

Closing the risk gap

How insurance innovation can accelerate CCS deployment.

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Executive summary

Carbon capture and storage (CCS) is essential for achieving decarbonisation goals – but new innovations to address risks are required.



The rapid deployment of Carbon Capture and Storage (CCS) infrastructure is essential for achieving global decarbonisation goals. However, the CCS value chain including emitters, transportation, and storage presents a unique set of technical, commercial, and regulatory risks. These risks are amplified by the complexity of ownership structures, cross-border operations, and the nascent nature of the industry at the required scale.

Historically, some governments, such as the UK, have played a pivotal role in absorbing the most challenging risks to jump-start CCS projects. As the sector matures, this approach is unsustainable, and there is a pressing need for innovative risk management strategies and insurance solutions to unlock private capital and ensure project viability.

This paper examines risk allocation across the CCS value chain from the perspectives of emitters and storage providers. It explores the spectrum of risk management approaches – treat, take and transfer – and highlights the limitations of traditional insurance products in addressing the unique challenges of CCS. The emergence of new insurance solutions, such as technology

performance guarantees and cross-chain liability cover, is discussed as a catalyst for industry growth.

The analysis underscores that most CCS projects will require a hybrid approach to risk management – one that combines robust commercial negotiations with tailored insurance products. The paper also identifies critical gaps in current insurance market capacity, particularly for carbon leakage and consequential loss, and calls for further innovation to support the sector's expansion.

Ultimately, the success of CCS will depend on close collaboration between project sponsors, insurers and governments to develop comprehensive risk frameworks. Without such innovation, the flow of capital necessary for large-scale deployment will be constrained, threatening the sector's growth and the broader transition to a low-carbon future.

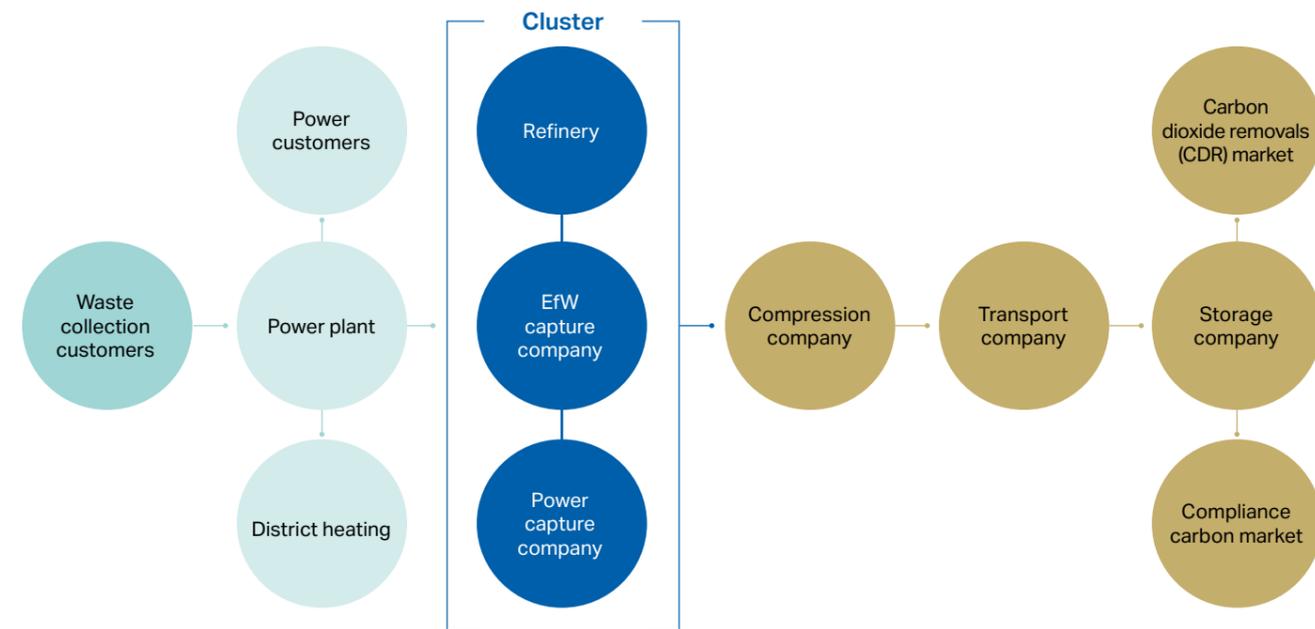
Innovative solutions are required to address risks within CCS value chains

CCS Hubs and Clusters are strategic approaches to decarbonize industries by sharing common transport and storage infrastructure for captured CO₂, pooling multiple emission sources into a 'cluster' served by a central 'hub' for cost-sharing, reduced risk, and economies of scale, making large-scale CCS more viable for heavy industries and essential for meeting net-zero goals.

An end-to-end integrated hub and cluster CCS value chain is highly complex and may include all or a subset of the following elements (figure 1):

1. Emitter's capture plants.
2. Onshore transportation and gathering system (barge, train, truck, pipeline).
3. Onshore temporary storage (tanks) and export port facilities.
4. Offshore trunkline or shipping.
5. Receiving terminal.
6. Onshore underground storage.
7. Offshore underground storage.

Figure 1: Example of CCS value chain for energy from waste (EfW)*



*Referred to as waste to energy (WtE) in some jurisdictions.



To make it even more complicated, each link in the chain may potentially have different equity partnerships, including government-equity ownership.

Each of these elements has its own individual risk profile in addition to the associated cross-chain risks. The more complex the value chain, the more complex the commercial negotiations and agreements become and this is exacerbated if the Shareholder equities change across the value chain.

The simplest risk profile involves an aligned model with a single entity, covering point-source emissions through to the sink, all within one country. A good example of this was the original Quest project in Canada (aligned ownership model in figure 2). At the opposite end of the complexity spectrum is a disaggregated system with multiple emitters, entering a transportation and storage network with multiple owners in the various components (disaggregated model in figure 2).

Given the cost of building these value chains, the first wave of CCS infrastructure is likely to have little to no redundancy of alternative infrastructure.

Figure 2: CCS value chain commercial ownership model and characteristics

Aligned ownership model

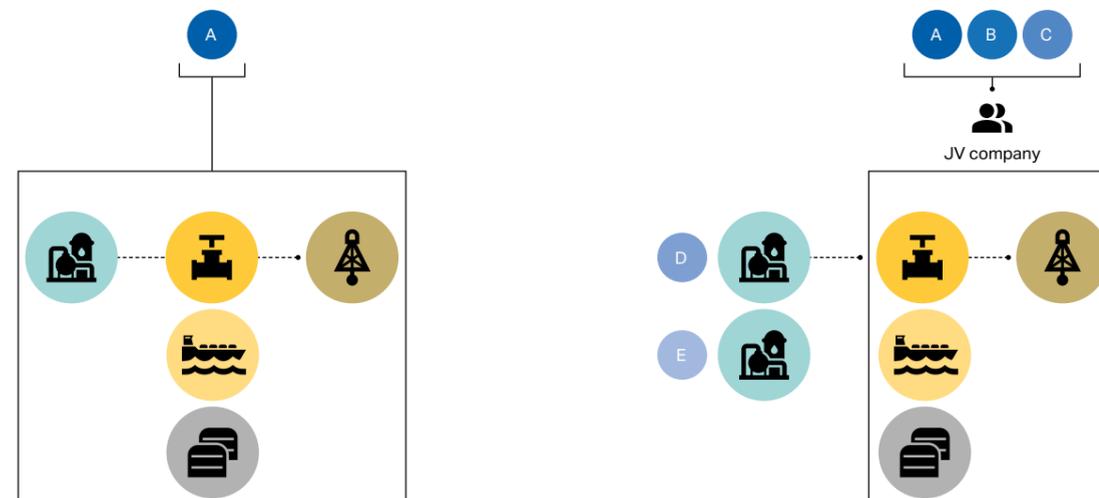
- **Simplest** – single entity ownership (company A) across capture, transport and storage.
- Single operator.
- Not applicable for clusters and hubs due to multiple CO₂ sources with different ownership structures.

Aggregated model

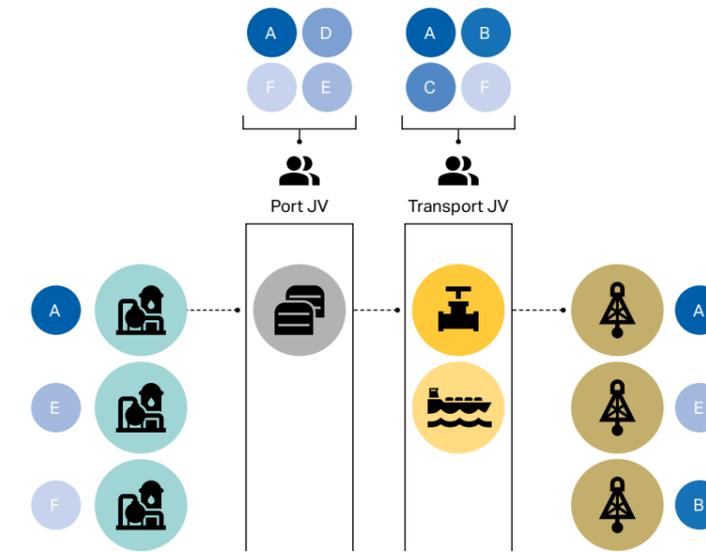
- Multiple capture companies (D and E).
- Multiple companies ((A, B and C) form a single operator through a joint venture company, which negotiates terms and conditions with multiple capture companies.
- UK Government has standard terms and conditions that all parties must enter into and regulates the tariff paid by emitters to the transport and storage company.

Disaggregated model

- Multiple capture and storage companies (A, E and F).
- Multiple companies operate different elements of the transport network e.g. port facilities are operated by a JV between companies A,D,F and E, separately to the shipping and pipeline which is operated by a JV between companies A,B,C and F.
- **The same company can be involved** – either directly or through JVs in multiple parts of the value chain (e.g. company A).
- Emitters may require separate negotiations with each value chain component.
- No single operator to ensure that the value chain functions correctly. Service is provided by specialists.
- Contractually very complicated with title, risk and liability needing to be apportioned.



Companies
 ● Company (colours and letters denote different companies)
 ● Capture, dehydration and compression
 ● Pipeline ● Shipment ● Storage ● Intermediate storage



In the absence of private sector commercial alternatives, governments have stepped in to shoulder some of the most challenging risks. Although it's served to kick-start this new industry, the position isn't sustainable in a world of economic and political trade-offs. This creates an exciting opportunity for the insurance industry to innovate and fill this void with a range of new insurance solutions.

Without this innovation, the capital allocation by sponsors and lenders is unlikely to be available and the industry will stall in its infancy. This innovation has started in earnest, by creating solutions like technology performance guarantees for capture equipment and cross-value chain risk cover for counter-party liabilities and leakage of CO₂. These innovations have begun with traditional covers in mind, leveraging experience in insuring financing, construction and operation of liquefied natural gas (LNG) infrastructure and adapting them for the specific risks of managing CO₂.

This paper addresses the risk-and-reward balance through the eyes of the emitters, transporters and store owners within the value chain.

Emitter perspective: Emitters are exposed to both the capture plant performance and the performance of the value chain downstream of the capture plant. Both these risks lead to very similar non-performance consequences for the Emitter- namely a potential reduction in the volume of CO₂ that is safely and permanently stored.

Excluding CDRs, the financial impact on the emitter depends on three distinct elements and potential mitigations. Firstly, how the risk was addressed in the design of the plant; secondly, the commercial negotiations; and lastly, the insurance products obtained prior to the final investment decision (FID). This leaves the regulatory risk of non-compliance associated with non-performance, which is more difficult to mitigate.

Capture plant non-performance creates two straightforward consequences, and a third, more complex implication:

- The first is a reduced volume of CO₂ transferred at the delivery point to the transportation and storage provider.
- The second is the fact that the emitter potentially must vent and/or there's leakage of CO₂.
- The final complexity comes if non-performance of this emitter impacts the transportation and storage provider, meaning they're unable to perform, impacting other emitters. For example, it may be the case that the entire process must be shut down for a period while off-spec CO₂ is vented or purged from the system.

These outcomes have technical, financial and regulatory consequences that must be managed.

If we think of risk as a spectrum, there are two end entities. We can call these 'take' and 'treat/transfer', but with many in-between configurations.



Effective risk management follows the principle of take, treat or transfer:

Take by consciously retaining risks that can be absorbed within the project consortium, e.g. certain operational risks that are manageable by experienced operators.

Treat through robust design (commercial as well as technical), clear performance guarantees and milestone-based funding to reduce the probability of failure.

Transfer via mechanisms such as revenue-sharing, risk-pooling, or insurance products. Insurance is emerging as a tool but is rarely sufficient on its own. Unless a project shows that the other methods are in place, insurers are unlikely to underwrite. New products, such as coverage for cross-chain performance or revenue disruptions may help bridge residual gaps, but only if combined with strong upfront structuring.

The take scenario: at one end of the consequence spectrum, the capture plant takes most of the risk with little risk being 'transferred or treated'. The capture plant is owned by the emitter – to minimise capital expenditure (CapEx) considerations, the technical sparing philosophy is lean, and minimum performance guarantees are given by the engineering, procurement and construction (EPC) contractor. The regulatory environment dictates that either the emitter is unable to produce the underlying product if the CO₂ isn't captured and sequestered; or is liable for environmental taxes if the CO₂ is vented or leaked.

In addition, the underlying product can't be sold as 'green or blue'; CDRs may not be generated; subsidies may need to be repaid or are withheld; credits/ taxes need to be obtained/paid; and the downstream value chain owners need to be paid for their transportation and storage services, even though no or reduced volumes are being sent.

The advantage of this scenario is that this commercial construct should result in the lowest possible CapEx, operating expense (OpEx) and tariffs for the emitter, as they're taking most of the risk. However, most emitters are unable to shoulder such risks. The emitter may also be looking to fund the CapEx via debt financing and it's likely that such risk taking would be unacceptable to lenders.

As we're seeing play out in practice, only large organisations with the ability to assume the risk on their own balance sheet, are likely to participate in the primary wave of building these end-to-end value chains.

The financial consequences of a downstream failure could be handled by back-to-back contractual agreements, but insurance can speed up any claims and minimise business disruption by providing cover across the chain for cross-liability risks.



The treat/transfer scenario: at the other end of the spectrum, the emitter has decided to manage the project risks by maximising the two ts – 'treat and transfer' – and only 'take' whatever risk is residual. The financial consequences of non-performance of the capture plant are either offset by performance guarantees from EPC contractors, or by build-own-operate companies who will accept some or all the risks.

Some of this risk could be transferred through technology performance warranties, particularly where EPC or original equipment manufacturers (OEM) contractors' balance sheets can't cover warranties sought. Similarly, OEMs with warranty or service obligations for equipment in the field may opt for fleet service cover to protect against excess cost.

In a maximum scenario, the emitter has also secured some form of consequential loss compensation via insurance (e.g. through tax credit or carbon credit insurances, although the market capacity for the latter needs to grow significantly to cover liabilities at scale) and then downstream liabilities are minimised by negotiating a low send-or-pay percentage with the transportation and storage providers.

The upside of this scenario is that the emitter is protected against both technical and commercial risks. However this will result in the highest costs and tariff due to the altered risk return profile with much of the risk being transferred to other parties.

Figure 3: Project life cycle, liabilities and potential insurance coverage



*If required

The role of insurance innovation: most projects will land somewhere between the two end points on this spectrum, through a combination of commercial negotiations and by utilising the following insurance products:

- If project finance is being sought, then sureties and technical performance guarantees are examples of insurance protection that could be deployed to improve the overall financeability of the project. Sureties could be taken out for either EPC in construction; for transport operators (likely to be on low margins); or for guarantees on longevity of storage. Technology performance guarantees cover for innovative technology deployed (for example, non-amine carbon capture) from OEMs with smaller balance sheets or shorter credit history could also help.
- Most individual asset insurances would likely be covered by existing policies, such as:
 - Construction all risks and delayed start-up insurance for the construction phase.
 - All operational risk cover, such as property damage, business interruption, professional indemnity, etc. during the operational phase.
 - Hull and cargo insurances for new dedicated CO₂ shipping transport.

- In addition to the risks covered at individual asset/owner level, the complexity of ownership of infrastructure in the value chain, coupled with the transfer of the CO₂, leads to needing policies across the entirety of the value chain, such as:
 - Carbon leakage insurance (to cover loss of CO₂ at any point) although this insurance market capacity needs to be developed further.
 - Business interruption caused by forced venting and/or off-specification CO₂.

From an emitter perspective, if there's a technical non-performance issue downstream of the delivery point, similar choices need to be made regarding 'transferring or taking' the risks. In theory, no tariff should be paid for the transport and storage services if CO₂ can't be accepted at the delivery point due to an issue downstream.

However, when the equity owners of the transport are different to the storage, if one goes down, the other will still wish to be paid, and vice versa. This type of risk could be covered by a new, innovative policy (to cover equitably the contingent business interruption following an event) and cover cross-chain liability gaps inherent in this value chain.



It may also be possible for the emitter to negotiate directly with only one counterparty, without visibility of the detailed commercial constructs between the separate transport and storage entities. However there's evidence from many of the recent negotiations between emitters and stores that it's extremely difficult for the former to secure compensation for consequential losses such as the loss of green premium and loss of underlying business revenue from the storage ventures, as these losses are too great compared to the revenues generated by tariffs.

Further emitter risks not yet mentioned include underlying business and marketing risks. For example, it's unlikely that the tenure of a guaranteed contract for the sale of the product and associated green premium will match the 15-20 years that service contracts need to underwrite the combined capture, transport and storage investments.

Additionally, any credits or CDRs generated would be subject to market dynamics, and prices assumed in investment proposals may in practice not eventuate. This latter risk can be reduced by trying to secure longer-term CDR contracts and/or hedging.



Storage perspective

Traditionally, most oil and gas (O&G) companies have in the main accepted the risks of technical non-performance for O&G projects, as they believed they were best placed to handle such risks. However, because oil and gas companies have historically targeted double-digit returns on their investments, their portfolios were able to absorb the overall risk profile, including the occasional project failure.

Most of the current players in CCS storage are international oil companies (IOCs) and national oil companies (NOCs), all of which were initially looking to take most of the subsurface risks in the expectation of similar returns to the oil industry. However it's become clear that as CO₂ is a waste product, applying a O&G risk reward balance to CCS resulted in storage tariffs that were too high for the current affordability of emitters (and, ultimately, the end consumers). So, to receive lower tariffs, emitters have either had to take some of the risks; insure; or, in some cases, governments have stood in as the insurer of last resort, e.g. the UK.

An additional consideration is that IOCs and, to a lesser extent, NOCs, haven't always looked to secure debt financing at individual project level. This is because the capital balance sheets of the parent companies were sufficient to fund such projects. Storage projects are moving away from this traditional O&G approach, and many of the recently announced large scale CCS projects have secured loans of up to 70%-80%. This has resulted in a shift of the risk towards the emitters,

as the storage providers need to create bankable projects by allaying the concerns of lenders or infrastructure investors.

From a storage perspective, technical non-performance results in the same financial and regulatory consequences as capture non-performance. The financial consequences of a store being unable to accept CO₂ include loss of tariff revenue and penalty payments – potentially including consequential losses – to upstream emitters and transportation providers if a high take-or-pay commitment has been agreed.

Leakage of CO₂ may include the requirement to purchase allowances or pay back tax credits. This is because title and ownership of the CO₂ is normally transferred to the store at the delivery point. Depending on the severity of any incident, the regulator may intervene and normally has the powers to force compliance or shut the store.

However many of the traditional oil and gas risks, including reservoir size (or capacity in the context of CO₂) and well uncertainty, remain uninsurable and are equally present in CCS; in our view, it's unlikely that insurance solutions will emerge to address these risks.

These financial impacts can be cushioned by negotiation of more favourable terms with the emitter (which would likely result in a lower tariff for the store), and/or obtaining insurance products.

Common risks across the value chain

As CCS is still very much a nascent industry there are very real political risks (both policy and regulatory) to be addressed.

In the simplest system a project that is combined capture and, transport and storage within a single country may be impacted if that country does not have either mature CCS policies or an associated regulatory system which is sufficiently developed to underpin investments of the magnitude required for integrated CCS projects.

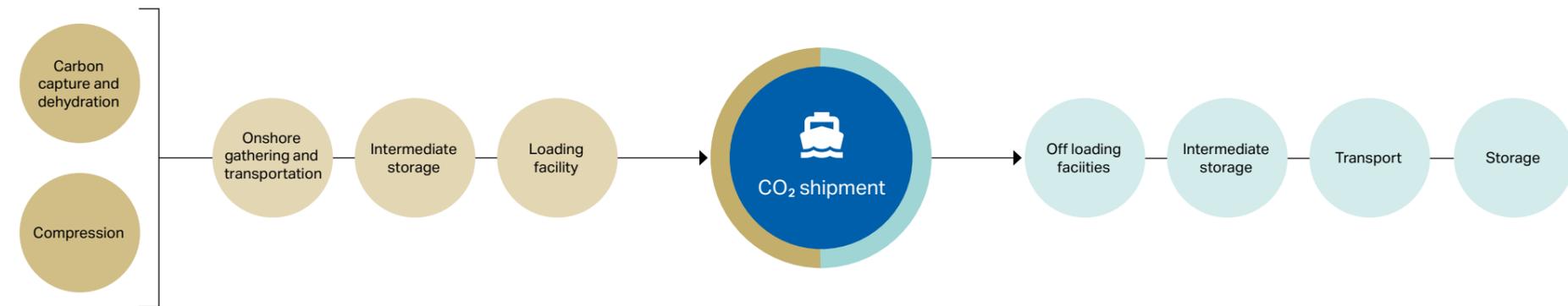
Equally, even in countries where there are regulations there are also the Political Risks associated with changing political parties or government sentiment as can be seen currently in the US. Whilst there is currently no insurance product that protects against the risks associated with regulatory change, there are products that entities can take out that offer a level of protection against licence cancellation.

The risk profile becomes increasingly complex where cross-border capture, transportation and storage is required due to the emitter country not having sufficient

of suitable geologic storage (see figure 4). This creates a Country-to-Country risk element that needs to be managed as business cases rely on transport across international boundaries and agreements between nations. Projects will therefore need to consider geopolitical implications, the spreading of risk so they are potentially not reliant on one country for their CO₂ solution and the willingness of governments to devote resources to the process

Figure 4: Transboundary CO₂ shipment complexities

Multiple customer countries



Conclusion

As CCS projects move from concept to reality, the industry faces a pivotal moment: the need to balance risk and reward across a fragmented and rapidly evolving value chain.

While the traditional risk management tools of treat, take and transfer remain important, the unique challenges of CCS demand new approaches and products, particularly from the insurance sector. Without such innovation, the flow of capital necessary for large-scale deployment will be constrained, threatening the sector's growth. By fostering collaboration between emitters, storage providers, insurers and governments, the CCS industry can develop robust frameworks that not only mitigate risk, but also accelerate the transition to a sustainable, low-carbon future.

Action is needed now.
Innovative risk solutions will be the linchpin for CCS success.





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