Oxford Open Energy, 2025, **4**, oiaf011
https://doi.org/10.1093/ooenergy/oiaf011
Research Article

Contracts and risk management in carbon capture, utilization, and storage projects

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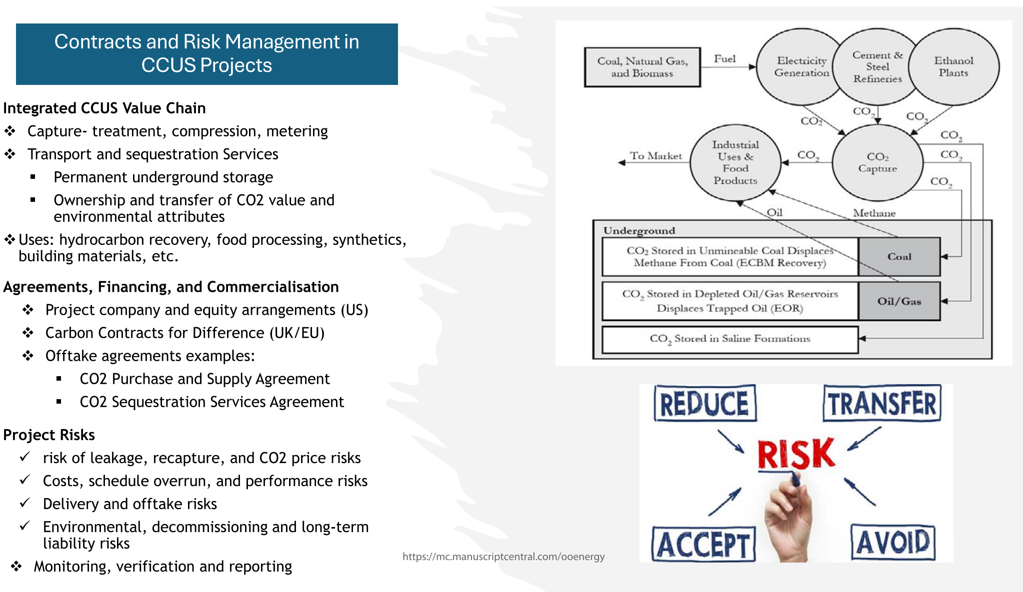
Abstract

The process of capturing carbon dioxide (CO_2) from one or more industrial or energy sources, then transporting the CO_2 via pipelines, and storing it permanently in underground formations or delivering it for different uses involves interconnected aspects and sectors. Thus, a typical carbon capture, use, and storage (CCUS) project requires committed engagement from operators in various industries, public and private financiers and stakeholders. The projects are developed around contractual arrangements, such as offtake agreements, in the backdrop of complexities and risks arising from the segmented nature of the value chain. These agreements are designed to consolidate the various aspects, secure firm commitments and the necessary upfront capital investment. Some of the potential risks that could impact the development of viable projects include the pricing or value of captured CO_2, loss of revenue stream due to shutdown of emission sources or carbon leakage and recapture, law and policy changes relating to fiscal incentives, ownership, and transfer of environmental attributes and long-term liability for stored CO_2, managing cost and project milestones, etc. This article identifies and reviews the broad categories of contractual and regulatory measures for mitigating CCUS project risks from a transactional law perspective. It discusses the context for viable carbon capture offtake and transportation arrangements *vis-à-vis* the measures being developed to mitigate risks and common issues encountered from early planning to operational stages, especially in the USA and Europe. It is noted that offtake and transportation arrangements play a key role in ensuring bankable CCUS projects and define the terms and conditions upon which parties engage in the interdependent aspects of capturing, delivering, or sequestering CO_2 permanently.

Graphical Abstract



Received: 10 July 2025; **Revised:** 1 December 2025; **Accepted:** 4 December 2025
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Lay summary
As policy measures regarding CCUS projects evolve globally, especially in the USA and Europe, contractual arrangements between project sponsors and relevant stakeholders are also being developed. Accordingly, a combination of regulatory and contractual risk management measures is essential to the evolution of the CCUS value chain from the planning phase towards making an investment decision and into actual operations, including addressing post-closure or project-completion obligations.

Keywords: carbon capture; industrial carbon management; CO_2 storage; net-zero energy; decarbonization; offtake agreements; contractual risks; regulatory risks; risk management

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Introduction

About 628 carbon capture, use, and storage (CCUS) projects were reported globally as of 2024, comprising 50 facilities in operation (three of which are dedicated transport and/or storage operations) and 44 under construction (seven of these are transport and/or storage) [1]. A project is considered to be in 'early development' when completing or has already completed a pre-feasibility or feasibility study, while those classified as under 'construction' have been determined to be viable and therefore received a positive final investment decision (FID). Agreeing to the FID presupposes that financiers, sponsors, and project developers are willing to bear the risks and undertake performance obligations under relevant regulatory and contractual frameworks. The projects in 'advanced development' phase are those in the process of completing or have already completed a frontend engineering and design for storage sites, and the proponent(s) are completing a submission or have submitted a field development plan or equivalent to regulators; while 'operational' CCUS projects are actively capturing, transporting, utilizing, and/or storing CO_2 [1]. In complex and capital-intensive ventures, such as CCUS, the relevant parties, sponsors, and developers engage in due diligence to identify and address material risks before moving from the planning and early development phase towards an FID [2], then construction, and actual operations [3]. In this context, 'risks' can be regarded as factors that create an element of uncertainty or potential loss in relation to the investment decision.

Some of the common risk factors for CCUS involve the reliability and scalability of the capture technology; the cost implications, since the technology usually cannot be mass produced and are designed for a particular project (e.g. cement, gas processing, and ethanol); potential shutdown of the carbon emitting facility which is essentially a main source of revenue for the CCUS project; delays due to permitting issues; and averting leakage [4] from the storage site or incidents leading to recapture [5]. There are different tools and measures [6] developed to address and mitigate these potential issues [7], depending on the jurisdiction and location of the project [8]. From a transactional law perspective, the risk mitigation and allocation measures can be broadly classified as (i) regulatory and (ii) contractual, although in most cases, a mix of approaches and tools exists. For instance, the technical risks associated with CO_2 storage can be managed effectively through robust regulatory oversight and leveraging demonstrated site assessment expertise [9], as well as competent site operations, to meet measurement, monitoring, and verification (MRV) obligations [10]. These MRV obligations are carefully incorporated and allocated amongst parties to respective offtake, transportation and storage arrangements, depending on the commercial structure of the CCUS project.

This article adopts a contextual approach to reviewing the emerging CO_2 offtake and transportation arrangements being developed while incorporating risk mitigation measures and addressing issues impacting project development from early planning to operational stages in the USA and Europe. The discussion highlights the main forms of CCUS contracts, including the key terms, relevant regulatory issues to be addressed, and material risks to consider in negotiating and executing these agreements. It briefly reviews the emerging global trends in operational and planned CCUS projects and concludes that contractual arrangements play a key role in ensuring bankable CCUS projects, defining the terms and conditions upon which parties engage in the interdependent aspects of capturing, delivering, or sequestering CO_2 permanently.

The context for viable CCUS arrangements

An integrated CCUS project involves capturing, processing, and utilizing, or injecting CO_2 into underground reservoirs for permanent sequestration. There are different interdependent segments and economic actors involved in executing the project when considered as a whole. The segmented nature of the value chain creates coordination and organizational challenges. Thus, it would be prudent to adopt a holistic approach to address risks and secure contractual obligations for the offtake, transportation, and permanent storage of captured CO_2. The potential issues and costs vary depending on factors such as the location of the emission sources, volume, and value of the CO_2 stream, and risks attributable to storage or sequestration requirements. About three or more principal actors are directly involved in executing the commercial arrangements in a typical CCUS project. Depending on the jurisdiction and the applicable regulatory framework(s), the main operators will comprise some variation of the following: (i) the emitter of CO_2 who owns or operates the energy or industrial facility [7], i.e. the source of emissions, (ii) capturer or owner of the CO_2 capturing technology, (iii) the CO_2 transporter or network of transporters, and (iv) the entity utilizing the captured carbon and/or operator of the underground storage site [11]. For instance, a major petroleum refiner and ethanol producer in the USA recently agreed to participate in a carbon capture project led by Summit Carbon Solutions [12]. As a result, the company has decided to transport carbon oxides captured from eight of its ethanol plants using Summit's multistate pipeline network, which spans the US-Midwest region and involves another ethanol producer [13]. In Europe, Norway's Northern Lights project is designed to transport CO_2 from several point sources around Europe and store it in a collective reservoir under the North Sea [14].

In North America [15], demonstration and pilot projects supported by legal and policy measures have enhanced the prospects of carbon capture systems in energy and industrial decarbonization processes involving hard-to-abate emissions [16]. The use of electrification or common zero-carbon energy systems like intermittent renewables that require firm energy storage solutions often becomes more costly or less efficient in such hard-to-abate

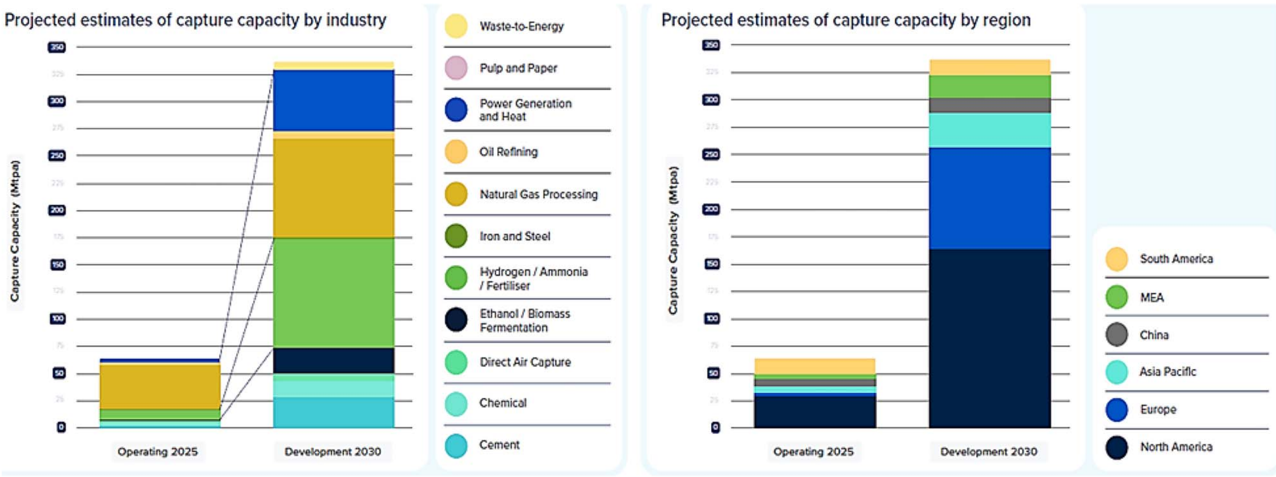

Figure 1. CCUS development projections by industry. Source: Global CCS Institute's global status of CCS report, 2025.

contexts [17]. In Europe, the 2023 revisions to the EU Emissions Trading Scheme (EU-ETS) supported considerable developments regarding the EU's carbon price, which is a main lever for advancing climate change mitigation technologies. While such policy initiatives have improved the prospects of financing and market entry for decarbonization systems such as hydrogen valleys and CCUS [1], the incentives were partially offset by cost inflation, high interest rates, and time overruns caused by issues like permitting delays and political uncertainties regarding existing fiscal measures in some jurisdictions [5]. Given these factors, contractual tools and governmental support have been key in de-risking and enabling projects moving towards an FID, construction and actual operations. As shown in Fig. 1, several projects in the hard-to-abate sectors, including hydrogen, ammonia, gas processing, cement, iron, and steel, are expected to be developed by 2030 and beyond.

The dynamics of carbon capture projects presuppose that offtake and transportation agreements are essential for connecting the interrelated segments and negotiating the terms and conditions for the transfer of captured CO_2, delivery, and subsequent use or sequestration [18]. The agreements serve as tools for project planning, risk allocation between sponsors and project participants, and for guaranteeing necessary revenue stream(s) and the project's feasibility. Another category of emerging contractual tools includes the UK's Industrial Carbon Capture Contract ('ICC Contract') [19] and the Carbon Contracts for Difference (CCfD) being adopted in several European countries [20]. The agreements are developed to boost investments and financial stability in the CCUS context. With CCfD arrangements, energy-intensive industries can expect to be compensated for about 15 years to cover their additional operating and capital costs incurred for decarbonization [21]. The UK's industrial carbon capture and waste business models are structured as CCfDs [22], and include (i) the hydrogen production business model; (ii) the dispatchable power agreement; (iii) the transport and storage regulatory investment model; (iv) the power BECCS model; and (v) the greenhouse gas removals business model [23]. Examples of similar contract-based schemes in Europe are the Netherlands' Sustainable Energy Production and Climate Transition (SDE++) scheme, Denmark's CCUS Fund, Germany's Climate Protection Agreements, and France's Contracts for Difference programme [24]. The Global CCS Institute's report on 'Carbon Contracts For Differences in Europe' notes that there are important differences relating to project eligibility criteria, scope, and implementation requirements applicable under these CCfD schemes [24]. However, an underlying theme is that CCfDs allow industrial decarbonization projects to compete for funding by offering a price and quantity of CO_2 reductions they can achieve relative to the business-as-usual scenario. Following a competitive bidding process, projects awarded a contract are guaranteed payments to bridge the gap between their offered strike price (i.e. cost of CO_2 reduction per tonne) and a reference carbon price [25], typically tied to the domestic carbon market price, such as under the EU ETS [21]. The guaranteed balancing payments or subsidies are expected to decline over time as the carbon price rises, and for projects with costs close to the carbon price, the actual subsidy may become negligible, while the contract serves mainly to provide greater certainty to financiers and sponsors.

The role of contracts and decarbonization risk management

Carbon capture technologies are mainly used for decarbonization and curbing greenhouse gas emissions from carbon-intensive energy and industrial processes. The underlying drivers in the deployment of these technologies are the various net-zero emissions and carbon neutrality objectives set by state and private actors. The IEA notes that CCUS can be considered essential in reducing the total cost of transforming conventional energy systems if properly valued amongst the portfolio of decarbonization technologies [26]. Earlier debates about the role of CCS in climate change mitigation and decarbonization efforts highlight the potential of CO_2-free, secure, and reliable power generation and net-zero carbon industrial applications, especially when CCUS is coupled with applications such as gas-fired generation, gas processing, or steam methane reformation [14]. Two major limiting factors to scaling up CCUS in most jurisdictions are the cost and risk-bearing implications of adding carbon capture, transport, and storage to existing processes, *vis-à-vis* the policy-level incentives and/or the price of carbon emissions under a business-as-usual scenario. Ideally, carbon capture projects will not move forward to FID if it is determined that the costs and risks are higher or cannot be efficiently mitigated. Hence, the specifics of relevant contractual arrangements regarding offtake and transportation, and/or those concerning the management of financial and CO_2 delivery risks, become essential.

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The development of viable projects requires innovative approaches beyond traditional liability allocation frameworks in typical offtake and transportation agreements. A valid contract in either common law or civil law jurisdiction comprises an offer, acceptance, and the intention to be bound by corresponding obligations as agreed by the parties [27]. In common law jurisdictions, there is a key requirement for 'consideration,' which is essentially the 'price' each party pays for the other party's promise or performance [27]. This exchange must be something of value, and it can take various forms like money, services, goods, or a promise to act or refrain from acting. Therefore, obligations of project parties and sponsors follow the specifics of the terms and conditions, which are agreed upon transactionally or arise due to applicable legal or regulatory provisions.

For instance, regulations may stipulate CO_2 capture and permanent storage thresholds needed to qualify for tax credits or subsidies, thus creating a minimum agreeable obligation on the party promising to provide the right capture equipment or access to transportation services. Likewise, a party undertaking to provide transportation and storage services would be mindful of the regulatory requirements concerning the transfer of long-term liabilities following the completion of the storage operations. Thus, in executing CO_2 offtake and transportation arrangements, it is usually necessary to consider emerging regulatory and market dynamics and how broader regulatory risk management provisions supplement contractual risk allocation measures (e.g. *via* insurance or contractual indemnities) as agreed amongst the parties.

Emerging trends in CCUS commercialization

Over the past decade, policy measures in countries like the USA, Norway, the UK, and Denmark have led to growing interest in commercial and project financing arrangements for CCUS [1]. Earlier projects were often designed to capture CO_2 from a single facility, like a coal-power plant or a gas processing unit, and thus were based on a single project framework. In this context, an operator manages the carbon capture, transport, and storage aspects. Several projects are now being designed using a hub-based model in which CO_2 is taken from several emitting sources, such as heavy industries and carbon-intensive power generators, and then transported and stored in a common location onshore or offshore [6]. The transportation and storage segments are typically owned and/or operated by another company or an incorporated special-purpose vehicle for the project [4]. Although the hub-based models are more complex to establish than the single-source value chain model, it is reported that the former offers benefits such as lower unit costs, sharing of risks amongst different specialized operators rather than one. Another noted advantage of the hub-based approach is the potential to standardize arrangements amongst multiple participants and new entrants, as well as scale up faster, given the economies of scale factor [28].

Most CCUS hubs are based around industrial clusters, where emission sources are close together, e.g. the UK Net Zero Teesside cluster or China's Junggar Basin. Other forms of hub-based arrangements are designed to connect emission sources that are dispersed geographically and connected by pipeline and/or shipping, such as in Northern Lights in Norway and a series of planned hubs in the Asia-Pacific region [28]. In the UK, at least seven major industrial clusters, or geographic areas representing about 50% of the nation's industrial emissions, have been identified. The aim is to deploy CCUS in these industrial areas to achieve high-impact emissions reductions, mitigating risk by enabling the operators to share CO_2 transport and storage infrastructure [29]. In 2023, the UK awarded a total of 21 licenses to 14 companies for CO_2 storage in depleted oil and gas reservoirs and saline aquifers [30]. The awarded locations can store up to 30 million tonnes of CO_2 per year by 2030 (i.e. ~10% of the UK's annual emissions). The licensing programme aimed to facilitate an energy transition hub, which includes CCS systems applied to gas-fired power generation, hydrogen production, and renewable offshore wind energy that could provide low-carbon energy for decades as part of the UK's efforts to reach future net-zero greenhouse gas emissions targets [30].

The Northern Lights/Longship project in Norway is designed to take CO_2 captured from point sources around Europe, transport it, and store it in a collective reservoir under the North Sea. The first phase of the project is largely subsidized by the Norwegian government and designed to store CO_2 from a waste-to-energy plant in Oslo and a cement factory in Brevik [28]. The captured carbon is processed and shipped to a point where it will be transported offshore by pipeline to a permanent storage site in a saline aquifer with a capacity to store at least 100 million tonnes of CO_2 [28]. In the second phase, the Northern Lights joint venture offers commercial storage services to companies across Europe. There are over 90 suitable capture sites already identified, including industrial point sources in the steel, biomass, cement, and hydrogen sectors. About seven CO_2 storage licenses were recently granted, while the seventh call for licensing storage sites on the Norwegian Continental Shelf was announced in June 2024 [14]. These developments are based on the legal framework under the EU's CCS Directive 2009/31/EC [31], which was incorporated into Norway's regulatory framework via the Norwegian Pollution Regulation, Petroleum Regulation, and CO_2 Storage Regulation [32]. As highlighted later in Part 4, EU-level guidelines issued pursuant to the CCS Directive help to facilitate a methodological approach for project developers and sponsors in dealing with the relevant local institutions and address project-level risks and issues. The guidelines relate to storage life cycle and risk management framework, characterization of the storage complex, CO_2 stream composition, monitoring and corrective measures, criteria for transfer of responsibility to the competent authority, and financial security and financial contribution [33].

In the USA, the 2021 Infrastructure Investment and Jobs Act (IIJA) [34] and amendments to Section 45Q of the Internal Revenue Code [35] under the (i) Inflation Reduction Act 2022 (IRA) [36], and (ii) Bipartisan Budget Act of 2018 [37], provide a suite of fiscal incentives leading to increased commercial interest in CCUS projects [38]. Some notable implications are the extension of the start of construction, lowering capture thresholds, and expanding transferability options for sponsors and potential investors [39]. Note that the fiscal incentives under the IRA and the IIJA were instituted during the previous US federal government administration led by President Joe Biden. Following recent developments led by the current President Trump administration, there were concerns that there would be some reversal or changes to the IRA provisions. This creates potential regulatory and fiscal risks that may have material implications for planned projects [40]. In July 2025, the US Congress passed the budget reconciliation bill (H.R. 1, the 'One Big Beautiful Bill') [41], containing numerous tax reform provisions championed by the current Trump-led administration, with its consequential implications for the IRA and potential impact on projects relying on IRA incentives [42]. At the time of writing this article, the One Big Beautiful Bill has been forwarded to the President for assent and enactment into law.

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Deploying CCUS as a decarbonization technology also supports the use of conventional energy resources that are considered more reliable in a net-zero context. For instance, gas-to-power or bioenergy with CCS, gas-fired turbines for industrial facilities that are hard to fully decarbonize, like cement and steel [43]. Wood Mackenzie's 2025 projections indicate a significant uptick in US CCUS projects [44]. The trend is also expected to lead to an increase in mergers and acquisitions, as well as a potential for large-scale startups amongst operators and project sponsors. Considering the emerging outlook, there is a need for adaptable agreements that reflect evolving industry dynamics, securing a viable market for captured CO_2 or serving as a tool to guarantee secure long-term storage arrangements.

Targeted regulatory and policy measures that demonstrate governmental support have been essential to addressing the hurdles and risks to project development globally. In 2022, the Canadian government introduced a CCUS investment tax credit valued at C$2.6 billion [45] ($1.93 billion) over the next 5 years. Likewise, recent CCUS projects in Europe have received considerable government support through investment cost and risk-sharing business models, as mentioned earlier [4]. The 'White Paper on Carbon Capture, Use and Storage' by the Association of International Energy Negotiators (AIEN) notes that funding models for CCUS typically involve one or more of following mechanisms: (i) direct capital subsidy to reduce the capital burden on the developer, (ii) a tariff subsidy, (iii) a preferential loan, which can reduce project Weighted Average Cost of Capital, and/or (iv) government equity investment to limit downside risks for project sponsors, while enabling the government to share in upside investment risks [4]. For example, the UK government provides financial incentives through subsidies from its carbon capture and storage infrastructure fund [46]. This fund, along with the CCfDs and ongoing revenue support schemes, are directed at covering capital expenditures (CAPEX), operational expenditures (OPEX), and transport and storage (T&S) fees, thereby ensuring emitters engaged in decarbonization receive financial backing in the form of capital grants [46].

In Denmark, the government has allocated over €3 billion of support to projects across the CCUS value chain. Through the EU Innovation Fund, Danish CCUS projects are eligible to apply for funding. This fund aims to allocate over €38 billion towards low-carbon technologies by 2030. More recently, in Asia, the Malaysian government proposed a 2023 budget to reduce carbon emissions [4]. The proposal also introduces new tax incentives for companies working on CCUS for economic development and to achieve carbon neutrality by 2050. Given the growing global investment in CCUS, particularly through subsidies, tax credits, and contractual frameworks across Canada, the EU, and Asia, it is expected that these financial mechanisms may be expanded, reduced, or maintained over time. This uncertainty underscores the need for a thoughtful risk strategy to ensure the long-term viability of CCUS projects.

Apart from financial and economic issues that impact the development and viability of CCUS projects (discussed above), there are two other essential factors to consider, i.e. (i) environmental concerns for subsurface storage, especially access rights to such underground formations, and (ii) allocation of risks for long-term liability for sequestered CO_2 [47]. In the USA, for instance, the Environmental Protection Agency (EPA) Class VI well permitting programme regulates the underground injection of carbon dioxide for long-term storage [48]. As of 2025, about 165 well applications [49] are under review, and eight final permits have been issued to applicants by the EPA. These Class VI permits are issued pursuant to the EPA's role under the US Safe Drinking Water Act to develop requirements and provisions for the Underground Injection Control (UIC) Programme. This programme regulates the injection of fluids (such as water, wastewater, brines from oil and gas production, and CO_2) into the subsurface for storage or disposal. The main goal of the UIC Programme is the protection of underground sources of drinking water, i.e. aquifers or parts of aquifers that supply a public water system or contain enough groundwater to supply a public water system now or in the future.

Contractual arrangements and CCUS

The following forms of offtake and transportation arrangements can be adopted in a typical CCUS project: (i) 'take-*or*-pay' contracts, which require the offtaker to pay for the captured carbon periodically, regardless of whether the offtaker takes the delivery; (ii) 'take-*and*-pay' contracts under which the offtaker only pays for CO_2 taken on an agreed price basis; (iii) throughput contracts where a pipeline owner or operator agrees to carry a minimum specified volume of CO_2 from one or more point sources in the pipeline at a contractually specified price; and (iv) long-term sales contracts whereby the offtaker agrees to take the contractually agreed-upon quantities of CO_2 from the project, usually for the life span of the project [50,51]. From a project financing perspective, these arrangements mirror similar agreements used in large-scale, capital-intensive, and multifaceted energy projects, such as the liquified natural gas (LNG) or for gas supply to power generation and storage. In a sales contract, the pricing is often based on an agreed formula or reference to an established index for pricing common to the specific industry [52]. A common example of a long-term sales contract is the LNG sale and purchase agreement, which plays a critical role in consolidating a multifaceted LNG project, comprising the delivery of natural gas, liquefaction, transportation, and regasification [53].

In negotiating CCUS offtake and transportation arrangements, the main objective is to outline necessary terms and conditions for the purchase, delivery, use, storage, pricing, and transfer of title or interests in the captured CO_2 [2]. Depending on the jurisdiction and the applicable regulatory framework, the adopted contract may involve some variation of the Carbon Dioxide Purchase and Supply Agreement (CPSA) or the CO_2 Sequestration Services Agreement (CSSA) [2]. Under the CPSA, parties would define the terms and conditions under which the emitter (seller) supplies the capturer (buyer) with CO_2 from the emitting facility [2]. Here, the emitter is selling captured CO_2 molecules to an end-user such as an oil and gas company that intends to inject them as part of an enhanced oil recovery operation. The CPSA can also be drafted as a CO_2 transportation and storage arrangement if the offtaker (i.e. buyer) is delivering the CO_2 to the owner of a storage facility for permanent sequestration. The CSSA is arguably more amiable to the hub-based project forms where multiple emitters seek to engage a 'service' provider. In this context, the service provider owns, leases, constructs, operates, or maintains a CCS system that will capture, transport, and sequester CO_2, while the emitter or cluster of emitters agrees to engage such service provider to exclusively undertake sequestration services as defined under the contract [2].

Unlike in the USA and Canada, contractual arrangements in Europe and the UK reflect a greater role for government institutions and state-owned entities in the commercialization of projects [4]. As mentioned earlier, several EU countries have introduced a CCfD programme for energy-intensive industries, while

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the European Commission has an industrial carbon management strategy [20]. With CCfDs [19], the carbon-intensive energy and industrial operators seeking to decarbonize using CCUS in a cost-efficient way (relative to the cost/price of carbon emissions) can be compensated by climate protection agreements, usually for about 15 years, to cover their additional costs (OPEX and CAPEX) incurred in the decarbonization of their production systems [20]. For example, the UK's Department of Business, Energy & Industrial Strategy published the CCUS Industrial Carbon Capture business models summary ('ICC business model'), together with the ICC Contract Heads of Terms in December 2022 [54]. The ICC business model was designed to incentivize the deployment of carbon capture technology by industrial users who often have no viable alternative to achieve deep decarbonization. The ICC Contract is essentially a private law contract between the emitter and the Low Carbon Contracts Company, for a 10-year term with the option for a 5-year extension (subject to certain conditions).

Amongst other things, the principles of contract law apply in the interpretation and implementation of the agreements executed by sponsors, parties, and operators in a CCUS project. One of such underlying principles is that, except where special rules apply, the formation of a contract requires 'a bargain' clearly agreed to by parties, and in common law jurisdictions 'a consideration' which can take the form of either a return promise or an actual performance [55]. In a typical CCUS context, a party, usually the project sponsor or owner of the carbon capture equipment, promises to make it available and take enough quantities of CO_2 and process it into a supercritical form. In addition, another party represents and promises to gain access to a CO_2 pipeline and storage site for transportation and sequestration, usually for a fee, i.e. consideration. Any conditions or factors that impact or pose a risk to the ability of these parties to fulfil their respective promises, therefore, become pertinent in the negotiations and drafting process. Such factors could be regulatory, environmental, or the financial viability of the project design.

Project development milestones, terms, and conditions

Contractual provisions are an avenue for sponsors and participants to specify the details of key milestones, conditions precedent to respective obligations, risk allocation measures, and potential long-term liabilities in relation to the project. According to the EU's Guidance Document for CO_2 storage life cycle and risk management framework, the six main phases and milestones during the life cycle of a typical CO_2 storage project based on the provisions of the CCS Directive are as highlighted in Table 1 [37]. The instructive guide outlines a methodological approach for implementing the relevant provisions of the CCS Directive as parties negotiate the details of their respective risk management measures, terms and conditions for going ahead with the project.

Generally, there are key terms that come into play in any commercial agreement, such as indemnities, warranties, conditions precedent, and force majeure. These are important tools for allocating risks, as well as qualifying obligations and liabilities in a contract [2]. This category of terms may be used to indicate a party's ability and acceptance to insure against (or bear) certain project risks. A warranty is a statement or promise, either express or implied, made about certain facts whereby the warrantor ensures that those facts are as stated. Additionally, a representation is a statement of presently existing facts, made either by words or by conduct, and intended to induce reliance and action by a party. Generally, statements about future conditions do not qualify as representations because there is incomplete information, and no one can know the future. The breach of a covenant, which is essentially a promise to act or not to act in the future, will typically support an action for damages or specific performance of contractual obligations.

The following terms can be expected in a typical CCUS contract to secure firm commitments and facilitate the efficient allocation and/or mitigation of risks, and implement the required activities and milestones.

(1) Definitions—The contract must clearly define the participants involved in a CCUS project, as there are often more than two parties, sometimes as many as five. In some cases, an entity [56] may assume multiple roles depending on its technical capabilities, financial capacity, resources, and risk appetite. Furthermore, parties must have a clear and mutual understanding of the key terms and conditions as defined for the purpose of the contract, as well as the duration of the contractual agreement, especially when it follows a particular licensing programme such as for CO_2 storage. A typical CCUS contract will likely be between 12 and 15 years, depending on the jurisdiction and activities involved [57].

(2) Conditions precedent—The contracting parties have conditions they must meet or waive before their respective contractual obligations become binding [2]. These often include constructing and testing the upstream carbon capture system, building the downstream sequestration infrastructure, and securing regulatory approvals. For example, in the USA, this includes obtaining a Class VI underground CO_2 injection permit from the EPA or a state institution with delegated primacy powers from the EPA, e.g. Wyoming and North Dakota [58]. In Canada, the Alberta Energy Regulator must approve the CCUS storage plan. Some contracts also include opt-out clauses, allowing parties to exit before the term ends. These may permit termination with simple notice or require unmet conditions (e.g. failure to secure permits) as a trigger, giving flexibility while managing risk.

(3) Volumes—Provisions regarding volumes or mass of captured CO_2 that the emitter must deliver are essential for guaranteeing capital recovery within an agreed time frame. As an initial matter, the contract should specify whether the volume will be expressed as a fixed volume or a percentage of the base volume. For example, if the emitter agrees to deliver a specified number of tons annually or a certain percent of the base volume, these provisions must also outline how any shortfall arising from a force majeure or offline maintenance and repairs of plants will be addressed, such as penalties or adjustments to delivery schedules. Such clarity ensures that both parties are aligned on expectations and can mitigate disputes and other risks effectively. Additionally, ownership of CO_2 must be clearly defined as it moves across the CCUS value chain, particularly where the capture, transport, and storage activities are carried out by different entities.

(4) Indemnity—This clause allocates potential risk, liability, and costs following an agreement of one participant to indemnify the other contracting party. Ordinarily, the sequesterer and the emitter may be liable for their actions or inactions that could result in foreseeable harm or loss to others, including willful misconduct and gross negligence. Examples include failing to transport CO_2 on schedule or preventable leakage resulting from the facility or pipeline. Depending on the stage of the CCUS project, it is critical to analyse the breadth of an indemnity clause. For example, in a CCUS transport contract [57], parties may either agree to a

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Table 1. EU CO_2 storage project life cycle and key milestones.

Project phase/Typical duration	Milestones (Competent authority/Project operator(s))
Phase 1 (0.5–2 years) Assessment of storage capacity. Early risk assessments and feasibility evaluations	Competent authority ■ Award of exploration permit—if required, conditions for storage permit under Article 8(1), CCS Directive.
Phase 2: (2–5 years) Characterization and assessment of the storage site	Competent authority ■ Approval and award of a storage permit Project operator(s) ■ Investment decision for storage project development.
Phase 3: Development (2–5 years) Monitoring plan, front-end engineering design, and construction, risk assessment update and corrective measures	Operator(s) ■ Start CO_2 injection operations and monitoring.
Phase 4: Operations (10–30 years)	Competent authority ■ Authorization of closure following a request from the operator under Article 17(1)(b) or a decision to withdraw the storage permit under Article 11(3) and to close the site under Article 17(1)(c). Project operator(s) ■ Closure—end of injection operations and continuous operational monitoring of injection. ■ Partial reclamation of the site.
Phase 5: Post-closure/pre-transfer (5–20 years)	Competent authority ■ Manage transfer of responsibility ■ Accept the responsibility for all legal obligations under Article 18(1) on behalf of the Member State, and release the operator from liability related to these obligations. Project operator(s) ■ Submit transfer report. ■ Make financial contribution available to the competent authority (Article 20). ■ End of operator involvement
Phase 6: Post-transfer (5–30 years)	Long-term stewardship of the site by Member State.

fault-based liability allocation, a no-fault (knock-for-knock) liability and indemnity allocation, back-to-back indemnity, or a tax credit indemnity [57]. Under the fault-based liability, parties may choose to bear the liabilities that are caused by their actions, and a party may indemnify the other party for damages or liabilities that the other party suffers because of the first party's actions. For example, if an emitter fails to transport CO_2 within the agreed timeframe due to negligence, they would ordinarily be liable for any resulting damages. On the other hand, parties may agree to a no-fault (knock-for-knock) liability and indemnity allocation. This approach ensures that each party is responsible for its personnel, property, and losses, regardless of fault. For instance, in a CCUS transport agreement, the pipeline operator would bear responsibility for any damage to its infrastructure, even if the emitter's actions contributed to the issue [59].

Additionally, a back-to-back indemnity structure ensures that liability flows down the contractual chain, meaning a subcontractor's indemnity obligations mirror those of the main contractor. For example, in a CCUS project, if a subcontractor handling CO_2 injection breaches their obligations, the main contractor may pass the liability down to them through a back-to-back indemnity clause. Lastly, the Tax Credit Indemnity protects parties involved in CCUS projects from financial risks related to tax credits. For example, under the US 45Q tax credit scheme, if an emitter fails to meet sequestration requirements, they may be required to indemnify investors or project developers for lost tax benefits [60]. Parties should watch out for potential trigger events, which could activate indemnity obligations. A well-drafted indemnity clause ensures clarity and mitigates risks for all parties involved.

(5) Change in law—As discussed earlier, the policy measures, laws, and regulations governing CCUS projects are evolving; hence, parties must anticipate material changes in policy or law during the lifespan of the project and plan accordingly. In the USA, for instance, Congress is considering whether to expand the 'Section 45Q' tax credit for carbon capture projects [61]. The likelihood of future changes in current regulations and incentives could change the structure of current or expected returns on future CCUS projects [62].

Risk management strategies for CCUS agreements

From a transactional law perspective, contractual representations and warranties regarding the capacity of respective parties to carry out any capture, transportation, and storage obligations are amongst the major steps towards project development and completion. Nevertheless, it is also important to assess and manage material risks as the process evolves, for instance, through the phases highlighted in the EU context in Table 1. The common approach is to allocate to the party or parties as required by law, or who is best suited to assume the risks in a just and reasonable manner. Allocating and mitigating such risks are essential in ensuring the project is commercially viable and bankable [63]. In

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the early process of negotiation, parties would ideally anticipate and manage the following risks:

(1) Planning and permitting: This requires parties to obtain permits from the appropriate government agency, and in instances where the transportation arrangement is across states, parties must plan to obtain permits from the government where CO_2 is being transferred. Where permitting for transportation is not secured in time, issues may arise as to which party will bear the costs for the delay. Parties must prevent this by discussing with the relevant authorities to ensure they obtain all required permits. If it becomes apparent that there will be gaps in risk allocation, these will need to be contractually allocated.
(2) Risk of accidents and leakage: Given the history and track record of the industry and operations of CCUS projects over the years, it can be posited that the risk of leakages and accidents is very low. Nevertheless, as with all industrial and complex activities, there are still lingering possibilities for accidents or leakages during the transportation and sequestration processes. Such risks are worth considering due to the long-term nature of CO_2 sequestration and the expectation of permanence, coupled with an ex ante reward for ensuring the CO_2 is removed and is not released into the atmosphere before and after the project is completed. Most jurisdictions have specific regulations stipulating obligations to monitor and ensure any risks and liabilities arising from potential accidents or leakages before and after project completion are properly addressed by either the private operator or the state.
(3) Construction and interdependency risk: This involves several risks associated with construction, where different entities are responsible for constructing different parts of the transport process infrastructure. In this case, a contract must be in place to address due dates for completion and operational deliverables for each part of the infrastructure. Sometimes, delays arise due to the nature of the construction; hence, the contract must anticipate these risks by showing how and by whom impacted parties will be compensated if the overall construction of the transport process infrastructure is delayed.
Interdependency risks are typically higher in a single-source model where one industrial emitter provides CO_2, which is transported via a dedicated pipeline to a single storage facility. This business model poses a significant interdependency risk because if the CO_2-emitting industry shuts down, the pipeline and storage facility are left without supply, resulting in stranded assets and revenue loss. Mitigating the likelihood of this happening requires parties to allow for multi-source, multi-sink networks, where CO_2 can be captured from multiple industrial sources.
(4) Continuous operation and maintenance blackout risks: When the transport process commences, maintenance, and operation risks may arise, including routine maintenance, temporary blackouts, and permanent cessation of part of the entire project. Parties will need to address these risks through contracts to establish the reliefs that would be available for contracting parties and to identify which party bears the risk for each such outage to prevent loss of value.
(5) Intellectual property risk: The separation and transport of captured CO_2 may require access to proprietary technology and processes. For example, many CO_2 transport pipelines rely on proprietary leak detection systems that use fibre optics, acoustic sensors, or machine learning algorithms to detect leaks and ensure safe operation. If these monitoring technologies are patented and owned by specific companies, pipeline operators or regulators may need to obtain permission to access real-time data or use the detection methods. This could create barriers to entry for new players in the CO_2 transport market and increase costs for infrastructure deployment.
(6) Investment risks: CCUS projects require heavy financial commitments from all the parties involved, including banks that are financing the projects. Here, contracts must be structured to anticipate and mitigate revenue risk because the CCUS project, by its nature, requires a stable and reliable revenue stream, which is sometimes lacking due to weak carbon pricing and fluctuating government subsidies and incentives, leading to limited commercial demand for stored CO_2 [64]. Here, parties must incorporate scenario planning to hedge against future fluctuations in carbon pricing and force majeure clauses to mitigate the impact of political risks and unforeseen, unavoidable and uncontrollable events that make performance impossible or impracticable.

Indemnity provisions are part of the essential instruments for addressing the highlighted risks and issues. These are collateral contractual obligations where one party, the indemnitor, promises to hold another, the indemnitee, harmless from loss, damage, or liability to third parties [1]. Thus, the concept of indemnification is a promise to reimburse another for a loss, damage, or liability suffered because of a third party's or one's own act or default. If the emitter is claiming the Section 45Q credits or other relevant environmental attributes, the service provider may provide an indemnity for (i) the value or replacement cost of any lost environmental attributes (subject to deductibles and caps) and (ii) the recapture of Section 45Q tax credits. Furthermore, if the emitter is claiming Section 45Q credits, it may seek full indemnity from the service provider for the loss of Section 45Q tax credits, other relevant environmental attributes, or their recapture. Third party insurers currently offer insurance policies covering Section 45Q credit recapture, but pricing on premiums for those policies remains high [2].

In negotiating CCUS contracts, the sequesterer's indemnity for breach of contract is one of the most heavily negotiated provisions in the contract. Some of the main issues that come up include the measure of recoverable damage; liability for environmental damage, covering both direct and third-party claims; and defining the indemnity trigger events, such as leakage, failure to transport, or planned outages and maintenance of the relevant facilities. Some pipeline and sequestration companies may be willing to provide an availability or uptime guarantee. In cases where *force majeure* is not applicable or an excused event, the pipeline company and party responsible for sequestration can seek insurance to help cover the risk [2].

Conclusion

The growth of CCUS projects globally underscores their critical role in achieving decarbonization and net-zero emissions targets. As highlighted, the evolution from single-source to hub-based models has introduced greater complexity but also opportunities for cost efficiency, risk management, and scalability. Revenue and cost-related contracts, such as CCfDs and project structuring arrangements, including offtake and transportation agreements discussed above, are pivotal in ensuring project viability by defining terms for CO_2 delivery, pricing, and risk allocation. These agreements are developed to address key

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elements like clear definitions, conditions precedent, volume commitments, indemnity clauses, and provisions for changes in law to mitigate risks effectively. A thorough due diligence and consideration of issues ranging from planning and permitting delays, construction and interdependency challenges, operational blackouts, intellectual property barriers, and investment uncertainties enhances robust contractual frameworks and strategic risk management that equally reflect the applicable regulatory measures. By anticipating regulatory shifts, securing permits, and incorporating flexible clauses like force majeure and scenario planning, parties can safeguard project bankability. It is noted that supportive policies, such as tax credits in the USA, subsidies in the UK, and investment funds in the EU and Canada, can enhance CCUS development but also introduce uncertainties that contracts must navigate.

Ultimately, the success of CCUS projects hinges on carefully crafted agreements that balance risk, ensure financial stability, and adapt to evolving regulatory and market dynamics. As global investment in CCUS grows, these contractual arrangements will remain essential tools for aligning stakeholders, securing revenue streams, and advancing the transition to a low-carbon future.

Author contributions

Tade Oyewunmi (Formal analysis [equal], Methodology [lead], Resources [equal], Supervision [lead], Writing—original draft [equal], Writing—review & editing [lead]), Champion Olatunji (Resources, Writing—original draft [equal])

Conflict of interest statement: None.

Funding

None.

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Oxford Open Energy, 2025, **4**, oiaf011
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