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Carbon Capture and Storage

Seeking a bankable business model

White paper - November - 2023

Context

- The International Energy Agency (IEA) and the Intergovernmental Panel on Climate Change (IPCC) recognizes Carbon Capture and Storage (CCS) as a critical technology to achieve the Net Zero target by 2050[1]
- The IEA's Sustainable Development Scenario suggests ~15% of the world's emission reductions to be achieved using CCS[1], which will require at least $1.5 trillion investment on an international scale[2]
- Private-sector investments are needed to achieve this level of funding, including debt financing, capital markets and other sources of capital
- **This report provides an overview of emerging CCS business models, specifically focusing on their bankability** - financial viability and attractiveness for potential private-sector investors
- Although various CCS projects and models are emerging across the world, **this report focuses on recent developments across advanced CCS domains - Europe and the US**
- **While licensing and permitting processes for CO_2 transport and storage are very important elements** in the investment decision process, **the detailed analysis of those is left for the future study**

Executive summary

CCS overview

- **Carbon Capture and Storage (CCS) is considered as one of the pivotal solutions to decarbonize hard-to-abate industries as well as to achieve negative emissions** through its application in bioenergy production
- **Since the 1970s, some elements of CCS technologies have been used** in the oil & gas and chemical industries. **However, to achieve the required scale CCS should develop into a comprehensive commercial solution** for various emitters underpinned by massive infrastructure
- **Full-scale CCS clusters are actively developing in Europe and the US**, with the first 1.5 Mtpa[7] CO_2 storage project launching in Norway in 2024. Meanwhile, **European governments are actively introducing push and pull regulations to grow the storage capacity** by a factor of 100 by 2030

CCS investability

- While **the first CCS projects receive significant government subsidies, scaling up the next wave will require private investments**. With current risk assumptions, investment in a mid-size CO_2 transport and storage project can yield medium to high single-digit returns
- However, **to become 'bankable' specific CCS investment hurdles should be addressed**, first **it should be economically attractive for emitters**, but also **various cross-chain risks and risks of long-term storage leaks should be mitigated**
- **The analysis indicated that only the UK has implemented an investable CCS business model** by taking an integrated cluster view on the infrastructure **and implementing the regulated asset base approach, which although might limit the expected returns**

CCS investment catalysts in Europe

- Although emitters in the UK, Netherlands and Denmark can receive local subsidies to cover a gap between CO_2 capture costs and the EU ETS price, similar **Contracts for Difference-like subsidies tailored to CCS should be introduced across Europe to support the emitter business case**
- **To make CCS investable, a guarantee-type of risk protection** (e.g. regulated asset-based models or EU ETS-baked fund) **should be established to support in case of low-probability high-impact events** (e.g., CO_2 leakage) until the insurance instruments for CCS are developed and affordable
- **Cross-border CO_2 transport and storage** (i.e., London Protocol) **should be enabled to allow emitters to access ideal storage locations**, as well as to promote competition among developers and **mitigate storage underutilisation risks through access to a wider pool of emitters**

1. CCS overview

Historically, CCS was used for EOR and gas processing. Rapid scale up of CCS for hard-to-abate industries and BECCS will be required in the next decade to reach the climate targets

Focus of this study

Enhanced Oil Recovery (EOR)	Decarbonizing own operations	Decarbonizing hard-to-abate industries	Bioenergy with CCS (BECCS)	Direct Air Capture (DAC)
Injection of CO_2 into oil reservoirs to extract hard-to-recover oil remaining in older fields	Capturing CO_2 from own projects (e.g. gas processing) to ensure license to operate	Storing of CO_2 from various industrial emitters (e.g., cement) to avoid CO_2 emissions	Generating electricity from bio-waste (e.g., waste-to-energy plant) and storing CO_2, thereby achieving negative emissions	Removal of CO_2 from the air with a storage, thereby achieving negative emissions
Historical adaptation since 1970s		**To scale up in next 10 years**		**Low technical readiness**

Sources: Deloitte analysis

Commercial CCS-as-a-service using a true merchant approach will be needed to offer the solution to various emitters, as opposed to integration along own O&G operations

CCS value chains and business models

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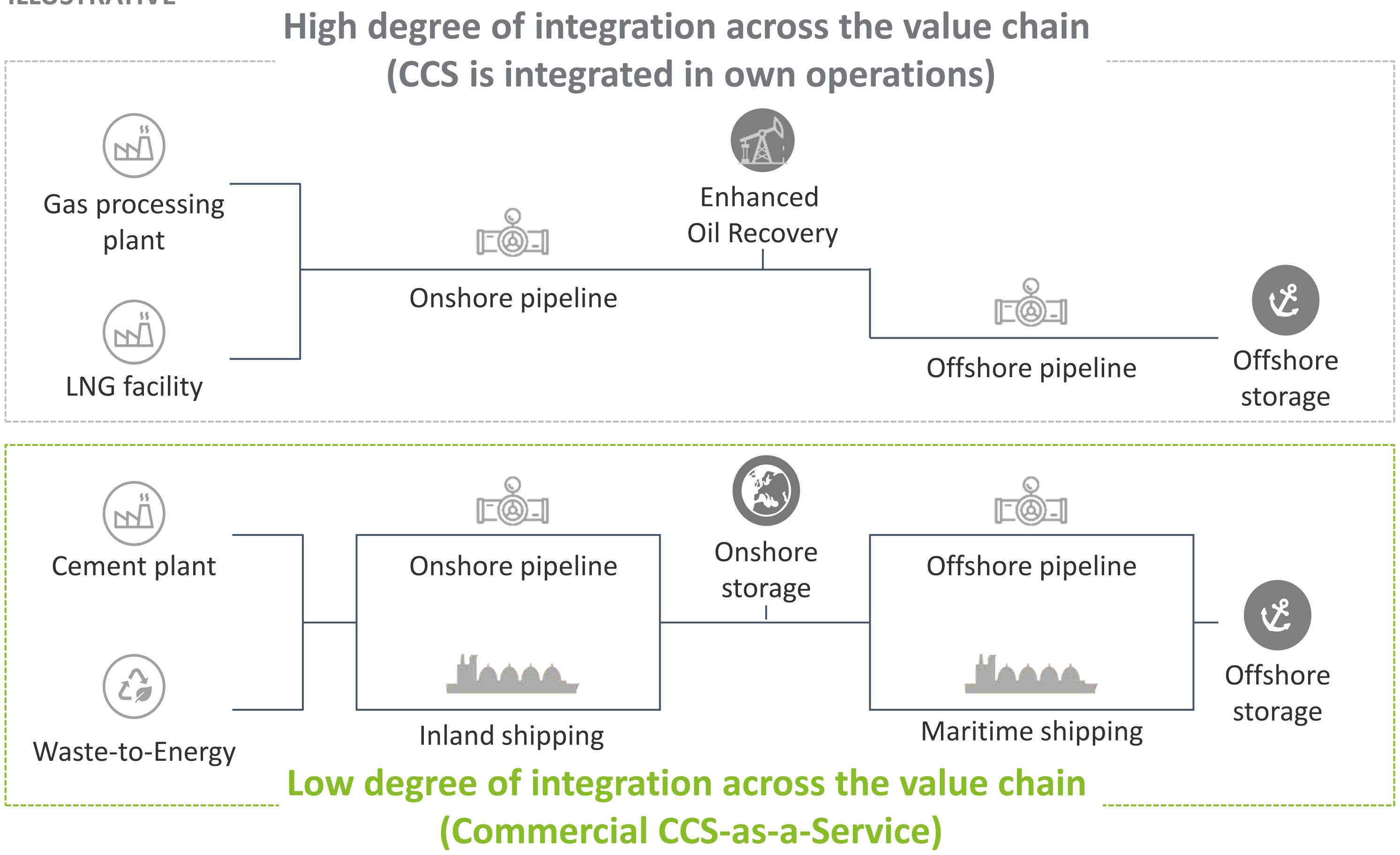


CCS Business Models

Integrated CCS

- Vertically integrated Oil & Gas company develops, owns and operates EOR / CO_2 storage
- **CO_2 is captured only from its own upstream and midstream operations**
- CO_2 transportation through its own onshore or offshore pipelines being a part of the integrated operations

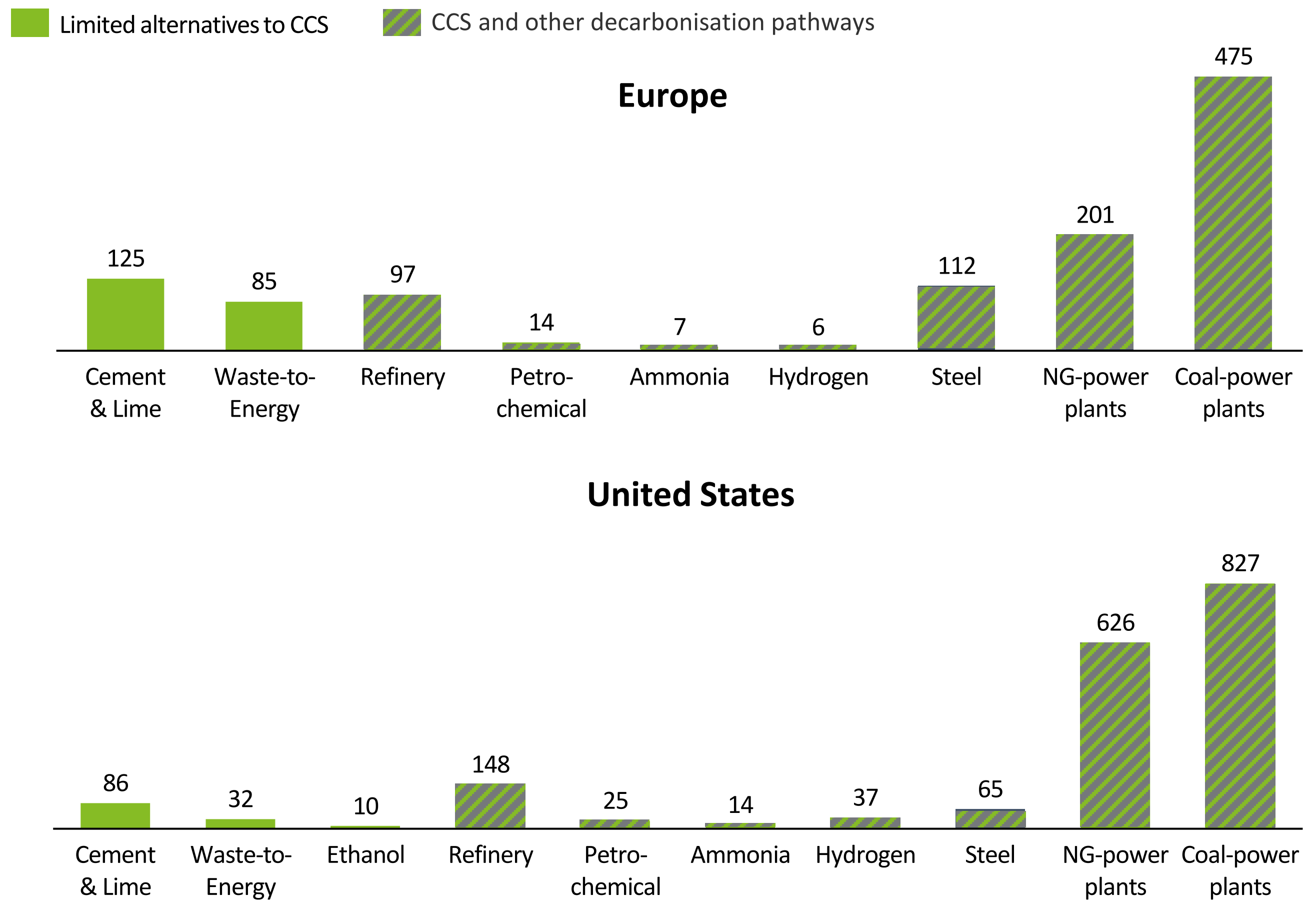
Commercial CCS-as-Service

- Development, ownership and operatorship of CO_2 storage could be allocated to multiple parties
- **CO_2 is captured from multiple independent emitters to be stored in multiple CO_2 storages**
- CO_2 transportation could be provided through various modes (e.g. shipping) by multiple independent parties

Sources: Deloitte analysis

The CCS-as-a-service market has the potential to be large, depending on the availability and costs of alternative decarbonization options for emitters

CCS potential in selected sectors[3,4,5,6] (CO_2 Mtpa | 2021)



Sources: EEA ETS[3], CREA[4], EPA GHGRP[5], U.S. Energy Information Administration[6], Deloitte analysis

Comments

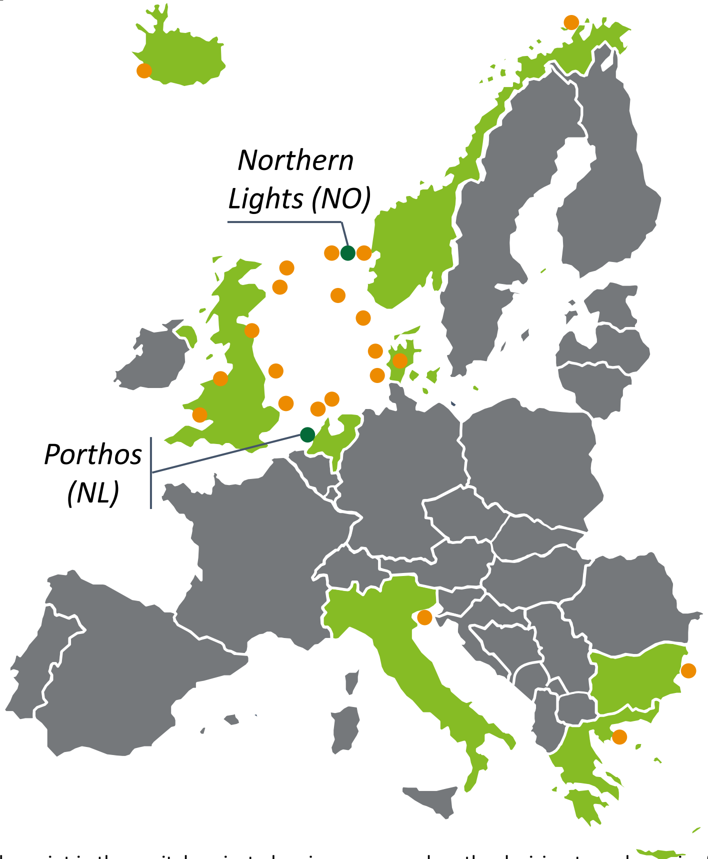
- Application of CCS depends on technical readiness, availability and cost of alternative decarbonisation solutions in specific sectors and regions:

  - **Cement, Lime and Waste-to-Energy sectors will need to use CCS** due to a lack of alternative decarbonisation solutions
  - **Refineries, petrochemicals** and **ammonia sectors may apply CCS as a part of a mix of solutions**, including low-carbon hydrogen and electrification
  - **Blue hydrogen** production from fossil gas **with CCS has a significant potential in the US**
  - The **steel sector may aim to use low-carbon hydrogen as a reducing agent**, and electrification, with consideration of CCS for addressing residual emissions
  - The **power sector may consider CCS** to provide a stable base load in networks with a high share of renewables. **The solution is being considered in the UK and the US, but currently controversial in the EU**

European policies push to expand CO_2 storage capacity from currently ~4 Mtpa, which has taken Final Investment Decisions, to operational ~100 Mtpa by 2030 to meet the demand

Overview of developing CO_2 storage projects in Europe[7] (2023)

- Development of major CO_2 storages
- CO_2 storage taken FID[1]



Comments

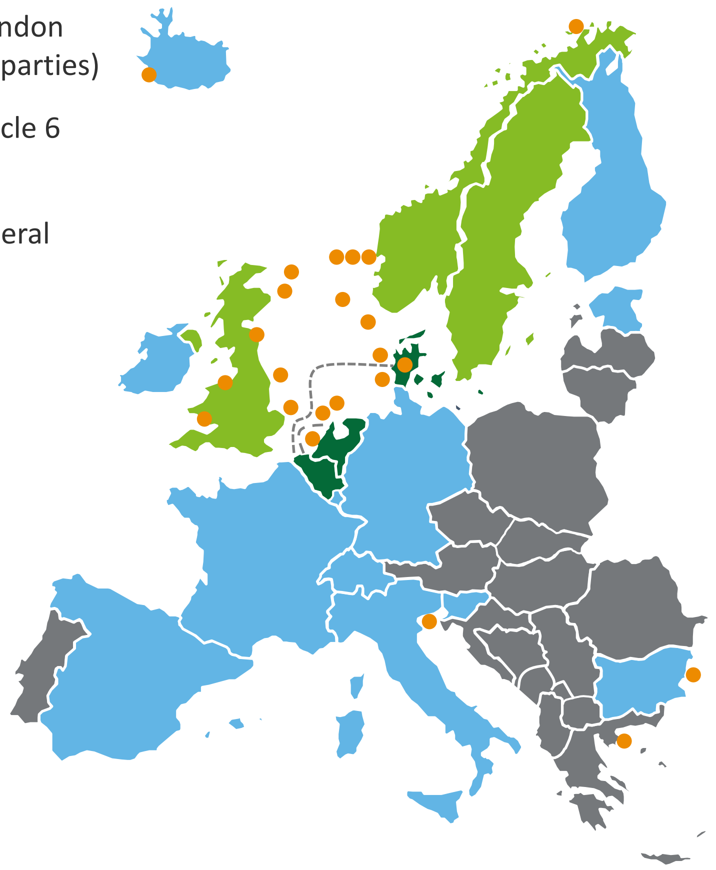
- **The EU Net Zero Industry Act** is contemplating **obligating oil & gas producers in the EU** to contribute to the CO_2-injection capacity (CO_2 storage) with the goal of achieving **at least 50 Mtpa of CO_2 by 2030**[8]
- Announced **CO_2 storage projects in the EU** total 35 Mtpa[7]; however, the analysis of progress indicates a capacity **~20-25 Mtpa at the advanced development stage**
- **CO_2 storage projects** are being **actively developed in the North Sea**, but development in **the Mediterranean Sea is progressing slow**, although being crucial to unlock the solution for emitters in Italy, as well as in the south of France and Spain
- Outside the EU, **Norway** has a significant storage potential and supportive environment; **currently announced projects will count to ~20 Mtpa**[7]
- **UK has an ambition to capture and store 20-30 Mtpa of CO_2 by 2030**[9] and has progressed with the selection of 2 clusters with total ~9 Mtpa CO_2 storage capacity for further development[14]

Notes: 1) Final Investment Decision - the point in the capital project planning process when the decision to make major financial commitments is taken and the construction begins
Sources: International Association of Oil & Gas Producers[7], Deloitte analysis

European projects can benefit from cross-border CO_2 imports to reduce commercial risks and achieve economies of scale, though adaptation of the legal agreements is required

CO_2 cross-border transportation in Europe (2023)[15,16]

- Development of major CO_2 storages
- Countries adapted London Protocol (contracting parties)
- Countries ratified Article 6 amendment
- Countries signed bilateral agreements
- --- Allowed CO_2 shipping



Sources: Columbia Law School[15], GE Gas Power[16], Deloitte analysis

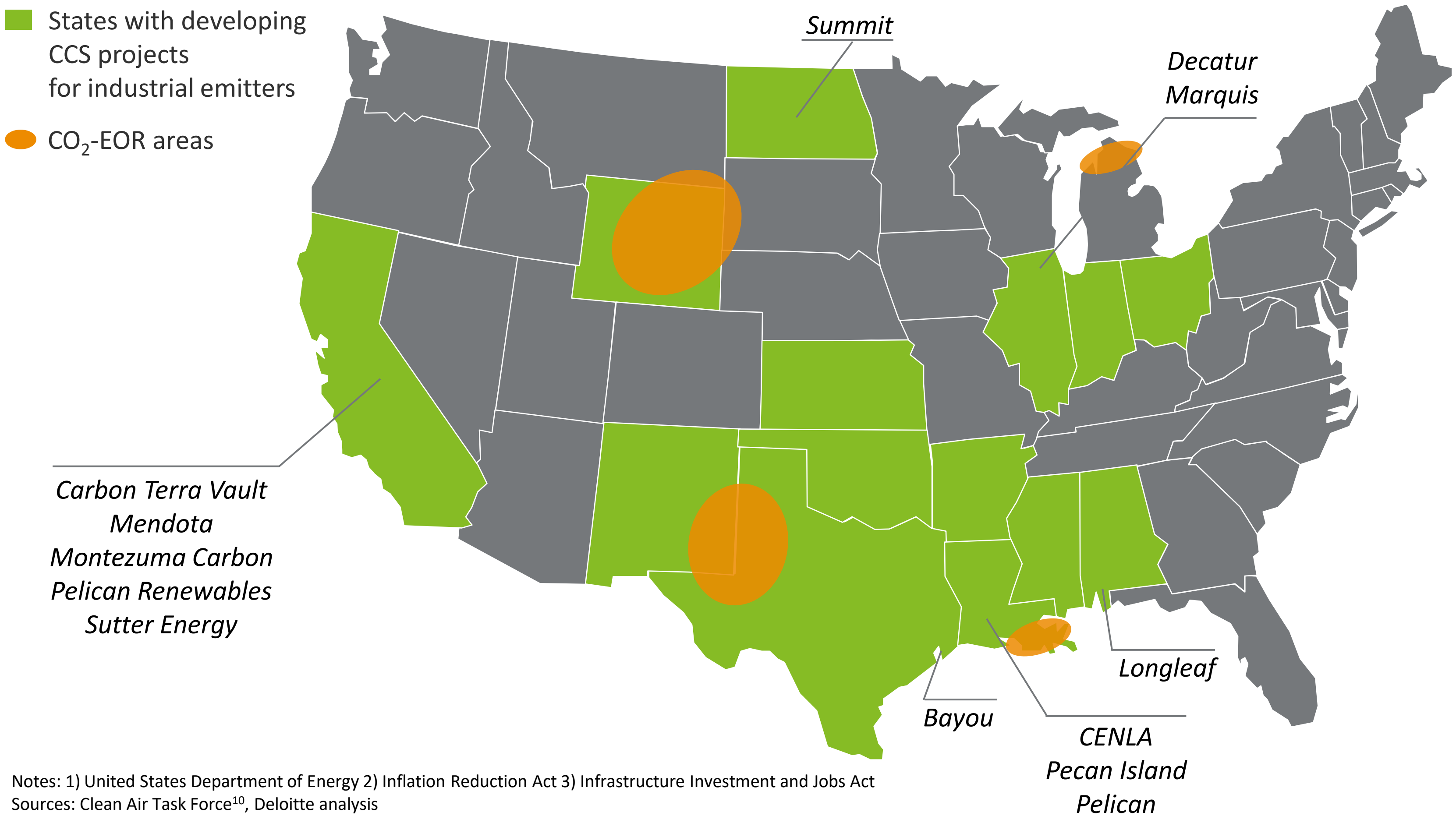
Comments

- **The objective of the London Protocol is to promote the effective control of all sources of marine pollution, including CO_2**
- Initially Article 6 of the London Protocol prohibits the cross-border transport of CO_2 with the purpose of permanent CO_2 storage
- In 2009, Norway proposed an Article 6 amendment allowing CO_2 export for CCS. However, it has yet to enter into force
- **In 2019, an additional resolution was adopted allowing two or more countries to export CO_2 if** certain conditions are met, including the requirement that **those countries have ratified the Article 6 amendment and entered into a bilateral agreement**[17]
- **Currently only two bilateral agreements were signed between Belgium and Denmark, as well as Belgium and the Netherlands**, allowing cross border transportation of CO_2 with the purpose of permanent storage
- **Some other European countries are working closely together to establish bilateral agreements** and fully kick off a European internal market for cross-border CO_2 transportation

- **1996** – Adoption of the London Protocol
- **2006** – Frist amendment (CO_2 streams incl. in waste definition)
- **2009** – Second amendment (Cross-border transport of CO_2 streams)
- **2019** – Provisional application is agreed by contracting parties
- **2022** – First bilateral agreement signed between Belgium and Denmark

Although there is no a firm target for CO_2 storage in the US, DOE[1] funding and subsidies under the IRA[2] and IIJA[3] are expected to boost CCS projects for industrial emitters

Overview of developing CO_2 storage projects in the US[10] (2023)



Notes: 1) United States Department of Energy 2) Inflation Reduction Act 3) Infrastructure Investment and Jobs Act
Sources: Clean Air Task Force[10], Deloitte analysis

Comments

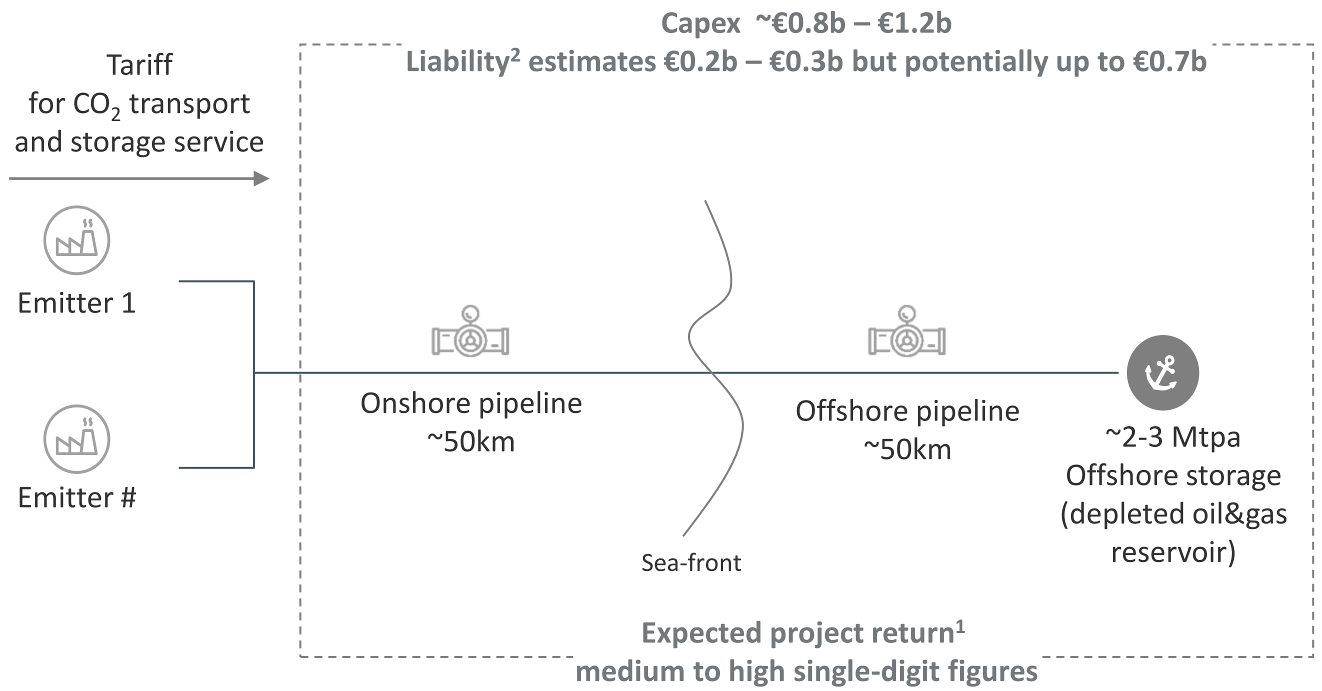
- **Since the 1970s, the practice of injecting CO_2 into nearly depleted oil fields** to extract additional oil has been applied in the US, which **represents the first case of CO_2 storage underground**
- **Introduction of a specific tax credit per ton of CO_2 captured and stored in 2018** along with additional revenues from EOR **initiated the development for a first few industrial CCS projects at power plants**
- **The further extension of the tax credit in 2022 (IRA[2])** and other supporting legislations **sparked announcements of a number of CCS projects across the US**
- However, **there is significant uncertainty in the project pipeline**, making it difficult to differentiate between **projects which are progressing with the development and those that are merely ambitions**

2. Investability of CCS projects

CCS is a multi-billion capital project with perceived high risks. Financial return could be in a range of a medium to high single-digit figures based on current risk assumptions

Expected financial project return[1] of mid-size CCS project

INDICATIVE



Comments

- **Commercial CCS business models** are emerging worldwide and there is **still significant uncertainty regarding some elements of the business case**, as well as expected returns
- **Limited empirical data on CO_2 capture, transport and storage technical performance**, with only a few operating projects **leads to uncertainty surrounding technical risks and therefore decreases expected project returns**
- **Development of the first full CO_2 storage and transport projects is primarily funded by** from the balance sheet of **major oil & gas companies with support of various government grants**, which allow for **the acceptance of higher risks and lower returns**

Notes: 1) Project Internal Rate of Return (IRR) 2) decommissioning liabilities and CO_2 leakage liabilities
Sources: Deloitte analysis

However, to make CCS an attractive investment for the private sector, specific CCS risks must be mitigated to ensure projects are 'bankable' and meet financing criteria

Overview of CCS business case and specific investment hurdles

NOT EXHAUSTIVE

How to make CCS attractive for the emitter?

CCS value chain

CO_2 capture	CO_2 transport	CO_2 storage

Elements of the business case

CO_2 capture	CO_2 transport	CO_2 storage
Compensation for CO_2 avoidance	Tariff for CO_2 transportation	Tariff for CO_2 storage
Volume of CO_2 captured	Volume of CO_2 transported	Volume of CO_2 stored
CO_2 capture CAPEX	CO_2 transport CAPEX	CO_2 storage CAPEX
CO_2 capture OPEX	CO_2 transport OPEX	CO_2 storage OPEX
		Decommissioning liabilities
		CO_2 storage liabilities

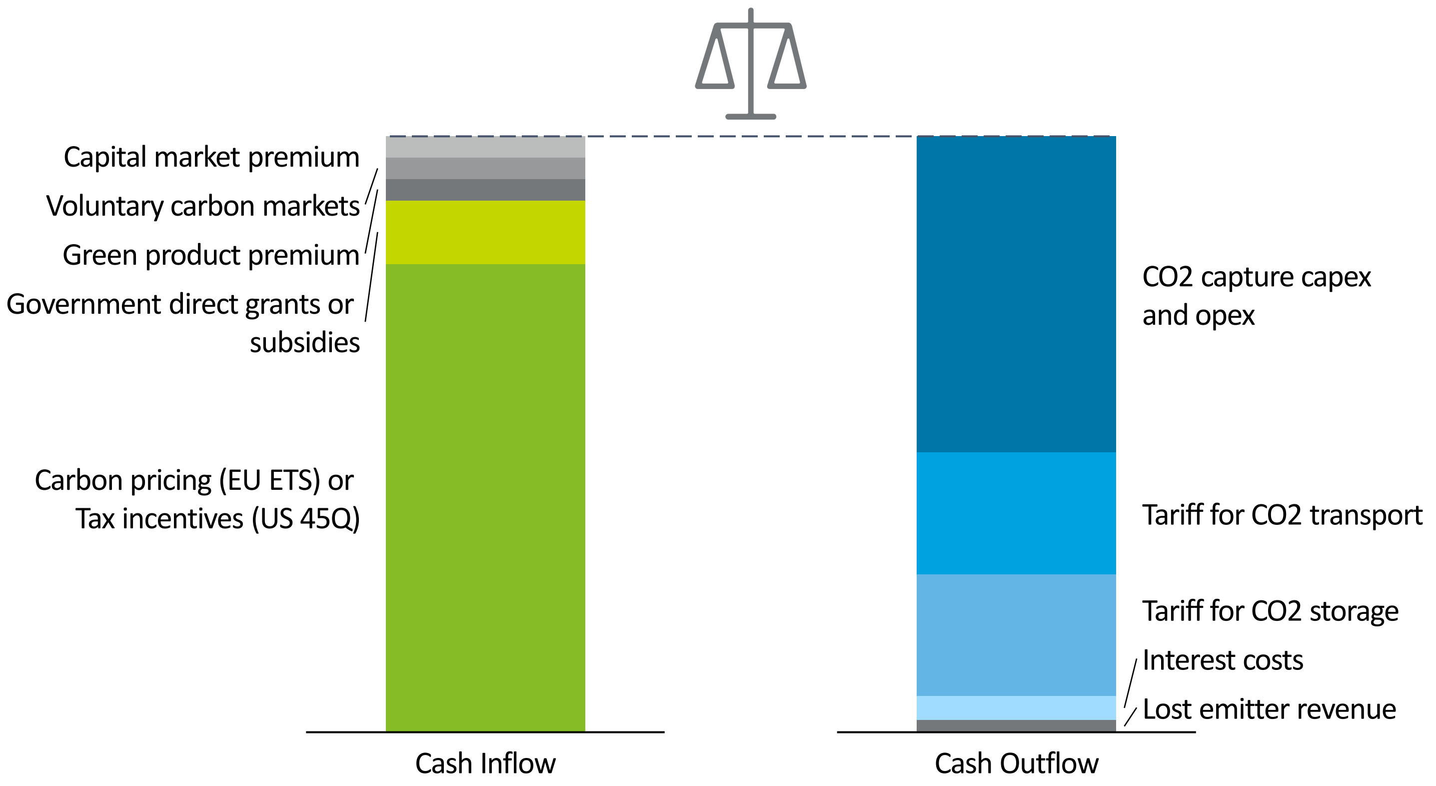
How to account for long-term storage leaks?

How to mitigate cross-chain risks of co-dependent projects?

Sources: Deloitte analysis

First, CCS should become economically attractive for an emitter. Various government and market instruments are being rolled out to cover CO_2 capture costs

Compensating CO_2 capture costs for the emitter



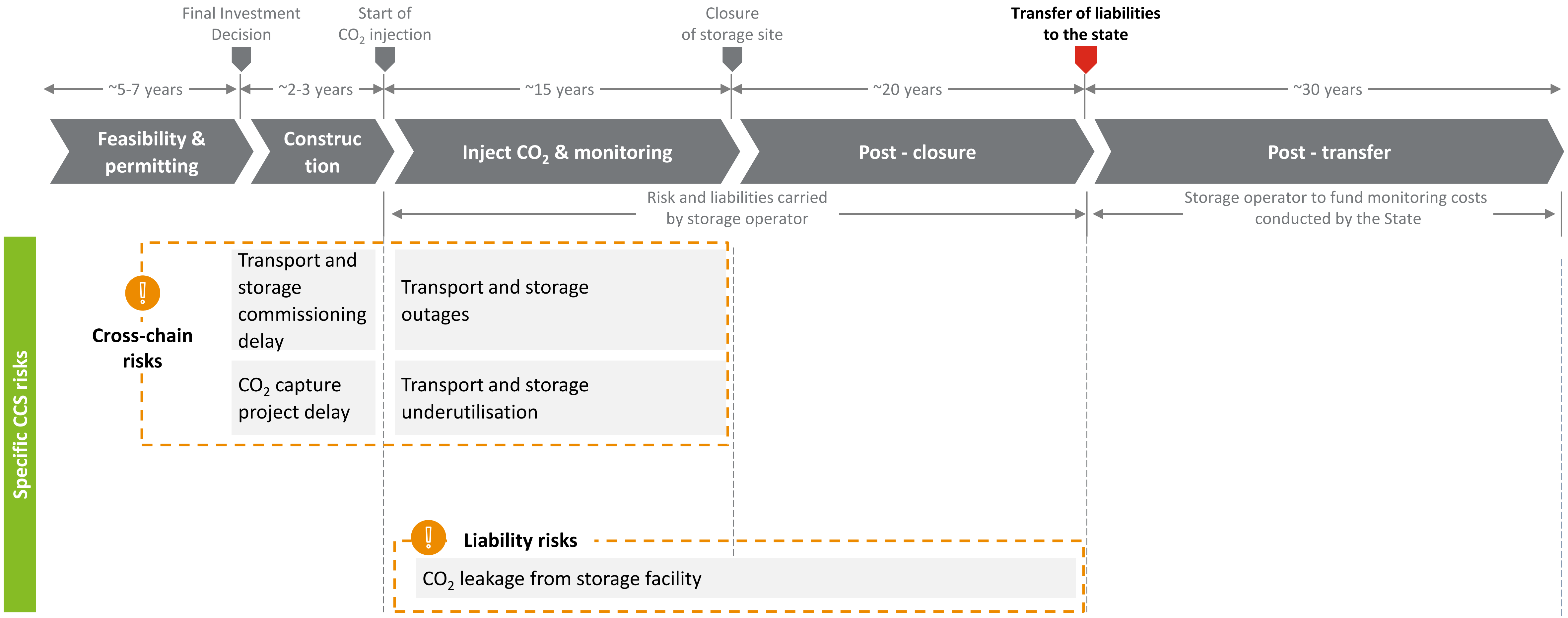
Comments

- **Carbon capture is a costly and complex technology**, which might account up to ~50% of the total costs of CCS for an emitter
- **Specific CCS solutions for some industrial facilities** located closed to a CO_2 storage **is becoming economically viable under European emission trading schemes**
- However, **in general various government subsidies and grants are still needed** to support emitter's business case
- **Emitters can seek other sources of additional revenue** to make CCS business case viable, **including voluntary carbon market and green product premiums**
- **However, scale up of voluntary carbon market is slow** and requires further compliance verification mechanisms
- Although additional cost of CCS as a price premium on a product is insignificant, **green premiums (e.g., 'green steel') cannot be yet factored in** without further development of the green markets

Sources: Deloitte analysis

Second, specific CCS risks should be mitigated - the cross-chain risks of co-dependent projects across the value chain and risks of CO_2 leakage from the storage in the long-term

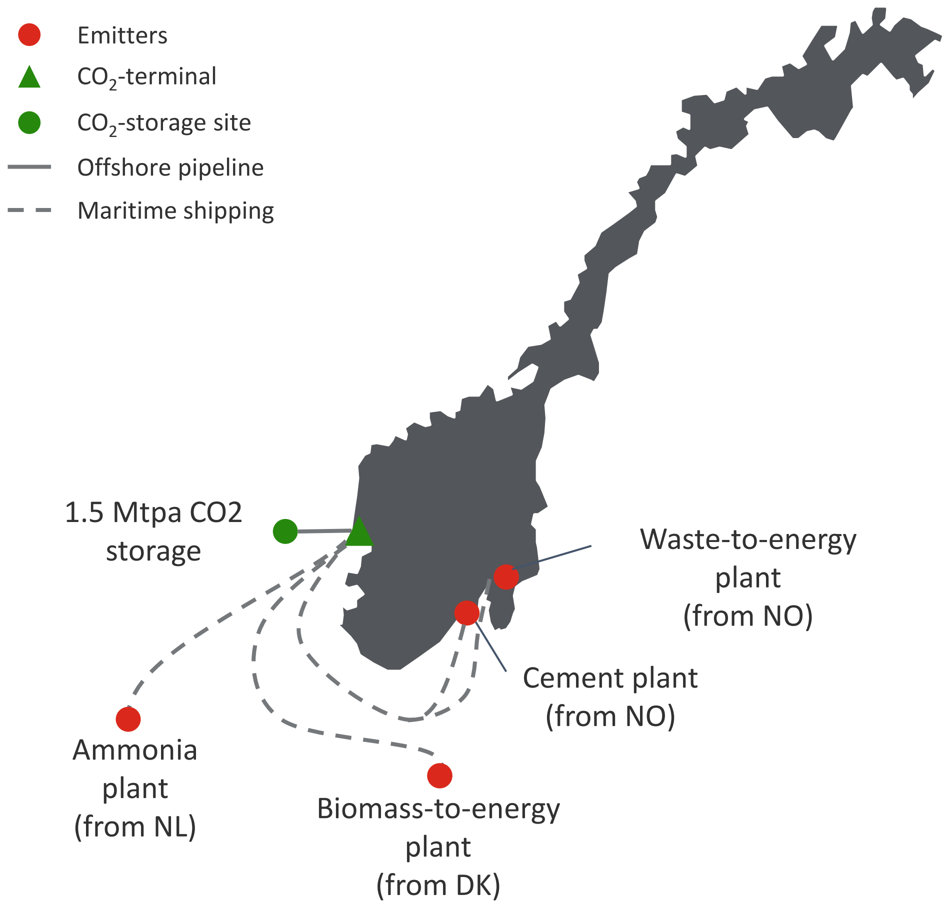
Specific CCS risks during the project life-cycle



Sources: Deloitte analysis

The Northern Lights CCS project in Norway recently faced a cross-chain risk when one emitter temporarily halted its CCS project, potentially leading to network underutilization

Northern Lights CCS project in Norway[11]



Sources: Northern Lights Project[11], Deloitte analysis

Comments

- **The Northern Lights project in Norway** is constructing **the world's first open-source CO_2 transport and storage Infrastructure**
- **The Phase I of the Northern Lights** took Final Investment Decision in 2020 and **plans to transport and store 1.5Mtpa[7] of CO_2 as of 2025** (initially late 2024)
- **The Northern Lights project and its first customers** (cement and waste-to-energy plants) **received significant** capex and opex **subsidies from the Norwegian government**
- **In April 2023 one of two initial customers** (waste-to-energy plant) **decided to put the CO_2 capture project on hold** due to a large increase in costs estimates
- Norther Lights is actively securing new commercial customers (ammonia plant in the Netherlands and biomass-to-energy plant in Denmark) to fill in the uncontracted capacity
- However, **it is likely that the CO_2 transport and storage infrastructure will be underutilized during some initial period**
- **Realization of such risks in a fully commercial project** with only funding from private investors **might result in an unfeasible business case**

CCS business models are being developed in Europe and the US. However, only the UK is viewed to set a holistic and bankable CCS framework, though it has yet to be proven

	UK	European Economic Area			United States
		Netherlands	Denmark	Norway	
Scope of scheme	Dedicated to CCS projects	Broad range of technologies (renewables and other CO_2 reducing tech)	Dedicated to CCS projects	Not yet replicable approach implemented	Dedicated to CCS projects
Support receiver	Emitter Transport & Storage company	Emitter	Emitter		Emitter
Duration	10 + 5 years	15 years	15 years		12 years
Specific CCS risks protection	Government provides protection against major risks	Not available	Not available		Not available
Additional considerations	✓ Comprehensive regulatory and commercial framework ✓ Adjustable CfD-type subsidy X Regulated return limits the interest of private investors X Complex and lengthy process	✓ CfD-type subsidy for emitter ✓ Straightforward subsidy award criteria X No specific CCS subsidy domain X Lack of flexibility in subsidy adjustments	✓ Adjustable CfD-type subsidy for emitter ✓ CCS dedicated subsidy fund X Additional complexity of subsidy award criteria	✓ Government is perceived to support CCS and storing of imported CO_2 in Norway X Dedicated support for the flagship project, but not yet a clear business model for the next wave of projects	✓ Straightforward tax credit structure X Sectors with high capture costs remain unprofitable X Uncertainty after the tax credit realization period X Total tax credit budget might not be sufficient
Bankability	✓	✗	✗	✗	✗

Sources: National CCS regulations[9,12,13,18,19], expert interviews, Deloitte analysis

UK has developed a regulatory and commercial framework that offers financial and risk mitigation support to emitters and CO_2 transport & storage providers

UK government

Emitter (CO_2 capture) — Potential Capital Grant (CIF); CCS subsidy scheme

Transport and Storage Tariff →

CO_2 transport & storage (T&S) provider — Potential Capital Grant (CIF); Regulated revenue

Emitter (CO_2 capture)

Financials

- Capital Grant and Capex repayments
- Subsidy for Opex (Contract for Differences mechanism)
- Subsidy for Transport & Storage tariff as a pass-through

Risk Protection

Key risks	Government protection
Construction risk	✓
T&S commissioning delay	✓
Commercial risk	✗
Operating risk	✓
T&S outages and T&S capacity constraints	✓
User Stranded Asset	✓
Decommissioning risk	✗

CO_2 transport & storage (T&S) provider

Financials

- Regulated revenue model where T&S company (single owner and operator of both onshore and offshore infrastructure) is allowed to charge emitters a certain Transport & Storage tariff

Risk Protection

Key risks	Government protection
Construction risk	✗
Stranded asset risk (demand risk faced by T&S)	✓
Underutilization risk	✓
Leakage of CO_2	✓
Outages risk	✗
Decommissioning risk	✓

Sources: UK government ICC and T&S business models[9,12], Deloitte analysis

Financial support for emitters can be extended up to 15 years and includes potential capital grant, various repayments and Contract-for-Differences like subsidies

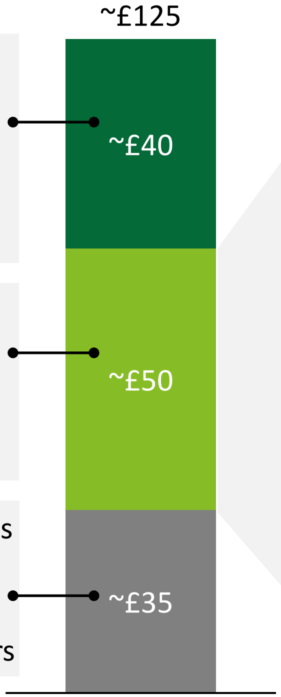
Overview of the financial support for an industrial emitter

ILLUSTRATIVE

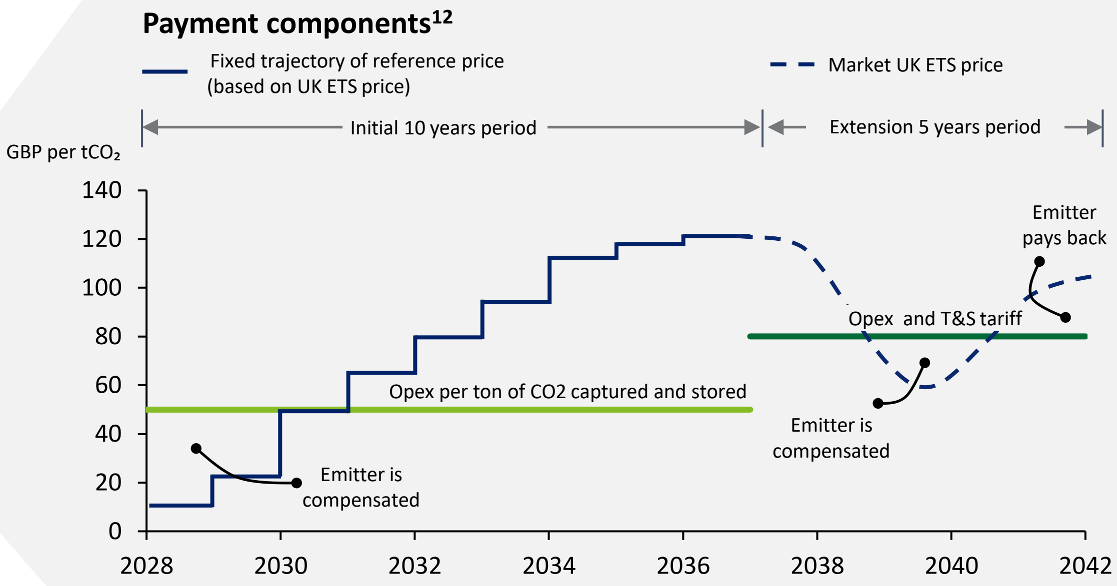
Transport & Storage charges are funded for an emitter during the first 10 year and treated as a pass-through

Emitter receives a subsidy for a difference between OPEX and the effective reference price (e.g. UK ETS – free allowance)

Emitter can receive a capital grant as well as CAPEX repayments as a fixed amount per ton of CO_2 captured and stored in first 10[1] years



Total levelised costs of CCS for emitter



- In the first 10 years, Emitter is compensated if Opex per ton of CO_2 stored is below the reference price
- Emitter can get an extension for another 5 years if certain performance and market conditions are met
- In the additional 5 years, the reference price is the UK ETS price, and the emitter must reimburse if UK ETS exceeds Opex + T&S tariff

Notes: 1) CAPEX shortfall period - If the capex has not been paid fully in the first 5 years due to lower CO_2 capture, it will continue to apply for up to a further 5 years
Sources: UK government ICC business model[12], Deloitte analysis

The government provides comprehensive protection for emitters and T&S providers against major risks, which makes the CCS proposition investable

	Risk	Description	Protection from the government
CO_2 emitter	Construction risk	Construction risk refers to the group of risks associated with construction phase, including cost overruns, delays, contractual issues, etc.	✓
	T&S commissioning delay	The risk of delay in the commission phase of T&S project. A delay in this stage can impact the overall project timeline and may result in postponed operational commencement	✓
	Commercial risk	Commercial risk refers to the risk associated with obtaining the finance, managing cashflows and continuing commercial industrial operations	✗
	Operating risk	Operating risk refers to the risk of the facility either overperforming or underperforming in capturing and storing CO_2 compared to the initially agreed-upon terms	✓
	T&S outages and T&S capacity constraints	T&S outages refer to the risk when T&S systems are temporarily unavailable or not in operation. T&S capacity constraints refer to the risk of capacity limitations of T&S infrastructure	✓
	User stranded asset	The term 'User Stranded Asset' refers to the risk that if the T&S network is discontinued, and no alternative T&S option is feasible, then the capture project is considered stranded	✓
	Decommissioning risk	Decommissioning risk refers to the challenges associated with the safe and effective closure, dismantling, and remediation of CCS facilities at the end of their operational life	✗
Transport & Storage provider	Construction risk	Construction risk refers to the group of risks associated with construction phase, including cost overruns, delays, contractual issues, etc.	✗
	Stranded asset risk (demand risk faced by T&S)	In this case stranded asset risk refers to the demand risk faced by T&S, e.g., where users are late in connecting to the network	✓
	Underutilization risk	Underutilization risk refers to the potential risk that T&S system may not be fully utilized or may operate below its optimal capacity	✓
	Leakage of CO_2	CO_2 leakage refers to the potential risk for CO_2 to leak from its intended storage location	✓
	Outages risk	T&S outages risk refers to the risk of T&S assets not operating and being unable to transport and store the captured CO_2 from relevant projects	✗
	Decommissioning risk	Decommissioning risk refers to the challenges associated with the safe and effective closure, dismantling, and remediation of CCS facilities at the end of their operational life	✓

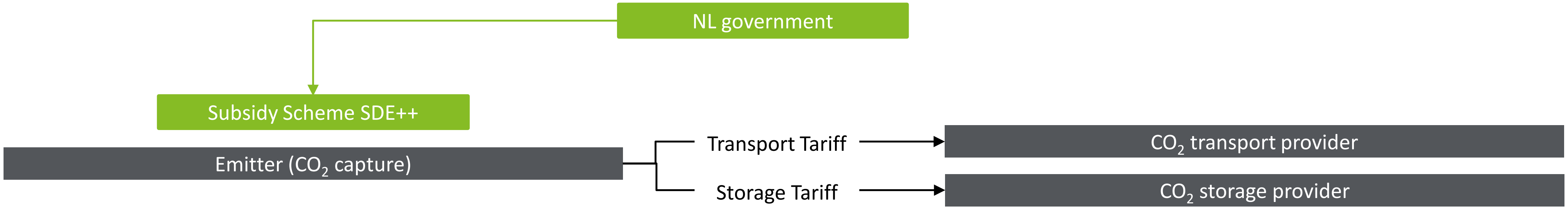
Sources: UK government ICC and T&S business models[9,12], Deloitte analysis

However, T&S provider operates under a regulated revenue scheme. While being transparent, it may deter private investors due to expected limited returns

Allowed revenue[9]	
Return on Capital	• **Return on Capital = Regulated asset value (RAV) * WACC** • **RAV** = **development spend** (Devex) + **construction spend and asset expansion** (Capex) + **rolled up cost of capital** (i.e., WACC during the construction period) – **depreciation and disposals** • **WACC** - will consider – **Expected costs of financing** – **Risks borne by T&S** (e.g., construction risk, development risk, technology risk, operational risk, etc.) – **Initial WACC will be determined in dialogue with the T&S**
Depreciation	• Depreciation – revenue collected from users to cover asset depreciation over the operational period and profiled to reduce payments in the early operational period to support the initial stages of the project
Opex	• Opex will be the allowed spend for efficient operational costs, which will have been agreed in the initial settlement • Opex allowance could also include user bad debt, expected hedging costs, expected private sector insurance premium etc.
Decommis-sioning cost	• Decommissioning – allowance to cover decommissioning costs of the T&S network at the end of assets life
Tax	• Allowed revenue will include an allowance for expected tax costs
Adjustments	• Adjustments – adjustment for pass-through costs and any required true-ups and incentives (can be positive and negative), including availability incentive, leakage incentive, connections incentive, construction delay

Sources: UK government T&S business models[9], Deloitte analysis

The Netherlands is yet to establish a comprehensive commercial CCS framework. Emitters can receive subsidy, but there is no dedicated support for transport and storage providers



	Emitter (CO_2 capture)	CO_2 transport and storage providers
Financials	• Emitters can apply for Dutch SDE++ subsidy, but will compete for funding with other decarbonization projects[1] • Emitter can seek additional financial support from EU subsidy schemes (e.g., EU Innovation Fund)	• Free market approach, unbundled CO_2 transport and storage providers can set tariffs based on its expected returns • CO_2 transport and storage providers can seek additional financial support from EU subsidy schemes (e.g., Connecting Europe Fund via Project of Common Interest status)
Risk Protection	• No specific mechanisms to protect emitters against major risks	• No specific mechanisms to protect transport and storage providers against major risks • Indirect government support is evident through the active involvement of state-owned companies in the development of CCS transport and storage infrastructure

Notes: 1) since 2023 domain fences for certain technologies are implemented (e.g., heating and ‘molecules’), but not for CCUS
Sources: SDE++ scheme[13], Deloitte analysis

Emitters can apply for Contract for Differences-like subsidies and receive a 15-year support covering the cost of CCS above the EU ETS price

Overview of financial support for an industrial emitter

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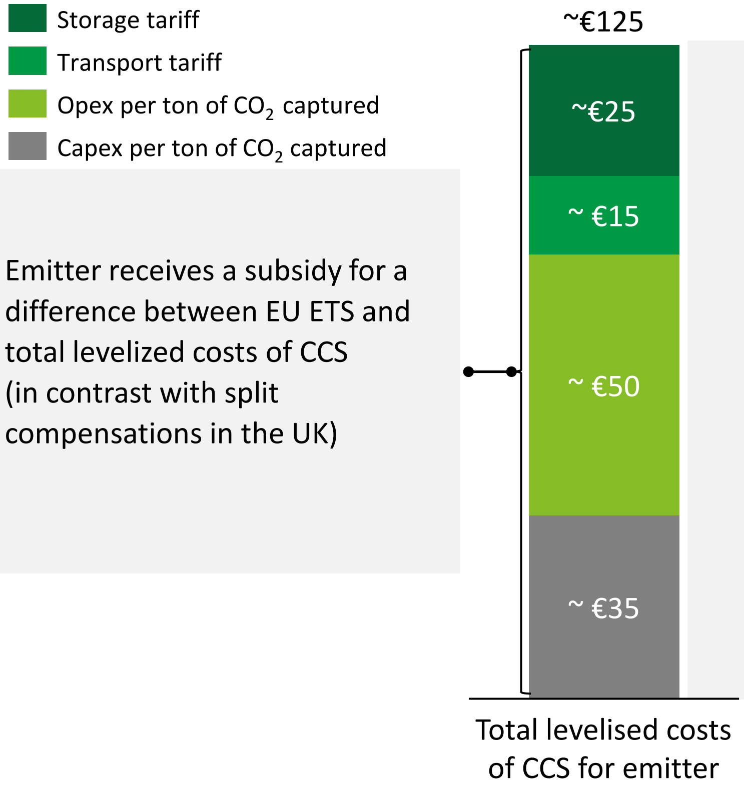
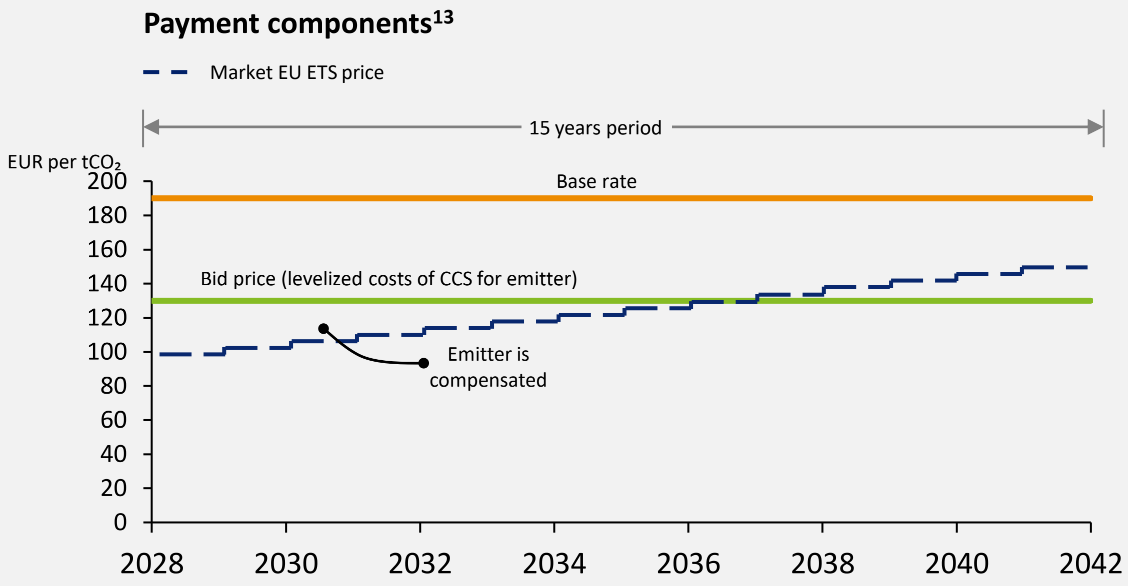


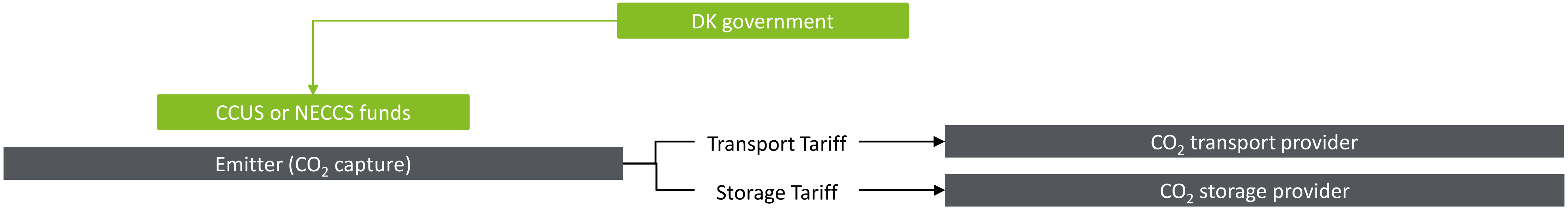
Emitter receives a subsidy for a difference between EU ETS and total levelized costs of CCS (in contrast with split compensations in the UK)



- CCS projects compete with other sustainable technologies in SDE++
- There is a maximum amount of subsidies emitter can apply for (the base rate upper bound)
- In case of the tariff increase and additional subsidy is needed, emitter needs to re-apply and might have a risk to lose the subsidy
- Granted subsidy is not adjusted for inflation during the 15 years period

Sources: SDE++ scheme[13], Deloitte analysis

Denmark has recently introduced two dedicated CCS subsidy schemes for emitters, but there is no dedicated support for transport and storage providers

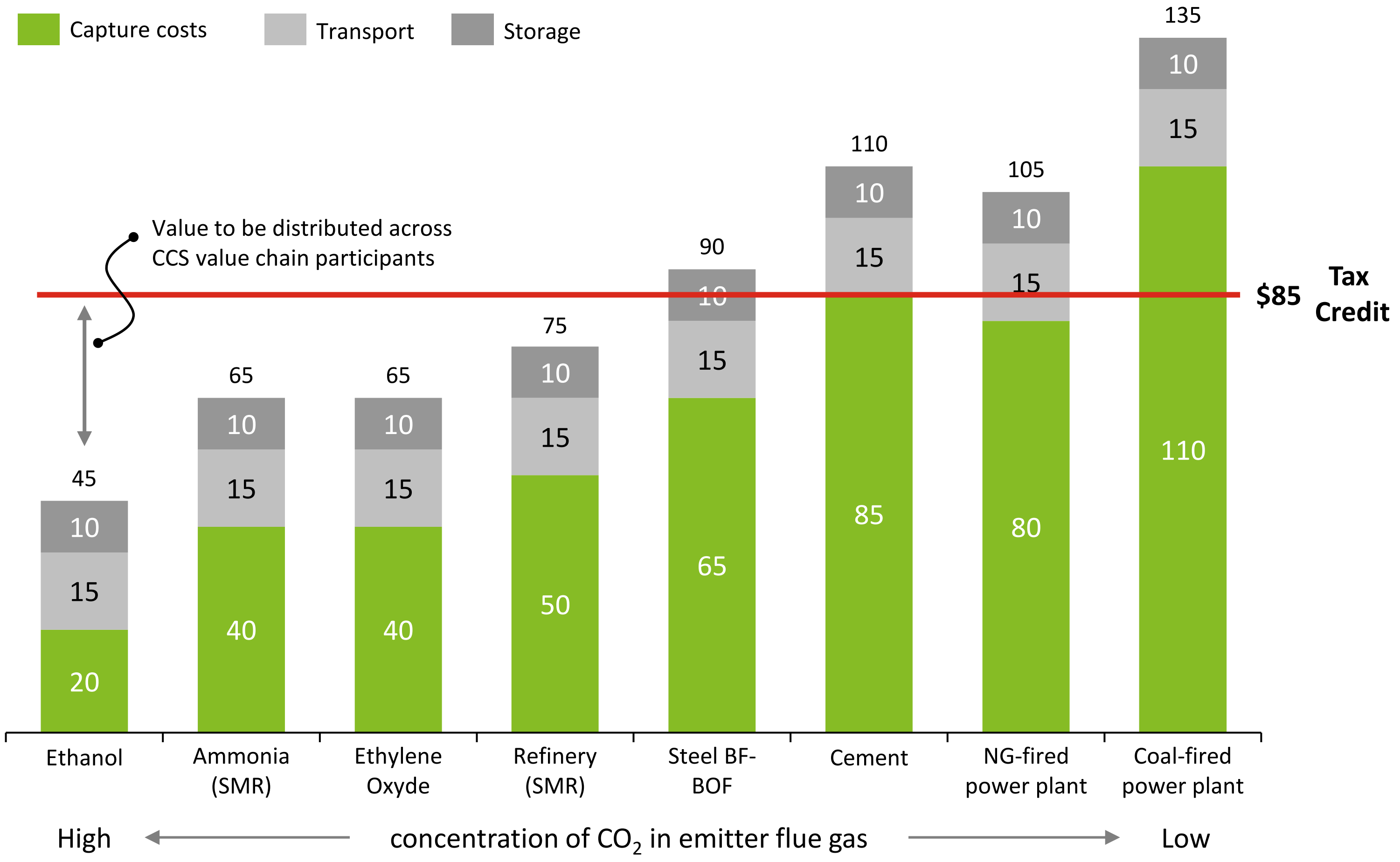


	Emitter (CO₂ capture)	CO₂ transport and storage providers
Financials	• Emitters can apply for CCUS subsidy fund with fossil and biogenic CO_2 sources being eligible (total target to store 2,7Mtpa of CO_2 from 2029) • Emitters can also apply for NECCS subsidy fund, dedicated to the negative emissions with only biogenic (including Direct Air Capture) sources being eligible (total target to store 0,5Mtpa of CO_2 from 2029)	• Free market approach, unbundled CO_2 transport and storage providers can set tariffs based on its expected returns • CO_2 transport and storage providers can seek additional financial support from EU subsidy schemes (e.g., Connecting Europe Fund via Project of Common Interest status)
Risk Protection	• No specific mechanisms to protect emitters against major risks	• No specific mechanisms to protect transport and storage providers against major risks

Sources: Danish Energy Agency[18], Deloitte analysis

IRA 45Q tax credit might be seen attractive. However, it is short for some emitters, has post-credit uncertainty and lacks support for low-probability high-impact events

Tax credit (45Q) mechanism in US (USD per ton of CO_2)



Sources: IEA[19], expert interviews, Deloitte analysis

Comments

- **The Inflation Reduction Act (IRA) provides $85 tax credit per ton of CO_2 stored** in saline geologic formations from carbon capture on industrial and power generation facilities
- **The claim period is 12 years** and developers can receive a 45Q tax credit as a fully refundable direct payment as if it were an overpayment of taxes (during first 5 years)
- **$85 per ton of CO_2 stored is not sufficient to make a viable business case for emitters with a low concentration of CO_2 in the flue gas** (e.g., cement, power plants) considering additional costs of CO_2 transport and storage
- **Emitters can seek additional financing from other sources**, including IIJA and DoE grants although being limited and for specific purpose (e.g. FEED study)
- The **lack of risk-sharing mechanisms and protections against low-probability high-impact events** significantly **limits the bankability of certain projects**

3. CCS investment catalysts in Europe

Only the UK business model demonstrates a holistic investable CCS proposition. Private-sector investments in CCS in other regions should be assessed on a case-by-case basis

Assessment of CCS bankability parameters

Category	Parameter	Description	UK	NL	DK	NO	US
Supporting policies and regulations	National CCS targets	Signal acceptance of CCS as a viable technology contributing to climate targets achievement	🟢 *20-30 Mtpa by 2030*	🟡 *Not mentioned but flagship projects are supported*	🟢 *4-9 Mtpa by 2030*	🟡 *Not mentioned but flagship projects are supported*	🟡 *No mentioned but importance of CCS is acknowledged*
	CCS legal and regulatory framework	Establish a legal framework, including permitting and operation, closure and post-closure obligations	🟢 *Adaptation of EU CCS Directive*	🟢 *Adaptation of EU CCS Directive*	🟢 *Adaptation of EU CCS Directive*	🟢 *Adaptation of EU CCS Directive*	🟡 *Various federal and state legislation*
	CCS commercial framework	Establishing a structured commercial framework, including economic incentives, legal structures and market mechanisms	🟢 *CCS business models*	🟡 *Only subsidy for emitters*	🟡 *Only subsidy for emitters*	🔴 *Not available*	🟡 *Only tax credits for emitters*
	Cross-boarder CO_2 shipping	Enable a cross-border, single market approach on CO_2 transport and storage	🟡 *Provisional application of LP Article 6*	🟡 *Bilateral agreement BE/NL*	🟡 *Bilateral agreement BE/DK*	🟡 *Provisional application of LP Article 6*	⚪ *Not relevant*
Emitter economics	Carbon pricing	Incentivize emitters to consider CCS solution	🟢 *UK ETS*	🟢 *EU ETS and carbon tax*	🟢 *EU ETS and carbon tax*	🟢 *EU ETS and carbon tax*	🔴 *No carbon pricing mechanism*
	CCS subsidies	Provide a stable support scheme to make CCS projects economically acceptable for emitters	🟢 *National Budget CCS Infra fund*	🟡 *SDE++ scheme*	🟢 *CCUS support scheme*	🔴 *Not available*	🟡 *IRA 45Q tax credit*
	Additional funding	Give an opportunity for CCS projects to get an access for broader innovation and infrastructure funding	⚪ *Not relevant*	🟢 *EU Innovation Fund Connecting Europe fund*	🟢 *EU Innovation Fund Connecting Europe fund*	🟢 *Enova EU Innovation fund*	🟢 *IIJA and DoE CCS funding and state-level support*
Risks mitigation	Cross chain risk	Support complex CCS value chains during the first phases of infrastructure development	🟢 *CCS business models*	🔴 *Emitters and T&S providers bear all risks*	🔴 *Emitters and T&S providers bear all risks*	🔴 *Emitters and T&S providers bear all risks*	🔴 *Emitters and T&S providers bear all risks*
	CO_2 leakage risks	Protect project against low-probability high-impact events during the technical and operational maturity of the CCS solution	🟢 *CCS business models*	🔴 *T&S providers bear all risks*	🔴 *T&S providers bear all risks*	🔴 *T&S providers bear all risks*	🔴 *T&S providers bear all risks*

Sources: expert interviews, Deloitte analysis

Several actions should be taken to make commercial CCS-as-a-service attractive for private investments in Europe and scale up the solution

Provide dedicated financial support for emitters

- **Europe has the most advance carbon emission trading scheme**, which is firmly established and **incentivised emitters to reduce carbon emissions** by setting a price per ton of CO_2 emitted
- However, CCS is still too expensive. A **Contract-for-Difference type subsidy would effectively allow emitter to bridge the gap between the total CCS costs and EU ETS prices** and make the project economically viable
- **Tailoring the subsidy instrument specifically to CCS**, e.g. allowing for certain recalculations of the required subsidy amount, **would provide the necessary stability and predictability**

Protect against low-probability high-impact events

- **CCS applications are limited to a few operational projects** in North America and Europe with majority using CO_2 for the enhanced oil recovery purpose. However, **the empirical data of operational CCS performance is limited**
- **The first full large-scale commercial CCS projects** in Norway and the Netherlands **received significant support from the European governments. However, a few projects will not be enough to de-risk the solution for private-sector investors**
- **Guarantee-type of risk protection** (e.g., regulated asset-based model or EU ETS-baked fund) **could be established to support in case of low-probability high-impact events** (e.g., CO_2 leakage)until the insurance instruments are developed and affordable

Ratify European cross-border CO_2 shipping

- **Europe has a potential to develop two large-scale CO_2 storage domains**, one **in the North Sea** and another **in the Mediterranean Sea**. This would allow to build the optimal CO_2 transport and storage infrastructure
- Recently, the **first few bilateral agreements on cross-border CO_2 transport for permanent storage offshore were signed** (e.g., Belgium and Denmark). **If other European countries follow suit, this could open a common CO_2 transport and storage market**
- This will also **allow emitters to connect to storages in the most economical way**, and **CO_2 storages to achieve the economies of scale while minimise commercial risks** by gaining access to a broader set of emitters

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