for the evaluation purposes, it is assumed that each revenue model is being implemented on its own, without combination with another (meaning no hybrid models are examined).

1. **CAPEX Risk (budget overrun)**: this risk criterion assesses who takes the risk of a potential increased investment cost during the implementation of the project when the selected revenue model is chosen.

2. **Commercial Risk (no clients/no business)**: in the context of this report, the commercial chain breakdown is considered as the event where there are no clients (capturers) or their business activity is very low and therefore the captured CO_2 volumes are low. The reasons might be the overall macroeconomic environment or business slowdown due to industry related events. Overall underutilization due to the capture side directly affects specific models on the T&S side. Some revenue schemes offer mechanisms to protect the investment to a certain degree in case of a commercial chain breakdown.

3. **Infrastructure Risk (availability, capacity, time)**: infrastructure risk refers to both the capture and T&S phase and portrays the risks each phase

will face in case of no operation, either due to no availability (e.g., areas where the T&S infrastructure is not available), size (e.g., the capacity of the T&S is fully utilized and thus no extra CO_2 could be served) or timing (e.g., infrastructure that is under maintenance and there is a significant delay in the completion of works). For example, in the T&S side, the network might not be available due to technical or financial constraints, and this will have a negative impact on the capture side, as the capture investor will not be able to transport and/or store the captured CO_2. The selected revenue model is evaluated based on the provision of the mechanism to effectively tackle infrastructure availability situations and protect to the maximum extend the involved parties.

4. Market Risk (CO_2 price volatility): this criterion refers to the volatility of CO_2 allowance price as determined in the market. It is one of the most important factors to influence the selection of a potential revenue model, as some models do not provide any protection against this volatility which can disincentivize mainly the capture side. However, the T&S side can be also severely affected because if there are no capture investors, then there is no business for the T&S as well.

5. Funding participation (construction and/or operational): it is perceived as the scheme of investors participating in a certain investment and is also an indication of who carries the burden of providing the funding.

6. Potential commercial upside: this criterion refers to the degree a revenue model can foster the potential increase in value, measured in monetary or percentage terms, of the investment.

7. Probability of investment recovery (construction and/or operational): in the context of this report, it is defined as the ease or difficulty to recover occurred costs (whether construction or operational) by the private investors and/or the State when a specific revenue model is applied.

8. Model implementation complexity: refers to the challenges the investors will have to face when implementing a certain revenue model in terms of administration, resources, time, procedures etc. An extremely complex revenue model which requires significant human resources, implementation time, rigorous process control while involving a plethora of stakeholders is most likely to be considered as a negative characteristic of the specific revenue scheme.

9. Model public acceptance: developers and investors are facing a growing challenge where more and more projects face public debate and criticism, both for technical and financial terms. In the context of this report, it represents the difficulty for a specific business model to overcome public acceptance constraints. For example, a private investment with high State funding is expected to be more challenged by the public compared to other models that the investment is recovered from the operation of the project. Finally, the public acceptance is evaluated only from the State's point of view, since it is expected that the State is most probably the key recipient of complaints etc.

The above criteria have been assessed in detail and based on the analysis, which is presented in Table 7. It is evident that the most attractive model for the State is the (plain) Emission Trading System (ETS) since there is no government participation in it. The ETS could be considered a free market, where the CO_2 allowance is the commodity, and the emitters are the investors. Whether the cost avoidance from trading in the ETS will be enough to recover the cost of the investment or not, is a risk that the capturer must undertake. With regards to the private side (capturers and T&S Operator), the revenue model that is considered the most attractive, is the Cost-plus. Under this framework, all costs (both construction and operational) can be shared with the State, depending on the potential application of a maximum cap. The risk sharing will be determined by the cap meaning that a high cap will increase the State's risk and decrease the investor's risk and vice versa.

The RAB model seems to be a sweet spot for both the State and the Investors, where the T&S Operator will recover the incurred costs through network usage tariffs, payable directly by the emitters/users, through a regulated tariff revision mechanism. There is significant experience already in place and acceptance of this revenue model by both the State and the private sector. In this revenue model, there are certain risks that the Operator might face, and the State needs to have commitment readiness to support through different mechanisms, at least in the early years of market operation. In applications where the number of users is low, the

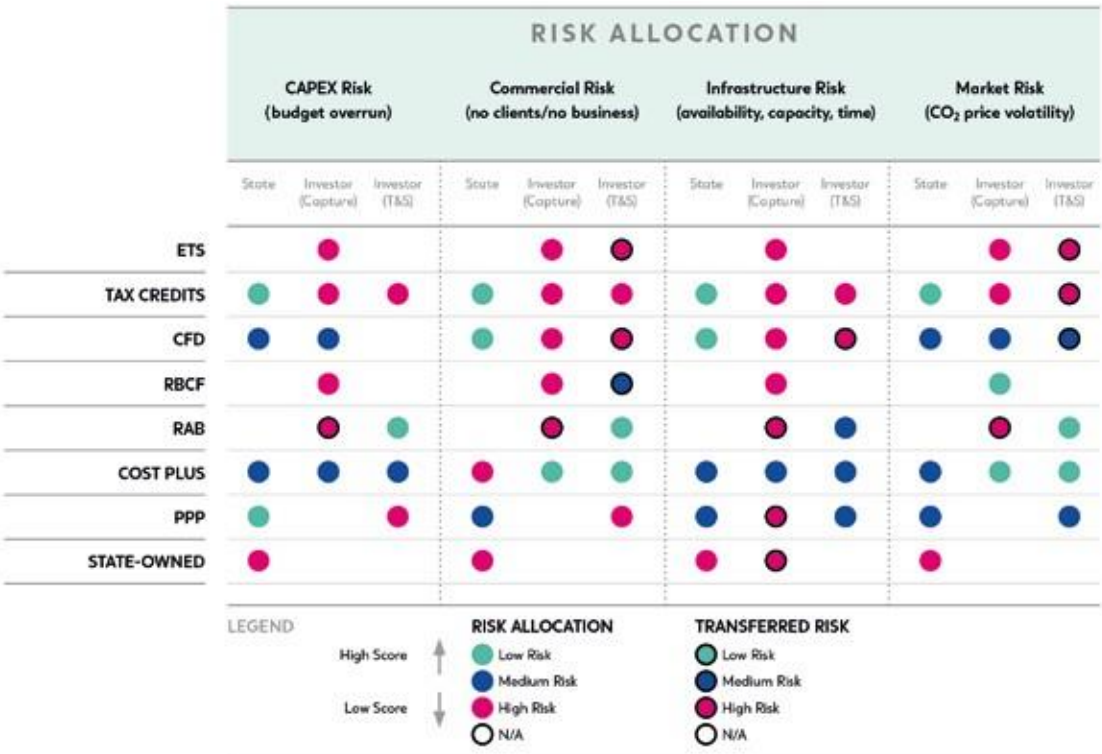
RAB model should be combined with an additional model to ensure that usage tariffs remain at reasonable levels. This implies that a hybrid model will most probably better share the risk between the stakeholders and allow the initiation of CCS projects.

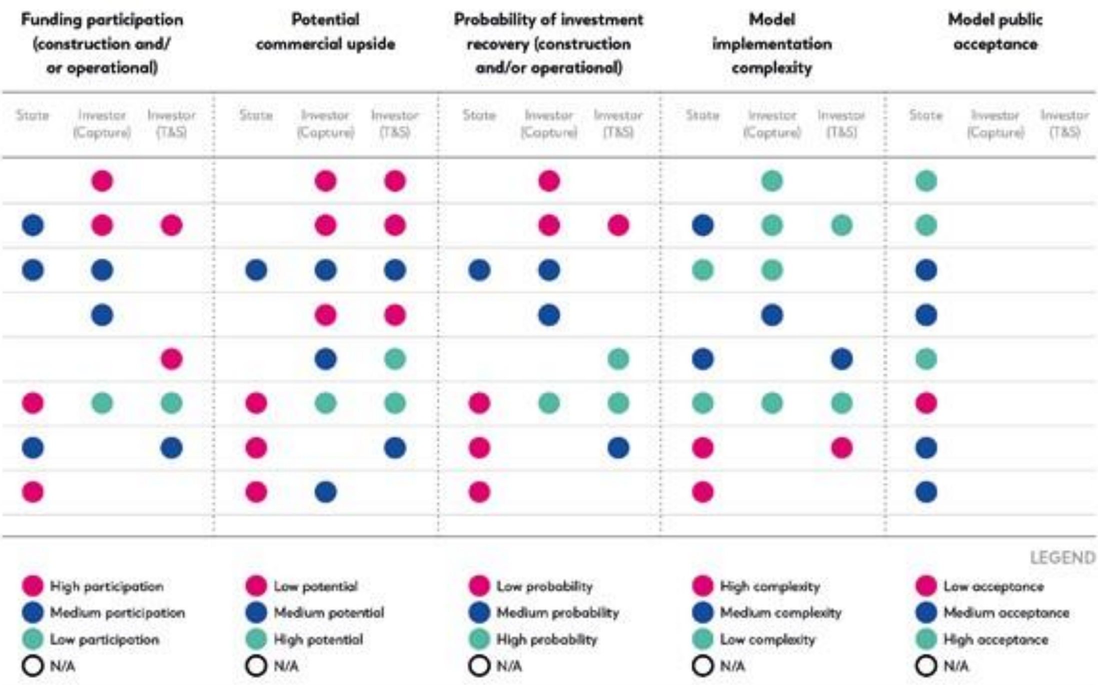
Additionally, based on the analysis below it is evident that certain risks are not directly associated with the implementation of a business model to the particular part of the CCS value chain, but are rather transfer risks. The transfer risks usually occur when one part of the value chain is delayed or its' operation is hindered due to market conditions, and this affects the other part of the CCS chain as well.

Some of the indicated transfer risks can be mitigated through market mechanisms, such as insurance policies or EPC contracts. For example, in the RAB model, a failure to expand the infrastructure according to the projected plans, or unavailability of the T&S network as a result of a technical failure, has a greater impact on the Capturer rather than the T&S Operator himself. This is due to the fact that the RAB model has provisions to regulate such occurrences for the T&S Operator, but the Capturer is exposed. If the network is not available for any reason, the Capturer cannot transport and store the already captured CO_2 volumes, and therefore is forced to pay for CO_2 allowances. For technical failures, there are insurance policies in place than could provide some level of security for both parties. In cases where there is a significant delay in the construction of the infrastructure of one part, and the other actor is forced to wait (regardless of which business model is applied), the mitigation action could be the implementation of an EPC contract with clauses which protect the Operator from unforeseen delays and incentivize the EPC contractor to perform according to plan.

There are, however, cases, where the mitigation actions to safeguard the successful implementation of the entire project lay on the State. This constitutes the State's interference risk. In other words, the State assumes the role of intermediary between all involved parties. For example, the ETS model applies to the Capture side. Any variations on the CO_2 allowance price, directly affect the Capturer, but they also affect the T&S Operator indirectly (transferred risk). If the CO_2 allowance price is lower than the

Table 7: Evaluation of the different business/revenue models in selected criteria




Funding participation (construction and/ or operational)
Potential commercial upside
Probability of investment recovery (construction and/or operational)
Model implementation complexity
Model public acceptance
State
Investor (Capture)
Investor (T&S)
LEGEND
High participation
Medium participation
Low participation
N/A
Low potential
Medium potential
High potential
N/A
Low probability
Medium probability
High probability
N/A
High complexity
Medium complexity
Low complexity
N/A
Low acceptance
Medium acceptance
High acceptance
N/A

levelized cost of CO_2 capture, then the capturing party is not incentivized to invest in a capturing facility. As a result, the T&S Operator might end-up without customers. In this example, one solution would be for the State to step in and perform a CfD contract with the capturing party, so that the risk of CO_2 price volatility is eliminated to the extent that makes the capturing investment break even, meaning that the strike price of the contract will be equal to the levelized cost of CO_2 capturing. This way, the State supports one side of the CCS chain through the elimination of a great risk factor (CO_2 price volatility) and this benefit extends to the other part of the CCS chain (the Operator) which can secure a minimum number of capturers (clients).

Although the State's interference means budgetary burden, it might – in some cases – be considered necessary in order to remove existing barriers and share some of the risks with the private side investors. However, this government involvement, at least during the initial stage of CCS deployment, can facilitate learning opportunities, offering potentially greater benefits to society than by leaving information dissemination to private firms. As well as contributing to local economic growth through supply chains and job creation, CCS generates a broad range of knowledge, industry and network spillover effects. Such spillovers have a strong spatial dimension and are therefore particularly important for regional development. This includes spillover effects to other businesses, but also broader effects on local communities, such as improving health and wellbeing and facilitating social cohesion. CCS can also play an important role in influencing attitudes and behaviors, and can therefore contribute to local sustainability agendas, for example in tackling climate change[10].

3.3 Funding Sources

Various funding sources could be considered to cover the cost of the revenue models and ultimately contribute financially to CCS[11]. Consideration

10. OECD, 2022

11. University of Edinburgh Business School: A Review of Business Models for Carbon Capture, Utilization and Storage Technologies in the Steel Sector: A Qualitative Multi-Method Study (2019)

should be given to the ability and willingness of each party to absorb the costs, as well as the ease with which the funding sources can be implemented and administered. Special attention should also be paid to protect vulnerable parties, such as consumers at risk of fuel poverty, or industry exposed to international competition.

Different revenue models may have different funding sources. However, this should not be a hard constraint and a combination of these mechanisms should be examined and used to spread the cost across the parties in the fairest or most acceptable manner.

Table 8: Evaluation of different funding sources

Source	Short Description	Pros	Cons
State Budget	Direct funding from the State budget could be recovered through general taxation, with the justification that every member of society benefits from policies to mitigate climate change	• Simplicity	• May not be applicable for developing/ poor economies • Taxpayers might react negatively (similar to cost socialization) • Does not promote development and competition in the sector
Emitters	All national emitters (power industry and other emitters) could be the source of funds through obligations or taxes. This allocation is the "polluter pays" principle and the mechanism could be through (increased) allocation of tradeable certificates (e.g., ETS) to emitters with installed carbon capture technologies, which are then purchased by other emitters	• Environmental and financial incentives that reflect a fair approach on the "polluter pays" principle	• Possible over-taxation • Risk of business bankruptcy, not being able to withstand the additional financial obligations • Carbon leakage

Source	Short Description	Pros	Cons
Fossil fuel suppliers	The majority of power, industrial and transport (aviation, maritime, road transport, rail) emissions are from combustion of fossil fuels, so the cost of reducing emissions from these fuels should be shared by the suppliers	• A strong incentive to transition to alternative fuels (hydrogen, biofuels etc.) • Competition drive: companies that can offer lower-carbon products will be able to charge less because they won't need to pay the tax, drawing customers away from their more polluting competitors, thus accomplishing the overall goal of lower CO_2 emissions	• A risk of cost transfer to the final consumers especially in cases of low elasticity where the demand is inflexible
Industrial product consumers	A price premium could be paid based on each (final) product's carbon intensity		• Increased cost of specific goods • There might not be alternative products available in the market for the consumers to purchase, in their attempt to avoid the increased cost of high carbon intensity goods

3.3.1 The role of subsidies

On December 21st, 2021, the European Commission announced that it had endorsed the new Guidelines on State Aid for Climate, Environmental Protection and Energy 2022 (CEEAG) which entered force in January 2022. They replace the EEAG, which entered force in 2014. The new Guidelines address aid to support decarbonization measures. This broad category encompasses all technologies that can lead to a reduction and removal of greenhouse gas emissions and thus, are eligible for aid. It targets support for two main sets of technologies:

— Renewable energy, biofuels, bioliquids, biogas and biomass fuels if compliant with sustainability criteria (to be defined in RED II delegated acts), waste and renewable hydrogen

— Technologies that contribute to the reduction of emissions such as low-carbon hydrogen, synthetic fuels using low-carbon energy, energy efficiency, high-efficient cogeneration, CCS, CCU, demand response, energy storage

These two groups are subject to the same approval regime (type of aid, aid intensity, etc.). This means that in principle all technologies are equally supported and should compete against each other in competitive multi-technology tenders in order to decarbonize in the most cost-effective way.

At the same time, the General Block Exemption Regulation (GBER) is currently undergoing a targeted revision with the aim to further facilitate green investments by widening its scope to cover and include aid for investments in new technologies, such as hydrogen and carbon capture and storage or utilization.

Below Table 9 summarizes the industrial-scale capture, utilization and storage projects across Europe that have received regulatory and funding support.

Table 9: CCUS projects in Europe that have received regulatory and funding support

Project name & country	Project status	Industry	Funding[12]	Additional info[13]
Norcem (Norway)	Under construction (commercial facility)	Cement & lime	The Norwegian government has provided substantial funding for the project through its national carbon capture and storage program. In addition to public funding, the Norcem project has also received financial support from private investors and the European Union. In 2019, Norcem was awarded a grant of approximately 12 million euros from INEA (Innovation and Networks Executive Agency), which is expected to cover around 25% of the total cost of the project.	Norcem project involves capturing CO_2 emissions from the flue gas of a cement factory owned by Norcem in Brevik, Norway. The captured CO_2 is then transported via pipeline to a subsea storage location beneath the North Sea, where it is injected and permanently stored in geological formations. The Norcem project is considered a key component of Norway's efforts to reduce greenhouse gas emissions and achieve its climate targets, as the cement industry is a significant contributor to global CO_2 emissions.
CalCC (France)	Advanced development (commercial CCS facility)	Lime	The CalCC project is supported by the French government and several industry partners. The project has also received funding from the European Union's Horizon 2020 program, which aims to support research and innovation in Europe. Overall, the total cost of the CalCC project is estimated to be around €60 million, with most of the funding coming from public sources.	Air Liquide and Lhoist have signed a Memorandum of Understanding (MoU) with the aim to decarbonize Lhoist's lime production plant located in Réty, in the Hauts-de-France region, using Air Liquide's innovative and proprietary CryocapTM carbon capture technology. It is expected to capture up to 100,000 tons of CO_2 per year and contribute to France's efforts to reduce greenhouse gas emissions.
K6 (France)	Advanced development (commercial CCS facility)	Cement	The Lumbres-K6 project is funded by a combination of public and private sources. The French government is providing financial support for the project through its national carbon capture and storage (CCS) program. The project is also receiving funding from the European Union's Horizon 2020 program. In addition to public funding, the Lumbres-K6 project is also being supported by several private partners, including the cement producer Vicat, which owns the Lumbres plant, and the CO_2 transport and storage company Air Liquide.	K6 plans to reduce CO_2 emissions at the Lumbres Cement Plant and avoid 8.1 Mtpa CO_2 emissions over the first ten years of operation. The goal is to maximize the usage of biomass-containing and other alternative fuels and to take advantage of already-decarbonated raw materials.

12. European Commission
13. Source: Global CCS Institute

Project name & country	Project status	Industry	Funding	Additional info
C2B (Germany)	Advanced development (commercial CCS facility)	Cement	EU Innovation Fund	Holcim will be a partner of the 'Carbon2Business' project which will deploy a second generation oxyfuel carbon capture process at Holcim's Lägerdorf cement plant in Germany, capturing over 1 million tonnes of CO_2eq annually and providing it as a raw material for further processing into synthetic methanol.
Kairos@C (cross border EU)	Expected commercial operation in 2025	Chemicals	Kairos@C received a grant of 356,9 million euros from the EU Commission Innovation Fund in 2022 for the realization of the project.	Air Liquide and BASF are planning to develop the world's largest cross-border Carbon Capture and Storage (CCS) value chain. The goal is to significantly reduce CO_2 emissions at the industrial cluster in the port of Antwerp. By avoiding 14.2 million tons of CO_2 over the first 10 years of operation, it will significantly contribute to the EU's goal of becoming climate neutral by 2050.
Air (Sweden)	Advanced development (commercial CCS facility)	Chemicals	Air project has received €97 million in funding from the EU Innovation Fund.	Project Air, which is being led by chemicals company Perstorp AB, is an industrial collaboration to build a unique production facility for sustainable methanol in Stenungsund, Sweden. Perstorp Group and Uniper will produce sustainable methanol for chemical manufacturing using circular production methods.
HySkies (Sweden)	Advanced development (commercial CCS facility)	Refining	In 2020, the Hyskies project was awarded €24.5 million in funding from the EU Innovation Fund.	HySkies is a partnership between Shell, Swedish utility Vattenfall and biojet producer Lanzajet, aims to manufacture synthetic sustainable aviation fuel and to install a carbon capture facility at its plant.

Project name & country	Project status	Industry	Funding	Additional info
Anrav (Bulgaria)	Advanced development (commercial CCS facility)	Cement	The Anrav project is a collaboration between several companies and research institutions from Bulgaria, France, Germany, and Belgium. In 2020, the Anrav project was awarded €12 million in funding from the EU Innovation Fund.	The first full-chain carbon capture and storage project in Bulgaria, linking CO_2 capture facilities at a cement plant with offshore permanent storage in a depleted gas field in the Black Sea, through an onshore and offshore pipeline system.
Go4Eco-planet	Advanced development (commercial CCS facility) Commissioning of the cement plant upgrade is planned for 2027.	Cement	The European Union (EU) Innovation Fund has awarded Euro228m towards the Go4ECOPlanet carbon capture and storage project at Lafarge Poland’s Kujawy cement plant. The project has a total cost of €380 million.	The project will use Air Liquide's Cryocap FG technology to capture the CO_2 at the plant. The CO_2 will be liquefied and transported by rail to a port and then injected into a depleted oil field for permanent storage. The transport and storage of CO_2 once it has left the cement plant will be accomplished by coopera- tion with other partners with knowledge and experience in the liquefaction, transport and storage of gases. The goal is to create a complete carbon capture and storage industrial and logistics chain.
BECCS (UK Drax project)	Advanced development (commercial CCS facility)	Electricity	In 2020, Drax secured £500 million in funding from a consortium of banks, to support the conversion of its remaining coal-fired units to biomass. The funding will also support the development of carbon capture technology at the plant. In addition to this private investment, Drax has also received funding from various government sources. In 2018, the UK government awarded Drax a £700,000 grant to support the development of bioenergy with carbon capture and storage (BECCS) technology at the plant. This funding was provided through the government's Energy Entrepreneurs Fund.	BECCS, stands for bioenergy with carbon capture and storage, and is a geo-engineering technique that, in addition to being an alternative for fossil fuel energy, removes carbon dioxide from the atmosphere. The Drax power station in the UK is currently undergoing a major transformation from a coal-fired power plant to a low-carbon energy producer, using biomass as its primary fuel source.

Project name & country	Project status	Industry	Funding	Additional info
BECCS (UK Drax project)	Advanced development (commercial CCS facility)	Electricity	Drax has also secured funding from international financial institutions, such as the European Investment Bank (EIB) and the Green Investment Group (GIG). In 2020, the EIB provided Drax with a £250 million loan to support the conversion of its remaining coal units to biomass, while the GIG has provided £400 million in funding to support the development of carbon capture technology at the plant. Overall, the funding for the Drax project in the UK has come from a range of sources, including private investment, government grants, and international financial institutions, reflecting the importance of the project in the transition to a low-carbon economy.	

4. The Way Forward: How to make CCS successful in Greece

In order to scale up the implementation of CCS, certain requirements and actions are needed[1]. Those requirements could fit in the following indicative categories: legal framework and policies, applications, and economic sustainability.

Legal framework and policies are the cornerstone for the right implementation of CCS. Government policies are an essential driver for CCS and can provide support through financing commitments. Along with policies, the development of suitable legal frameworks for CCS is critical, particularly for storage. It needs to be clear and predictable but also flexible, focusing on the unique characteristics of each project/plant. Regulation should focus on administration and permits (in terms of storage, for the operation of storage and access to the subsurface) across the project lifecycle and address necessary standards to protect the environment and human health through environmental impact assessments, public consultations, mandatory monitoring schemes, environmental emergency plans and long-term liability studies. Just as with any major industrial project, a well-functioning and clear permitting process is important for CCS projects. The framework should be transparent and precise enough so that the applicants should be able to base their business decisions on it and make solid forecasts and plans. To ensure that the relevant authority can assess, and process permit applications in a timely manner, governments should make sure that the relevant regulatory authority has adequate resources, capacity and decision-making power. Additionally, mechanisms are needed to engage the public and address concerns regarding CCS development.

In the case of Greece, the framework follows the basic principles of the CCS Directive. However, more flexibility is required. An important step towards that was the new provision which allows holders of hydrocarbons' explo–

1. IRENA Reaching Zero With Renewables Capturing Carbon 2021

ration and exploit permits to take advantage of the exploration already performed and the data collected to obtain an exploration permit for CO_2 storage in (parts of) the concession area. The international practice shows that the same flexibility is also required with holders of CO_2 exploration or storage permits; under certain conditions, they should be allowed to transfer these permits to third parties, instead of abandoning a project.

The **transportation** of CO_2 via ships presents a viable but expensive alternative to pipelines, particularly for short to medium distances. To ensure the safe transport of carbon dioxide, specialized ships must be designed and constructed with advanced safety features and monitoring systems capable of handling the unique properties of carbon dioxide. Despite the complexity of liquid CO_2 carriers, one of the main advantages of this transportation method is the ability to transport large quantities of CO_2 over long distances, making it possible to capture and store emissions from remote industrial sites. However, the technology behind liquid CO_2 carriers must be scaled up substantially to improve the competitiveness of future designs. Innovative solutions, such as on-board carbon capture technology coupled with cleaner maritime fuels, could constitute a key option for the years ahead. By extending the life of existing vessel fleets, these solutions would help reduce greenhouse gas emissions while driving progress towards a sustainable future.

When it comes to **storage** issues, provided that the CO_2 storage in saline aquifers is allowed under Greek Law[2], its wider use must be deployed. The guidance documents of the CCS Directive stress their importance and underline that because of their large capacity, wider distribution than depleted oil and gas reservoirs and availability, saline aquifers are an important geological storage option across Europe. The first guidance document provides that Member States should consider alternative uses for saline aquifers such as geothermal use when considering opportunities for permitting, along with any synergies between storage and other uses. The second guidance document discusses in more detail critical parameters

2. Despite the wording in the Greek Ministerial Decision which prohibits it, in 2011 the Presidential Decree 51/2007 was amended in order to include storage in saline aquifers in accordance with the Directive 2000/60/EC.

for their deployment: characterization and assessment of a saline aquifer storage site could be difficult because of the lack of data compared to storage in a depleted oil and gas field. However, saline aquifers normally present fewer hazards from pre-existing well penetrations. Such pre-existing wells are widely recognized as being the largest technical risk for leakage of CO_2 from geological storage in oil and gas fields.

Risk and liability particularly associated with transportation, injection and storage have been identified as critical barriers to scale up CCS deployment. Some of the traditional risks and liability provisions and models have been adopted from oil and gas operations, but the storage aspects are becoming a novel risk, exposing a still limited knowledge and experience of the industry. Some regulatory frameworks have begun to address these points by introducing early liability models to decrease risk and increase insurability and confidence in CO_2 projects[3]. However, further consideration of the role of public and private actors (operators and investors) in allocating and managing risks is critical, as is the engagement of the insurance sector.

With respect to the most appropriate **business/revenue models**, a detailed evaluation of different criteria provides the pros and cons of each revenue model and thus its implementation attractiveness. It appears that a combination of revenue schemes will be required to make CCS successful, for all parties involved. In order to create a competitive business environment - where investors can recover costs within a reasonable timeframe, users are incentivized to capture CO_2, T&S operators reduce usage tariffs and expand the infrastructure – risks should be properly allocated, creating a balance in this emerging market. Learning from the experience and sharing knowledge with more advanced countries where CCS projects are already successfully operating will enhance the efficient kick-off of such projects.

Large-scale demonstration, FOAK and lighthouse applications might prove beneficial in establishing a mature landscape for **commercial projects**. Whilst the technological principles of CCS are known, there is still room for techno-

3. Havercroft, I. (2019), Lessons and Perceptions: Adopting a commercial approach to CCS liability, Global CCS Institute

logical refinement and much to learn about both its practical applications in different contexts as well as the economic and wider social implications of their use. The priority must be to establish more large-scale projects with extensive analyses along with wide sharing of the experience acquired in order to develop both the knowledge base and confidence of policy makers and investors. Additionally, research, development & demonstration (RDD) support needs to be expanded, including cross-border collaboration.

Finally, **absence of economic sustainability** is a key factor that could terminate planning and deployment of CCS projects. Experience from operating commercial units in Europe shows that financial incentives and state support are needed, especially in the first phase of CO_2 capturing. Support schemes of the past have been complex and often not been sustained. Countries therefore need to create stable, balanced but dynamic financial support to improve investors' confidence.

Learning from experience can also help. To stimulate R&D in general, tax incentives are usually more effective than subsidies. A notable example relevant to CCS is the US Section 45Q that offers tax credits to federal taxpayers who capture CO_2 emissions of at least 25,000–500,000 tpa CO_2 for utilization, 100,000 tpa in industrial CCS or 500,000 tpa CO_2 from electricity generation, and either utilize (including via EOR) or store CO_2 in geological formations. Projects must have initiated the construction works by 1 January 2026, and tax credits will be available for 12 years to provide more certainty for investors. The credit value is USD 50/tCO_2 for CO_2 destined for geological storage and USD 35/tCO_2 for EOR or utilization[4].

In the **European Union**, the European Commission's Innovation Fund (previously NER 300 programme) provides grants to highly innovative technologies and big flagship projects at commercial scale, regardless of their size. In addition, the European Investment Bank (EIB) Project Development Assistance increases the investment readiness for CCS projects in order to receive funding from the Innovation Fund. The EU also offers public grants under the European Research Framework programmes (e.g., Horizon2020 or Horizon Europe), such as CEMCAP or LEILAC CCS projects

4. US IRS (Internal Revenue Service) (2021), 26 U.S. Code § 45Q - Credit for carbon oxide sequestration, 26 U.S. Code Title 26 - INTERNAL REVENUE CODE

in the cement industry. Such examples will likely drive some CCS deployment, but such mechanisms need to be broadened to other countries and expanded to address emerging demand.

An interesting case is also presented by the Dutch government, which adopted a feed-in contractual subsidy mechanism under the SDE1 ++ scheme[5] to reward the most cost-efficient CO_2 reductions in industry. This covers the uncommercial part of investing and operating CCS on industrial plants. However, CCS support is limited to a maximum of 7.2 MtCO_2/year to help prevent it displacing of implementing other cost-effective tools nor hinder the development of long-term sustainability solutions.

Overall, establishing a functional CCS value chain would yield significant benefits for the environment, economy, and industry of Greece. By achieving its net-zero targets and meeting the growing demand for low-carbon goods, Greece can position itself as a leader in sustainable development. The development of CCS technology can provide a competitive edge to Greek industries, create employment opportunities, and attract substantial funding from the EU, particularly through the Innovation Fund. Moreover, it will support the economic viability of the Prinos carbon storage project. As a result, the establishment of a CCS value chain will pave the way for a cleaner and more prosperous future for Greece, while contributing to the global efforts to combat climate change.

The enabling framework for CCS in Greece is complete. The experience of other EU countries can serve as useful examples of how certain policies work in practice. Designing the correct policy and regulatory frameworks depends on a more diverse set of actors being consulted in the process, with the deployment of CCS properly targeted and focused on specific end uses within certain sectors.

5. The SDE++ subsidy is a contractual payment of the difference between a base rate and a correction amount. The base rate is the price required to make an investment economic, i.e. the cost of the investment and operation of the climate technology. For CCS the base rate covers the cost to capture, transport and store (T&S) the CO_2. While the base rate remains unchanged over the contract period, the correction rate will be adjusted annually. The correction amount reflects the market price of the output, for renewables this is the market price of electricity. For CCS support the correction rate represents the average EU ETS of the respective year.

5. Appendix A: Projects

5.1 Global Projects

A1.1 Century Gas Plant

Century plant is the largest single industrial source CO_2 capture facility in North America. Capacity of up to 8.4 Mtpa however only 5 Mtpa is being used. The plant also produces Methane gas for the market. The CO_2 is for use in Occidental Petroleum's EOR projects in the Permian Basin. The facilities were built by Sandridge Energy. Occidental Petroleum is thought to have invested $1.1 billion in the development of the plant.

The Permian Basin of West Texas and southeast New Mexico is one of the largest and most active oil basins in the United States, with the entire basin accounting for approximately 15% of total United States oil production. Occidental produces approximately 16% of the basin. The project allows Occidental Petroleum to use at least 3.5 trillion cubic feet of CO_2 for EOR projects throughout the Permian Basin and to develop approximately 500 million barrels of reserves from currently owned assets at an attractive cost.

Table A.1: Description of Century Gas Plant

Century Gas Plant	
Country	USA
Project Type	Industrial Capture
Industry	Natural Gas
Project Status	Operational
Operational Year	Phase 1 commenced operation Oct 2010, phase 2 completed late 2012
Project Duration	2010- Ongoing
Storage Field	Various
Storage Location	Onshore
Storage Capacity	Not defined
Injectivity	5-8 Mtpa
Storage Method/Distance	43 km onshore pipeline
Business Proposition	-
Entities Responsible/ Organizations	Occidental
Profitability	Enhanced oil recovery
Funding/Funding T&C	No funds allocation – Private investment
Capture Ownership	Occidental
Transportation Ownership	Occidental
Storage Ownership	Occidental
Risk Management	Occidental
Cost Notes	$ 1.1 billion
Additional Notes	-

A1.2 Gorgon Carbon Dioxide Injection

Gorgon is an onshore natural gas processing facility producing LNG from an offshore conventional natural gas field. Based on Barrow Island, the Gorgon Project includes an LNG facility with 3 processing units.

Carbon dioxide sourced from the gas processing facility, compressed and transported to injection wells in a 7 km pipeline the Dupuy saline aquifer 2.3 km beneath Barrow Island.

The project is in operational phase since 2019.

Figure 17: *Gorgon project topology.*

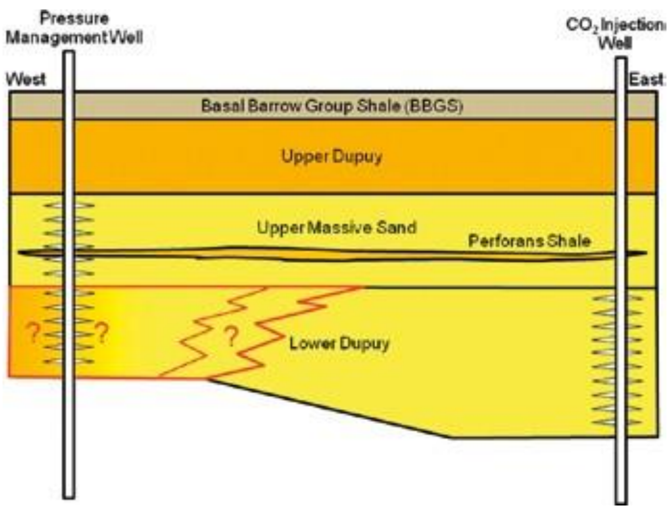


Figure 18: *Injection site of Gorgon, (Source: Trupp, M., Frontczak, J., Torkington, J. The Gorgon CO_2 Injection Project-2012 Update, Energy Procedia 37 (2013) 6237–6247).*

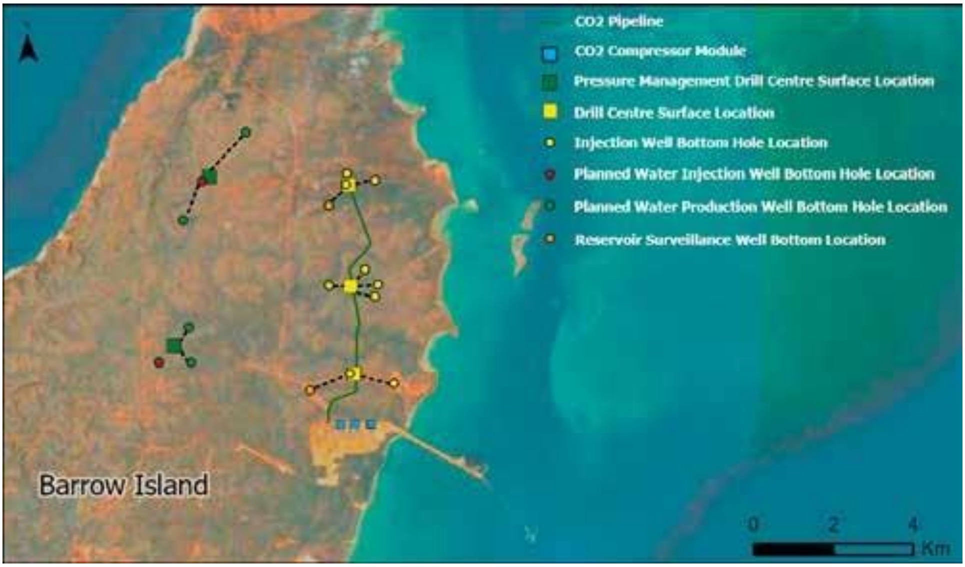


Figure 19: *Gorgon's project topology.*

Table A.2: Description of Gorgon Carbon Dioxide Injection

Gorgon Carbon Dioxide Injection	
Country	Australia
Project Type	Industrial Capture
Industry	Natural Gas Processing for LNG
Project Status	Operational
Operational Year	2019
Project Duration	40 - 45 Years
Storage Field	A deep saline aquifer reservoir (Beneath Barrow Island known as the Dupuy Formation)
Storage Location	Onshore
Storage Capacity	120 Mtpa
Injectivity	3.4-4 Mtpa
Storage Method/Distance	Well padding onshore development with 3 well pads

Gorgon Carbon Dioxide Injection	
Business Proposition	CCS injection was planned in anticipation of carbon-tax avoidance. Initial driving is to remove CO_2 impurity to process LNG.
Entities Responsible/ Organizations	One full Chain Joint Venture (Capture/Separation/T& S): Chevron (47.3 percent), ExxonMobil (25 percent), Shell (25 percent), Osaka Gas (1.25 percent), Tokyo Gas (1 percent) and JERA (0.417 percent).
Profitability	Significant royalty and tax benefits, all of which increase profitability. On top of that, the project has received a fund of AUD 60 million as a part of the low emissions technology demonstration fund (LETDF Australia) – Model: Tax Credits.
Funding/Funding T&C	Public Funding: AUD 60M (The Australian Government as part of the Low Emissions Technology Demonstration Fund), CCS cost: AUD 2 billion. More than AUD 150M spent on investigation and development prior to FID.
Capture Ownership	Private JV is responsible for Design construction of the separation train.
Transportation Ownership	Private JV
Storage Ownership	Private JV
Risk Management	Private JV
Cost Notes	No information
Additional Notes	1. Private JV shall meet CO_2 capture limits otherwise penalties will be applied. Penalized (up to AUD 250M) by the Government in 2021 for sequestering less CO_2 than planned. 2. The Government agreed to take the long-term liability for the storge of CO_2 under the Gorgon project, under conditions that the project partners are liable for CO_2 injection phase also for 15 years post closure duration.

A1.3 Ras Laffan Capture Project

Qatar Energy Minister, Saad Sherida Al-Kaabi, announced in October 2019 that a 2.1 Mtpa "carbon recovery and sequestration facility" had been "successfully commissioned". He said, *"With such new carbon capture and storage projects, Qatar's LNG industry will be capturing and sequestering more than 5 mmty of CO_2 by 2025".* The comments were made in the context of discussion of significant increases in Qatar's capacity for LNG production and export. The implication seems to be that a capture plant is already running, probably supplying to EOR, and that there are plans for its expansion, or additional plant. This news came out of a conference in London, however, no independent sources of information on the project have been found.

Table A.3: Description of Ras Laffan Capture Project

Ras Laffan Capture Project	
Country	Qatar
Project Type	Industrial Capture
Industry	LNG
Project Status	Operational
Operational Year	2019
Project Duration	-
Storage Field	Unknown
Storage Location	Unknown
Storage Capacity	-
Injectivity	2.1 Mtpa
Storage Method/Distance	Unknown
Business Proposition	Unknown
Entities Responsible/ Organizations	State owned
Profitability	-
Funding/Funding T&C	State

Ras Laffan Capture Project	
Capture Ownership	Qatargas
Transportation Ownership	-
Storage Ownership	-
Risk Management	State
Cost Notes	-
Additional Notes	The project must be considered as uncertain up to date (2022)

5.2 European Projects

A2.1 Sleipner

Sleipner was the world's first commercial CO_2 storage project. The natural gas produced from the Sleipner West field contains up to 9% CO_2, however, in order to meet gas sales specifications CO_2 should be set at a maximum of 2.5%. Therefore, the CO_2 is removed/separated from the produced hydrocarbons at the platform before being injected into Utsira Sand formation, a relatively shallow saline aquifer.

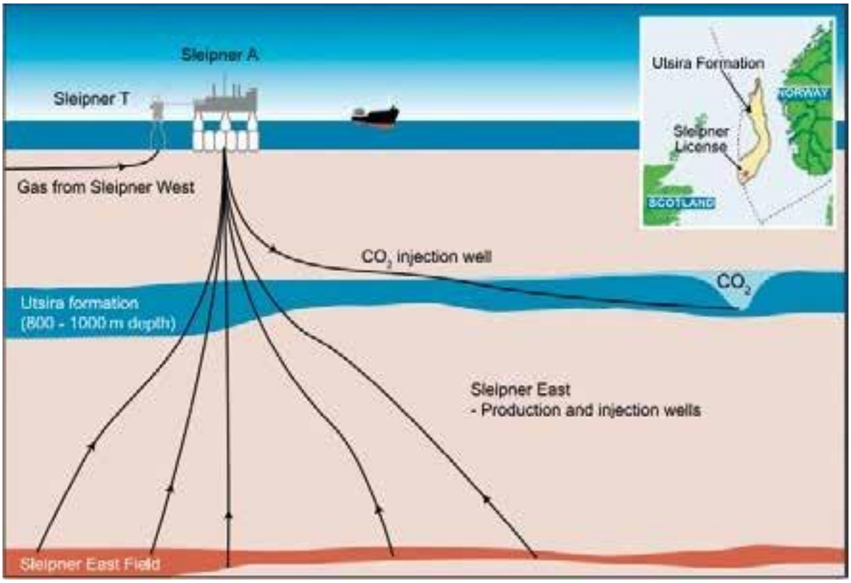


Figure 20: *Simplified diagram of Sleipner project, (Source: Figure 5.4 from S. Holloway, R. Kamal, D. Keith, P. Lloyd, P. Rocha, B. Senior, J. Thomson, T. Torp, T. Wildenborg, M. Wilson, F. Zarlenga and D. Zhou. 2005, Underground geological storage. In: IPCC Special Report on Carbon Dioxide Capture and Storage. Prepared by Working Group III of the Intergovernmental Panel on Climate Change [Metz, B., O. Davidson, H. C. de Coninck, M. Loos, and L. A. Meyer (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 442 pp).*

Table A.4: Description of Sleipner project

Sleipner	
Country	Norway
Project Type	Industrial Capture
Industry	Natural Gas Power
Project Status	Operational
Operational Year	1996
Project Duration	Since 1996-Ongoing
Storage Field	Saline Aquifer
Storage Location	Offshore
Storage Capacity	More than 16 Mt CO_2 injected since 1996 (2016) - ongoing

Sleipner	
Injectivity	0.85 Mtpa
Storage Method/Distance	Direct injection
Business Proposition	CO_2 tax was one of the drivers for Statoil's/Equinor to re-inject the removed/scrabbed CO_2 (9% to 2.5%)
Entities Responsible/Organizations	Private Join Venture (Equinor, Operator 58.35%, Exxon 17.24%, LOTOS 15%, KUFPEC 9.41%)
Profitability	1.Avoidance of Norwegian CO_2 tax (NOK 1million/day) 2. Natural gas sales. Model: Tax Credits
Funding/Funding T&C	Funded by the Joint Venture as part of the field development and production activity
Capture Ownership	1. CO_2 is rather separated than captured 2. Funded by the Joint Venture as part of the field development and production activity 3. T&S not separated from capture/petroleum activities, so no customer obligations
Transportation Ownership	1. Funded by the Joint Venture as part of the field development and production activity 2. T&S not separated from capture/petroleum activities, so no customer obligations
Storage Ownership	1. Funded by the Joint Venture as part of the field development and production activity 2. T&S not separated from capture/petroleum activities, so no customer obligations
Risk Management	Private JV
Cost Notes	$ 100 million
Additional Notes	-

A2.2 Snohvit

Snøhvit is an LNG project in the Barents Sea offshore Norway. Snøhvit is the first major development on the Norwegian continental shelf with no surface installations (it is not operated by platform, but by subsea templates). Snøhvit LNG Project consists of nine wells, 8 for production and 1 for injecting carbon dioxide (0,7 Mt/year). Carbon dioxide is separated onshore and transported back with a separate pipe (153km subsea pipeline) to a subsea tieback, and then is injected into a deep saline aquifer formation (2600m below seabed). Injection of CO_2 started in 2008, with CO_2 being injected into two different formations.

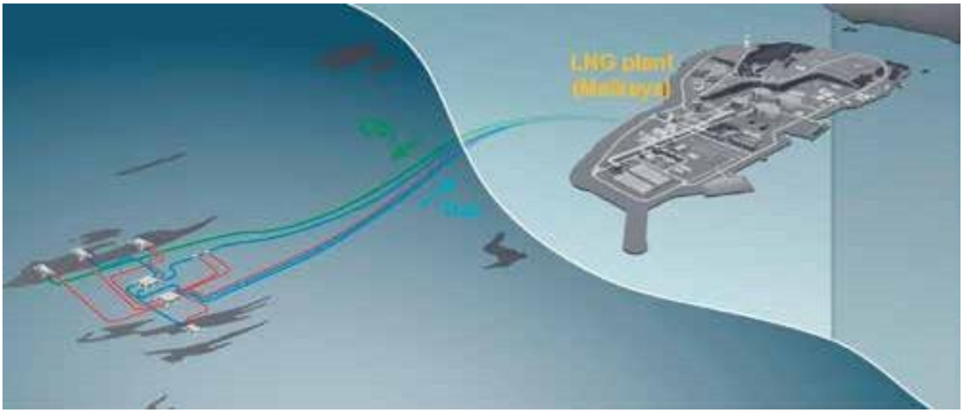


Figure 21: *Simplified diagram of Snohvit project, (Source: Equinor, "Ensuring safe storage operations: learning from Sleipner and Snøhvit Philip Ringrose, presented at Baltic Carbon Forum (BCF 2020) 14th October 2020").*

Table A.5: Description of Snohvit project

Snohvit	
Country	Norway
Project Type	Industrial Capture
Industry	LNG Facility
Project Status	Operational
Operational Year	2008
Project Duration	Since 2008 - Ongoing
Storage Field	Deep saline aquifer formation (2.6 km below sea bed)
Storage Location	Offshore
Storage Capacity	Maximum injection is planned to be between 31-40 Mt
Injectivity	0.7 Mtpa
Storage Method/Distance	Subsea Development
Business Proposition	Avoidance of Norwegian CO_2 tax
Entities Responsible/Organizations	Private (Statoil/Equinor) as a part of the field development and production activity, Owner of the LNG plant
Profitability	1. Avoidance of Norwegian CO_2 tax 2. Natural gas sales. Model: Tax Credits
Funding/Funding T&C	No funds allocation. Private (Equinor) investment as part of Snohvit field development plan

Snohvit	
Capture Ownership	Separation rather than capture-Private (Equinor)
Transportation Ownership	Private investment- Private (Equinor)
Storage Ownership	Private (Equinor) as a part of the field development and production activity
Risk Management	Private (Equinor)
Cost Notes	-
Additional Notes	-

A2.3 Longship

The Longship project will capture CO_2 from Norcem's cement factory and from Fortum Oslo Varme's waste to energy plant in the Oslo area (1.5 Mt/year). The captured CO_2 will be shipped to Norway's west coast, from where it will be transported offshore through a pipeline to be permanently stored in a saline aquifer formation. The transport and storage part of the project, known as Northern Lights, is designed to take additional volumes in future from other capture projects in Norway and beyond (second phase of the project – 5 Mt/year).

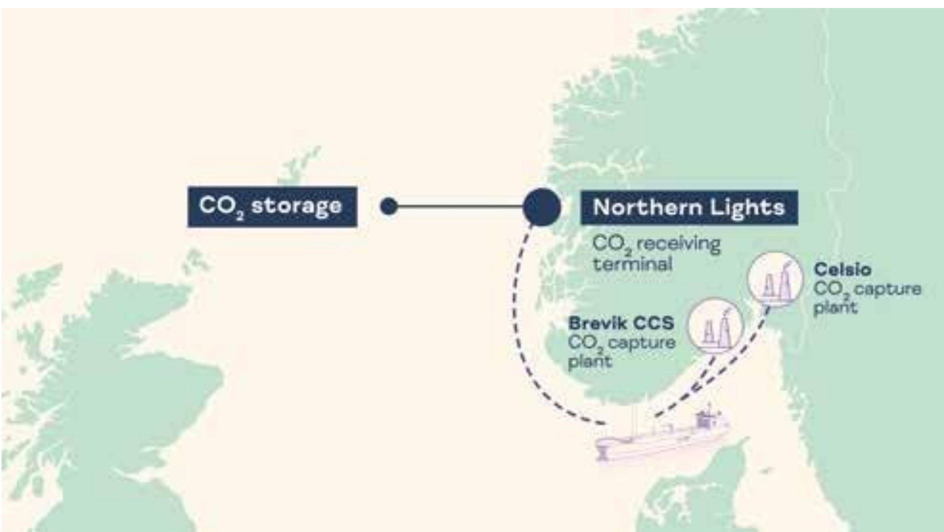


Figure 22: *Longship project, (Source: Northern Lights, The Government launches 'Longship' for carbon capture and storage in Norway, September 2020).*

Table A.6: Description of Longship project

Longship	
Country	Norway
Project Type	Industrial Capture
Industry	Cement & Waste to Energy
Project Status	In Design
Operational Year	2024
Project Duration	First phase: 25 Years + Second phase (commercial stage)
Storage Field	Saline Aquifer
Storage Location	Offshore
Storage Capacity	Not mentioned (Refer to Project Phases)
Injectivity	1.5 Mtpa first phase according to the Governmental White paper Second phase: 5 Mtpa (At commercial stage)
Storage Method/ Distance	Capture from two sites, transport by ship and pipeline
Business Proposition	Acquire Knowledge of CCS (CO_2 shipping) and Expanding the CCS Market
Entities Responsible/Organizations	One Main JV is the Northern Light JV (Equal distribution, Equinor, Shell, Total) for Development and Operations of CO_2 Transportation and Storage. For Capture, each industry (Norcem Cement/Fortum Oslo Varme) is responsible for construction and operation of capturing plants.
Profitability	Unlikely at the first stage. Most likely on the second one, as in the first stage the state has committed to covering up to 80 of the investment cost as well as the operation cost for 10 years. Commerciality of the project is expected in the second phase (25 years after operations start). Model: Cost plus

Longship	
Funding/Funding T&C	1. The State covers a large share of the project costs through funding. Whereas the cost and risk distribution in the negotiated agreements entail a percentage distribution of actual costs between State and industries. 2. The State's funding will be dependent on the actual costs of the project and will therefore increase if project costs increase, up to the agreed maximum limit. 3. The cost distribution agreed for the project is that the state covers 80 per cent of the investment costs and the companies cover 20%. 4. Meanwhile, for the operational phase, the state will cover 95% of the costs for the first year of operation, 90% for the second year, 85% for the third year and 80% for the fourth year of operation. 5. The funding period agreed on is ten years from the start-up of operations (commissioning). 6. Moreover, if a second well and/or third ship is needed, the State will cover 50% of these costs, with the maximum amount limited to 830 million NOK. 7. The State will also bear a share of the cost risk for unexpected incidents.
Capture Ownership	1. Norcem Cement and Fortum Oslo Varme Waste Management will be responsible for capture plant design, construction and operations. 2. The possibility of Northern Light JV to add additional customers and continue operational beyond the 10 years funding.
Transportation Ownership	Northern Light JV (Equinor, Shell and Total)
Storage Ownership	Northern Light JV (Equinor, Shell and Total)
Risk Management	Capital, Transport, Storage, Monitoring - Shared between Public/Private (80% Public). Capture - Public/Private (Norcem Cement/Fortum Oslo Varme)
Cost Notes	Norcem: 4.5 BNOK (CAPEX, OPEX 10 years) Fortum Oslo Varme: 6.4 BNOK (CAPEX, OPEX 10 years) Northern Lights: 14.2 BNOK (CAPEX, OPEX 10 years
Additional Notes	-

A2.4 HyNet

HyNet North West will use the existing pipelines to transport CO_2 from industry around the region. The CO_2 will then be stored in its depleted hydrocarbon reservoirs, located around 20 miles offshore in Liverpool Bay. The only new construction required will be a (33 km) pipeline from the Stanlow Industrial Complex to the tie-in with the existing pipeline which will allow it to link up with the existing pipelines. In addition to the CCUS project, HyNet North West will also create the UK's first hydrogen network. The HyNet consortium has built partnerships with 40 companies in the region (some of those will be the emitters of CO_2 for the CCUS system, some will be involved in the production of low carbon hydrogen, and some are the future consumers of the low carbon hydrogen). The CCUS will have in the first phase a capacity of 4.5 Mt/year and will rump up to 10 Mt/year after 2030.

Figure 23: *HyNet project topology, (Source: Cadentgas, HyNet North West Hydrogen Pipeline: Project overview).*

Table A.7: Description of HyNet project

HyNet	
Country	UK
Project Type	Industrial Capture
Industry	Natural Gas Power
Project Status	In Design
Operational Year	Operational by 2025 - FID to be completed by 2022
Project Duration	Not defined yet (most likely more than 25 years)
Storage Field	In depleted gas reservoirs in Liverpool Bay
Storage Location	Offshore
Storage Capacity	Not defined yet (depends on the storage sites)
Injectivity	1st phase: 4.5 Mtpa - 2nd phase: 10 Mtpa
Storage Method/Distance	Onshore & Offshore pipelines
Business Proposition	1. To commercialize CCS in the UK 2. Hydrogen production from gas (Hydrogen Revenue) 3. CO_2 price avoidance 4. Creation of T&S network with potential to expand and reduce costs for future capture sites
Entities Responsible/Organizations	Multi-partner consortium (The HyNet consortium has built partnerships with 40 companies in the region). Progressive Energy Ltd (lead the project) Cadent Gas Ltd (H_2 and NG pipeline operator) - ENI (CO_2 onshore and offshore transport, CO_2 facilities, injection and storage). Essar Oil (refinery operator and construction of the H_2 production plant). CF Fertilizers and other industrial entities that will support the overall projects in different stages
Profitability	Sales of blended gas & hydrogen (local and national gas bills). All investments made by the industrial site are valued and costs are recovered from 'consumers' under regulation (RAB revenue model)
Funding/Funding T&C	Public Funding
Capture Ownership	Emitters will have their own capture plant at their sites
Transportation Ownership	ENI is responsible for onshore and offshore CO_2 Transportation
Storage Ownership	ENI is responsible for CO_2 storage and injection facilities
Risk Management	Not defined yet (probably government will need to take on the key risks for CCUS chain failure)
Cost Notes	£920M total infrastructure cost
Additional Notes	-

A2.5 Acorn

Project is located in north-east Scotland at the St Fergus Gas Terminal and will take advantage of existing oil and gas infrastructure. There are two key elements to the Acorn project: Acorn CCS & Acorn Hydrogen. Acorn CCS can repurpose existing gas pipelines to take CO_2 directly to the Acorn CO_2 Storage Site.

Phase 1 of Acorn CCS offers a low capital cost start from existing industrial emission sources at the St Fergus gas terminal (60km from Aberdeen). Acorn Hydrogen can take North Sea natural gas and reform it into clean burning hydrogen with the CO_2 emissions created from generating the hydrogen, safely removed and stored using the Acorn CCS infrastructure.

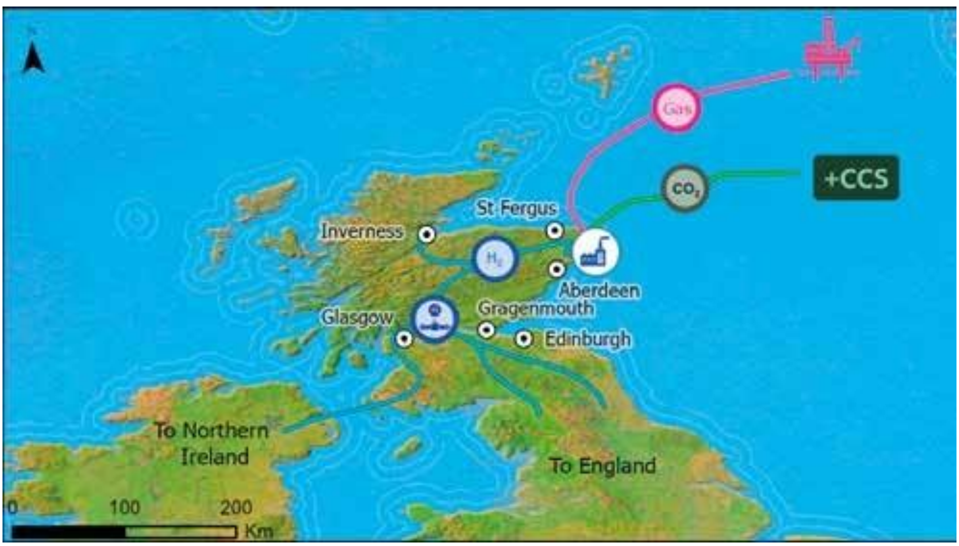


Figure 24: *Simplified diagram of Acorn project.*

Table A.8: Description of Acorn project

Acorn	
Country	UK
Project Type	Industrial Capture
Industry	Natural Gas Power
Project Status	In Design
Operational Year	Operational in 2026 Construction works will start in 2023. Drilling will take place in either 2023 or 2024. Subsea installations between 2024 and 2025. Commissioning and first injection in either 2025 or 2026.
Project Duration	The project has a long-term outlook to 2060
Storage Field	1st phase: in saline aquifer 2nd phase: several storage sites will be examined
Storage Location	Offshore
Storage Capacity	Not defined yet (depends on the storage sites)
Injectivity	1st phase: 0.3 Mtpa 2nd phase: over 12 Mtpa
Storage Method/ Distance	Onshore (new) & Offshore (existing 20in) pipelines - offshore distance is 100 km Two new wells will be drilled for CO_2 injection (subsea development)
Business Proposition	1. Decarbonization of the region and establish a strategic and transnational CO_2 transportation infrastructure capable of delivering over 12 Mtpa of CO_2 2. Promotion of Blue Hydrogen Production (through the Acorn Hydrogen project, North Sea natural gas would be reformed into hydrogen, with CO_2 emissions mitigated through the Acorn CCS infrastructure)
Entities Responsible/Organizations	Private Joint Venture with the support of UK & Scottish government Private JV: Storegga (through its wholly owned subsidiary Pale Blue Dot Energy), Shell, & Harbour Energy signed an agreement with the owners of the Segl and Fuka Gas Terminal at St Fergus. Storegga is the lead developer of the project Shell is working as the Technical Developer
Profitability	1. Avoidance of CO_2 tax 2. Hydrogen sales
Funding/Funding T&C	Public & Private Funding Project is funded and supported by industry partners (Storegga, Shell and Harbour Energy), the UK and Scottish Governments and the EU. Acorn CCS feasibility project funded through EU ERA-NET ACT programme, further funding from UK & Scottish Governments and the EU. Also, Acorn CCS has received funding/ support at different stages from Chrysaor, Shell and Total and Pale Blue Dot Energy

Acorn	
Capture Ownership	Private Joint Venture
Transportation Ownership	Private Joint Venture
Storage Ownership	Private Joint Venture
Risk Management	Capital - Shared between Public/Private. Capture, Transport, Storage, Monitoring - Private JV
Cost Notes	The overall investment (Capture, Transport & Storage) is about 75-145 euro/ tonne CO_2
Additional Notes	-

A2.6 Teesside

The East Cluster includes both Net Zero Teesside (NZT) and Zero Carbon Humber (ZCH) which have formed the Northern Endurance Partnership, which is responsible for CO_2 transportation & storage. The captured CO_2 will be transported offshore via a subsea transport/export pipeline to an offshore platform, located approximately 100 km offshore in the North Sea, and injected into a depleted oil field. Some CO_2 would also be injected and stored in a saline aquifer to provide substantial future storage capacity and diversity. The project aims to utilize the North East CCS Transport Network which is currently under construction.

Figure 25: Overview of Teesside project, (Source: (The Oil and Gas Climate Initiative').

Table A.9: Description of Teeside project

Teesside	
Country	UK
Project Type	Industrial Capture
Industry	Natural Gas Power
Project Status	In Design
Operational Year	2026
Project Duration	The project has a long-term outlook to 2060
Storage Field	Depleted oil fields - Some CO_2 would also be injected and stored in a saline aquifer
Storage Location	Offshore Storage
Capacity	Not defined yet Injectivity
8.25 Mtpa (by 2030)	
Storage Method/ Distance	Onshore & Offshore pipelines
Business Proposition	1. To commercialize CCS in the UK 2. CO_2 price avoidance 3. Economies of scale of industrial cluster
Entities Responsible/Organizations	The East Cluster includes both Net Zero Teesside (NZT) and Zero Carbon Humber (ZCH) which have formed the Northern Endurance Partnership. 1. Northern Endurance Partnership is a JV between: BP, Eni, Equinor, National Grid Ventures, Shell and Total. 1.1. Net Zero Partners (capture): BP, Eni, Equinor, Shell & Total 1.2. Zero Carbon Humber (capture): Associated British Ports, British Steel, Centrica Storage Ltd, Drax Group, Equinor, Mitsubishi Power, National Grid Ventures, PX Group, SSE Thermal, Saltend Cogeneration Company Ltd, Uniper, and the University of Sheffield's Advanced Manufacturing Research Centre (industrial partners for CO_2 emissions and capture)
Profitability	CO_2 price avoidance. Model: Tax Credits
Funding/Funding T&C	Government Funding. Government support of 50% CAPEX, but repayment of the other 50% CAPEX in shaped repayment. Potential cap to government support if CAPEX unexpectedly high. Pre-FID costs covered by the government. - 100% OPEX covered by government if properly incurred (open-book recovery). - £ 1m for pre-FEED feasibility study - £ 3.8m for conceptual design study - £28m from UK Research and Innovation's (UKRI) Industrial Decarbonization Challenge (IDC) fund in March 2021. - £21.5M (Mar 2021) for infrastructure components in Phase 2 of the UKRI Industrial Strategy Challenge Fund (ISCF)

Teesside	
Capture Ownership	Capture plant owned and operated by emitter
Transportation Ownership	NEP partnership
Storage Ownership	NEP partnership
Risk Management	Capital - Government carries capital risk. Capture, Transport, Storage, Monitoring - Shared between Public/Private
Cost Notes	-
Additional Notes	-

A2.7 PORTHOS

PORTHOS is developing a project to transport CO_2 from industry in the Port of Rotterdam and store this in depleted gas fields beneath the North Sea. PORTHOS stands for Port of Rotterdam CO_2 Transport Hub and Offshore Storage. The CO_2 that will be transported and stored by PORTHOS and will be captured by various companies. The companies will supply their CO_2 to a collective pipeline that runs through the Rotterdam port area. The CO_2 will then be pressurized in a compressor station. Afterwards, it will be transported through an offshore pipeline to a platform in the North Sea, approximately 20 km off the coast. The PORTHOS project was started by the Port Authority in 2017 as successor to ROAD and other projects. The objectives of the project are to link emitters in Rotterdam's industrial areas to the OCAP pipeline, and to offshore storage in depleted gas fields along with the potential to bring in CO_2 from sources in the Antwerp and North Rhine Westphalia areas. The Authority is taking the initiative to provide transport and storage infrastructure and will expect companies in its area to make use of the facilities to reduce their emissions over time - or take other equivalent measures.

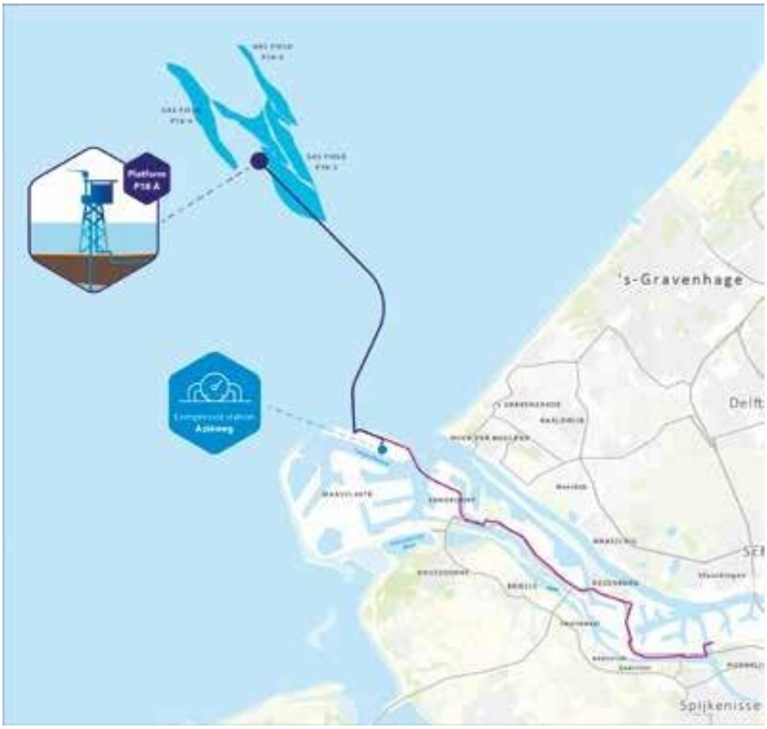


Figure 26: *PORTHOS CO_2 transport and storage C.V., (Source: https:/www.porthosco2.nl/en/project/).*

Table A.10: Description of PORTHOS project

PORTHOS	
Country	Netherlands
Project Type	Industrial Capture
Industry	Chemical Refining
Project Status	In Design
Operational Year	2024 - Possible first storage late 2023
Project Duration	15 Years
Storage Field	Depleted Gas
Storage Location	Offshore
Storage Capacity	37 Mt
Injectivity	2.5 Mtpa
Storage Method/ Distance	1. Onshore Pipeline to collect CO_2 from industrial sources: 32km/42" 2. Onshore-Offshore Pipeline: 22 km/16"
Business Proposition	1. Anticipated contribution from NL government to the cost difference between purchasing emission rights and paying the costs of CCS (through a cost plus-like mechanism) 2. Economy of scale from multiple emitters 3. Insulation from carbon pricing to secure industries 4. Creation of T&S infrastructure which can encourage further industrial capture 5. Industry commitment to "national climate agreement" 6. Reduction of CO_2 of Netherlands by 14% and advancement of CCS in the country
Entities Responsible/Organizations	Two Joint Ventures (Private-Public) 1. Private Joint Venture (Capture): ExxonMobil- AirProducts - AirLiquide and Shell 2. Public Joint Venture (T&S): Energie Beheer Nederland (EBN), Gasunie and Port of Rotterdam Authority
Profitability	Unlikely as state aid is dedicated to cover the difference of capture and storage cost compared to ETS credit), Hint: State aid will be reduced year over year as ETC price is expected to increase. Model: Contract for Difference (CfD)

PORTHOS	
Funding/Funding T&C	Dutch government support + EU funding 1. Nov'17, EU approve Dutch Gov aid of 3M € for expansion of OCAP pipeline. 2. Jan'19, associated project, CO2TransPorts, awarded EUR 6.5M as Project of Common Interest. This involves the port companies of Rotterdam, Antwerp and North Sea Port, also including Ghent, Terneuzen and Vlissingen 3. Oct'20, €2.1 billion in NL Gov grant money through the SDE++ scheme for PORTHOS' four customers: Air Liquide, Air Products, ExxonMobil and Shell (Grant Duration: 15 years) 4. Feb'21, final award of 102M € Connecting Europe Facility (CEF) of the European Union funding for construction works
Capture Ownership	1. Private JV will be responsible for Construction & Operation of capture sites 2. Possibility of additional CO_2 emitters after project commissioning
Transportation Ownership	Public JV will be responsible for Construction and Operation
Storage Ownership	Public JV will be responsible for CO_2 storage with Gasunie being the operator
Risk Management	Capital - State (SDE Scheme)/ Public JV Entities. Capture - Private JV (Four companies). Transport - Public JV (EBN-Gasunie- and Port of Rotterdam). Storage, Monitoring - Public JV
Cost Notes	Cost percentage relative to the total cost: Capture: 47% Transport: 38% Storage: 15%
Additional Notes	1. Transformation of operation rights from TAQA to Gasunie (Private to Public) 2. Allocation of funds is in a step wise decreasing order 3. Similarity with Prinos Case (Storage/ Capacity/Distances) 4. Funds are allocated along the Project duration with possibility of suspension in case of CCS are covered with ETS price at any time in the project

6. Appendix B: Details

Area of Regulation	Norway	UK
Responsible parties	Ministry of Petroleum and Energy (resource management) Ministry of Climate and Environment (environmental issues)	CCUS Council Department for Business, Energy and Industrial Strategy (up to 2016) North Sea Transition Authority (NSTA, ex OGA) The licensing authorities depend on the type of activities: in case of an offshore controlled place it is OGA, in case of a place in Scotland the Scottish Ministers.
Implementation	Storage Regulation (main one - all carbon capture, transport and storage activities not related to petroleum activities) Petroleum Regulation (chapter on carbon capture, transport and storage activities in relation to petroleum activities) Pollution Regulation (environmental requirements of the CCS Directive; applies to all carbon capture, transport and storage activities) CCS as part of petroleum activities (whether for the purpose of EOR or permanent storage on the continental shelf): Regulated under the existing petroleum regime: –The Petroleum Act and Regulations (production licensee required, conditions for transportation, storage and monitoring as part of approved Plan for development and operation) –The Pollution Control Act and Regulations (permit to inject CO_2, requirements for the composition of the CO_2-stream, monitoring) –The CO_2-levies Act	Energy Act 2008 Carbon Dioxide (licensing) Regulations 2010 - The Storage of Carbon Dioxide (Amendment of the Energy Act 2008 etc.) Regulations 2011 - The Storage of Carbon Dioxide (Inspections etc.) Regulations 2012

on regulation per country

Greece
Ministry of Environment and Energy Hellenic Hydrocarbons and Energy Resources Management Company (exploration and storage licensing)
The Ministerial Decision 48416/2037/E.103/2011 incorporates the CCS Directive 2009/31/EC.

Area of Regulation	Norway	UK
Scope of application	Areas of Exploration: Only offshore geological storage below the seabed is considered within Norwegian law. The reasoning behind this limitation is based on geological assessments of suitable areas.	Controlled places: in England, Wales or Northern Ireland, or in, under or over so much of the internal waters of the United Kingdom as are adjacent to England, Wales or Northern Ireland. In relation to Scotland, "controlled place" includes a place in Scotland or a place within the seaward limits of the territorial sea adjacent to Scotland.
Ownership	The Norwegian State has the proprietary right to subsea reservoirs on the continental shelf for exploitation of said reservoirs for storage of CO_2 and has an exclusive right to management of said reservoirs.	DNE

Greece
CO_2 storage in geological formations that extend in the Greek Territory, including seabed, continental shelf and subsoil up to the limits of the area where the Hellenic State has sovereign rights, according to the United Nations Convention on the Law of the Sea (UNCLOS), ratified with Law 2321/1995 (A' 136).
State

Area of Regulation	Norway	UK
Permitting System	Only exploration and storage of CO_2 on the continental shelf is allowed. A subsea reservoir's suitability as a storage location shall be determined through a characterization and assessment of a potential storage location and surrounding area according to specific criteria. A subsea reservoir shall only be selected as a storage location if there, under the conditions proposed for such use, is not a significant risk of leakage, and there is also not considered to be any risk of health or environmental damage of significance. Any CCS activity requires an exploration permit, an exploitation permit and finally an injection permit before any CO_2 may be stored.	Before granting a storage permit the authority must be satisfied that: (a) the storage complex and surrounding area have been sufficiently characterized and assessed in accordance with the criteria set out in Annex I to the Directive, (b) no part of the storage complex extends beyond the territories of the member States, (c) under the proposed conditions of use of the storage site, there is no significant risk of leakage or of harm to the environment or human health, and (d) the conditions in paragraph (3) are met. Regulation 15 amends the Environmental Damage. Regulations to include the operation of storage sites pursuant to the CCS Directive as an activity for which there is liability under the Environmental Damage Regulations. The Secretary of State may by order designate a submarine pipeline as an eligible CCS pipeline.

Greece

CO_2 storage is not allowed:

- in a place of storage with a storage complex which extends beyond the area mentioned in the first bullet and,
- in the water column and underground aquifers

Exploitation of a storage facility requires a) storage license, b) one Operator per facility and c) no conflicting interests of the specific storage facility.

Area of Regulation	Norway	UK
Licensing System	Prospecting license (non-exclusive) Exploration license (exclusive) Exploitation license (exclusive) (subject to impact assessment) Post-closure: Transfer of responsibility to State c/o Ministry of Petroleum and Energy (MPE) Financial mechanism	The OGA is the licensing authority for offshore storage, except within the territorial sea adjacent to Scotland, which Scottish ministers authorize. The OGA regulates offshore carbon dioxide storage, approves and issues storage permits, and maintains the carbon storage public register. In addition to applying for a license, developers must obtain a grant of the appropriate rights from The Crown Estate or the Scottish Crown Estate.

Greece

Exploration license

Storage license

Procedures for the granting of storage permits are open to all entities with the necessary capacities, so that permits are granted on the basis of objective, published and transparent criteria.

Entities that already hold a right or a license to explore and exploit hydrocarbons in a certain area and who already have sufficient data to document the eligibility of the area as a storage site, can obtain (they or an associated entity) the right to store CO_2 in that same area.

Area of Regulation	Norway	UK
Environmental regulation	An impact assessment in a plan for development and storage of CO_2 in a subsea reservoir shall account for the effects the development may have for commercial and environmental circumstances, including preventive and mitigating measures. The impact assessment shall be submitted to the Ministry no later than concurrently with a description of the development. In areas where multiple subsea reservoirs for storage of CO_2 are to be developed, the licensee will be able to prepare an impact assessment for a larger overall area. A joint impact assessment may also be prepared for developments that are also subject to impact assessment pursuant to other legislation. The Ministry shall, on the basis of the consultation, decide whether or not there is a need for additional studies or documentation concerning certain aspects. Any additional studies shall be submitted to the affected authorities and those who have given their opinion on the impact assessment for statements before a decision is made in the case. This deadline for statements should be no less than two weeks. The Ministry's case presentation shall state how the effects of the development and received statements have been assessed, and what significance they have been assigned. The case presentation shall assess whether conditions shall be set with a view toward restricting and compensating for negative effects of significance. Acceptance criteria based on Directive 2009/31/EC and London Protocol: –CO_2 stream shall consist overwhelmingly of carbon dioxide –No waste or other matter to be added for the purpose of disposal –CO_2 streams may contain incidental associated substances from the source or capture process, but concentrations of all incidental and added substances shall be below levels that would:	DNE

Greece

Acceptance criteria based on Directive 2009/31/EC and London Protocol:

–CO_2 stream shall consist overwhelmingly of carbon dioxide

–No waste or other matter to be added for the purpose of disposal

–CO_2 streams may contain incidental associated substances from the source or capture process, but concentrations of all incidental and added substances shall be below levels that would:

- Adversely affect the integrity of the storage site or the relevant transport infrastructure
- Pose a significant risk to the environment or human health, or
- Otherwise breach the requirements of applicable EC legislation

–Injection of CO_2 streams will be accepted subject to an analysis of the streams, including corrosive substances, and a risk assessment having been carried out, showing that the contamination levels are in line with accepted criteria

Area of Regulation	Norway	UK
Environmental regulation	• Adversely affect the integrity of the storage site or the relevant transport infrastructure • Pose a significant risk to the environment or human health, or • Otherwise breach the requirements of applicable EC legislation Injection of CO_2 streams will be accepted subject to an analysis of the streams, including corrosive substances, and a risk assessment having been carried out, showing that the contamination levels are in line with accepted criteria	DNE

Greece

Regulation		
Monitoring / Inspections	The Ministry or the entity it authorizes shall superintend the storage location at least once per year up to three years after shut-down, and then every five years until the responsibility has been transferred to the State, represented by the Ministry of Petroleum and Energy. During these regulatory supervisions, the Ministry or the entity it authorizes shall inspect relevant injection and monitoring facilities, reservoir conditions, and any effects of the storage complex on the environment. The regulatory supervision shall, insofar as possible, be coordinated with regulatory supervisions by the pollution authorities pursuant to Section 35-11 of Regulation No. 931 of 1 June 2004 relating to pollution control (the Pollution Regulations). Following each regulatory supervision, the Ministry or the entity it authorizes shall prepare a report on the regulatory supervision results. The report shall assess whether the provisions in these Regulations have been adhered to, and whether additional measures are necessary. The report shall be submitted to the operator and made available to the public no later than two months after the regulatory supervision is complete.	This section applies if a license holder fails to comply with any provision of the license. The licensing authority may direct the license holder to take steps which the licensing authority considers necessary or appropriate to comply with the provision within a period specified in the direction. The licensing authority must consult the license holder before giving directions under subsection (2). If the license holder fails to comply with a direction under subsection (2), the licensing authority may— a) comply with the direction on behalf of the license holder, or b) make arrangements for another person to do so. A person taking action by virtue of subsection (4) may— a) do anything which the license holder could have done, and b) recover from the license holder any reasonable costs incurred in taking the action. A person ("P") liable to pay any sum by virtue of subsection (5)(b) must also pay interest on that sum for the period beginning with the day on which the person taking action by virtue of subsection (4) notified P of the sum payable and ending with the date of payment.

Greece

Regular and extraordinary inspections of all storage complexes that fall within the scope of this decision, in order to control and promote compliance with the requirements of the decision as well as to monitor the effects on the environment and health are coordinated by the Ministry of Environment and Energy.

The Operator is obliged to monitor and report the storage process to identify the injection of the CO_2, potential anomalies and/or leakages, significant negative effects on the surrounding and especially water, human populations and other users of the biosphere, assessment of potential corrective actions, short and long-term safety of the storage complex and more.

In case of anomalies and/or leakages of CO_2, the Operator is obliged to immediately inform all responsible parties and proceed with all necessary corrective actions. If the Operator does not proceed with the necessary actions, the responsible parties will do, and the cost will be recovered by the Operator.

Area of Regulation	Norway	UK
Monitoring / Inspections		The rate of interest payable in accordance with subsection (6) is a rate determined by the licensing authority as comparable with commercial rates. The license holder must provide a person taking action by virtue of subsection (4) with such assistance as the licensing authority may direct. The power to give directions under this section is without prejudice to any provision made in the license with regard to the enforcement of any of its provisions.
Responsible party and scope of liability	The licensee is liable for pollution damage regardless of guilt. The provisions concerning the licensee's responsibility shall apply equivalently to an operator that is not a licensee when the Ministry of Petroleum and Energy has so decided through approval of operator status. If the Ministry of Petroleum and Energy has made a decision pursuant to the first paragraph, compensation claims shall first be directed to the operator. In the event that any part of the compensation is not covered by the operator upon maturity, it shall be covered by the licensees according to their ownership interest in the permit. If any party does not cover its share, this shall be distributed proportionately among the others. If it is substantiated that an unavoidable natural occurrence, act of war, act of public authorities or similar force majeure has considerably contributed to the damage or its scope under circumstances that are outside the control of the responsible party, the responsibility can be reduced insofar as reasonable, taking into particular consideration the scope of the activities, the sufferer's situation and insurance options on both sides. In the event of pollution damage from facilities in areas outside the Norwegian continental shelf, the party authorized by the competent authority to conduct the activities with which the facility is associated, shall be regarded as the licensee.	DNE

Greece
DNE

Area of Regula-tion	Norway	UK
Shut-down and post-op-eration	A storage location shall be shut down if: a) The conditions stipulated for shutdown in the storage license issued by the pollution authorities pursuant to Chapter 35 of Regulation No. 931 of 1 June 2004 relating to pollution control (the Pollution Regulations) and in the consent for injection and storage have been fulfilled, b) The King consents to the shutdown on the basis of an application from the operator. From when a storage location is shut down pursuant to (1)(a) or (b) and until responsibility for the storage location is transferred to the State, represented by the Ministry of Petroleum and Energy, pursuant to Section 5-8(1) and (6), the operator is still responsible for monitoring, reporting and implementation of corrective measures in line with the provisions in these Regulations. The operator is also responsible for sealing the storage location and removing the injection facilities. The obligations in the second paragraph shall be fulfilled on the basis of a post-operation plan that has been prepared by the operator based on best practices in the area, and in pursuance of Appendix II to these Regulations. A preliminary post-operation plan shall be submitted to the Ministry or the entity it authorizes for approval pursuant to Section 4-6(p). Before shutdown of a storage location pursuant to (1)(a) and (b), the preliminary post-operation plan shall, if necessary, be updated in accordance with the risk analysis, best practices and technological improvements and then submitted to the Ministry or the entity it authorizes for approval as the final post-operation plan.	When the authority approves a proposed post-closure plan in respect of a storage site in accordance with the licensing regulations, the authority must determine the minimum period (the “minimum period”) that must elapse between the date of closure of the storage site and the termination of the license. The minimum period must be no less than twenty years from the date of the closure of the storage site. Where the minimum period has not elapsed and the authority considers that the condition set out in regulation 8(a) has been met, the authority may reduce the period determined under paragraph (1), which reduced period becomes the minimum period. The authority must notify the license holder, as soon as reasonably practicable, of the minimum period.

Greece

DNE

Area of Regulation	Norway	UK
Comments / Review of the implementation regulations	It is the only country in Europe that has adopted specific provisions on leakage from CO_2 transport pipelines. Further projects are needed to get a better picture of the functioning of the regulations and the content of the requirements therein.	CCUS Council: The CCUS Council acts as a forum for engaging the CCUS sector on discussing and addressing key strategic issues. Carbon Capture and Storage Infrastructure Fund: In March 2020, the Carbon Capture and Storage Infrastructure Fund (CIF) was announced. The CIF is instrumental to state support that is expected to be allocated to CCUS. The CIF will primarily support capital expenditure on transport and storage (T&S) networks and industrial carbon capture (ICC) projects. A license may authorize, in such circumstances and subject to such conditions as are specified, the transfer of the license to another person (or the inclusion of another person as a joint license holder).

Greece

The Ministerial Decision provides for the issuance of secondary legislation specifying different areas of the exploration and licensing process; however, no such decision has been issued so far.

Area of Regulation	Netherlands
Responsible parties	Ministry of Economic Affairs and Climate Policy is responsible for handling applications for permits, dealing with monitoring and liability costs, as well as closure of the site, also responsible in taking over accountabilities after closure.
Implementation	The CCS Directive has been adopted in the Dutch Mining Act; Dutch Mining Decree; and the Dutch Mining Regulation.
Scope of application	DNE
Ownership	DNE
Permitting System	Exploration Permit: Once the minister has received an application for a permit, other parties will have the opportunity to also submit an ap-plication for the same area. The minister then decides, on the ba-sis of the information provided in the applications, who will be grant-ed the permit. This means that an exploration permit, leading to the identification of a suitable site, does not guarantee a storage permit. Storage Permit: The monitoring plan, the termination plan and the provision of financial security will have to form part of the CO_2 storage permit (inte-gral permit).

Spain	Italy
Ministry for the Ecological Transition and the Demographic Challenge	Ministry of Economic Development Ministry of the Environment Other bodies: National Committee (responsible for managing the registry, identifying areas for exploration, processing of applications etc.), Technical Secretariat for the storage of CO_2
Act 40/2010, of 29 December 2010 (the CCS Act), which incorporates the EU Directive. In addition, the rules contained in Legislative Royal-Decree No. 1/2016 of 16 December 2016 on integrated pollution control should be taken into account.	The Italian Decree n. 162/2011, published on the G.U. della Repubblica Italiana incorporates the EU Directive. The decree has been amended 4 times with the last amendment in September 2020.
Geological storage of CO_2 in underground structures in Spain, including its territorial sea, its exclusive economic zone and its continental shelf.	Geological storage of CO_2 in the Italian territory and in the area of the exclusive economic zone and the continental shelf defined in the United Nations Convention on the Law of the Sea.
The geological formations belong to the state.	The works necessary for exploration are declared of public utility to all effects.
Exploration Permit Storage Permit	The Ministry of the Environment and the Ministry of Economic Development with a special decree identify the areas which can be selected for storage.

Area of Regulation	Netherlands
Licensing System	Exploration Permit Storage Permit
Environmental regulation	DNE

Spain	Italy
Exploration License (term: not more than 4 years, extension for maximum 2 years); procedure: The competent body must decide on the applications for research permits within a maximum period of one year. Storage license (term: 30 years and renewed for two 10-year terms). The approval of a storage concession will imply the declaration of public utility of the superjacent lands that are necessary for the establishment of the injection facilities, as well as their auxiliary facilities, for the purposes of forced expropriation and exercise of the right of way.	Exploration License (term: 3 years, extension for maximum 2 years, revoked if work has not commenced within 1 year). Storage license (simpler licensing process for volumes less than 100,000 tons), which can be transferred under certain conditions.
An environmental impact assessment is required for the storage permit.	The Decree n.162/2011 states that the permissions for the exploration of the geological storage of the CO_2 shall be subjected to the environmental impact assessment procedure established in the Decree n.152/2006.

Regulation	Netherlands
Monitoring / Inspections	DNE

Spain	Italy
The licensee must monitor the injection facilities and the storage complex, including, where possible, the CO_2 plume, and, where necessary, the surrounding environment, in order to compare the real behavior of CO_2 and of the formation water, in the storage place with the modeling of said behavior, detect significant irregularities, leaks, negative effects, evaluate the effectiveness of the corrective measures adopted. The monitoring will be based on a plan prepared by the licensee. The competent body of the autonomous community will establish a system of routine or specific inspections of the storage complexes in order to verify and reinforce their compliance, as well as to monitor the effects of the CO_2 storage complex on the environment and human health. The inspections will include activities such as visits to the surface facilities, including the injection facilities, the evaluation of the injection and monitoring operations carried out by the licensee and the verification of all the records held by the licensee.	The supervisory and control bodies are: a) the UNMIG and its territorial offices, for the application of the mining policy regulations and for technical support to the Committee within the Technical Secretariat b) ISPRA for environmental controls and monitoring of the storage complex and for technical support to the Committee within the Technical Secretariat c) the National Fire Brigade Corps (VVFF), for aspects of competence regarding the verification of the adoption of all the technical and managerial measures. The activity of supervision and control includes inspections at the storage complex, the surface facilities, including injection facilities, operations valuation injection and monitoring carried out by the operator and the verification of all relevant data kept by the manager. Periodic inspections are usually carried out at least once per year. Occasional inspections take also place in certain cases.

Area of Regulation	Netherlands
Responsible party and scope of liability	In case leakage or significant irregularities occur, the operator has to notify the competent authority, in the Dutch case the Minister of Economic Affairs and Climate Policy and take necessary corrective measures. In case the operator is unable to do so, the competent authority will take over. In this case, the operator has to surrender emissions allowances under the Emissions Trading System (ETS) for resulting emissions into the atmosphere for at least 20 years after obtaining the permit, or after closing the storage site. However, in the Netherlands the minister can decide to shorten or prolong this. Liability for damages to the environment is dealt with by means of the Directive on Environmental Liability (Directive 2004/35/CE, 2004) and damage to health and property is dealt with at the Member State level. In the Netherlands, this is regulated by means of the Dutch Civil Code (article 6.162 and 6:174-177). These provisions are general and do not pertain to CCS specifically. The length of liability for damages under these provisions differs from between 5 years after discovery of the damage to 20-30 years after the activity has caused damages. However, after a period of 30 years any liability under the Dutch Civil Code ends.
Shutdown and post-operation	When the conditions of the permit are met, for instance relating to the volume of CO_2 stored, the storage site will be closed permanently. Upon closure, a post-closure plan is required, which has to be approved by the authority. In the case of the Netherlands, the Minister of Economic Affairs and Climate Policy. After closure, all legal responsibilities for the site, including monitoring and corrective measures can be transferred to the competent authority after a period of 20 years. However, this is only possible in case the authority is convinced the CO_2 is stored safely and a financial contribution by the operator has been made. This includes a financial contribution for monitoring efforts for at least 30 years, which contribution lies between 1 and 10 million euros. Operators are therefore at least for a period of 50 years responsible for monitoring. After this period, the responsibility is taken over by governmental authorities.

Spain	Italy
The operator of the site is liable for any damage or leakage that might happen during the operational period. This responsibility is limited to twenty years following the closure of the site. After closure, liability is shifted to the government, as long as the operator has provided conclusive evidence that the storage site has been completely and safely sealed. The shift of responsibility, however, is not automatic.	The responsibility rests with the licensee. Especially in the event of spills, the operator is obliged to return a number of emission allowances corresponding to unduly released emissions. After the closure of a storage site and until the transfer of responsibility of the site, the operator continues to be responsible for monitoring, reporting and corrective measures. The operator is also obliged to seal the storage site and to dismantle the injection facilities. If a storage site closes due to revocation of the license, then the Ministry of Economic Development is responsible for monitoring and any corrective measures.
Post-operation the Government is responsible for adopting the necessary measures to carry out the monitoring of the storage sites after the transfer of responsibility, including those related to the coverage of the monitoring costs of the aforementioned storage sites, as well as those others that are necessary to ensure that the stored CO_2 remains completely and permanently confined.	The closure activities of a storage site are subject to authorization by the Ministry of Economic Development and the Ministry of the Environment and in agreement with the region territorially concerned. A provisional plan for the post-closure phase must be sent to the Ministry of Economic Development, the Ministry of the Environment and to the region concerned.

Regulation	Netherlands
Comments / Review of the implementation regulations	The holder of a storage license can only transfer his license to another person with the written approval of the minister. Disadvantages: This framework makes it possible to obtain a license for a CCS project, but at the same time leads to a number of uncertainties. Firstly, the storage site permit procedure is a competitive one; Secondly, the costs of liability, beyond the EU ETS rights, as well as the costs of monitoring are not clear beforehand. There are a number of exceptions the minister can make to shorten or prolong the period of costs for the operator. Thirdly, any third party seeking access to the existing transport infrastructure comes across a lack of rules, even though the EU mandates Member States to create such rules. In order to ensure CCS implementation, the legislator could seek to remedy these uncertainties by removing them as much as possible, while still fostering safety and affordability of the technique. Financial policy instruments can also contribute to this.

Spain	Italy
Exploration and storage licenses may be granted even in cases where there are mining or hydrocarbon rights over all or part of the same area granted. The total or partial transmission of research permits and storage concessions will be subject to the authorization of the competent Administration in each case for their granting, prior proof of compliance by the purchaser with the requirements to be the owner of the same (If the concession is granted on land which does not belong to the applicant, the land is potentially subject to expropriation by the public administration and later transfer to the applicant, who in turn must pay appropriate compensation.).	Among the weaknesses identified are: high costs associated to each CCS investment, the integration of a capture unit to power plants causes the loss of the 20-30% of efficiency, lack of financial incentives, need for further scientific studies. Threats: 1. The identification of the storage potential in Italy is difficult for two main reasons. On one side, a developed knowledge of the geological sites has not been deepened from the perspective of carbon storage. On the other side, there is a lack of studies assessing the storage capacity and the suitability of sites. 2. The current EU Direction (as well as the corresponding Italian transposition) assigns to the infrastructure designers the total responsibility of the project and of the injection, which discourages private investors. 3. Social public acceptance of CCS.

7. Appendix C: Details on risks

Risk Clusters	Risks & Challenges	Classification	
Economic & Market	CO_2 Emissions Price (Weak and/ or uncertain CO_2 price)	Capture	Emitter/ User
			State
		Transportation & Storage	T&S Operator
			State
	Investment cost & higher than anticipated construction cost	Capture	Emitter/ User
			State
		Transportation & Storage	T&S Operator
			State
	Operational cost and higher than expected	Capture	Emitter/ User
			State
		Transportation & Storage	T&S Operator
			State
	Value chain & market background	Capture	Emitter/ User
			State
		Transportation & Storage	T&S Operator
			State

and challenges per cluster

Risk Description
Loss of incentive for capture if CO_2 price drops below certain level.
Increase in subsidies if CO_2 price fall below certain limit (e.g., in a CfD, lower ETS price results in an increase in gap between EU ETS and levelized cost of capture).
Loss of incentive for capture would result in a underutilization of transport and storage infrastructure, increase in transportation fees, and potential revenue loss.
Depending on the subsidy term, the State may overburden CO_2 price volatility risk.
The emitter bears the construction cost of the capturing facility.
The State can decide to incentivize the investment cost through direct subsidy, or through indirect subsidy (linked to the CO_2 price). Increased construction costs, mean increased costs for the government.
The Operator bears the construction cost of the T&S network.
The State could decide to incentivize the investment cost through direct subsidy. Increased construction costs, mean increased costs for the government.
The emmiter bears all operational costs.
Depending on the subsidy mechanism, increased operational costs, mean increased costs for the government.
The T&S Operator bears the operational cost of the network.
Depending on the subsidy mechanism, increased operational costs, mean increased costs for the government.
-
-
The size, routes and potential demand for transportation services via ships will determine the viability of operations.
-

Risk Clusters	Risks & Challenges	Classification	
Technical & Operational	Failure to deliver CO_2 (emitter)	Capture	Emitter/ User
			State
		Transportation & Storage	T&S Operator
			State
	Failure to receive CO_2 (T&S)	Capture	Emitter/ User
			State
		Transportation & Storage	T&S Operator
			State
	Leakage of CO_2	Capture	Emitter/ User
			State
		Transportation & Storage	T&S Operator
			State
	CO_2 Quality (fail to meet specifications)	Capture	Emitter/ User
			State
		Transportation & Storage	T&S Operator
			State
	Delay in works completion	Capture	Emitter/ User
			State
		Transportation & Storage	T&S Operator
			State
	Underutilization of facilities	Capture	Emitter/ User
			State
		Transportation & Storage	T&S Operator
			State
	Terminal to ship interface	Capture	Emitter/user
			State
		Transportation & storage	T&S Operator
			State

Risk Description
Failure to deliver (for technical or business reasons) can lead to longer investment period payback.
Depending on the subsidy scheme, the State might bear part of the cost.
Decreased volumes for transportation and storage lead to lower revenue.
Depending on the subsidy scheme, the State might bear part of the cost.
The captured CO_2 might have to be released into the atmosphere, and the emitter will have to pay the CO_2 allowance cost.
The State might need to bear the extra CO_2 allowance costs on the emission side.
Decreased revenue due to lower activity. Extra costs related to operation restoration.
The State, depending on the subsidy mechanism, might need to cover some of the increased operational costs.
-
-
The financial mechanism envisaged in the regulation, provides the resources to cover the costs related to CO_2 leakage in both operational and post-closure period.
-
Drop in the quality of CO_2 stream can lead to drop in the accepted volumes for transportation & storage. Moreover, corrective actions may lead to increased capture costs.
Depending on the subsidy mechanism, the government might need to fund the increased operational cost.
Potential increase in operating costs due to corrective actions. Decrease in accepted volumes, and potential revenue loss.
Depending on the subsidy mechanism, the government might need to fund the increased operational cost.
Delay in works completion may lead to higher overall constructions costs.
To incentivize the capture investors, the State could cover the costs related to delay in construction completion.
Delay in works completion lead to higher overall constructions costs.
To incentivize the T&S investors, the State might need to provide additional funding.
Lower cost avoidance, due to underutilization, leading to a longer investment payback period.
The State might need to fund the difference between the expected utilization compared to the actual.
Decreased revenues due to lower activity.
The State might need to fund the difference between the expected utilization compared to the actual.
-
-
Not meeting the optimum technical parameters may lead to decreased revenue.
Identifying the optimum technical parameters is of great importance, therefore the State might need to cover associated costs.

Risk Clusters	Risks & Challenges	Classification	
Cross – chain	Force majeure	Capture	Emitter/ User
			State
		Transportation & Storage	T&S Operator
			State
	State instructed changes	Capture	Emitter/ User
			State
		Transportation & Storage	T&S Operator
			State
	Regulatory amendments (considered an additional operational cost)	Capture	Emitter/ User
			State
		Transportation & Storage	T&S Operator
			State
	Breach of contract	Capture	Emitter/ User
			State
		Transportation & Storage	T&S Operator
			State
	Transportation footprint	Capture	Emitter/ User
			State
		Transportation & Storage	T&S Operator
			State

Risk Description
Lower cost avoidance, leading to a longer investment payback period.
The State might need to fund the difference between the expected utilization compared to the actual.
Decreased revenue due to lower activity.
The State might need to fund the difference between the expected utilization compared to the actual.
-
The State is liable to pay all additional costs due to changes instructed by itself.
-
The State is liable to pay all additional costs due to changes instructed by itself.
Increased costs related amendments to the regulatory framework, lead to additional operational costs.
Depending on the subsidy mechanism, the State might bear the extra cost.
Increased costs related amendments to the regulatory framework, lead to additional operational costs.
Depending on the subsidy mechanism, the State might bear the extra cost.
Risk of losing funding.
If there is State subsidy in place, there is a risk of overspending.
Risk of losing funding.
If there is State subsidy in place, there is a risk of overspending.
-
The transportation carbon footprint might negate the CCS GHG reduction benefits
-
The transportation carbon footprint might negate the CCS GHG reduction benefits

8. Appendix D: Detailed comparison

Revenue model	CAPEX Risk (budget overrun)	Commercial Risk (no clients/no business)	Infrastructure Risk (availability, capacity, time)	Market Risk (CO_2 price volatility)
ETS	If the investment cost increases, all risk lies to the capturer.	In case of a business slowdown or interruption, the capturing side does not capture CO_2 and therefore cannot benefit from the cost avoidance, thus the risk is high. But this extends also to the T&S side (transfer risk) since, no CO_2 captured means lower (or no) revenue at all.	Similarly, to the commercial risk, if the T&S infrastructure is not available, then the captured CO_2 cannot be stored, therefore the capturer needs to pay for CO_2 allowances on otherwise captured volumes.	CO_2 price is directly linked to the success of the investment in this model. If the investment incentive is lost for the capturer (high risk), then the T&S Operator is affected as well (high transfer risk), as Capturers who do not invest in capturing facilities, are lost clients for the T&S side, and therefore the cost recovery for the T&S network becomes slower.

between the models on selected criteria

Funding participation (construction and/or operational)	Potential commercial upside	Probability of investment recovery (construction and/or operational)	Model implementation complexity	Model public acceptance
The capturer is solely responsible for the investment.	The potential for a commercial upside is low for both capturers and T&S operators. Since this mechanism purely depends only on the CO_2 market prices, there is a high risk for the capturers of not recovering even the investment cost and thus it seems very unlikely to have additional upsides. For the T&S side, if the capturers purely depend on the ETS means very low incentives and thus no to little clients.	For the emitters who wish to offset their investment cost through the cost avoidance of the EU ETS, there is a high risk linked to the CO_2 price volatility.	There are fairly straight-forward administration, monitoring and reporting obligations.	ETS is a mechanism already in place, so this could be publicly acceptable.

Revenue model	CAPEX Risk (budget overrun)	Commercial Risk (no clients/no business)	Infrastructure Risk (availability, capacity, time)	Market Risk (CO_2 price volatility)
Tax credits	The main risks in the tax credit mechanism lies with the investors side.	All obligations lie with the private investors side and thus all risk.	For the private investor the risk is high, since infrastructure failure means no CO_2 capturing, and therefore no cost avoidance from the CO_2 allowances side. Additionally, no T&S operation means reduced revenues to the T&S side as well and thus increased risk from the use of the tax credits mechanism.	Tax credits need to be connected to CO_2 prices to take out some of the private sector's risk (at the expense of the State). For the T&S side, the CO_2 price has an indirect effect, as low CO_2 allowance prices, could mean less capturers and/or less CO_2 volumes, and therefore less revenue for the Operator.

Funding participation (construction and/or operational)	Potential commercial upside	Probability of investment recovery (construction and/or operational)	Model implementation complexity	Model public acceptance
The government does not bear any direct funding, but only loses potential income from the regular taxation of the business activity. For the private investors the risk is high since they are responsible to cover all costs.	Application of this model might potentially lead to increased benefit for the private investors in case the tax credit is higher than required for the investment recovery.	The tax credit mechanism might not be enough for the investors to recover the costs occurred in the construction/operation phase. The size of the risk is directly related to the amount of the tax credits.	For the government side, although this subsidy method has been successfully implemented in the past, there is some administration and monitoring complexity. For the private investor, there is no risk or complexity.	The reduction in corporate tax that results is not a direct form of funding and thus is more easily accepted. Additionally, avoided emissions benefit both the climate and the economy and thus could be publicly accepted.

Revenue model	CAPEX Risk (budget overrun)	Commercial Risk (no clients/no business)	Infrastructure Risk (availability, capacity, time)	Market Risk (CO_2 price volatility)
CfD	Increased investment cost might imply higher risk for the investor as well as the State (in case of enhanced participation in the additional cost). It depends on the terms of the bilateral agreement between the State and the investor. In all cases, it is considered that the risks are shared between the parties.	The government does not face any risk, since the CfD compensates only the CO_2 volumes that are actually captured, transported and stored. But the risk is high for the capturer not being able to capture and/or transport and store adequate volumes. There is a transfer risk also for the T&S side, although the CfD mechanism does not apply directly to the Operator. This risk is significant since not (or low) captured volumes mean no (or low) infrastructure utilization and thus lower than anticipated revenue.	The government does not face any risk, since the CfD compensates only the CO_2 volumes that are actually being captured, transported and stored. But the risk is high for the Capturer not being able to capture and/or transport and store adequate volumes. If the disruption is significant, then State involvement might be necessary to keep the market viable. There is a transfer risk also for the T&S side, similar to the Commercial risk.	The CO_2 price volatility affects both the government and private investors. Initially, the State might end up funding significant amounts in case the CO_2 prices remain low for a long period of time, and on the other hand private investors might experience slow investment recovery in cases where the CO_2 prices go marginally above the capture cost.

Funding participation (construction and/or operational)	Potential commercial upside	Probability of investment recovery (construction and/or operational)	Model implementation complexity	Model public acceptance
According to projected developments in the EU ETS, the State's funding participation is expected to constantly decrease as EU allowances are expected to increase. The funding is shared between the State and the Capturer.	Not capped CfD: the State could potentially recover some of the initial financing (if prices go above the strike price which is usually the cost of capture). For the investor side, no room for upsides exist since the cost is hedged to a specific agreed strike price. Capped CfD: no upside for the State but beneficial only for the investor (since after the CO_2 prices surpass no extra resources should be returned to the State).	For the private side, the risk is mitigated as any downward price volatility that might affect the cost avoidance, will be offset by the State through the CfD. However, there is some risk that in some cases, the strike price of the contract might be set too high (overcharging the State) or too low (under-funding the Investor).	This is not a complex mechanism as it has been applied globally in many different markets and there is accumulated experience. Offers stability in transactions and operations.	Although CfD contracts are available in the market for many years, it is considered that the public awareness for these types of instruments is low, and therefore a medium risk exists.

Revenue model	CAPEX Risk (budget overrun)	Commercial Risk (no clients/no business)	Infrastructure Risk (availability, capacity, time)	Market Risk (CO_2 price volatility)
RBCF	In case the construction cost exceeds certain limit, the investor is exposed to high risk, as over budget spending might not be accepted in the terms of the financing.	Risks apply throughout the CCS chain, as the financial institution(s) will fund only if environmental targets are achieved (i.e., reduction in emitted GHG to the atmosphere). There is also a transferred risk to the T&S side in case of very ambitious targets that could decrease capturers' incentives to invest and thus leaving the T&S infrastructure with limited revenue sources.	Similarly to the commercial chain breakdown, high risks apply on the capturer's side, as the financial institution(s) will fund only if environmental targets are achieved (i.e., reduction in emitted GHG to the atmosphere).	The CO_2 allowance price is not affecting the stakeholders as funding received is based on the achieving preset environmental targets.

Funding participation (construction and/or operational)	Potential commercial upside	Probability of investment recovery (construction and/or operational)	Model implementation complexity	Model public acceptance
Funding might come from multiple sources (e.g., World Bank). The risk for the investor is linked to the level of participation of funding instruments to the total investment.	For the investors, potential (low probability) upside might come in case of increased environmental goals (on top of the agreed). In such case there is transfer opportunity for the T&S side to generate more revenue, if the capturers are taking advantage of the potential upside of overachieving the climate targets and thus creating more utilization to the T&S.	Generally, for the investor, there is a medium risk in cases of very ambitious targets not achieved and therefore not receiving the funding. This explains the medium probability instead of high.	There is a certain degree of implementation complexity for all involved parties. The investor needs to follow the process of funding request submission and also monitor the execution of the prerequisites (milestones) in order to receive the funding.	Moderate acceptance for the public since funding is linked to environmental targets only.

Revenue model	CAPEX Risk (budget overrun)	Commercial Risk (no clients/no business)	Infrastructure Risk (availability, capacity, time)	Market Risk (CO_2 price volatility)
RAB	Increased investment cost is not considered a risk for the T&S operator, since the RAB model provides the mechanism for covering extra costs through the usage tariffs. But this budget overrun will affect the capturers (transfer risk) as they will pay for the increase in the costs through the respective increase in the tariffs.	The commercial chain breakdown could cause lower revenue for the Operator. But since the RAB model has provisions related to the cost recovery, eventually the end users might bear the extra cost (transfer risk for the Capturer).	If the T&S network is not available for usage, the Operator bears part of the risk depending on the obligations and the nature of the breakdown. There is also a transfer risk for the Capturers due to the potential increase in usage tariffs.	The CO_2 price volatility does not affect the T&S side due to the nature of the investment recovery of the RAB. However, low utilization might increase usage tariffs for the capturers and thus the transferred risk.

Funding participation (construction and/or operational)	Potential commercial upside	Probability of investment recovery (construction and/or operational)	Model implementation complexity	Model public acceptance
The investment for the T&S side is being recovered by the market, through the usage tariffs. Nevertheless, the T&S Operator is solely responsible to fund the investment.	Capturers could potentially benefit from increased cost avoidance in case the usage tariffs are lower compared to CO_2 allowances. For the T&S side investors, the RAB mechanism offers secured return of investment, but also provides the opportunity of having unregulated services.	Investment recovery under normal operational conditions, is guaranteed in the RAB model through the Required Revenue concept. User tariffs is the main revenue stream through which the investor will recover the investment and operational costs, in a regulated environment.	It is a complex revenue model, requiring resources for the monitoring obligations and the regulation of the tariffs. But since there is significant experience in implementing the RAB model in Greece, the risk is considered medium.	This model has been implemented in the past in multiple infrastructures throughout the energy industry (e.g., electricity grids, gas pipelines etc.)

Revenue model	CAPEX Risk (budget overrun)	Commercial Risk (no clients/no business)	Infrastructure Risk (availability, capacity, time)	Market Risk (CO_2 price volatility)
Cost plus	In case of increase in the projected investment cost, it is considered that the risks are shared between all involved parties, as special terms (like a cap mechanism) in the bilateral agreement will probably be applied, as a form of incentive mechanism to control costs.	Regardless of whether there are users or not, the Operator will be compensated by the State. Also, the same applies for the capturer. Since all risks lie with the State, it is considered that this model may not promote competition as the Operator lacks the drive to attract users to the network, if not incentive mechanisms are provided.	There is risk sharing between all parties involved, as the Operator is responsible to operate and maintain the network in an efficient and economically sensible manner. Depending on the type of infrastructure risk and the provisions of the cost-plus agreement, the risks for the Operator might by minimum (green) to very high (red). Therefore, it is considered that the risk sharing applies to all involved parties.	The CO_2 price is not directly relevant to this model. The CO_2 volatility does not affect the capturer/ Operator since the State bears all costs. However, for the State the is medium risk in cases were the very low prices (and thus low incentives to capturers) might lead to underutilization of an existing T&S infrastructure.

Funding participation (construction and/or operational)	Potential commercial upside	Probability of investment recovery (construction and/or operational)	Model implementation complexity	Model public acceptance
Low risk for the investors since in most cases and under normal operational conditions, the majority of risks/ costs are allocated to the State.	The cost plus provides upside by definition since it covers all costs with an additional profit for the investor. Longship profit sharing during the funding period: for both the capturer and the T&S operator a profit sharing mechanism with the State is in place where if a predefined level of ROI is achieved, then part of the net cashflow goes to the State.	For the capturer and the T&S operator there is low risk, as all cost (plus the agreed profit) are covered by the State. On the contrary, this is a high-risk model for the government as it absorbs the majority of the risks/ costs. Similar to the commercial upside for the State, in case of a profit sharing between the State and the investors part of the State's investment/ financing could be retrieved.	Straight forward approach, nothing complex regarding the administrative implementation.	Public might be skeptical towards a mechanism where essentially all costs are covered by the government in a private investment.

Revenue model	CAPEX Risk (budget overrun)	Commercial Risk (no clients/no business)	Infrastructure Risk (availability, capacity, time)	Market Risk (CO_2 price volatility)
PPP	There is a great risk for the T&S operator of mis-calculating the investment cost. In case of larger than anticipated costs, then the private investor bears all risks. The State is not affected.	For the Operator the risk is high with respect to the loss of clients and therefore loss of income. For the State, depending on its participation in the funding, the risk is considered medium.	For the Operator, infrastructure non-availability leads to lower utilization and thus revenue. For the State, depending on its participation in the funding, the risk is considered medium. But for the capturer, although the PPP model is not directly applied, the risk is high, as if the T&S infrastructure is not available, the capturer is not able to inject the captured CO_2 (transfer risk).	The CO_2 price volatility affects both the Operator and the State. If the price levels are too low, the capturers lose the incentive to invest, and this means lost customers for the Operator leading to increased risk for the whole project/ infrastructure

Funding participation (construction and/or operational)	Potential commercial upside	Probability of investment recovery (construction and/or operational)	Model implementation complexity	Model public acceptance
Ability to raise additional finance in an environment of budgetary restrictions, make the best use of private sector efficiencies to reduce cost and increase quality and speed up infrastructure development. Both involved parties share risks and costs. However, usually the government's participation is the cost for the land and licensing / permitting process, which is not proportional to the costs that the operator will have to undertake.	Potential upsides for the State might occur through bilateral agreements with the investors (e.g., rent of land etc.) The T&S side could have some upside in case the (pre) agreed tariffs attract more clients than anticipated.	Since the tariffs are calculated by the Investor, but through a regulated (capped) mechanism, a miscalculation on the usage tariffs might mean loses or slow funds recovery. This is a medium probability since it is neither not possible to happen nor very likely to happen. For the State, in the vast majority of cases the PPP model is not supposed to recover the financing since the purpose of providing such is not based on commercial incentives but more of national targets, social benefits etc. Part of the financing (usually very small) might be recovered taking into consideration potential upsides that might occur in the operation of the infrastructure depending on the bilateral agreements with the operators.	Although the experience accumulated in this model in Greece, is significant, the implementation complexity is quite high, and is mainly related to monitoring, reporting obligations and the set-up of the respective mechanisms that should be in place.	This model is considered publicly acceptable, as Especially in Greece the PPPs have been applied for many years in diverse business sectors. There is only some concern that this scheme could potentially create non-competitive or closed markets.

Revenue model	CAPEX Risk (budget overrun)	Commercial Risk (no clients/no business)	Infrastructure Risk (availability, capacity, time)	Market Risk (CO_2 price volatility)
State owned	High risks for the State, as increased costs in State owned infrastructure could occur, and this means additional budget burden.	In case of a commercial chain breakdown, the State bears high risk of ending up with an infrastructure that nobody is using (stranded asset).	All responsibility lies with the State to keep the infrastructure running (high risk/ cost). In case the network is not available, regardless of the whether the project is designed to create social benefits or to make profit, the capturers are affected as well (high transfer risk), as they will not be able to transport and store the captured CO_2.	CO_2 price volatility (especially at the lower end) might not incentivize emitters to invest on capturing technologies and use the T&S infrastructure. Therefore the risk is high for the State.

Funding participation (construction and/or operational)	Potential commercial upside	Probability of investment recovery (construction and/or operational)	Model implementation complexity	Model public acceptance
All risks are borne by the State as a single shareholder.	Very little to no upside for the State; only through indirect benefits as a result of overall compliance to energy transition/net zero efforts. Capturers could potentially benefit from increased cost avoidance in case the usage tariffs (if applied) are lower compared to CO_2 allowances.	The investment recovery mainly depends on whether the government will decide to apply usage tariffs.	Higher complexity since the State is responsible for the end-to-end implementation and operation.	Medium risk of public acceptance, mostly challenging the overall necessity of such investments.

Definitions / Glossary

Aquifer	an underground layer of water-bearing, permeable rock, rock fractures, or unconsolidated materials (gravel, sand, or silt)
Asset	a resource with economic value that an individual, corporation, or country owns or controls with the expectation that it will provide a future benefit
Carbon intensity	the emission rate of a given pollutant relative to the intensity of a specific activity; or an industrial production process
Climate finance	local, national or transnational financing aimed at supporting mitigation and adaptation actions that will address climate change
Competent Authority	part of a government responsible for transposing the requirements of European regulations into national legislation
Consumer	a person, company or organization that purchases goods and services for personal use
Emitters	facilities that emit greenhouse gas
Exchequer	the government department that is responsible for receiving and dispersing the public revenue
Fossil fuels	any of a class of hydrocarbon-containing materials of biological origin occurring within the Earth's crust that can be used as a source of energy, such as coal, oil or gas.
Fund	pool of money that is allocated for a specific purpose

Geological storage	the placement of CO_2 into a subsurface formation so that it will remain safely and permanently stored
Hydrocarbon	an organic compound consisting entirely of hydrogen and carbon, naturally occurring and forming the basis of crude oil, natural gas and coal
Liability	sum of money that a person or company owes
NECP	a 10-year integrated national energy and climate plan for the period from 2021 to 2030 to meet EU's energy and climate targets for 2030
Revenue model	a framework for generating financial income
Subsidy	money granted by the government or a public body either to help keep the prices low or encourage an investment to happen
Supplier	a person, company or organization that provides something needed, such as a product or service
Tax Credit	amount of money that taxpayers can subtract directly from the taxes they owe
Water column	a vertical expanse of water stretching between the surface and the bottom of a body of water

Abbreviations

CAPEX	capital expenditures
CCS	carbon capture and storage
CCU	carbon capture and utilization
CCUS	carbon capture, utilization and storage
CfD	contracts-for-difference
CO_2	carbon dioxide
DNE	does not exist
EEA	European Economic Area
EOR	enhanced oil recovery
ETS	emissions trading system
EU	European Union
FOAK	first-of-a-kind
GHG	greenhouse gas
Gt	gigatonnes
Gtpa	gigatonnes per year
IRENA	International Renewable Energy Agent
ktpa	kilotonnes per year
Mtpa	megatonnes per year
MWh	megawatt hour
NDC	National Determined Contributions
NECP	National Energy and Climate Plan
NGO	non-governmental organizations
NZE	net-zero emissions
OECD	Organisation for Economic Co-operation and Development
OPEX	operating expenditure
RES	renewable energy source
T&S	transport and storage
tCO_2	tonne of CO_2
UK	United Kingdom
US	United States

Founded in 2011 with the Greek state as its sole shareholder, Hellenic Hydrocarbons and Energy Resources Management (HEREMA) manages national interests regarding the exploration, research, and production of hydrocarbons. The company also works methodically to accelerate the development and monetization of Greece's upstream hydrocarbon industry, with a particular focus on natural gas, in view of the significant and positive impacts the industry could have on Greece's economic and social development.

Furthermore, HEREMA is also designated the competent national authority for the licensing and monitoring of CCS projects as well as for other gas and liquid storage projects (UGS). HEREMA was also designated the competent national authority for the research, exploration and selection of Organized Offshore Development Areas for Wind Farms and installation areas, and the granting of research and exploitation rights for these projects, further expanding our company's scope.

Driven by the belief that the world needs to urgently transition to a sustainable carbon-neutral economy and bearing in mind the pivotal role of natural gas as a bridging fuel, HEREMA's management established a new vision for the company focused on being an enabler of Greece's energy transition goals.

To this end, the company has recently undertaken numerous initiatives to strengthen environmental and social governance in the sector through new governance frameworks, while steps are being taken aimed at accelerating the exploitation of the country's natural gas deposits. Likewise, and as part of the company's role in supporting the attainment of the goals set out in Greece's National Energy and Climate Plan (NECP), HEREMA has established a New Ventures department focused on exploring synergies between the oil and gas industry and new energy technologies such as Carbon Capture and Storage, offshore wind farms and hydrogen.

Through the acquisition of DEPA International Works, HEREMA participates in important infrastructure projects, such as the IGB and East Med pipelines, which will enhance the verticalization of our energy system.

As the single administrator of Greece's hydrocarbons data archive, HEREMA prioritizes taking measures to strengthen its data library with new geophysical and geochemical data, and continuously update its assessment of the hydrocarbon potential of Greece's geological basins. Because of this, HEREMA has unparalleled technical know-how and expertise regarding Greece's hydrocarbon potential.

The company has created strategic synergies with academic institutes, major market players, and government authorities and is working with investors and legislators to leverage its offshore expertise to contribute to the deployment of new energy technologies.

HEREMA maintains an open-door policy and attractive conditions for potential investors and looks forward to welcoming new partners to further develop Greece's energy resources.

HEREMA Team

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Aristofanis (Aris) CEO of the Hellenic Hydrocarbons and Energy Resources Management (HEREMA) holds a PhD in geology and geophysics, a master's degree in environmental oceanography and a bachelors in geology. Prior to his appointment by the ministerial cabinet as the CEO of HEREMA, Mr. Stefatos held senior and top management positions (Portfolio Manager, CTO, COO, and Chairman of the Board) in private E&P companies in Norway and has been a founding partner of five Norwegian companies within the oil and gas E&P and broader sector, including companies developing innovative environmental and digitalisation solutions. Throughout his 24 years of work experience, Mr. Stefatos has received academic distinctions and has also worked with the establishment of technical and de-risking workflows for new technologies and has been involved in the technical maturation of exploration prospects and drilling. He has worked in geological basins in Europe, North America, the Indian Ocean, the West Coast of Africa, and South East Asia. He has a proven track record of five oil and gas discoveries in the Norwegian and the Barents Sea. From 2019 to 2021, Mr. Stefatos served as the honorary consul of Greece in Bergen Norway.

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Efthimios holds a BS in geology from the Aristotle University of Thessaloniki and MS and PhD degrees in geophysics from the University of Utah, with a specialisation in electromagnetic methods. He has conducted research in advanced imaging and inversion algorithms for subsurface characterisation and has worked on the modelling and interpretation of surface, borehole and airborne geophysical data for hydrocarbon, mineral and geothermal exploration. He has held various senior management and business development positions in the oilfield services industry, where he was responsible for large multi-disciplinary teams working on G&G data integration and for global sales and marketing of the multi-physics portfolio, including, software, data acquisition, processing and interpretation. He has recently returned to Greece to manage HEREMA's geoscience department and provide management consultancy services in the fields of hydrocarbon exploration and new energy.

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Ismail holds a BS in Petroleum Engineering with a major in Reservoir Engineering from Shiraz University and MSc in Petroleum Engineering from the Technical University of Crete. Currently, he is pursuing a PhD at the National Technical University of Athens specializing in well control strategies for carbon injection in subsurface storage applications. He has conducted research on a range of topics, including enhanced oil recovery, smart water injection, flow assurance and subsurface carbon storage. Since 2019, Ismail has been working at HEREMA, where he is currently holding the position of Lead Subsurface Engineer – Reservoir Engineer. In his role, he leads projects related to hydrocarbon exploration and production, as well as energy transition initiatives. In addition, he provides technical and advisory support on aspects related to reservoir engineering, O&G field development plans and carbon subsurface storage.

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Theodoros is working in the energy sector since 2014 covering upstream and downstream sectors. He started his career working as a Petroleum Engineer for 2 years in an oil & gas consultancy company in Aberdeen (UK), performing field development planning studies. Then he was working for 6 years as a Project Engineer for a construction company in Athens and he was responsible to manage, from large to smaller scale EPC projects in oil & gas industry. Since 2022 he is working in HEREMA as a Project Engineer and he is involved in a variety of energy projects (CCS, Offshore Wind Farms, Natural Gas etc.). He holds a diploma in Mining Engineering from the Technical University of Crete and a MSc degree in Petroleum Engineering from Heriot Watt University in UK. He is a member of the Technical Chamber of Greece.

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Katerina is Attorney-at-Law and practices energy and public law. She has great expertise as legal advisor of the public sector for investments projects and regulatory affairs. She has worked as special legal counsel to the Minister of Energy and she has participated in significant projects of national importance (concession of Piraeus Port Authority, PPP project for hospital of Preveza, HRADF project for the Hellenic ports). The last two years she is legal advisor to HEREMA for the hydrocarbons leasing agreements and CCS projects.

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Dimitris leads the Strategy & Operations practice of KPMG in Greece. He specializes in large scale strategy, restructuring & transformation projects. His clients include some of the largest Greek private sector clients as well as many government bodies & institutions. In his career to date with Kantor / Booz&Co where he led the Management Consulting Practice and PwC where he led the Strategy & Operations practice, he has acquired extensive experience in operations optimization within the Greek industrial sectors. He specializes in large scale strategy, restructuring & transformation projects, value chain operations optimization & advanced commercial analytics and machine learning assignments, as well as large privatizations & investments evaluations. Dimitris holds an Engineering Diploma in Chemical Engineering from the National Technical University of Athens, a MSc. degree in Automatic Control & Systems Engineering from University of Sheffield and a MSc. degree in Operations Management from the University of Manchester. Finally, Dimitris is ACCA certified in Accounting & Finance.

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Giannis is a Manager at KPMG's Strategy & Operations department leading the Energy & Utilities team. He is a member of the Technical Chamber of Greece since 2009. Giannis has more than 11 years experience in the Energy & Power sector with his expertise being the electricity markets. He specializes in business analysis and planning, market analysis, regulatory framework monitoring/analysis, load/demand forecasting, pricing, risk management, product development and portfolio management. Prior to his current role, he worked as Senior Researcher at E3-Modelling for projects related to energy system analysis for EU27, UK and the Energy Community countries, Strategic Planning Manager for electricity, natural gas and energy services at Elpedison and also as a Management Consultant for the Energy Sector at PwC. Giannis holds an Engineering Diploma in Electrical & Computer Engineering from the Technical University of Crete and a MSc. degree in Energy Production and Management from the National Technical University of Athens.

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Theodossis Tompras is a partner at CPA Law, independent member of KPMG international Legal and Tax Network. He has been a Member of the Athens Bar since 2003 and is a qualified Supreme Court Lawyer. Theodossis is specialized in network industries (TMT & Energy) and a leading TMT and Networks Regulation practitioner. He has handled multiple M&As and clearance procedures at national & European Commission level, while he was involved in numerus debt & structured finance transactions, spectrum auctions and regulatory procedures in both the Energy & TMT sectors. In this respect, he has represented market players and participated in public consultations and administrative procedures & hearings before a broad spectrum of NRAs, ranging from:

— NTPC (EETT),

— RAE (Regulatory Authority for Energy-PAE),

— HACSP (Hellenic Authority for Communication Security and Privacy-ΑΔΑΕ),

— Greek DPA (ΑΠΔΠΧ),

— to NCRTV (National Council for Radio and Television-ΕΣΡ) and

— HCC (Hellenic Competition Commission-EA),

as well as DG Comp and DG Connect. He joined CPA Law in 2020 after 15 years of in-house experience as a C-level executive in the Electronic Communications and Energy sectors. Since 2012, Theodossis was WIND Hellas' General Counsel and a member of WIND Hellas Management Team, also served WIND Hellas between 2006 to 2010 as the company's Regulatory Affairs Director, while between 2010 to 2011 Theodossis have worked as

GC in the energy sector. Theodossis was listed in Legal500 "General Counsels Powerlist: Greece & Cyprus 2018" while during his term with WIND Hellas' the latter's Legal Department was listed in Legal500 "GC Powerlist: Greece and Cyprus Teams 2019".

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Alexandros started his banking career in 1992 at Salomon Brothers (later Citigroup) in London at the Infrastructure and Transportation Group. In 1999, he undertook investment banking in Greece and was engaged in the largest privatizations, equity offerings, IPOs and M&A. In 2007, he assumed the position of Deputy Managing Director at Piraeus Bank. He was also a member of the Executive Committee and the Board of Directors. In 2012, he was appointed CEO of Geniki Bank, following its buyout by Piraeus Bank. In 2013, he returned to Piraeus Bank as an Advisor to the CEO where he spearheaded a number of transformational projects including the full review and rationalization of retail banking fees and commissions structure, the introduction of the first e-auction platform in order to increase efficiency and transparency of own real estate asset sales, and the creation of a strategic procurement unit in order to reduce drastically operating expenses without negative repercussions on the bank's business. In 2019, Alexandros joined Praxia bank in the position of Chief Operating Officer. Alexandros holds a Master's in Advanced Mechanical Engineering from Imperial College of Science Technology & Medicine and an MBA from INSEAD.

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Alexandra is a supervising senior advisor at KPMG's Strategy & Operations department. She has professional experience of 18 years in the energy and procurement sectors. She has successfully managed the construction of renewable energy projects in Greece and abroad, as well as regulatory projects related to the transformation and change of operation of the natural gas market in the country. Prior to her current role, she worked as Research Advisor for NCSR Demokritos, where she performed the life cycle analysis of the first operational hydrogen refueling station in Greece. During her collaboration with Demokritos, she also participated in the Market study preparation for DESFA, regarding the introduction of hydrogen in natural gas networks, where she was responsible for the market monitoring and regulation mechanisms. Alexandra holds an Engineering Diploma in Chemical Engineering from the National Technical University of Athens.

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Katerina Seferli is a lawyer at CPA Law, independent member of KPMG international Legal and Tax Network. She is admitted before the Court of First Instance and member of the Athens Bar. Katerina specializes in regulatory as well as corporate law. At CPA Law, she is mainly engaged in energy and regulatory projects. She has participated in numerous multidisciplinary projects while she has advised clients on complex regulatory issues. Before joining CPA Law in 2021, she worked for an energy group and various organizations. Katerina holds a LL.B and a LL.M from the National and Kapodistrian University of Athens, a minor in Finance from the American College of Greece while she has attended courses in Germany and the UK.

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