Legal and Regulatory Frameworks for CCUS

An IEA CCUS Handbook

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Abstract

Carbon capture, utilisation and storage (CCUS) technologies are set to play an important role in putting the global energy system on a path to net zero. Successfully deploying CCUS relies on the establishment of legal and regulatory frameworks to ensure the effective stewardship of CCUS activities and the safe and secure storage of CO_2.

Several countries have already developed comprehensive legal and regulatory frameworks for CCUS. These form a valuable knowledge base for the growing number of countries that have identified a role for CCUS in meeting their climate goals, but which are yet to establish a legal foundation for CCUS, and particularly for CO_2 storage. Increasingly, existing frameworks are also being tested as more commercial CCUS projects are developed, with important learnings for regulators.

This IEA CCUS Handbook is a resource for policy makers and regulators on establishing and updating legal and regulatory frameworks for CCUS. It identifies 25 priority issues that frameworks should address for CCUS deployment, presenting global case studies and examining how different jurisdictions have approached these issues. The handbook is supported by a web-based legal and regulatory database, and model legislative text that is found at the end of this report.

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Chapter 1
Introduction

Context of this CCUS Handbook on Legal and Regulatory Frameworks

Meeting net zero goals will require widespread deployment of carbon capture, utilisation and storage (CCUS). CCUS is the only group of technologies that can contribute to deep emission reductions in key sectors, including heavy industry, while also supporting the removal of CO_2 from the atmosphere. In the IEA Net Zero Emissions by 2050 Scenario (the Net Zero Scenario), CCUS deployment grows by a factor of almost 200 to reach more than 7.6 billion tonnes of CO_2 captured in 2050.

The successful global deployment of CCUS at this scale will depend on the establishment of robust legal and regulatory frameworks that provide effective stewardship and oversight of CCUS activities. Such frameworks will serve multiple objectives, with the foremost being to ensure safe, secure and permanent CO_2 storage in deep geological formations. CCUS laws and regulations must also ensure the protection of the environment and public health, clarify the rights and responsibilities of CCUS stakeholders, and provide a legal foundation for the development, operation and long-term management of CO_2 storage resources. Importantly, effective regulation of CCUS activities can help to build public confidence in, and acceptance of, the technology.

Global experience of regulating CCUS activities is growing. More than 20 national and sub-national jurisdictions have established laws and regulations for CCUS and these laws are increasingly being applied as the pipeline of CCUS facilities in operation or development expands.

At the start of 2022, around 30 commercial CCUS facilities are operating in nine countries – some dating back to the 1970s and 1980s. Although around two-thirds of these projects are concentrated in North America, commercial CCUS facilities are now under development in more than 25 countries. For some countries, these planned facilities will be among the first to test existing legal and regulatory frameworks for CCUS; for others, new laws and regulations may be required.

This IEA CCUS Handbook is a resource to develop and update legal and regulatory frameworks for CCUS. It identifies 25 priority issues that frameworks should address for CCUS deployment, and presents global case studies on how different jurisdictions have approached these issues.

The handbook is supported by a comprehensive online **CCUS Legal and Regulatory Database** that provides examples of legislative approaches to CCUS from around the world. The handbook also updates the 2010 IEA CCUS Model Regulatory Framework, with **Model Legislative Text** providing sample wording as a reference for relevant authorities when developing tailored CCUS legislation for their national or regional context. The Model Text also provides example definitions of common terms used within CCUS legal and regulatory frameworks.

The handbook does not consider legislative and policy approaches that aim to incentivise investment in CCUS, for example legislation for tax credits or grant programmes. Although such incentives are important for the broad deployment of CCUS, the focus here is on the legal oversight and regulation of CCUS activities.

The handbook is structured as follows:

Chapter 1 – **Introduction** provides an overview of the importance of regulating CCUS activities and identifies key regulatory issues for CCUS.

Chapter 2 – Developing legal and regulatory frameworks outlines the questions policy makers should consider when formulating regulations. The chapter offers a six-step process intended to help governments begin this process.

Chapter 3 – Regulatory foundations identifies the fundamental regulatory issues that provide a base for incorporating CCUS activities into frameworks.

Chapter 4 – Key issues for CO_2 storage lays out the legal and regulatory areas that frameworks must address in order to promote safe and secure geological storage. This chapter looks at how various governments from around the world have treated such issues as measurement, monitoring and verification, transfer of storage site stewardship, and post-site closure liabilities.

Chapter 5 – International issues and CCUS hubs looks at the variety of legal and regulatory issues and implications that stem from cross-border projects.

Chapter 6 – Other key and emerging issues details further regulatory considerations as CCUS technologies grow to meet the demands of a net zero future.

About the IEA CCUS Handbook series

Meeting net zero goals will require a rapid scale-up of CCUS globally, from tens of millions of tonnes of CO_2 captured today to billions of tonnes by 2030 and beyond.

The IEA CCUS Handbook series aims to support the accelerated development and deployment of CCUS by sharing global good practice and experience. The handbooks provide a practical resource for policy makers to navigate a range of technical, economic, policy, legal and social issues for CCUS implementation.

The role of CCUS in reaching net zero ambitions

CCUS refers to a suite of technologies that involve the capture, use and storage of CO_2. The CO_2 can be captured from large point sources, including power generation and industrial facilities that use either fossil fuels or biomass for fuel. The CO_2 can also be captured directly from the atmosphere with direct air capture (DAC) technologies. If not being used on site, the captured CO_2 can be compressed and transported by pipeline, ship, rail or truck to be used in a range of applications, or injected into deep geological formations (including depleted oil and gas reservoirs and saline aquifers), where it is trapped and permanently stored.

CCUS carries considerable strategic value as a climate mitigation option and will play an important role in meeting net zero goals. In the Net Zero Scenario, more than 7.6 billion tonnes (Gt) of CO_2 are captured, transported and used or stored globally in 2050. CCUS contributes to emission reductions in almost all parts of the energy system, with four major roles:

Tackling emissions from existing energy assets. If left unmitigated, today's power and industrial plants could emit a further 600 Gt CO_2 until the end of their technical lives – nearly 17 years' worth of current global energy sector emissions. This is especially important for emerging economies with relatively young coal-fired generation fleets. Retrofitting these plants with CCUS can be a strategic option in some cases to help avoid emissions that may otherwise be "locked-in".

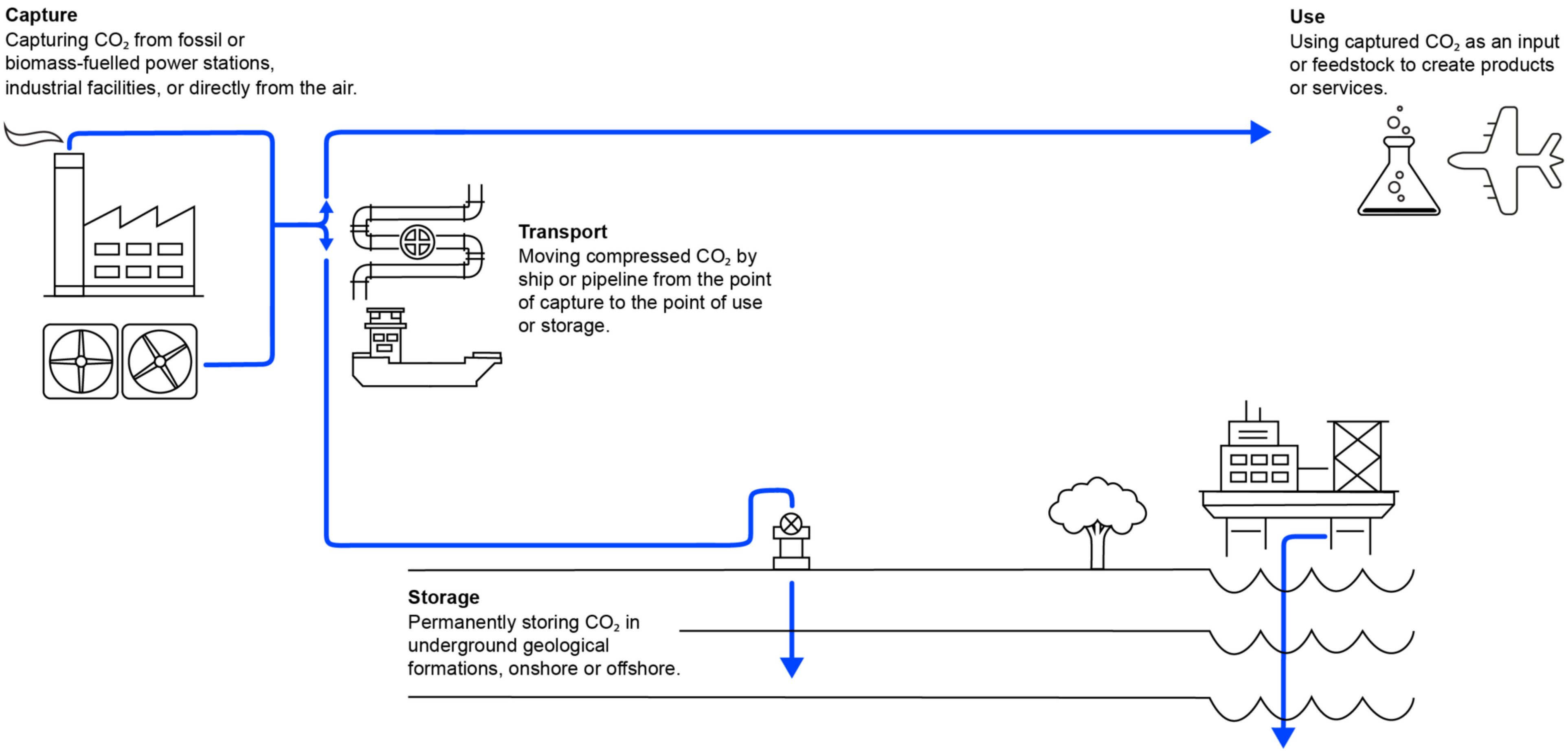
Reducing emissions in hard-to-abate sectors. CCUS is one of the few available options to reduce emissions in certain sectors, such as heavy industry (cement, steel and chemicals production) and long-distance transport (including synthetic fuels for aviation). In the Net Zero Scenario, approximately 40% of the CO_2 captured in 2050 is from energy-related emissions and process emissions from heavy industry.

Providing a platform for low-carbon hydrogen production. CCUS can support a rapid scaling up of low-carbon hydrogen production to meet current and future demand from new applications in transport, industry and buildings.

Removing carbon from the atmosphere. For emissions that cannot be avoided or reduced directly, CCUS represents an important technological approach for removing carbon and delivering a net zero energy system. In the Net Zero Scenario, approximately 2.4 Gt CO_2 are captured from bioenergy and DAC in 2050, with 1.9 Gt of this CO_2 permanently stored for carbon removal to balance remaining emissions in transport and industry.

Regulating CCUS requires consideration of the full value chain

Schematic of the CCUS value chain



The importance of regulating CCUS as the project pipeline expands

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

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

Regulatory issues associated with CO_2 capture, transport and use will often fall within the scope of existing regulatory frameworks for industrial activities, including oil and gas, waste management, health, safety and environmental considerations for industrial sites, property rights and transport. While these areas may require little or no modification to existing frameworks as compared to CO_2 storage, it is important that governments review existing domestic and international frameworks in order to remove any potential barriers to CCUS deployment.

Experience with CCUS regulation is growing and evolving

In 2010 the IEA released a Model Regulatory Framework to support countries that were developing, or considering developing, regulatory approaches for the large-scale deployment of CCUS. The model framework provided a starting point for developing regulations, with “Model Text” that could be amended or added to as appropriate. The model framework has been applied in reviews of legal and regulatory frameworks for Mexico and South Africa (supported by the World Bank), as well as in other national and sub-national contexts.

Since the publication of the model framework, substantial experience has been gained in the regulation of CCUS projects. Additionally, CCUS applications and technologies have continued to evolve, highlighting the need for flexibility in regulatory approaches as well as the need to review existing frameworks periodically. Around 30 commercial projects have started operations and the pipeline of projects in development has now grown to more than 200. While CCUS has been primarily used in association with natural gas processing or fertiliser production, a growing number of projects for hydrogen, steel, bioethanol and power production applications are either already operating or currently planned.

CCUS projects have also emerged in more countries. Prior to 2010, most projects were located in the United States. While the United States still hosts around half of all projects, commercial projects are today operating in eight other countries, including Australia, Brazil, Canada, China, Norway, Saudi Arabia, the United Arab Emirates and Qatar.

In some cases, the growing fleet of operating or planned CCUS projects has provided an opportunity to apply and test CCUS regulatory frameworks that were established many years ago. For example, Australia and Canada have had legal and regulatory CCUS frameworks in place for more than a decade (including at sub-national levels). Meanwhile, other countries are now starting the process of developing legal and regulatory frameworks for CCUS to meet climate goals.

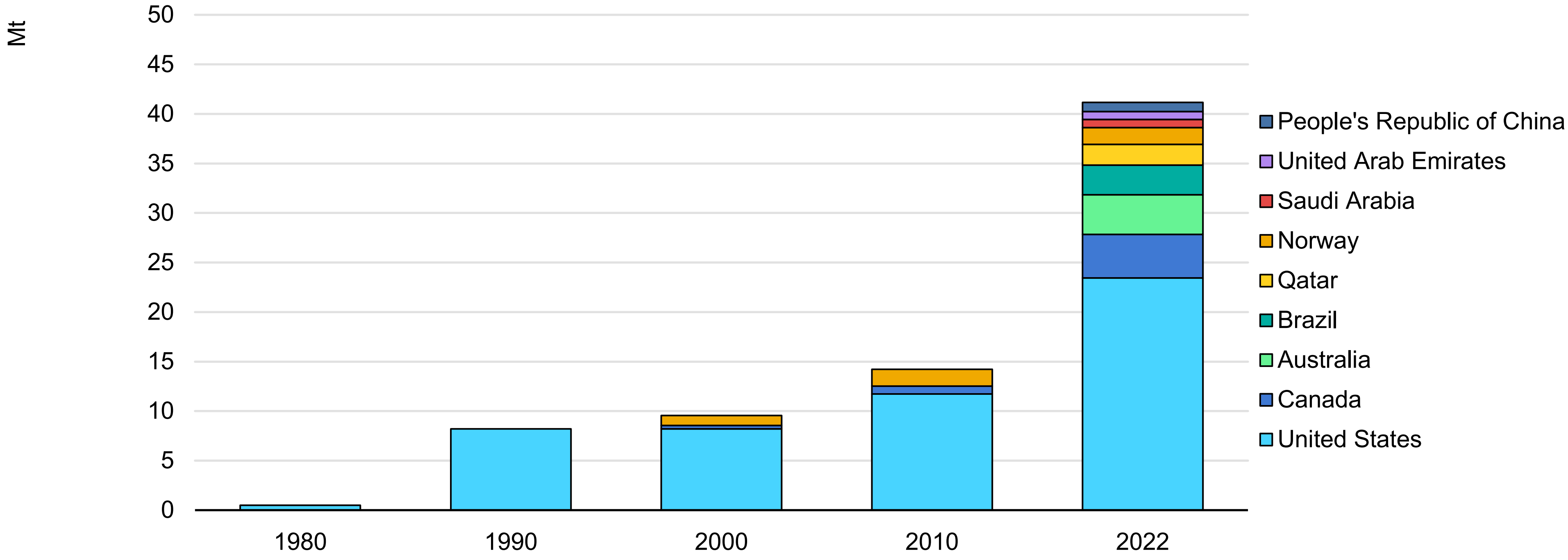
Regulatory considerations for CCUS deployment have also evolved since the 2010 Model Regulatory Framework. For example, there is a growing trend to move beyond single-chain projects and instead target industrial clusters and storage hubs. A hub approach can enable CO_2 capture from multiple sources and promote greater efficiencies and economies of scale. At the same time, hubs can trigger a range of legal and regulatory issues related to network access, as well as international or transboundary legal considerations if transport or storage infrastructure spans multiple countries or jurisdictions. In 2019 a major barrier to the cross-border transport and offshore storage of CO_2 was largely resolved with the provisional application of the 2009 amendment to Article 6 of the London Protocol, although bilateral agreements to operationalise it have yet to be struck.

The development of hubs may also prompt governments to reassess how CO_2 transport is regulated. While pipelines are generally the cheapest way to transport CO_2 in large quantities onshore and – depending on the distance and volumes – offshore, CO_2 transport by ship can offer greater flexibility than pipelines, including where there is more than one offshore storage facility available to accept CO_2. Frameworks may need to be reviewed to ensure that they cover and do not act as regulatory barriers to transporting CO_2 by ship.

Carbon removal is also gaining attention as the world shifts focus towards a net zero future. Technology-based carbon removal approaches can remove CO_2 from the atmosphere by combining bioenergy with carbon capture and storage (BECCS) or via DAC with CO_2 storage. This can help to balance emissions in sectors that are technically challenging or prohibitively expensive to decarbonise. Legal and regulatory frameworks may need to be amended or updated to accommodate – for example – CO_2 capture from the air rather than from point sources only.

Global CCUS projects have been concentrated in the United States, though deployment is diversifying across regions

Global CO_2 capture capacity at large-scale facilities by country



Sources: IEA analysis and tracking; Global CCS Institute CCS Facilities Database https://co2re.co/.

Key legal and regulatory issues for CCUS

The IEA has identified 25 priority legal and regulatory issues for CCUS deployment, as set out in the table below. These issues are discussed in detail in Chapters 3-6 of the handbook and supported with Model Regulatory Text. These issues are broadly grouped into eight categories:

- **Defining the regulatory scope**: issues that set the legal parameters for the classification and ownership of CO_2.
- **Environmental reviews and permitting**: requirements for operators to minimise environmental and public health impacts through detailed assessments and data collection and reporting.
- **Enabling first-mover projects**: approaches to reduce regulatory barriers and provide certainty to first- and early-mover projects.
- **Ensuring safe and secure storage**: issues that cover the full range of the storage development process, from resource assessment to the site closure process. This includes robust monitoring and reporting requirements for operators and financial security obligations, including any requirements to remediate the CO_2 storage site.
- **Addressing long-term storage liabilities**: issues surrounding requirements and responsibilities of operators and the relevant authority following the closure of a storage site.
- **International and transboundary issues**: regulatory issues that may arise from the cross-border transport and storage of CO_2.
- **Facilitating CCUS hubs**: considerations for enabling shared CO_2 transport and storage infrastructure.
- **Other key and emerging issues**: points that reflect recent developments and experience, but which may not be addressed in detail in current frameworks.

These issues address all aspects of the CCUS value chain, with a strong focus on how frameworks function to ensure the safe and secure storage of CO_2. For each issue, the handbook provides a description and general considerations for those designing relevant regulatory and legislative approaches. The issue descriptions are followed by case studies and examples of regulatory approaches.

While the aim is to highlight a range of legal and regulatory considerations for CCUS, there is no intention to be exhaustive or advocate a one-size-fits-all approach. It is recognised that individual governments should address issues according to their own particular circumstances.

Legal and regulatory issues for CCUS deployment

Page range	Category	Issue	Description
34-37	**Defining the regulatory scope**	Classification and purity of CO_2	Relevant classifications and characterisations of CO_2, e.g. as a waste, hazardous waste, pollutant, dangerous good, or commodity. Also the qualitative or quantitative requirements or standards for CO_2 streams.
		Ownership and title of CO_2	Defining CO_2 ownership along the CCUS value chain and over the life of a CCUS project.
38-49	**Environmental reviews and permitting**	Environmental impact assessment (EIA)	Applicable environmental protections and EIA requirements, including specific considerations for CO_2 storage.
		Permitting and authorisation	Application and issuance processes for CO_2 injection and storage permits, any prerequisites for permitting and commencement of injection, and any review, modification/cancellation and surrender mechanisms.
		Public engagement and consultation	Rights, obligations and mechanisms for public participation in CCUS activities, including by publication of proposals and permit registers, review and response processes, obligations to consider comments and avenues for legal or administrative challenge.
50-52	**Enabling first-mover projects**	One-off legislation	Dedicated legislation for a specific CCUS project in the absence of an existing, comprehensive framework.
		Preferential approaches and projects	Preferential development rights, including for CO_2 storage exploration and development, and special administrative and permitting arrangements for projects identified as being of strategic interest.
55-67	**Ensuring safe and secure storage**	Storage resource assessment	Regulation of the process to identify CO_2 storage resources suitable for development, including regional screening, site screening, site selection, initial characterisation and detailed characterisation.
		Ownership of pore space	Implications of legal ownership of subsurface geology, including pore space for CO_2 storage, which differs between regions.
		Measurement, monitoring and verification (MMV) plans	Monitoring and reporting obligations with respect to establishing baselines and identifying irregularities, and any requirements for independent verification of data.
		Storage site inspections	Inspection provisions, including mechanisms for authorising inspectors, inspector access rights, and operator obligations to allow access and share information.
		Operational liabilities and financial security	Allocation of liability, and obligation to post financial security, for damage or loss that occurs prior to any post-closure permit surrender or transfer of liability, and any regulator step-in and cost recovery mechanisms.
		Site closure process	The process for site decommissioning and closure, including conditions to be met prior to closure, obligations to plug wells, remove surface infrastructure and monitor stored CO_2, mechanisms for release of any financial security and compliance certification mechanisms.

Page range	Category	Issue	Description
68-72	**Addressing long-term storage liabilities**	Long-term liability post site closure	Arrangements (if any) for the transfer to the state or relevant authority of liability in respect of a closed CO_2 storage site and/or injected CO_2, including any preconditions, any post-closure period that must elapse prior to the transfer, and any liability retained by operator.
		Financial assurances of long-term site stewardship	Mechanisms under which operators are required to contribute financially to the costs of long-term site stewardship of a CO_2 storage site following any site closure.
73-80	**International and transboundary issues**	Regulating cross-border CO_2 transport	Captured CO_2 can move across one or more jurisdictions, which may trigger certain national or international regulatory requirements.
		Compliance with the London Protocol	Obligations and requirements for cross-border transport of CO_2 under the London Protocol and the 2019 Resolution for Provisional Application of the 2009 CCS Export Amendment.
		Interaction of pressure fronts across international borders	Interaction of subsurface geology, specifically pressure fronts in large CO_2 storage formations, occurring across jurisdictional boundaries.
		Overlap between multiple frameworks	Potential overlap between multiple regulatory frameworks, for example where projects outside the United States are credited under California's Low Carbon Fuel Standard with specific regulatory requirements.
81-85	**Facilitating CCUS hubs**	Access to shared transport infrastructure	Obligations or arrangements to allow third-party access to CO_2 transport infrastructure, including any right to refuse access, and relevant compensation and dispute resolution mechanisms.
		Facilitating shared storage infrastructure	Obligations or arrangements to allow third-party access to storage sites, including any right to refuse access, and relevant compensation and dispute resolution mechanisms.
86-94	**Other key and emerging issues**	Treatment of CO_2 removal technologies	Treatment of CO_2 removal technologies, such as DAC, within existing and future legal and regulatory frameworks.
		Interaction with other surface and subsurface resources	Interaction of CCUS projects – and storage infrastructure in particular – with other subsurface and surface resources, such as oil and gas activities and offshore wind.
		Transitioning from CO_2-EOR (enhanced oil recovery) to dedicated storage	Regulatory considerations for transitioning CO_2-EOR operations to dedicated CO_2 storage.
		CCUS-ready requirements	Comprehensive criteria for facilities to be considered ready and able to adopt CCUS in the future.

Priority actions for policy makers and legislators

Establish the foundation

- Identify key regulatory issues.
- Review international best practices, approaches and standards.
- Assess existing regulatory frameworks for CCUS activities.
- Identify regulatory gaps and barriers.
- Find the framework approach that fits best (e.g. adopting project-specific legislation, a comprehensive framework or hybrid approach) and build regulatory support capacity.
- Put in place a regulatory review process to regularly assess frameworks.

Define the regulatory scope

- Review definitions of hazardous waste, pollutants and commodities to ensure the classification of CO_2 under existing frameworks does not act as a barrier to CO_2 transport or storage.
- Clearly define CO_2 ownership across the CCUS value chain, especially for frameworks that may promote a common carrier model for transport.

Establish environmental safeguards and support public engagement

- Use existing frameworks to assess environmental review requirements and incorporate specific assessment needs for CCUS projects where needed.
- Assess the opportunity to use permitting approaches within existing frameworks as a base for storage site exploration and development, and for CO_2 pipelines.
- Ensure relevant authorities have enough internal capacity to review and process permitting applications.
- Establish rights, obligations and mechanisms for public engagement and consultation for CCUS developments.
- Promote public consultations early on in the project development process to foster public stakeholder confidence.

Enable first-mover projects

- In the absence of a comprehensive CCUS framework, consider project-specific legislation to facilitate the development of CCUS projects.
- Consider preferential rights and administrative arrangements for early CCUS projects identified as being of strategic interest.

Ensure safe and secure storage

- Set the parameters for what CO_2 storage resources can be developed, based on a range of performance criteria.
- Clearly define pore space ownership to avoid storage resource assessment and development complications.
- Establish minimum requirements for MMV plans.
- Ensure the relevant authority can verify, by way of storage site inspections and data reporting, that storage projects are performing as intended.
- Ensure the storage operator is financially capable of remediating any potential problems that may arise during site operators.

Address long-term storage liabilities

- Clarify the ownership and long-term responsibility and liability for stored CO_2 and establish responsibilities for addressing and remediating the seepage of CO_2 from the formation.
- If the relevant authority assumes long-term stewardship and liability of the storage site, ensure that requirements are in place, prior to transfer, for the operator to demonstrate confidence that there is no significant risk of future leakage.
- Consider establishing financial security requirements, such as a fund, to cover the long-term monitoring and management costs of the storage site.

Address international and transboundary issues

- Outline provisions that account and allow for the cross-border transport and storage of CO_2.
- Ensure mechanisms are in place for the early identification and resolution of subsurface CO_2 migration or pressure propagation across borders.
- Develop and share publicly bilateral agreements for cross-border transport of CO_2 under the provisional application of the 2009 CCS export amendment to the London Protocol.
- Establish guidelines that recommend what to do in the event of overlap between multiple frameworks.

Facilitate CCUS hubs

- Outline conditions for access to shared CO_2 transport and storage infrastructure, such as technical capability and capacity.
- Ensure access to shared CO_2 infrastructure is non-discriminatory and dispute mechanisms are in place.

Manage other emerging and strategic issues

- Ensure frameworks consider the treatment of CO_2 removal technologies, such as BECCS and DAC with CO_2 storage (DACS), including measurement and quantification of emission removals.
- Consider suitable spatial planning interactions between CCUS and other resources, such as oil and gas reservoirs, geothermal and offshore wind installations.
- Establish a pathway with clear and robust requirements for CO_2-EOR projects that transition to dedicated storage operations.
- Where alternative solutions are not viable and CCUS cannot be immediately adopted, consider CCUS-ready requirements for any new emissions-intensive industrial or power facilities.

Chapter 2
Developing legal and regulatory frameworks

Getting started

Developing comprehensive legal and regulatory frameworks for CCUS will almost always involve substantial planning and consultation that can take up to several years. For example, implementation of the world's first national (offshore) CO_2 storage laws in Australia took over five years, from 2003 to 2008. The experience gained from this early work can inform the development of future frameworks.

Policy makers and regulators encounter several overarching considerations in planning for the development of CCUS laws and regulations, including:

- What is the anticipated role of CCUS in meeting national energy and climate goals?
- How will CCUS laws and regulations fit within existing legal frameworks?
- Are regulatory guiding principles available, for example to address issues such as long-term CO_2 storage liability?
- Who are the key stakeholders and how will they be consulted?
- Is there a process to review or amend the framework in the future, to account for changes in the sector or lessons learned?
- Are the regulatory authorities sufficiently resourced to oversee CCUS activities?

While recognising that each jurisdiction will have established processes for developing laws and regulations, this chapter sets out six steps that can help to guide the development of CCUS regulation:

1. Identify key regulatory issues.
2. Review international best practices, approaches and standards.
3. Assess existing regulatory frameworks for CCUS activities, including identifying gaps and barriers.
4. Identify options for regulating CCUS.
5. Find the best fit and build regulatory support capacity.
6. Review frameworks regularly.

Step 1: Identify key regulatory issues

This handbook defines 25 key legal and regulatory issues for CCUS, as set out in the table on page 15. Most concern the safe and secure storage of CO_2, but a number of cross-cutting and emerging issues are also considered, for example the development of industrial CCUS hubs and legal considerations for technology-based CO_2 removal. These issues have come into global focus since the 2010 IEA Model Regulatory Framework was developed. However, many issues – particularly around CO_2 storage – are longstanding considerations for the development of CCUS regulations.

While these 25 issues can provide a starting point for a national or regional assessment, governments should also seek to identify and define issues within their specific policy and regulatory context. For example, certain issues may already be codified in regulations covering resource extraction or environmental impact procedures. The anticipated role of CCUS within a jurisdiction may also shape the identification of key issues, for example by focusing attention on particular applications or regions.

Complementing the list of key regulatory issues, the handbook's Model Text provides language that governments can use to incorporate jurisdictionally appropriate additions and amendments to new or existing frameworks. The Model Text can be found at the end of the handbook in the Annex.

Step 2: Review international best practices, approaches and standards

It is important to understand the international legal and regulatory context when developing domestic CCUS regulation. Reviewing established legal frameworks for CCUS provides a useful starting point in the process. This handbook highlights best practices from several established frameworks.

International standards can actually shape domestic regulatory regimes or provide a baseline framework in the absence of a comprehensive CCUS regulatory framework. For example, ISO 27914 and ISO 27916 establish requirements and recommendations for the geological storage of CO_2 and its use in EOR, respectively. These two standards, which are designed to complement each other, serve different purposes – ISO 27914 is designed to promote the commercial, safe, long-term containment of CO_2 and ISO 27916 is designed to quantify and document the amount of CO_2 stored during EOR.

Efforts are underway to standardise various other aspects of CCUS operations. The ISO Technical Committee 265 is working on standards for CO_2 pipeline transport systems, risk management, flow assurance, transition from CO_2-EOR to storage and CO_2 transport by ship.

Applying ISO 27916 to 45Q in the United States

In the United States, the 45Q tax credit provides up to USD 50 per tonne of CO_2 permanently stored and USD 35 per tonne of CO_2 used for EOR or other industrial applications, provided emission reductions can be clearly demonstrated.

In order to claim the tax credit and demonstrate secure storage, operators have had to follow regulatory guidelines outlined under Subpart RR of the Environmental Protection Agency Greenhouse Gas (GHG) Reporting Program. Operators that report under Subpart RR self-certify CO_2 volumes in order to claim the tax credit.

In January 2021 the Internal Revenue Service issued new guidance that now allows operators of CO_2-EOR projects the choice to continue reporting under Subpart RR or abide by ISO 27916. Operators that choose to apply ISO 27916 cannot self-certify and instead must have documentation certified by a qualified independent engineer or geologist.

Both Subpart RR and ISO 27916 require an assessment and monitoring of potential leakage pathways, quantification of inputs, losses and storage through a mass balance approach, and documentation of steps and approaches. However, ISO 27916 does not require public reports on the amount of CO_2 stored, whereas Subpart RR does.

Step 3: Assess existing regulatory frameworks for CCUS activities, identifying gaps and barriers

A comprehensive review of existing laws and regulations potentially applicable to CCUS activities is an important step in developing CCUS-specific frameworks. Similar to the international assessment, this review should take into account the main regulatory issues identified in Step 1. This provides the basis to identify any gaps or barriers in regulatory frameworks.

Governments should consider the following issues when carrying out this review:

- **How can existing regulatory frameworks be used to address issues raised by CCUS operations?** For example, existing oil and gas legislation may offer a good starting point to develop a CCUS framework.
- **Do existing frameworks act as a barrier to aspects of CCUS?** For example, groundwater protection legislation may prevent CO_2 injection into certain saline aquifers.
- **Are there any unintended consequences?** For example, hazardous waste regulation may classify CO_2 as a pollutant and prevent injection, limit its transport or add further permitting requirements.

Other areas of existing regulatory frameworks may also govern energy production, land use planning, property rights, and health and safety.

Next, governments should identify whether there are any gaps in existing domestic laws and regulations, and if so, how such gaps can be addressed. In other words, what are the regulatory issues that existing frameworks or international practices fail to address?

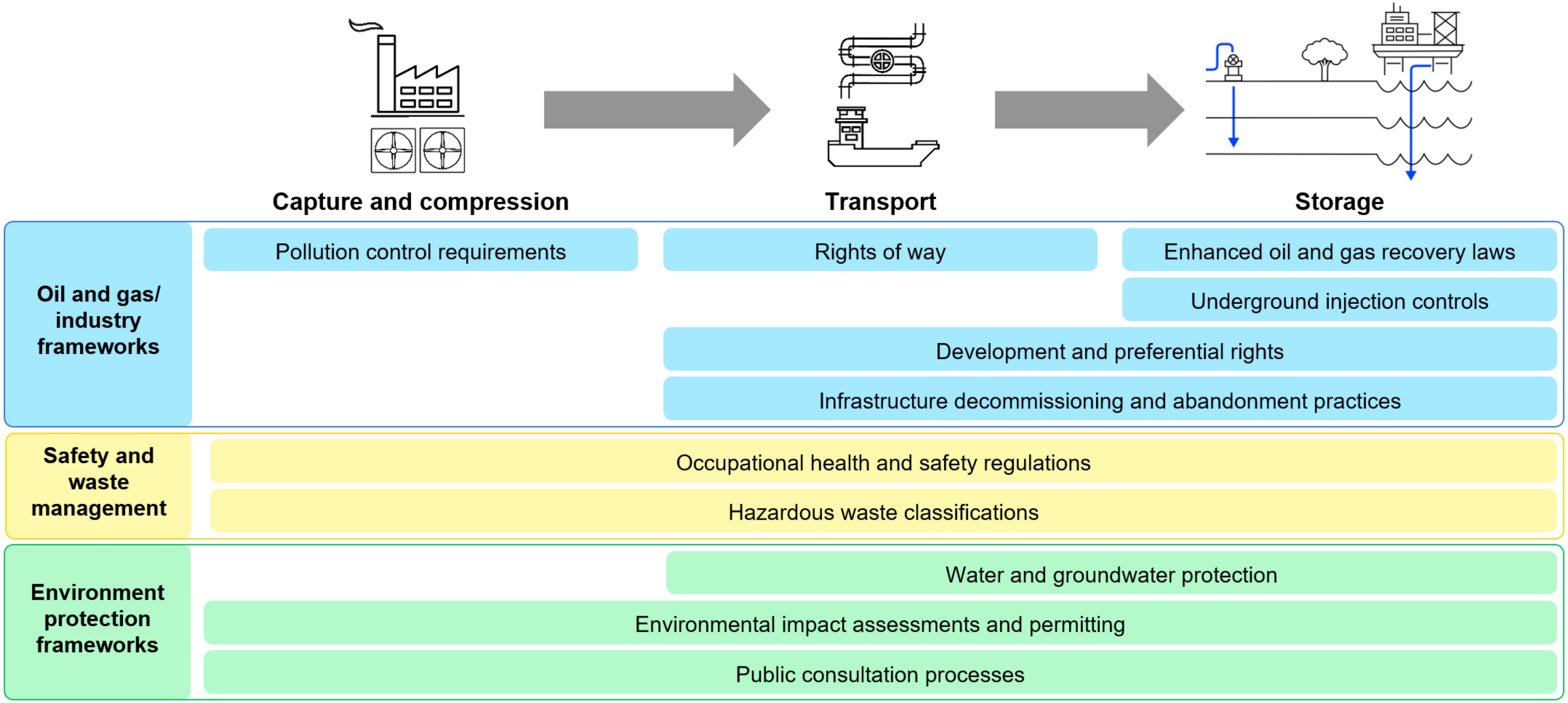
Likewise, it is important to identify major barriers to CCUS, either in existing legislation or in the solutions to address the gaps.

To perform the gap and barrier analysis, existing legislation and regulation should be assessed to determine:

- Their suitability to handle the specific risks involved in CCUS operations and whether modifying their scope to cover CCUS would help fill the regulatory gaps.
- Whether specific exemptions are required to remove any barriers to CCUS.
- Whether adding requirements or removing barriers would create any unintended consequences for existing activities and operations.
- Any potential conflicts between frameworks and, if possible, which law would prevail.

The analysis then leads to specific actions to close gaps and/or remove barriers.

Examples of existing regulations that may be relevant for CCUS activities



Case study: Developing a legal and regulatory framework in Indonesia

Indonesia has made significant progress in building the necessary tools to facilitate CCUS investment in order to meet its net zero goal by 2060. It has gained early experience through the Gundih Pilot Project and has demonstrated strategic interest in CCUS through the launch of the Institut Teknologi Bandung Centre of Excellence for CCS and CCU in 2017 and the early development of several planned commercial CCUS projects.

To facilitate the deployment of CCUS, the Ministry of Energy and Mineral Resources has prepared a draft regulatory framework for CCUS, the first of its kind in Southeast Asia. The framework, in the form of a draft ministerial regulation, builds on a 2019 draft Presidential Decree that outlined regulatory areas for a CCUS framework.

Rooted in the country's existing oil and natural gas regulations, the draft framework relies on the holders of oil and gas leases to spearhead CO_2 storage development and operation. Storage activities, which include dedicated storage operations as well as those associated with enhanced hydrocarbon recovery, are to be conducted within the existing lease areas, such as in depleted oil and gas fields. The framework also includes a transfer mechanism whereby the government assumes long-term monitoring, stewardship and liability following the approval of site closure.

In addition to the technical and legal requirements needed to ensure safe and secure CO_2 storage, the draft framework also outlines several business and economic aspects. For example, the framework outlines potential pathways to monetising carbon credits for the project and its partners. In addition, the framework outlines conditions under which storage operators may grant third-party access to storage facilities.

The Ministry of Energy and Mineral Resources has proposed that the draft regulation, which must be harmonised by other ministries and obtain presidential approval, be a priority for 2022.

Step 4: Identify options for regulating CCUS

Based on the analysis in Steps 1-3, governments may have several options for regulating CCUS activities. In some cases, only minor modifications to existing laws and regulations may be needed; in other cases, major modifications or new legislation may be required. As is the case in other regulatory frameworks, there may be trade-offs involved in the various options – such as the trade-off between the time it takes to amend or develop comprehensive legislation for CCUS activities and the goal of expediting new project development.

Identifying regulatory options in South Africa

South Africa has identified CCUS as a key technology to meet its emissions reduction targets while also balancing social and economic considerations. In 2010 South Africa released its Atlas on the Geological Storage of Carbon Dioxide, the first major milestone in identifying potential storage sites in the country. A detailed analysis of the country's legal and regulatory frameworks followed, which aimed to develop possible legal and regulatory pathways for CCUS in South Africa. This work identified several regulatory options:

- **Option 1**: Modify waste legislation as the primary means to regulate CCUS activities. Under this status quo approach, only minor amendments to existing legislation would be required. However, it would not address other regulatory issues, such as subsurface access rights and long-term liability, potentially causing project development delays or deterring potential investment.
- **Option 2**: Amend parts of existing waste legislation, but also rely on provisions in existing environmental legislation (such as those covering environmental impact assessments). It is unclear whether or not this approach would provide a sufficiently robust regulatory framework for risk assessment and permitting.
- **Option 3**: Build on existing mineral and petroleum development legislation as the basis for regulating CO_2 injection and storage activities. Compared to Options 1 and 2, this approach provides greater clarity to subsurface access rights, permitting procedures for CO_2 storage site development, financial requirements for operators, management of site closure and long-term site stewardship. However, it would require significant drafting and modification.
- **Option 4**: Develop standalone CCUS legislation, which would cover all aspects of CCUS activity. This option would require significant time to develop.

Step 5: Find the best fit and build regulatory support capacity

After a comprehensive review of existing frameworks and identifying potential options for regulating CCUS, governments have two routes to developing a CCUS regulatory framework:

- **Revise existing frameworks to cover CCUS activities**. As outlined in Step 4, governments can amend existing frameworks to regulate CCUS projects. This could be appropriate where there is substantial legislation already in place that covers aspects of CCUS activities. This approach could provide a testing ground for emerging CCUS regulation and public engagement programmes.
- **Develop a dedicated CCUS regulatory framework**. If existing frameworks are not sufficient, governments can develop dedicated CCUS frameworks for commercial deployment. Comprehensive regulatory frameworks often take several years to develop, and it is important to consult with relevant stakeholders throughout the process, including the planning and post-implementation phases.

In many cases, governments may choose to adopt a hybrid approach in which certain existing regulations are amended – such as those governing the oil and gas sector or the water sector – and some regulations are created via new legislation.

No matter which approach is taken, governments should define the framework's parameters in partnership with stakeholders – this involves outlining geographic coverage, exclusions and prohibitions based on the relevant authority's jurisdiction. For example, depending on which relevant authority is in charge, the framework's scope may be limited to regulating onshore storage, offshore storage, geological storage or volume of CO_2 in excess of specified minimum volumes.

In any case, governments should ensure that the relevant authorities have enough resources to carry out their regulatory requirements. It is vital that they are equipped with sufficient funding, staff and expertise to oversee the implementation of CCUS regulations.

Along those same lines, governments should ensure that stakeholders are actively informed on how to comply with regulations – this is particularly important for CO_2 storage regulations, which often require comprehensive storage site monitoring and reporting. This may require regular workshops and training, for both the relevant authority and other stakeholders, such as operators.

Taking these steps will help:

- Ensure the safe, secure handling and storage of CO_2.
- Protect human health and the environment.
- Reduce regulatory delays.
- Ensure timely completion of CCUS projects.

Case study: Framework development approach in Mexico

Mexico's comprehensive assessments of regulating CCUS activities provide insights into how a government might approach developing a framework.

In 2012 the Asia-Pacific Economic Cooperation (APEC) forum commissioned a report examining CCUS legal and regulatory regimes for APEC economies, including Mexico. The study was the first general assessment of a framework for CCUS activities in the country, and provided a starting point for future studies.

With the support of the World Bank, an in-depth assessment was developed in 2016 to examine the existing regulatory framework for CCUS activities in Mexico and identify adjustments for CCUS project implementation. It adopted a comprehensive approach, resulting in recommendations for a CCUS framework in Mexico.

- **Step 1:** At the outset, the study drew up a list of 38 key regulatory issues based on the IEA's 2010 Model Framework. It grouped the issues into five categories based on the life cycle of a CCUS project. These regulatory issues provided the basis of the study's analytical approach.
- **Step 2:** The study then examined the regulation of CCUS activities in countries with well-developed CCUS regulatory frameworks. These included Australia, Canada, the United States and the European Union. Information was gathered from reports, academic publications, legal instruments and publications from international organisations. The study matched the key regulatory issues against the main aspects of each regulatory framework in the jurisdictions studied.
- **Step 3:** The next step was an extensive assessment of existing laws and regulations that might apply to CCUS activities in Mexico. The assessment found relevant legislation that may apply or be amended to cover some CCUS activities. This analysis applied the same list of key regulatory issues and formed the basis for identifying gaps and barriers in existing legislation.
- **Step 4:** Next, the study assessed potential gaps between issues covered by existing regulations and issues covered by international best practices. The primary purpose of this gap analysis was to provide a foundation for recommendations on developing a regulatory framework, by means of using or amending existing legislation or creating new legislation.
- **Step 5**: Based on the steps above, the study made recommendations on how to amend the regulatory framework for CCUS activities in Mexico. The recommendations were framed around the main categories of issues identified in Step 1.

The detailed analysis of legal and regulatory issues provided a basis for the government of Mexico to develop and adapt the existing regulatory framework for each key stage in the CCUS project timeline.

Step 6: Review frameworks regularly

Regulatory frameworks for CCUS should not be static. As governments gain experience from implementing regulations and learn lessons from early-mover projects, they should review their frameworks periodically to ensure that laws and regulations continue to support CCUS activities.

The level of review is likely to depend on how a jurisdiction's framework is structured. For example, if a jurisdiction has a comprehensive CCUS framework, a detailed review that identifies current regulatory issues and gaps may be required. In most cases, this is likely to require modifications to the existing framework in order to address regulatory gaps. Conversely, if a jurisdiction's CCUS framework is directed at a specific project and is shaped by one-off legislation, the review is likely to be more targeted at the regulatory issues encountered by the project. Any changes are likely to require new legislation and the further build-out of the regulatory framework for CCUS.

Project developers and relevant authorities with first-hand experience of the regulatory process can provide valuable input to the regulatory development and review process. Input should also be solicited from a wide range of stakeholders across industry, academia, research organisations, international experts, environmental organisations and local government to ensure that a variety of perspectives is taken into account.

Regulatory Framework Assessment in Canada

In 2011 the government of Alberta initiated a nearly two-year review of its CCUS regulatory framework. The Regulatory Framework Assessment (RFA) was a multi-stakeholder process guided by a steering committee, which reviewed the technical, environmental, safety and monitoring requirements for CCUS.

The purpose of the RFA was to identify any regulatory issues or barriers to CCUS deployment by examining the existing regulatory framework in Alberta and best practices in other countries. Over the course of the review, the assessment considered several guiding principles, such as:

- Protecting the environment and potable water sources.
- Ensuring the long-term liability of stored CO_2 would not become a financial burden on Albertans.
- Promoting clear and open communication with stakeholders.
- Making use of site-specific risk management for CCUS activities.
- Considering potential resource interactions with stored CO_2.
- Leveraging experience in the oil and gas industry for CCUS.

The principles fed into the RFA's 71 recommendations, which identified specific opportunities to improve Alberta's regulatory framework for large-scale CCUS activities. The recommendations are summarised in the table below.

Alberta's Regulatory Framework Assessment for CCUS activities

	Summary of recommendations for the government of Alberta
Applications, approval and regulatory framework	• Clearly define how projects are classified as CCUS or for CO_2-EOR, and the process to transition from CO_2-EOR to permanent storage. • Define the role and responsibilities of each regulator and create clear industry guidance. • Determine conditions under which an environmental impact assessment should be required. • Require monitoring, measurement and verification (MMV) plans and closure plans to accompany CCUS-related applications. • Consider subsurface CO_2 injection applications on a case-by-case basis, and give the regulator flexibility. • Conduct a review of applications for CCUS tenure to determine the need for surface-level environmental protections. • Evaluate potential to impact other resources (including pore space). • Encourage CCUS project developers to work together; allow developers to apply for access to another operator's pipelines or storage sites if private negotiations fail; change tenure agreements to enable tenure to be revoked if it remains unused. • Require projects to report release of CO_2 and reconcile earned emissions credits.
Public consultation	• Review and update notification and consultation requirements, including that everyone within the tenure boundary be informed about the CCUS project. • Develop emergency planning zones around CCUS project infrastructure. • Improve public access to information on the regulatory process. • Clarify that CCUS operators can apply for access to conduct MMV or reclamation activities over the entire area of the storage lease.

	Summary of recommendations for the government of Alberta
Risk assessment and monitoring	• Require MMV and closure plans to be based on a project-specific risk assessment. • Determine if Alberta should adopt all or part of the Canadian Standard Association standard for geological storage of CO_2. • Conduct research on Alberta's use of amines and their effects, and determine if further regulation of post-combustion capture technologies is needed. • Require CO_2 storage sites to demonstrate sufficient capacity, injectivity and containment parameters. • Define concentrations of other components for injection well activities and require certain well casing strings to be cemented from the well base to the surface. • Evaluate if further research is needed on methods for detecting leaks from CO_2 pipelines.
Site closure and long-term liability	• Clarify the process for closing a CO_2 storage site and the information closure plans must contain. • Establish performance criteria for closing a storage site. • Transfer liability for CO_2 credits to the Crown when a closure certificate is issued. • Set project-specific fees for a post-closure stewardship fund that covers the costs of long-term monitoring and maintenance, CO_2 credits liability and costs associated with unforeseen events. • Require operators to post financial security to pay for site closure and reclamation in case they become defunct.

Source: Adapted from Alberta's RFA.

Chapter 3
Regulatory foundations

Defining the regulatory scope

Typically, legal instruments include a section that defines how certain terms used within the document are to be interpreted. In the case of CCUS regulatory frameworks, definitions will generally be required to describe the scope and meaning of certain technical terms; clarify the meaning of certain events, activities or processes; and implement certain standards, conventions or agreed requirements as set out in international legal instruments. A list of definitons can be found at the end of this handbook in the Annex.

To further define the scope of CCUS regulations, governments should consider how CO_2 may be classified under existing regulations, such as whether it is classified as a waste or a commodity. This may influence how CCUS operations are regulated. In addition, it is important that regulations define CO_2 ownership along the value chain.

Classification and purity of CO_2

The legal classification of CO_2 has potential implications for the way existing regulatory frameworks might apply to CCUS operations. This is because classifying captured CO_2 as reflecting certain properties – or classifying the act of capturing, transporting and storing CO_2 as similar to existing activities, such as waste management – may mean that aspects of existing regulations will apply to CCUS operations. Existing regulations may inadvertently classify CO_2 as hazardous, waste, a pollutant or a commodity.

Streams of captured CO_2 for transportation and injection will contain some impurities. The type of constituents present, and their relative concentrations, will depend on the source from which the CO_2 is generated and captured, as well as any material entrained in the CO_2 stream as a consequence of capture and other treatment processes. From a technical perspective it is important to reduce or remove certain impurities. For example, some impurities may have a corrosive effect on CO_2 pipelines and well casings.

It is important that frameworks do not adopt arbitrary constraints in regulating CO_2 purity levels. When designing CCUS regulatory approaches, several issues relating to impurities need to be considered:

- concentration of impurities
- total flow of impurities
- addition of other matter for the purpose of waste disposal
- potential impacts of impurities.

Global examples and approaches

In the United States, United Kingdom and European Union, CO_2 captured, transported or stored is mainly excluded from definitions of waste, pollutant or nuisance.

In Montana, injection of CO_2 into a storage reservoir is excluded from the definition of "contamination of groundwater" and is exempt from groundwater permit requirements. In North Dakota, CO_2 that is permanently stored, or stored in the short term, with no leakage does not constitute a pollutant or nuisance. In Texas, CO_2 streams are excluded from definitions of hazardous waste. The regulations note that a CO_2 stream may include "incidental associated substances" derived from the source and added to the stream to improve the injection process.

The London Protocol – an international agreement on preventing marine pollution – prohibits the export of "wastes or other matter" to other countries for dumping or incineration at sea. CO_2 streams, which must consist "overwhelmingly" of CO_2, were originally included in this prohibition. However, amendments to the protocol in 2009 enable CO_2 transport and storage; this is discussed in further detail in Chapter 5.

Amending US offshore regulations to allow sub-seabed CO_2 storage

In November 2021 the United States amended key parts of its regulatory framework to allow for the offshore storage of CO_2 in federal waters.

Prior to the changes, the regulatory framework under the Outer Continental Shelf Land Act primarily applied to the siting and permitting of oil and gas activities and certain types of renewable energy projects (e.g. offshore wind). The original framework maintained a narrow focus when applied to offshore CO_2 storage activities, only covering the use and storage of CO_2 for EOR activities on existing oil and gas leases and the sub-seabed storage of CO_2 from onshore coal-fired power plants. Captured CO_2 from other power generation sources or industrial facilities and CO_2 removed from the air were not explicitly mentioned in the framework.

The recent changes, which were included under comprehensive infrastructure legislation, clarify definitions of CO_2 streams and storage, add leasing and rights-of-way provisions for CO_2 storage activities and address potential waste issues associated with sub-seabed CO_2 storage.

Definitions: the definitions of a "carbon dioxide stream" and "carbon sequestration" were added to the framework to clarify and affirm the regulator's jurisdiction over sub-seabed CO_2 storage. The new definition of CO_2 storage expands the original scope, which only covered CO_2 captured from coal-fired power plants, to account for CO_2 that has been "removed from the atmosphere or captured through physical, chemical, or biological processes that can prevent the carbon dioxide from reaching the atmosphere".

Leasing provisions: the changes give the relevant regulatory authority the power to grant leases, easements and rights of way for offshore CO_2 storage projects. These new provisions are especially important for the supporting CO_2 transport infrastructure.

Clarification of waste material: the new framework specifically excludes "carbon dioxide stream(s) injected for the purpose of carbon sequestration" from existing ocean waste regulations. This change also helps to clarify waste definitions in state waters.

The new framework requires the regulatory authority to develop regulations within one year to establish the permitting and leasing arrangements for offshore CO_2 storage leases in federal waters.

These changes to the US regulatory framework for offshore CO_2 storage further highlight the importance of reviewing definitions and classifications of CO_2 in existing frameworks in order to remove barriers to CCUS deployment.

Ownership and title of CO_2

The ownership of CO_2 should be clearly defined as it moves across the CCUS value chain. This is especially important for non-integrated projects where the owner and/or operator of a CO_2 capture facility may be different from the transport or storage operator. Defining who owns the captured CO_2 throughout the value chain can help establish who is responsible for any potential leakage along the way, and in some cases determine eligibility for policy incentives.

Commercial contracts will dictate CO_2 ownership in most cases, although existing regulations can influence ownership obligations, especially for CO_2 transport. Common, contract and private carrier models can be used for CO_2 transport; unlike private carriers that own the CO_2 until the point of delivery to a third party, neither common nor contract carriers will assume ownership of the CO_2 they transport. These models are explained in further detail in Chapter 5.

In jurisdictions with an existing oil and natural gas industry, pipeline regulations could be extended or adapted to cover CO_2 transport. For example, in the United States, CO_2 pipelines largely operate as private carriers, owning the CO_2 in the pipeline until it is ultimately delivered to a third party. This largely mimics the early days of oil pipelines in the country, which operated as private carriers until federal laws and regulations established them as common carriers.

Frameworks can also influence CO_2 ownership transfer as it relates to the long-term stewardship of the storage site. In some cases, such as in Norway, there is no explicit mention of CO_2 ownership and it is assumed that CO_2 ownership is transferred from the operator to the government alongside the transfer of long-term stewardship. In other jurisdictions, such as in Nebraska (United States), the title of the stored CO_2 is explicitly mentioned in the regulation when addressing the transfer of long-term site responsibility to the government.

Environmental reviews and permitting

The environmental review process for CCUS projects consists of several layers of assessments and permitting requirements across the value chain. Existing frameworks can typically address the majority of review requirements for CO_2 **capture** and **transport** infrastructure, although small changes may need to be made to regulations to account for technical requirements. In contrast, CO_2 **storage** infrastructure requires targeted regulatory attention in order to minimise potential leakage and safety risks. CCUS-specific approaches, as outlined in this report, should be developed to ensure safe and secure CO_2 storage. Governments can use existing oil and gas or mining frameworks as a basis for some permitting requirements and injection authorisations.

Environmental impact assessments

Completion of an environmental impact assessment (EIA) is standard practice for major infrastructure projects in many jurisdictions and would typically be a requirement for any projects receiving multilateral and donor finance. The EIA should identify local and regional environmental impacts and provide options for minimising them. Impacts are likely to include those associated with emissions to air and water, the use of water and solid waste generation, as well as the impacts on organisms, such as aquatic life, at-risk species, etc.

Existing EIA laws or international and corporate standards are likely to cover the major surface components of a CCUS project, such as CO_2 source, capture installation, transport installation, wells and any surface facilities at injection sites. Similarly, any surveying activities such as seismic acquisition are also likely to be covered by appropriate EIA arrangements.

While the EIA process varies depending on the jurisdiction, the main steps tend to include the following:

- screening
- scoping
- analysis of alternative options
- project description
- environmental baseline review
- legislative review
- impact identification, prediction, significance and mitigation
- environmental management plan and monitoring programme
- reporting
- review
- project implementation and operation.

Global examples and approaches

Victoria (Australia), Norway and the United Kingdom consider environmental impact in the assessment for issuing storage permits.

Victoria and the United Kingdom specifically mention human health in the assessment for issuing storage permits. The United Kingdom derives its environmental protection requirements from the European Union CCS Directive, to include the operation of storage sites as an activity for which there is liability under the Environmental Damage Regulations. The United Kingdom includes land protection and sustainable development in its environmental protection regime for developing CCUS projects.

Norway's approach puts an emphasis on the protection of the geological area of subsea reservoir and requires operators to consider any transboundary environmental effects. As part of the EIA, the relevant authority requires storage operators to assess and consider the following environmental consequences of the development and operation of a storage site:

- Describe discharges to sea and emissions to air.
- Describe any material assets and cultural artefacts that may be affected as a result of the development.
- Assess the consequences of the chosen technical solutions.
- Clarify how environmental criteria and consequences have been used as a basis for the chosen technical solutions.
- Describe possible and planned measures to prevent, reduce and if possible compensate for considerable negative environmental impact.

Permitting and authorisation

Just as with any major industrial project, a well-functioning and clear permitting process is important for CCUS projects. To ensure that the relevant authority can assess and process permit applications in a timely manner, governments should make sure that the relevant regulatory authority has adequate resources and capacity.

In many jurisdictions, permitting of **CO_2 capture facilities** will not require major modifications to existing laws and regulations.

Permitting of **CO_2 pipelines** is likely to involve the modification of existing laws rather than the introduction of a large tranche of specific new measures. While the properties of CO_2 lead to different design specifications compared with natural gas, CO_2 transport by pipeline bears many similarities to high-pressure transport of natural gas. From a permitting perspective, this means that existing legal and regulatory frameworks for the oil and gas industries can be used to support the development of CO_2 pipelines. For example, key regulatory considerations for CO_2 transport that may also apply to existing frameworks include:

- Health, safety, civil and environmental protection rules.
- Pipeline siting, routing and rights-of-way requirements.
- Eminent domain authorisations.[1]
- Laws relating to the reuse of pipeline infrastructures or decommissioning.

In some cases it may be necessary to develop secondary guidelines under existing legislation to cover specific technical matters relating to CO_2 transport, such as properties of the CO_2 stream and pressure and release characteristics.

Permitting processes for **CO_2 storage** typically involve two main phases:

- **Authorisation for site exploration** can be implemented in different ways, varying from a single authorisation or licence to a combination of multiple authorisations or licences. Given the similarities between the techniques used to explore for oil and gas and those used to explore for CO_2 storage, oil and gas frameworks can act as a basis for CO_2 permitting arrangements. Key areas that exploration authorisation should address include clarification of rights, exclusivity of information and development, time-limiting authorisations and storage market operation.
- **Authorisation for injection and storage activities** should require significant detail on how the project will operate. This includes modelling results, a monitoring plan, and details on how the project will be closed, such as decommissioning and rehabilitation plans.

[1] Eminent domain refers to the power of the government to expropriate private property and convert it to public use, provided that adequate compensation is given to the property owners.

In many cases, frameworks require storage operators first to have an exploration licence before applying for an injection and storage permit.

Global examples and approaches

Issuance of storage permits is generally subject to conditions such as the technical competence of the operator, its financial strength and monitoring requirements. These conditions can be very specific. In the European Union, under the CCS Directive storage permit applications must state, among other things, the total quantity of CO_2 to be injected and stored, prospective sources and transport methods, composition of CO_2 streams, injection rates and pressures and proposed monitoring and post-closure plans. In Northern Ireland (United Kingdom), storage permit applications must include, among other things:

- A proposed monitoring plan.
- A proposed corrective measures plan.
- A proposed provisional post-closure plan.
- Details of financial security.

In some jurisdictions, only holders of an exploration permit can apply for an injection and storage permit. In Queensland (Australia), parties who are not holders of an exploration licence cannot apply for a storage licence. However, in British Columbia (Canada), holders of petroleum and natural gas permits, leases or exploration licences may apply for a storage reservoir lease.

In Norway, an exploration licence is needed to undertake exploration activities. It is contingent on the licensee having the financial strength and technical competence to conduct exploration activities. Similarly, the granting of an exploration licence in the United Kingdom may include conditions relating to financial security, licence reviews, pre- and post-site closure, and termination of the licence (including financial arrangements).

In the European Union, the holder of an exploration permit must have the sole right to explore the potential of a CO_2 storage site and no conflicting uses of the site are permitted during the time in which the exploration permit is valid. For a storage site, permitting priority is thus given to the exploration permit holder, subject to several conditions.

In Alberta (Canada), exploration permit holders are not guaranteed the exclusive right to evaluate, test or inject captured CO_2 within the permit area.

Permitting for CO_2 storage in the United States is overseen at the federal level by the Environmental Protection Agency (EPA) through the Underground Injection Control (UIC) programme. Class VI well classification under the UIC programme applies to wells used to inject CO_2 for geological storage. The permit application and approval process for Class VI wells has taken several years in some cases, in part due to the novelty and structure of the process itself.

By law, the EPA is the designated authority for the UIC programme. However, if certain requirements are met, the legal framework allows the EPA to delegate Class VI well approval and enforcement authority to states – this is known as state "primacy". In principle, state primacy can free up regulatory capacity and resources at the EPA by transferring the responsibility to state regulatory authorities. In addition, states may be better equipped to address challenges that may arise within their own borders. However, in practice state regulatory agencies may also face capacity and resource limitations on implementing the review of Class VI applications in a timely manner. To date, only two states (North Dakota and Wyoming) have been granted Class VI primacy, although others are in the process of application (Louisiana) or pre-application (Arizona and West Virginia). The process for allowing states to acquire primacy for Class VI well permitting may improve over time – while it took North Dakota nearly five years for its application to be approved, Wyoming's application was approved in less than a year.

There are efforts to improve the Class VI permitting capacity of the EPA and states. Funding under the 2021 Infrastructure Investment and Jobs Act allocates USD 25 million to the US EPA and USD 50 million to states to implement Class VI permitting regulations.

By comparison, permitting for CO_2 transport infrastructure in the United States is usually handled by individual states, unless a pipeline crosses federal lands. In Canada, CO_2 pipelines also fall under provincial regulation, unless a pipeline crosses through multiple provinces or the Canadian border.

In states such as Texas and New Mexico, CO_2 pipeline projects have eminent domain authority, which allows developers the right to acquire lands for the public use of pipeline development. In Louisiana, eminent domain authority is expanded to surface *and* subsurface rights for operators that have obtained approval from the relevant authority.

Permitting the Illinois Industrial CCS project in the United States

The Illinois Industrial Carbon Capture and Storage (ICCS) Project, with a capture capacity of 1 $MtCO_2$/year, is the largest CCUS project in the United States and the only one with dedicated CO_2 storage. The project, which captures CO_2 from an ethanol facility and injects it on site into a sandstone formation for geological storage, was one of the first projects to navigate the Class VI permitting process under the US EPA.

Between 2010, when the Class VI framework was finalised, and 2021, the EPA only issued six permits. The FutureGen 2.0 project received four permits, but the project was cancelled before the wells could be drilled and constructed. The other two permits were granted to Archer Daniels Midland for its two co-located projects at an ethanol facility in Illinois: the Illinois Basin-Decatur Project, a large-scale CO_2 storage demonstration project, and ICCS.

Because the ICCS project was one of the first to test the new regulatory framework, the permit approval process took over three years, with additional time needed for review before actual CO_2 injection could occur.

The Class VI framework is a phased process that starts when the project submits its application to the EPA. After a public participation period, the EPA issues a Class VI permit, which allows the project to drill an injection well and submit post-construction data to the EPA for review. The EPA then reviews this information for consistency with the permit application, and if any issues or inconsistencies are raised, the project must modify its permit application. If no issues are raised, the EPA grants the project the authority to begin CO_2 injection. The timeframe between granting the Class VI permit and eventual CO_2 injection authorisation can be highly variable. In total, the entire process for the ICCS project from initial application to injection authorisation took nearly six years:

- July 2011: the ICCS project submitted its Class VI permit application to the EPA.
- April 2014: the EPA granted a draft permit.
- May 2014: the EPA conducted a public hearing to solicit stakeholder feedback on the draft permit.
- December 2014: the EPA granted the ICCS project a final Class VI permit.
- January 2016-March 2017: the ICCS project submitted initial data to the EPA, which required the project to modify its permit before injection could be authorised.
- April 2017: the ICCS project began CO_2 injection.

The ICCS project's experience with the first-ever Class VI application highlights the importance of early and transparent engagement with regulators and also the valuable experience gained by both regulators and project developers in implementing early projects within new regulatory frameworks.

Public engagement and consultation

Legal and regulatory frameworks should have mechanisms to engage the public and address concerns regarding CCUS development. Providing opportunities for public stakeholders to engage in the regulatory process as it applies to CCUS projects for site exploration, selection and operation is vital to ensure that a project can proceed. Associated risks and benefits, as well as the measures being taken to manage such risks, should be communicated to the public to build confidence in the safety of the project.

Many jurisdictions will already have existing regulatory provisions dealing with public consultation procedures, usually as part of planning law frameworks and linked to the environmental review process. In order to foster public stakeholder confidence, consultations should take place as early as possible in the project development process, with a view to being able to accommodate feedback and make adjustments to the project as required. Effective dispute resolution mechanisms are also needed to support the resolution of any conflicts of interest.

Methods for public engagement include government committing to:

- Transparent reporting of the authorisation process, including highlighting key developments and regulatory decision points, as well as providing opportunities for public input at each stage of the process.
- Community meetings and workshops to present and discuss a planned project.
- Internet portals containing technical information relating to a project, including risk assessments and measures taken to mitigate risks.
- Formal and informal educational activities throughout the authorisation process and during project development, operation and closure.

Global examples and approaches

A requirement and process to engage the public are present in nearly every jurisdiction. However, the structure of the process and the actual interface with stakeholders varies between frameworks.

In Victoria (Australia), the regulatory framework provides significant detail on what information is to be published about the project. It takes a bottom-up approach, where permit holders are required to consult communities and municipal councils first. In the United Kingdom, the relevant authority has flexibility in excluding certain information from the public record, such as determining whether or not some information would prejudice to an unreasonable degree a person's commercial interests.

At the national level in the United States, regulations tend to focus on providing public notice, rather than requiring public engagement.

There are four overarching categories of public notice for CCUS in the United States:

- **Rulemaking**: this process occurs when the relevant federal authority is forming new, or changing existing, regulations. The opportunity for public engagement during this process is meaningful, as the public has an opportunity to express views to the relevant authority before a regulation is finalised, such as occurred with the Class VI permitting requirements for geological storage of CO_2.
- **Permitting**: public notice plays an integral role in the permitting process and is required during the application phase. This may include access to reporting and non-confidential data, notification of project activities via mail or newspaper and public meetings and hearings.
- **Environmental reviews**: public consultation is a key pillar of the review of potential environmental impacts of a CCUS project. Active public involvement and engagement can occur through meetings, hearings, workshops, calls and media communication.
- **Environmental information**: public notice opportunities can also exist throughout the lifetime of CCUS projects through public access to environmental information. For example, the United States framework involves various reporting requirements for large projects, which the public can access via an interactive website with mapping features.

Opposition to the Barendrecht project in the Netherlands

Proposed by Shell in 2008, the CCUS demonstration project aimed to store approximately 10 $MtCO_2$ in a depleted natural gas reservoir located under the town of Barendrecht. However, strong public opposition delayed the project's implementation and contributed to its eventual cancellation. Over the course of several years, public opposition to the project grew, creating a "snowball effect" in which unanswered initial concerns led to an eventual distrust of the project. Key lessons from the public engagement campaign included:

- **A lack of adequate representation from the national government in the early stages of the project** led many stakeholders to believe that Shell was the only proponent of the project. This gave rise to a lack of understanding of the project's role in the national context and its importance in climate mitigation efforts.
- **Insufficient communication** of technical information to local leaders sparked more questions than answers.
- **Limited informal discussions** between the developers and stakeholders meant that it was difficult to discuss project nuances. This magnified polarised opinions on the project.

Involving stakeholders early on in the development process is a critical component of building public trust. It is therefore important for frameworks to require a public engagement process so that the regulatory process addresses concerns and mitigates future roadblocks.

Drawing lessons for the Quest CCS project in Canada

Building on the experience in Barendrecht, the Shell Quest CCS project in Alberta undertook extensive public outreach with a successful outcome. The Quest project, which captures approximately 1.2 $MtCO_2$ per year for permanent storage in a saline aquifer, developed a public engagement strategy early on in the development process, with the purpose of developing "mutually prosperous, long-term relationships with neighbours living in close proximity to Shell's operations".

One part of this effort was the creation of a Community Advisory Panel, made up of local residents, members of the academic community, and representatives from local government and relevant authorities. The panel provided, and continues to provide, a forum for stakeholders to provide input on the design and implementation of the project's MMV plan.

Another successful element of the project was the engagement of stakeholders at their own events, such as fairs or community events. This helped reach a broader audience and a set of community members outside traditional engagement meetings.

Through a comprehensive public engagement programme, the Quest project was able to achieve regulatory approvals and public support. The Quest project continues to experience local support through its extensive stakeholder engagement activities.

Legal and regulatory challenges to CCUS projects in the United States

Public support is critical to ensuring that CCUS projects are developed. Opposition to projects can arise in the form of legal or regulatory challenges, which often relate to projected impacts on the environment and local community.

Challenges can occur when a party, whether an individual or an organisation, files a lawsuit against the CCUS project or developer. In some jurisdictions, lawsuits can also be brought against the relevant authority responsible for approving the project. Generally, the allegation is that the project or relevant authority has violated existing law or regulatory processes. Legal cases can take several months to years in the court system, adding unforeseen costs and delays. Challenges can also occur during the regulatory process, such as during public consultation before the issuance of permits.

Examples of legal and regulatory challenges to CCUS projects in the United States are limited, but can provide insight into any potential challenges to future projects.

In 2014 a private individual filed a petition with the EPA against the ICCS project in Illinois, challenging a CO_2 storage permit associated with the project. Among other issues, the individual argued that in issuing the Class VI permit to the ICCS project, the EPA (1) failed to consult with other relevant authorities regarding the project's impact on endangered species, and (2) failed to include provisions in the permit that would properly compensate Illinois property owners for CO_2 that migrated into their pore space. An appeals board reviewed the challenge and ultimately decided to dismiss the petition because the individual did not file an appeal within the required regulatory timeframe.

In 2015 a group of landowners filed a lawsuit against the EPA, challenging the EPA's issuance of CO_2 storage permits for the FutureGen project, also in Illinois. The group initially asked the EPA to review the permits through a regulatory appeals process; however, after being denied a review, the group filed a petition in court, asking a judge to review the case. Around this time the FutureGen project was experiencing other delays and challenges that ultimately resulted in the suspension of federal funding. Shortly before legal arguments were set to begin for the case, the FutureGen project determined it did not have enough funding to continue with development. In 2016 a federal judge ruled that the lawsuit against the EPA was no longer relevant and closed the case.

While legal and regulatory challenges to CCUS projects are not generally the primary reasons behind a project's cancellation, the challenges may result in added costs and delays. This can even impact the relevant authority's ability to issue permits, as staff resources may be affected by ongoing challenges. By allowing for public engagement opportunities and early stakeholder consultation, frameworks can help to mitigate against future challenges.

Public engagement efforts: Tomakomai Demonstration Project

The Tomakomai project is the first large-scale CCUS demonstration project in Japan. During 2016-2019 the project captured CO_2 from a coastal oil refinery in Hokkaido for offshore storage in a saline aquifer. A key factor in the project's success was the ability of the project developer, Japan CCS Co., Ltd (JCCS), to secure public support through a sustained public engagement campaign.

JCCS designed and conducted public outreach with the objective of ensuring that local stakeholders in Tomakomai City (population 170 000) and surrounding areas understood the project, the safety and security of CO_2 storage, and the purpose of CCUS. Public outreach included:

- **Disseminating information about CCUS**: In 2011 a survey of local residents found that the majority of respondents wanted open disclosure of information, confirmation of safety and reliability, and dissemination of CCUS information. In response, JCCS held dozens of panel exhibitions to inform local residents about the need for CCUS, its role in climate mitigation, and examples of current projects operating safely.
- **Maintaining constant and thorough co-operation with the government**: JCCS provided prompt information to relevant authorities, fishery co-operatives, port operators and local industries. In annual forums, hosted by an association comprised of local government and industry representatives,

the Ministry of Economy, Trade and Industry would present on the project's status. This gave local residents a sense of ease that the national government and local governments support the project and have clearly defined roles.

- **Avoiding a one-way flow of information by encouraging conversation with all parties**: At the start of operations, residents expressed concerns about CO_2 leakage. However, as local outreach activities continued, the frequency of these concerns decreased.
- **Designing activities to create a personal connection**: Events targeted different age groups (children, adults and seniors) with the aim of creating several opportunities to promote understanding of CCUS. For example, activities for children focused on hands-on experiments, while activities for adults aimed to dispel concerns about CCUS by explaining the technology.
- **Consideration of local community benefits**: JCCS used a website, in-person events, posters, brochures, Manga comics, symposiums and academic conferences to highlight the benefits of the project to the local community.

In late 2019 the project achieved its demonstration target of 0.3 Mt of CO_2 captured and ceased injection as planned. Monitoring of the stored CO_2 will continue during the post-injection period.

Enabling first-mover projects

The development of comprehensive legal and regulatory frameworks for CCUS can take several years, but there are opportunities for governments to facilitate first-mover or early CCUS projects in parallel with the development of these frameworks. Options include project-specific legislation and preferential arrangements. Such strategies can be important to offer support for early CCUS deployment, while still maintaining the safety, security and environmental integrity of CCUS projects. In turn, these projects can offer valuable lessons and practical experience to inform the development of CCUS regulations.

One-off or project-specific legislation

First-mover projects can accelerate the general development of CCUS technologies. In addition to the technical learnings of early projects, several legal and regulatory lessons may be learned to help develop or improve a CCUS-specific framework.

However, some level of existing regulation and legal parameters must already be in place for first-mover projects to start operation – potentially leading to a "chicken and egg" problem. In some regions where no existing legal or regulatory frameworks were in place for CCUS, project-specific regulations or exemptions from existing regulations have helped move early projects forward.

Global examples and approaches

In Victoria (Australia), Western Australia, Illinois (United States) and Alberta (Canada), legislation has been passed to facilitate the development of specific projects.

In Victoria, the CO2CRC Otway Project was a first-of-a-kind pilot project and Australia's first end-to-end demonstration of CCUS. The project was initiated in 2004 when there was no legislation for regulating CCUS activities. During the second phase of the pilot project, Victoria finalised new CO_2 storage legislation. However, the legislation did not fully cover the continuation of the Otway pilot and project-specific regulation was put in place to exempt the project from certain parts of the new legislation.

In Western Australia, the Gorgon CO_2 injection project was the subject of project-specific legislation. The legislation provided a mechanism for transferring the long-term liability for the stored CO_2 to the state and Commonwealth post-closure, subject to specific conditions.

In Illinois, project-specific legislation provided the original FutureGen project with adequate liability protection, land use rights and permitting certainty. Although the project was never realised, the legislation contained provisions concerning the transfer of title and associated CO_2 storage liabilities to the state.

Preferential approaches and projects

In an effort to jump-start industry interest and deployment, governments can also designate CCUS projects as strategically important to reaching climate goals. This may allow projects to benefit from streamlined approvals or accelerated reviews.

Global examples and approaches

In Indonesia, under a draft ministerial regulation, early storage development activities will be limited to the holders of existing oil and gas leases. This can expedite storage development as the geology (including depleted oil and gas reservoirs) in these areas is already well understood, with large amounts of data available, and the companies holding the leases have the subsurface expertise and project management experience needed for CO_2 storage developments.

In the European Union, the TEN-E Regulation is a policy that focuses on linking the energy infrastructure of EU countries. It defines the criteria for projects of common interest (PCIs). The regulation was updated in May 2022 to align with the European Union's 2050 climate neutrality objectives.

The priority thematic area for "cross-border CO_2 networks" includes CO_2 transport and storage infrastructure between EU member states and with neighbouring third countries. Eligible infrastructure includes pipelines, CO_2 storage facilities linked to cross-border transport of CO_2 (excluded prior to the update), and fixed facilities for liquefaction and buffer storage that are associated with further transportation. Other transport methods – ships, barges, trucks and trains – are now referenced, but do not appear to be considered eligible. The infrastructure for geological storage that is applicable to this regulation is the associated surface and injection facilities necessary to allow the cross-border transport and storage of CO_2, and CO_2 transport infrastructure is currently limited to pipelines.

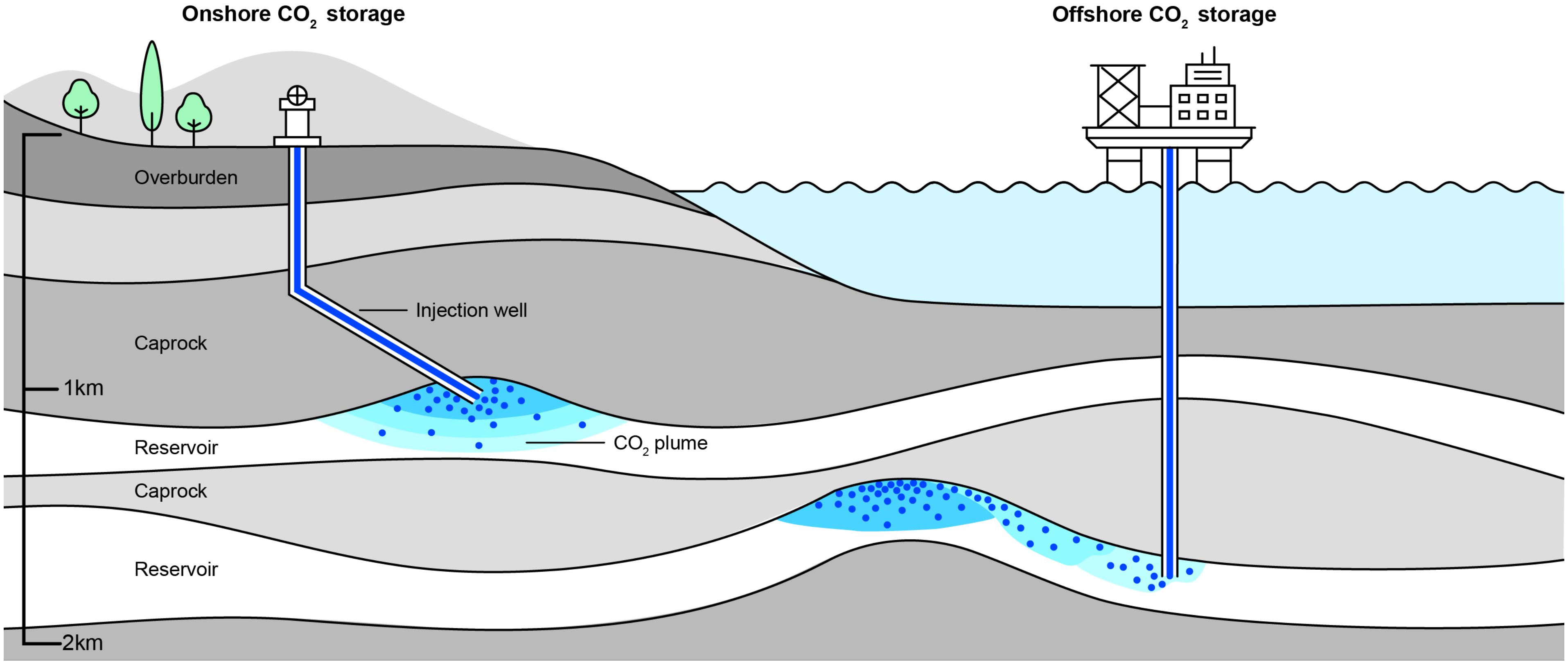
In addition to receiving access to funding, projects that have PCI status may also receive preferential treatment from relevant authorities in the context of permitting and environmental assessment. PCIs can benefit from accelerated planning and permitting, a single authority for obtaining permits, and lower administrative costs from streamlined environmental review processes:

- **Article 7** of TEN-E gives "priority status" to PCI projects, which ensures rapid administrative processing and allows the projects the status of the highest national significance possible in the permit granting process.
- **Article 8** requires member states to designate one national authority responsible for facilitating and co-ordinating the permit granting process.

Chapter 4
Legal and regulatory issues for CO_2 storage

Storing CO_2 in geological formations

Schematic of onshore and offshore CO_2 storage



Ensuring safe and secure storage

The safety and security of geological storage are essential to the successful widespread adoption and sustained public acceptance of CCUS, and its effectiveness as a carbon mitigation measure.

Geological storage involves injecting CO_2 into a suitable geological formation where it will remain trapped in a defined area. Technical, economic and social characteristics determine which resources are suitable to develop into CO_2 storage sites.

The overwhelming focus of legal and regulatory frameworks for CCUS is on ensuring the safety and security of geological storage sites. To this end, many frameworks have relied on methodologies established in the IPCC GHG Inventory Guidelines.

This chapter considers the key legal and regulatory issues for the initial assessment of storage resources and the development, construction and operation of a site.

Legal and regulatory considerations during resource assessment

	Resource assessment	Site development	Construction	Operation	Closure	Post closure and beyond
Description	• Process to identify and study CO_2 storage resources in a region with the aim of identifying resources that can be developed into storage sites	• Project planning aimed at ensuring a site has completed all development and design activities	• Construction of surface facilities, connection to transportation lines, expansion of MMV instrumentation, and drilling of any additional wells	• Period of time during which CO_2 is actively injected into the subsurface	• Injection has ceased • Decommissioning of infrastructure not required to monitor the site • Abandonment and closure of any wells not required for monitoring	• Period after injection ceases where the CO_2 plume is still actively being monitored • Remediation activities as required • Transfer of site responsibility, if applicable
Legal and regulatory issues	• Regional screening, site screening, site selection, initial characterisation, detailed characterisation • Ownership of pore space • Other cross-cutting issues: interaction with other surface and subsurface resources	• MMV plans • Storage site inspections • Defining operational liabilities and financial security • Other cross-cutting issues: environmental impact assessments, permitting, public engagement, project-specific legislation, preferential rights and projects, shared storage infrastructure transition from CO2-EOR to dedicated storage			• Site closure process and certification • Long-term responsibility post-closure (e.g. maintenance of storage site and long-term liabilities) • Finance assurances of long-term site stewardship	

Storage resource assessment

The assessment of CO_2 storage resources involves identifying the physical, chemical and geological characteristics of a potential resource to determine how effective it will be at trapping and storing CO_2. It also involves assessment of social and environmental considerations. Governments can play an important role in the process by conducting countrywide assessments to identify the most suitable or prospective storage resources.

Jurisdictions with an oil and gas sector may benefit from existing subsurface data already collected by the industry. These data are often proprietary so relevant authorities should work with industry to make best use of the data. There are many parallels between CO_2 storage and oil and gas resource assessments – starting from a regional evaluation of prospective resources that relies primarily on existing data, to more detailed evaluations of prospects that appear to be promising sites. The detailed evaluations of oil and gas resources typically involve the use of similar logging, testing and modelling techniques as those needed to perform site characterisation for CO_2 storage sites.

The storage resource assessment generally includes the following steps:

- regional screening
- site screening
- site selection
- initial characterisation
- detailed characterisation.

It is important that legal and regulatory frameworks set the parameters of the resource assessment process to ensure that only suitable resources are developed. Frameworks should ensure that adequate geologic, hydrogeologic, geochemical and geomechanical data are collected and analysed. This data should be used to inform the development of injection well construction and operating plans, provide inputs for the modelling requirements to characterise reservoir behaviour, and establish baseline information for monitoring data collected over the life of the injection period.

Global examples and approaches

In Norway and the European Union, the suitability of a storage location is determined through the assessment of a potential storage location and surrounding area according to set criteria. A formation can only be selected as a storage site if there are no significant environmental, health or leakage risks.

In the European Union, these criteria include the following steps that must be carried out according to best practices at the time of assessment and to certain specified standards:

- data collection
- building the three-dimensional static geological earth model

- characterisation of the storage dynamic behaviour, sensitivity characterisation and risk assessment.

A similar approach is taken in Australia. Exploration permit holders must undertake a work programme of site characterisation to establish the characteristics and extent of underground storage formations in the permit area. As part of this, permit holders must assess the feasibility of injecting CO_2 into any identified storage formations and their suitability for permanent storage in a safe manner that will not compromise the integrity of the storage formation.

In the United States, CO_2 storage site operators are required to obtain a UIC Class VI permit from the relevant authority in order to inject CO_2 for geological storage. The regulatory framework seeks to identify appropriate CO_2 storage sites that will "provide adequate storage capacity to store the injected carbon dioxide and a competent confining zone that will contain the injected carbon dioxide". The CO_2 storage framework in the United States is based on legislation protecting water resources – as such, regulations for CO_2 injection and storage tend to focus on underground drinking water resources.

The regulatory framework outlines several requirements, including specific site characterisation requirements to identify potential risks and eliminate unacceptable sites. Regulations require Class VI permit applicants to submit a vast array of information before CO_2 injection, such as:

- Maps and cross sections of the area of review.
- Location, orientation and properties of known or suspected faults and fractures that may transect the storage site, along with the determination that they will not interfere with CO_2 containment.
- Data on the depth, areal extent, thickness, mineralogy, porosity, permeability and capillary pressure of the injection and conforming zones.
- Information on fractures, stress, ductility, rock strength and in situ fluid pressures within the conforming zones.
- Information on the seismic history of the area.
- Geological and topographical maps and cross sections.
- Maps and stratigraphic cross sections indicating the general limits of drinking water resources, water wells and springs, and their positions relative to the injection zones and direction of water movement.
- Baseline geochemical data on subsurface formations.

The site characterisation process includes a general characterisation of regional and site geology, followed by detailed characterisation of the injection zone and conforming zones. Importantly, site characterisation is an iterative process, whereby data are updated and refined before operation of the well. Final site characterisation data are collected as the injection well is drilled, core samples are taken and analysed, and tests are performed as described in the relevant regulations.

Ownership of pore space

In many jurisdictions, the subsurface geology – including the pore space into which the CO_2 is injected – is owned by the state or province. However, this is not the case in all jurisdictions. For example, in the United States subsurface ownership rights usually rest with the surface owner. Where pore space or mineral rights are owned by the state or federal government, access can be granted through various instruments such as leases or tenure agreements. Where the rights to the subsurface are held privately, access is usually negotiated through private contracts.

Global examples and approaches

In Victoria (Australia) and Norway the state, and in Alberta (Canada) the province, owns all underground geological storage formations and pore space below the surface.

In Alberta, legislation designates the government of Alberta as the owner of all pore space, with the exception of pore space under federal land. Accordingly, a CO_2 storage project requires a grant of rights from the government whether by way of lease or tenure agreement covering the pore space.

In the United States, pore space rights are complex in many states. In general, the surface owner has the rights to the pore space under the property. At least four states have clarified pore space ownership specifically for CO_2 storage:

- Montana gives authority regarding underground CO_2 storage to the relevant state authority and grants surface owners pore space ownership.
- North Dakota defines pore space for CO_2 in geological storage and establishes the pore space as property of the surface owner.
- Wyoming states that the surface owner is presumed to own the geological pore space below the surface, but adds that mining and drilling rights will be given a higher priority than geological storage activities.
- Nebraska confers pore space rights to the surface owner, unless the “reservoir estate” has been previously severed from surface rights.

Furthermore, it is not uncommon for the mineral rights of a property to be separated from the surface ownership. For example, an oil and gas company may own the mineral rights to several private properties – this allows the company to access a surface owner’s pore space as reasonably necessary to produce the oil and gas on the property. This is not only limited to primary oil and gas production; mineral rights also extend to CO_2 used in enhanced oil recovery as long as the purpose of the operation is to extract minerals. In contrast, the injection of CO_2 for the sole purpose of geological storage does not involve the extraction of minerals, creating complex pore space issues in many states.

Legal and regulatory considerations during site development, construction and operation

	Resource assessment	Site development	Construction	Operation	Closure	Post closure and beyond
Description	• Process to identify and study CO_2 storage resources in a region with the aim of identifying resources that can be developed into storage sites	• Project planning aimed at ensuring a site has completed all development and design activities	• Construction of surface facilities, connection to transport lines, expansion of MMV instrumentation and drilling of any additional wells	• Period of time during which CO_2 is actively injected into the subsurface	• Injection has ceased • Decommissioning of infrastructure not required to monitor the site • Abandonment and closure of any wells not required for monitoring	• Period after injection ceases where the CO_2 plume is still actively being monitored • Remediation activities as required • Transfer of site responsibility, if applicable
Legal and regulatory issues	• Regional screening, site screening, site selection, initial characterisation, detailed characterisation • Ownership of pore space • Other cross-cutting issues: interaction with other surface and subsurface resources	• MMV plans • Storage site inspections • Defining operational liabilities and financial security • Other cross-cutting issues: environmental impact assessments, permitting, public engagement, project-specific legislation, preferential rights and projects, shared storage infrastructure transition from CO_2-EOR to dedicated storage			• Site closure process and certification • Long-term responsibility post-closure (e.g. maintenance of storage site and long-term liabilities) • Finance assurances of long-term site stewardship	

Measurement, monitoring and verification plans

A measurement, monitoring and verification (MMV) plan or process is at the core of any effort to ensure safe and secure operations. The purpose of an MMV plan is to ensure that techniques and processes are in place to detect and minimise CO_2 migration or leakage.

Monitoring a CO_2 storage site will generally involve a portfolio of techniques to monitor for temperature and pressure changes, seismic activity and other indicators. These are used to detect and observe injected CO_2 and to monitor the primary storage formation, storage complex, overburden and surface for changes that could indicate leakage. MMV plans should not be static and tend to change in scope as a project progresses from the pre-injection phase, through the injection phase and to the post-injection phase. As such, it is important that frameworks adopt a non-prescriptive approach based on what monitoring should achieve, rather than adopting specific techniques. This will also ensure regulations remain appropriate as monitoring technologies and techniques evolve.

At a minimum, an MMV plan must detail a monitoring programme and methods sufficient to:

- Establish and maintain a baseline survey for the storage site until injection commences.
- Monitor the injection facilities, the storage site (including the CO_2 plume) and the surrounding environment.
- Compare the ongoing monitoring results against the baseline survey for the storage site.
- Compare the actual behaviour of the storage site against its anticipated behaviour based on the results of the site characterisation process and monitoring results.
- Detect, attribute and assess significant leakage, unintended migration or other irregularity in the storage site.
- Quantify, as required by the relevant authority, the volumes of CO_2 associated with significant leakage or unintended migration.
- Detect migration of CO_2.
- Detect significant adverse effects on the surrounding environment.
- Assess the effectiveness of any corrective measures taken.

It is common for frameworks to require periodic updates to the MMV plan, which provide new monitoring data of the storage site. Risk assessment is an iterative activity, and monitoring results are used to inform and update the project risk assessment. Often, this is a prerequisite for the transfer of ownership and liability to the relevant authority, if applicable.

Global examples and approaches

In South Australia, operators are required to provide a report regarding their geophysical activities on a regular basis to the relevant minister. In Victoria, also in Australia, operators must submit an injection and monitoring plan to the relevant minister, setting out, among other things:

- A description of the proposed monitoring techniques.
- A monitoring and verification plan detailing how the behaviour of any stored greenhouse gas substance will be monitored.
- An estimate of the cost of the monitoring and verification activities to be undertaken after the greenhouse gas injection and monitoring has been transferred to the state.

In the European Union, operators are required to monitor the injection facilities, the storage complex and where appropriate the surrounding environment, for a number of specified purposes, including:

- Comparison of actual and modelled behaviour of CO_2 and formation water.
- Detection of significant irregularities, migration or leakage.
- Detection of significant adverse effects on the environment.

Operators must then submit a report to the relevant authorities at least once a year with details of the monitoring results, and the quantities and properties of CO_2 streams delivered and injected. Operators are also responsible for monitoring and reporting measures after a storage site has been closed, but monitoring may be reduced to a level that allows for detection of leakages or significant irregularities after transfer of responsibility. There are special criteria in place for establishing and updating the monitoring plan and for post-closure monitoring activities.

In Norway, the relevant authority monitors the injection facilities and storage location at least once per year up to three years after site closure, and then every five years until responsibility has been transferred to the government.

In Alberta (Canada), updated MMV plans must be submitted every three years along with an updated closure plan. Updated results are incorporated into simulations and models so that actual and predicted behaviour can be compared and the MMV plan can be updated as necessary.

In the United States, storage operators must include the following information in the MMV plan, in addition to other monitoring and reporting requirements, to be reported annually to the relevant authority:

- The mass of CO_2 injected into the subsurface.
- The mass of CO_2 produced from oil or gas production wells or from other fluid wells.
- The mass of CO_2 emitted from surface leakage.
- The mass of CO_2 emissions from equipment leaks and from vented emissions of CO_2 sources.
- The mass of CO_2 sequestered in subsurface geological formations, calculated by subtracting total CO_2 emissions from CO_2 injected in the reporting year.
- The cumulative mass of CO_2 reported as sequestered in subsurface geological formations in all years since the facility became subject to the regulation.

Storage site inspections

CCUS regulatory frameworks should allow the relevant authority to verify, by way of storage site inspections and data reporting, that storage projects are performing as intended. Inspections are not unique to CCUS operations and occur in most industrial operations. They involve access to both property and information. Inspections are more likely to be necessary in the early stages of a project and during the injection phase than later in the project life cycle, given that these are the periods when the least is known about the storage site. Regulatory frameworks should also allow the authority to take enforcement measures.

Global examples and approaches

It is common to require annual inspections during active CO_2 injection and a certain level of inspections post site closure.

In Northern Ireland, annual routine inspections are required after CO_2 injection commences up until the third anniversary of site closure. Routine inspections are required every five years during the post-closure period. In addition, site inspections are authorised if the relevant authority becomes aware of leakage, significant irregularities or a breach of permit terms.

In the European Union and Norway, routine inspections must take place until the transfer of responsibility to the state. The CCS Directive provides for a system of routine and non-routine inspections of storage complexes that are undertaken at least annually until three years after site closure and every five years thereafter until transfer of responsibility to the relevant authority (after which they cease). Non-routine inspections can occur in certain specified situations. In Norway, the ministry is to inspect the storage location at least once per year up to three years after closure, and then every five years until the responsibility has been transferred to the state.

In Saskatchewan (Canada), inspections are more ad hoc: the relevant authorities can make inquiries and conduct inspections and examinations.

In order to achieve compliance with the regulatory framework, the relevant authority can issue certain enforcement measures. In Victoria (Australia), the relevant minister can issue improvement notices that require an operator to take action within a specified period to remedy a violation or breach of licence conditions. This can include prohibition notices against the carrying out of any CO_2 injection, monitoring or other sequestration activity, or any other specified action in order to avoid an immediate risk to the public, property or the environment.

Similarly, in the United Kingdom and the European Union, the relevant authority can give directions to licence holders in order to achieve compliance.

Operational liabilities and financial security

It is generally accepted by industry and authorities currently involved in CCUS that the storage site operator is the entity that is best placed to bear any liability for damage caused by a storage site during the exploration, operation and closure periods. It is important to ensure that the operator is also financially capable of covering any potential problems that may arise during site operations.

Global examples and approaches

In Australia, operators in South Australia and Victoria must carry out human health and environmental impact assessments for the storage site or storage complex, as well as establish plans identifying relevant risks. To ensure the financial security of operators, any party holding an authority for sequestration activities must obtain a rehabilitation bond prior to undertaking operations. Rehabilitation bonds secure the payment of a specified amount for any rehabilitation, clean-up or pollution prevention work that may be necessary as a result of CO_2 sequestration operations.

In Norway, the potential for force majeure is considered in the legislation – for example, an operator's responsibility can be reduced in cases such as an unavoidable natural occurrence or an act of war. In the European Union, the operator remains responsible for all obligations relating to the surrender of emissions trading allowances in case of leakages and preventive and remedial actions. In Norway and the European Union, operators of a storage site must prove that adequate provisions can be established to meet all obligations arising under the CCUS regulations. The financial guarantee must be valid and effective when injection starts.

In the United States, operators of Class VI injection wells for geological storage of CO_2 have specific financial responsibility requirements to assure the availability of funds for the life of a project. A range of financial instruments are accepted to provide this insurance, such as trust funds, surety bonds, credit lines, insurance, self-insurance (subject to strict stipulations) and escrow accounts.

In Texas, the same logic applies: holders of CO_2 storage facility permits are required to provide evidence demonstrating the permit holder's financial responsibility and resources for:

- corrective action
- injection well plugging
- post-injection storage facility care and storage facility closure
- emergency and remedial responses

each year until the facility has reached the end of the post-injection storage facility care period.

Legal and regulatory considerations during closure, post closure and beyond

	Resource assessment	Site development	Construction	Operation	Closure	Post closure and beyond
Description	• Process to identify and study CO_2 storage resources in a region with the aim of identifying resources that can be developed into storage sites	• Concrete project planning aimed at ensuring a site has completed all development and design activities	• Construction of surface facilities, connection to transportation lines, expansion of MMV instrumentation, and drilling of any additional wells	• Period of time during which CO_2 is actively injected into the subsurface	• Injection has ceased • Decommissioning of infrastructure not required to monitor the site • Abandonment and closure of any wells not required for monitoring	• Period after injection ceases where the CO_2 plume is still actively being monitored • Remediation activities as required • Transfer of site responsibility, if applicable
Legal and regulatory issues	• Regional screening, site screening, site selection, initial characterisation, detailed characterisation • Ownership of pore space • Other cross-cutting issues: interaction with other surface and subsurface resources	• MMV plans • Storage site inspections • Defining operational liabilities and financial security • Other cross-cutting issues: environmental impact assessments, permitting, public engagement, project-specific legislation, preferential rights and projects, shared storage infrastructure transition from CO2-EOR to dedicated storage			• Site closure process and certification • Long-term responsibility post closure (e.g. maintenance of storage site and long-term liabilities) • Finance assurances of long-term site stewardship	

Site closure process

Regulations should establish a clear understanding of the steps needed to close a storage site and the roles and responsibilities of all stakeholders in the stewardship of the site thereafter (see also next section on long-term liabilities). The site closure process commences after injection has stopped and will typically involve the decommissioning of infrastructure including wells (except that needed for ongoing monitoring) and land rehabilitation. If the relevant authority assumes long-term responsibility for the closed site, the operator must show that the site has been appropriately decommissioned and that there is no significant risk of future leakage. Existing approaches that include a transfer of responsibility generally require evidence that the CO_2 is securely stored and that all risks have been mitigated, and a minimum time period to have elapsed prior to storage site closure.

Global examples and approaches

In Australia, Norway, the United Kingdom and the United States, the relevant authority must approve site closures under certain conditions, such as land rehabilitation and removal of all injection infrastructure.

In Northern Ireland, licence holders are required to submit a provisional post-closure plan before obtaining a storage permit.

In Victoria (Australia), operators are required to complete the following steps once CO_2 injection activities have ceased:

- Notify the relevant authority that the injection activities have been completed.
- Plug or close off any wells.
- Remove all injection infrastructure.
- Rehabilitate the site.
- Surrender the right to inject CO_2 under the relevant licence (although this surrender will be limited only to the right to inject CO_2, and will not constitute complete surrender of the licence).

Once injection ceases, operators are required to apply for a site closure certificate within 30 days.

In Norway, site closure can either be approved by the relevant authority (after certain conditions are met) or by the King following an application by the operator.

In the United States, the relevant authority outlines the processes for well plugging, post-injection site care and site closure for UIC Class VI well operators. For example, required injection well plugging activities include flushing the well with a buffer fluid, testing the external mechanical integrity of the well, and emplacing cement into the well in a manner that will prevent fluid movement that may endanger underground drinking water resources.

Nebraska introduces a framework for CO_2 storage

In May 2021 Nebraska adopted legislation that establishes a legal and regulatory framework for the geological storage of CO_2 in the state. The framework assigns a relevant authority to oversee and regulate facilities that inject and store CO_2, and aligns injection well permitting requirements with state and federal regulations.

Clarity of pore space ownership: the framework vests the "reservoir estate" (pore space) with the surface owner, unless the reservoir estate has already been previously separated. The framework clarifies that mineral rights are not included in the reservoir estate. However, mineral rights do have priority over the surface and reservoir estate in terms of development.

Unitisation: the concept of condensing or combining different ownership units into one project with a designated operator is known as unitisation. The framework allows for a storage project to be unitised so long as there is consent among the owners of at least 60% of the physical volume of the reservoir. The reservoir owners that do not consent to unitisation must be equitably compensated.

Permitting: the operator is required to obtain a storage permit from the relevant state authority and the relevant federal authority. The permitting process requires the operator to perform several steps:

- Pay a fee, which will be deposited into a storage fund.
- Hold a public hearing with notice to all mineral lessees and owners, surface owners and reservoir estate owners within the storage reservoir and within half a mile of the reservoir's boundaries.
- Commission findings that the storage facility is suitable and will not endanger human health or the environment, and is in the public interest.

Storage fund: the framework establishes a storage fund, which will be financed by operator fees – including a fee levied on each tonne of CO_2 injected and stored. The amount of the fees will be based on the relevant authority's anticipated expenses in regulating the storage facility during the construction, operational and pre-closure phases, as well as anticipated expenses associated with the long-term monitoring and management of the storage facility.

Long-term ownership and liability: following the end of CO_2 injection operations, the operator can apply for a certificate of project completion. The certificate may only be issued if the storage operator:

- Shows it has addressed all pending claims regarding the storage facility's operation.
- Shows that it has received an authorisation of site closure from the relevant authority.
- Shows that any wells, equipment and facilities to be used in the post-closure period are in good condition and retain mechanical integrity.

If granted, the certificate transfers the ownership and liability of the storage site to the state, which will be responsible for the long-term monitoring and management of the storage site.

Addressing long-term storage liabilities

To date, the issue of long-term liability has been one of the most challenging and complex issues associated with regulation of CO_2 storage activities. The issue of long-term liability centres on the "in perpetuity" responsibility for the stored CO_2 after injection ceases and the site is closed. How jurisdictions treat long-term liability is a key consideration for storage developers, and without clarification it can be a major barrier to CO_2 storage development.

While the risk of CO_2 leakage in a well-designed, correctly operated site is very low and generally becomes even lower with time and after injection ceases, the potential impacts of a future leak should be considered. These impacts could include environmental (e.g. CO_2 being released into the atmosphere or migrating into potable water resources) and economic impacts (e.g. if an entity were required to pay prevailing carbon prices or provide restitution for any damage). Given such, it is vital that frameworks have the processes and mechanisms in place to address long-term liability.

In several jurisdictions, relevant authorities require operators to contribute to the costs associated with long-term stewardship of the CO_2 storage site. Existing oil, gas and mining frameworks can act as a potential model for governments to structure stewardship obligations, including post-closure, rehabilitation and remediation activities. Other frameworks, such as waste disposal and management regulations and underground water protection regulations may also act as a relevant model.

Long-term liability post site closure

Long-term liability is generally addressed in one of three ways:

- **A provision is made for the transfer of liability to the relevant authority**.[2] In this case, the operator is generally required to meet a number of stringent conditions to ensure that there are negligible risks of future leakage before transferring liability of the storage site to the relevant authority.
- **Long-term liability explicitly rests with the operator**. Monitoring and reporting requirements remain to ensure safe and secure storage, though the frequency of reporting requirements may vary.
- **Long-term liability is not explicitly addressed**, with the implication that the operator would retain responsibility for the storage site in perpetuity. (In some cases, the operator may be state-owned; therefore, the issue of transferring liability may not arise).

There are several arguments in favour of transferring long-term liability to the relevant authority. First, there is the potential that operators may be unable or unwilling to take on liability for an indefinite period. The lack of a process to transfer stewardship of a storage site may discourage or deter initial investment in storage development. Second, when compared to sovereign states, private storage operators may have limited lifespans that may not support indefinite stewardship duties or financial assurance of liabilities. This could ultimately see responsibility falling back to the relevant authority in the long term, but without the conditions and assurances required under an explicit transfer mechanism. Finally, CO_2 storage could be seen as a public good and, therefore, it may be justified to pass the long-term responsibility for a site to the relevant authority provided identified risks have been mitigated.

However, there is also a concern that a framework that transfers liability to the relevant authority in the post-closure period may create a moral hazard during the operational period. In other words, the storage operator may behave differently than if it were fully exposed to long-term liabilities. However, frameworks can address this concern by setting clear conditions for the transfer of responsibility and ensuring that the level of risk for the stored CO_2 is reduced as far as possible before the transfer of liability takes place. Such conditions are often a combination of both time-related and performance-based elements.

If long-term liability is to be transferred to the relevant authority, it will generally be a requirement that the operator demonstrates, prior to transfer, confidence that there is no significant risk of future leakage or other irregularities in the storage site. Furthermore, transfer of liabilities is unlikely to absolve the operator from any

[2] Long-term site stewardship can also be transferred to the state. Unless otherwise noted in this chapter, relevant authority can also mean the state.

future issues resulting from their fault or negligence during the operational or closure period. Even after the site has closed and liability is transferred, the relevant authority must have in place a plan of action and the necessary expertise to remediate and prevent any potential seepage of CO_2 from the subsurface.

Global examples and approaches

In Australia, Norway and the United Kingdom, long-term responsibilities and liabilities are transferred to the government, although there is a difference in the timing of this transfer between these three jurisdictions.

In Western Australia (Australia), under the project-specific Barrow Island Act, long-term responsibility is transferred from the Gorgon CO_2 storage project to the state and Commonwealth after the expiry of a 15-year period beginning on the date that CO_2 injection ceases, subject to strict conditions. The relevant authority must "be of the opinion" that:

- The CO_2 that has been injected into a geological storage formation in the licence area is behaving and will continue to behave in a predictable manner.
- Risks associated with the permanent storage of CO_2 have been reduced to as low as reasonably practical.
- The CO_2 will not present a risk to public health or the environment.

In addition, the operator must provide to the relevant authority detailed information on the conditions of the storage site, an assessment of potential migration and leakage, a risk management plan in the event of leakage and a long-term monitoring and verification plan.

Pursuant to the CCS Directive, in Norway and the United Kingdom the state assumes liability after the expiry of a 20-year period from the date of closure of a storage site, and after the operator provides evidence indicating that the stored CO_2 will be completely and permanently contained. In Norway and the United Kingdom, financial requirements are a criterion for the transfer of long-term liability, which is not required, for instance, in Australia. For example, in Norway the operator must make a financial contribution that will cover, at a minimum, anticipated monitoring expenses for a period of 30 years.

The CCS Directive requires the operator to prepare a report that demonstrates the following:

- The conformity of the actual behaviour of the injected CO_2 with the modelled behaviour.
- The absence of any detectable leakage.
- The evolution of the storage site towards a situation of long-term stability.

In the United States, responsibilities differ depending on the specific regulatory framework. For instance, under the EPA's UIC programme, Class VI well operators are required to monitor the storage site post injection for 50 years, or at the discretion of the relevant authority if the operator demonstrates that risks will subside. However, under California's Low Carbon Fuel Standard (LCFS) this post-injection monitoring requirement is 100 years. Yet, neither of these frameworks outline the transfer or long-term liability to another entity. These specifications are typically found at the state level, where several states have a process for the transfer of long-term liability to the state government:

- In Indiana, project-specific legislation allows the storage operator to transfer liability and ownership of the CO_2 storage facility to the state government, following project completion and plugging the well.
- In Texas, the state School Land Board assumes long-term ownership for offshore CO_2 storage. After verification of permanent storage, the board acquires the title, right and interest in and to the stored CO_2.
- In Louisiana and North Dakota, the state assumes liability after 10 years and requires a certificate of well closure and project completion, and proof of well integrity since well closure. Notably, in Louisiana, if the operator cannot show that the CO_2 reservoir has mechanical integrity, then the state can still assume ownership of the storage facility but not the liability. Louisiana law specifies that transfer of ownership does not assume transfer of liability.
- In Montana, the state assumes liability after 30 years following a two-step process. First, a certificate of completion is issued after the operator has demonstrated that no CO_2 movement or leakage has occurred for a period of 15 years. Then, after a further 15-year period, the liability can be transferred to the state.
- In Nebraska, the long-term ownership and liability of the storage site is transferred to the state upon the issuance of a certificate of project completion. Regulatory details on the requirements to obtain the certificate and the timeframe for transferring ownership have not yet been formulated.

Financial assurances of long-term site stewardship

CCUS frameworks can require the operator to contribute to the costs associated with long-term stewardship of the CO_2 storage site. This can help reduce the financial exposure of the operator (or relevant authority if responsibility is transferred) after site closure in the unlikely event of leakage. This contribution can be accrued over the course of the project or simply be required at the time of authorisation for storage site closure.

Global examples and approaches

In Victoria (Australia), Alberta (Canada), Norway and the European Union, each holder of an injection and monitoring licence has to pay an amount towards the estimated long-term monitoring and verification costs for the storage site. In Victoria and Norway, the amount must be paid in annual instalments before the transfer of responsibility to the relevant authority. In the European Union and Norway, the amount must at least cover anticipated monitoring costs for a period of 30 years.

In United States, some states have established storage funds for the long-term management and monitoring of CO_2 storage sites.

- In Louisiana, the storage operator must pay a fee into a storage trust fund for a minimum of 10 years, up to a maximum of USD 5 million for each operator.
- In Kansas, the relevant authority collects injection fees, penalty fees for violations, permitting fees and well fees that feed into the state's fund. For example, the relevant authority can collect penalties for the release of CO_2 from storage facilities of up to USD 10 000 per violation per day. The relevant authority can use the fund to pay for the cost of development and issuance of permits, compliance monitoring, inspections, well closures, underground storage closure, long-term monitoring and enforcement actions, among other activities.
- In Wyoming, a special fund has been established to fund the measurement, monitoring and verification of storage sites following site closure certification. CO_2 storage permit holders pay into this fund either via a lump sum closure fee or as a fee per tonne of CO_2 injected (which has yet to be determined).
- In Montana, the operator has the option of setting up a fund for long-term site management. If the operator opts to hand liability to the state 30 years after well closure, then the operator must pay into a storage fund account during the injection period. However, if the operator opts not to set up a fund, then the operator is liable for the project indefinitely.

Chapter 5
International considerations and CCUS hubs

Regulating cross-border CO_2 transport

The transport of CO_2 between or across multiple countries is a growing issue as policy makers and regulators look to link multiple capture facilities with low-cost storage resources. The development of industrial clusters and storage hubs highlights a need for frameworks that can account for legal and regulatory issues that may arise from cross-border CO_2 transport.

Captured CO_2 can be shipped between two or more jurisdictions under several scenarios. This may trigger certain national or international regulatory requirements.

- Capture of CO_2 in one jurisdiction and subsequent transport across borders by pipeline, ship or other means of transport for storage in a different jurisdiction.
- Transit arrangements in which CO_2 passes through a third jurisdiction to arrive at its final storage destination.
- Unintended migration or leakage of injected CO_2 in the subsurface across jurisdictional borders.
- Use of storage complexes that span jurisdictional borders.
- Secondary effects from storage activities occurring across jurisdictional borders (e.g. due to a subsurface pressure front or displacement of subsurface fluids across borders).

Global examples and approaches

In the European Union, the CCS Directive establishes a legal framework for environmentally safe geological storage of CO_2. It relies and expands on existing legal frameworks to outline extensive requirements for securing CO_2 transport networks and storage sites.

The directive requires member states and their relevant authorities to put in place provisions for transboundary CO_2 transport, transboundary storage sites and transboundary storage complexes. In the event that the transport of CO_2 crosses borders, member states must jointly apply provisions of the directive and other relevant legislation.

Compliance with the London Protocol

The London Protocol was adopted on 1 November 1996 to update and supersede the International Maritime Organization (IMO) London Convention, an international agreement on preventing marine pollution.

Until 2019 the protocol had been a major international legal hurdle for the development of regional CO_2 transport infrastructure, as it effectively prohibited the transport of CO_2 across national boundaries for sub-seabed storage. In 2009 the protocol was amended to remove this barrier, effectively allowing CO_2 streams to be exported for CCUS purposes between contracting parties. However, the amendment must be ratified by two-thirds of the contracting parties in order for it to come into force. To date there has been little progress in reaching this ratification threshold.

In October 2019 Norway and the Netherlands, with the endorsement of the United Kingdom, secured the IMO's approval of an interim solution to the slow-moving ratification of the 2009 CCS Export Amendment. The resolution, which was formally accepted with the support of several countries, allows countries to agree to export and receive CO_2 for offshore geological storage via bilateral (or multilateral) agreements. Building on this momentum, the two countries signed a memorandum of understanding in November 2021 agreeing to finalise a bilateral agreement in 2022.

The 2019 resolution marked a major step forward in the development of transboundary CCUS projects. This enabled Norway to proceed with the Northern Lights Project, which plans to transport and store CO_2 from across Europe. Although no bilateral agreements have yet been submitted to the IMO, the first agreements or arrangements will provide an example of the level of detail required to comply with the resolution.

Under the 2019 resolution:

- Contracting parties (CPs) and non-contracting parties are required to co-operate to ensure the sharing of information on the characterisation of the geological formation, storage integrity, and potential migration and leakage pathways, among other areas.
- For non-contracting parties, the United Nations Convention on the Law of the Sea (UNCLOS) establishes an overarching framework for the governance, management and protection of the world's oceans and the marine environment, including the seabed and subsoil.

Although the provisions of UNCLOS are general, there is an obligation on its parties to consider the environmental impacts of CCUS project activities on the marine environment, and it is arguable that applying the provisions in the London Protocol would be regarded as the best practice in doing so.

Cross-border maritime CO_2 transport under the 2009 amendment and 2019 resolution for provisional application of the London Protocol

London Protocol status of country capturing CO_2 for export	London Protocol status of country receiving CO_2 for storage: Contracting party	London Protocol status of country receiving CO_2 for storage: Non-contracting party
Contracting party (CP)	CPs must deposit a declaration of provisional application of the 2009 amendment with the IMO. CPs must establish an agreement or arrangement that includes "confirmation and allocation of permitting responsibilities, consistent with the provisions of the protocol and other applicable international law". This includes reference to the [CO_2 specific guidelines'] conditions related to the composition of CO_2 streams and CO_2 storage permitting. These agreements or arrangements must be notified to the IMO.	The exporting CP is accountable for compliance with the provisions of the protocol. The CP must establish an agreement or arrangement with the non-CP that, at a minimum, provides the same environmental protections as if the CO_2 were being stored by a CP. This includes the issuing of permits and permit conditions. In the case of a breach of the agreement or arrangement by the non-CP, the CP should "engage in consultations to rectify". In the case of a "significant ongoing breach", the CP is required to "terminate the export".
Non-contracting party (Non-CP)	CPs must establish an agreement or arrangement with the non-CP and notify this to the IMO. CPs must ensure that the CO_2 received is "overwhelmingly" comprised of CO_2 and that the exporting country demonstrates appropriate consideration of incidental associated substances in the CO_2 stream, with treatment if needed.	Not governed by the protocol; may be subject to UNCLOS.

Sources: IEAGHG (2021); IMO (2013).

Interaction of pressure fronts across international borders

The storage of CO_2 across international borders has the potential to create complex legal and regulatory challenges between jurisdictions. Because storage reservoirs and basins are not defined by country borders, the storage of CO_2 in one country has the potential to affect storage resources in another.

One such example is the **migration of CO_2** across international borders. The 2012 CO_2 Specific Guidelines of the London Protocol defined the transboundary subsurface movement of CO_2 as:

"the movement of CO_2 streams across a national boundary within a transboundary sub-seabed geological formation after the CO_2 streams have been injected. The transboundary sub-seabed geological formations may extend into the jurisdiction of another state or into the high seas."

With this guidance, the subsurface movement of CO_2 across boundaries is not considered an export. Furthermore, the guidelines require that if a contracting party to the London Protocol injects CO_2, it must share information with neighbouring jurisdictions and relevant authorities regarding the characterisation of the CO_2 storage formation – such as capacity and injectivity, storage integrity, and potential migration and leakage pathways.

Another example is the **propagation of pressure** across international borders. Pressure propagation can occur if the CO_2 that is injected into a storage reservoir causes pressure changes in a different part of the reservoir. If the storage reservoir crosses international borders, the interaction of these pressure fronts may reduce the practical storage capacity in neighbouring jurisdictions. Given the limited development of transboundary storage resources today, there are limited examples of pressure propagation that show cause for concern in the short term. The Michigan Basin, for instance, spans the borders of Ontario (Canada) and Michigan, Ohio and Pennsylvania (United States). The regions on either side of the border are home to process emissions-intensive industry. Any assessment and characterisation of the basin should account for pressure propagation impacts across the border.

However, unlike the transboundary subsurface migration of CO_2, existing legal and regulatory frameworks tend to overlook the interaction of pressure fronts between neighbouring countries. Frameworks tend to look at pressure as a critical parameter for measuring and monitoring potential CO_2 leakage. And while some frameworks do indeed address transboundary impacts of CO_2 injection and storage, such as in Norway, these impacts tend to focus on environmental effects rather than pressure propagation.

Notably, in the long term as more storage resources are developed, frameworks should seek to address the legal uncertainty of transboundary pressure front interactions.

Overlap between multiple frameworks

It is well understood that CCUS projects located within a certain jurisdiction generally fall under that jurisdiction's legal and regulatory framework. What is less well understood is what happens if a CCUS project falls under multiple frameworks. Although it has yet to be tested, the overlap between legal and regulatory frameworks can increase the uncertainty and complexity of a CCUS project if not accounted for properly.

A prime example of the potential for framework overlap can be found in the requirements of the California LCFS, which seeks to decrease the life cycle carbon intensity of the state's transport fuels through a credit trading system. In 2019 the LCFS was extended to allow CCUS projects to generate credits, giving projects access to a trading system in which credits averaged around USD 187/tCO_2 in 2021.

Importantly, projects do not have to be located within California to qualify under the LCFS, leaving the door open for potential overlap with other regulatory frameworks for CCUS. Under the LCFS framework, CCUS projects can be located anywhere in the world, as long as the transport fuel associated with the project is sold into the California market. DAC projects, in contrast, are not tied to this fuel market selling requirement.

Eligible facilities, which include projects that capture CO_2 from oil and gas production, refining, alternative fuel production,[3] and directly from the air, must fulfil strict storage site and financial resource requirements. For example, the CO_2 storage site must be located onshore in saline reservoirs, depleted oil and gas reservoirs, or through CO_2-EOR, and monitored for a period of at least 100 years post injection. To generate credits, CCUS projects are subject to annual reporting requirements to monitor and verify emission reductions.

Because of the location flexibility under the LCFS, CCUS projects could be required to operate under two separate frameworks: the comprehensive requirements under the LCFS, as well as the regulatory framework of the jurisdiction in which the project operates. In some cases, there may be significant overlap between frameworks. For example, if the CCUS project is located in the United States, the requirements for injection wells under the LCFS closely follow the Class VI injection well requirements for geological storage under the US EPA's regulatory framework. However, in some cases the regulatory requirements of the frameworks may

[3] This includes production of ethanol, renewable diesel, renewable gasoline, alternative jet fuel, biogas from anaerobic digestion, electricity supplied to electric vehicle charging, hydrogen, and any other alternative transport fuel listed in sections 95482(a) of the LCFS regulation.

diverge, with one framework calling for different steps than the other. In the same case of a CCUS project the United States, the LCFS requires minimum post-injection site monitoring of 100 years, far longer than the default 50-year monitoring requirement under the Class VI permitting regime.

Comparison of requirements under the LCFS and selected regulatory frameworks for CCUS

	LCFS (California)	United States*	Norway	Victoria (Australia)	Alberta (Canada)
Post-injection monitoring period	100 years	50 years (default)	20 years	Not specified	10 years (recommended)
Financial responsibility	Operator must deposit 8-16.4% of generated credits, based on project risk rating, in a buffer account	Financial assurances required to cover corrective action, injection, well plugging, post-injection site care and any emergency response applied to the endangerment of underground drinking water sources	Operator must make a financial contribution that will cover, at a minimum, anticipated monitoring expenses for a period of 30 years	Operator must pay an annual fee determined as a percentage of the total estimated cost of long-term monitoring and verification	Operator must pay a per-tonne fee, determined for each individual project, into a post-closure stewardship fund
Transfer of long-term stewardship	No	No	Yes	Yes	Yes

* Includes requirements under the EPA's UIC Class VI well permitting programme.
Sources: IEA; Global CCS Institute (2019).

Facilitating CCUS hubs

The development of CCUS hubs could play an important role in accelerating the technology's deployment. The principal benefit of a hub approach is the possibility of multi-user CO_2 transport and storage infrastructure, enabling economies of scale, lower costs and less complexity in the value chain. Shared infrastructure can also allow smaller industrial facilities, for which dedicated transport and storage infrastructure may be impractical and uneconomic, to adopt CCUS as a mitigation solution. At least 40 CCUS hubs are in development globally – including in Australia, Europe and the United States.

Government leadership and co-ordination is likely to play an important role in the successful development of hubs and shared infrastructure. Legal and regulatory frameworks should ensure fair and open access to shared infrastructure in order to maximise transport and storage potential.

Access to shared transport infrastructure

The buildout of CO_2 transport infrastructure is critical to the widespread deployment CCUS. It is important that frameworks, whether existing or new, remove any barriers to the expansion of transport infrastructure or its shared access.

The two main options for the large-scale transport of CO_2 are pipeline and ship. For shorter distances and smaller volumes, CO_2 can also be transported via truck or rail, generally at a higher cost per tonne of CO_2. Large-scale transport of CO_2 by ship will soon be demonstrated as part of the Northern Lights Project in Norway. In contrast, CO_2 transport via pipeline has been taking place for decades, with more than 8 000 km of CO_2 pipelines in the United States.

Frameworks can enable and encourage shared access to CO_2 transport infrastructure by outlining the conditions under which operators must grant third-party access. For example, third-party access may be a requirement for projects that receive public funding.

One main consideration to take into account is the operating model of the CO_2 transport infrastructure. Ownership of CO_2 pipelines, for example, may dictate third-party access and the expansion of networks.

- Under a **private carrier model**, CO_2 pipelines are generally owned and operated by a company for internal purposes, such as in an integrated project where the operator captures, transports and stores the CO_2, or contracts with selected third parties to offload the CO_2 for storage or utilisation purposes. This requires several contracts to be negotiated between parties.
- Under a **common carrier model**, CO_2 pipelines offer transport services to third-party users under a standard set of terms and access is typically allocated in an equitable way. In this case, CCUS regulatory frameworks should outline conditions for third-party access.

Frameworks should also establish appropriate dispute resolution processes to deal with any potential access refusals by operators and/or claims by potential new market entrants.

Separate regulatory considerations may apply to CO_2 transported by ship. Although less common than pipeline transport, moving CO_2 by ship to dedicated storage sites can provide flexibility and be an attractive mode in certain regions, such as the North Sea. Frameworks should ensure that existing laws and regulations consider and accommodate the future transport of CO_2 by ship and do not unintentionally act as barriers.

Global examples and approaches

In the European Union, regulatory frameworks covering CO_2 transport have historically focused on access to pipelines and often overlook CO_2 transport by ship or other modes.

While it primarily concentrates on CO_2 storage, the CCS Directive aims to ensure that potential operators can obtain "fair and open" access to CO_2 transport networks. Certain considerations should be taken into account when providing for access to shared infrastructure, such as whether capacity can be made reasonably available, or if there are any insurmountable incompatibilities of technical specification. The directive allows infrastructure operators to refuse third-party access if there is a lack of capacity. Importantly, the directive defines CO_2 transport networks as a "network of pipelines" and does not mention other transport modes, such as by ship.

This lack of clarity for transport of CO_2 by ship is also reflected in the EU Emissions Trading Scheme (ETS) regulations, which apply to CO_2 that is captured and transferred to a storage facility either directly or via pipeline. Uncertainty in these regulatory frameworks can raise legal questions over whether or not CO_2 emissions from ship transport must be accounted for under the ETS. As regards ETS compliance, it is unclear who should be held liable for the fugitive and operational CO_2 emissions associated with the transporting of CO_2 by ship, or how these emissions should be calculated or measured.

In 2019 Norway suggested in a letter to the European Commission that the producer of the CO_2 remains liable until the CO_2 arrives for storage, and the calculation of any fugitive CO_2 emissions along the shipping route would be made according to agreements between the CO_2 producer and the shipper. The Commission confirmed these suggestions, although changes to the CCS Directive and ETS regulatory frameworks are likely to be needed in place of one-off project confirmations to clarify the role of other CO_2 transport modes.

In the United States, there is a patchwork of regulations facilitating shared access to CO_2 pipelines, and most pipelines operate on a private carrier model. At the federal level, CO_2 pipeline operators may be required to provide non-discriminatory access only when the pipeline crosses federal lands. The relevant authority can grant rights of way to pipeline operators, establishing rules for pipeline siting, third-party access and rate conditions.

Most states do not specify third-party access requirements for CO_2 pipelines. However, in Texas, which hosts a large CO_2 pipeline network, pipeline operators have the option to choose whether to become a common carrier. In this situation, the pipeline operator is subject to certain obligations, but is also granted certain rights, such as eminent domain.

Recommendations for third-party access in Alberta

In 2013, as part of the Regulatory Framework Assessment, the government of Alberta issued six recommendations on how to facilitate access to shared CCUS infrastructure:

Market considerations should be the primary driver behind access to CO_2 pipelines. In this regard, pipeline operators and third parties should be expected to explore all reasonable avenues of private negotiation before applying to the regulator for access.

The common carrier system should be expanded to apply to all CO_2 pipelines. This system is used in the upstream oil and gas industry when parties cannot agree on access conditions. However, the Oil and Gas Conservation Act does not include CO_2 pipelines in the common carrier system. Under this system, a party that is denied access to another party's pipeline can apply to the relevant authority and seek approval to receive non-discriminatory access to the pipeline.

Pipeline operators should undertake some form of "open house", where the operator invites interest from other parties desiring access to the pipeline. This process can help to ensure that the pipeline is correctly sized to meet regional needs and therefore help reduce the likelihood of applications for common carrier orders.

All CO_2 storage operations should be encouraged to use shared transport infrastructure whenever feasible and reasonable. This would help to minimise the incremental environmental footprint of CCUS projects and reduce industry costs.

Common carrier orders, and more specifically the application of prorating within a common carrier order, should be the option of last resort. In a review of open access requirements for CO_2 pipelines, significant attention was paid to the issue of prorating. For CO_2 capture facilities, reduced access to a pipeline would mean that they would vent a portion of the captured CO_2, with multiple environmental and financial consequences.

The review also recommended that the government of Alberta consider taking a larger role in the **regional planning of CO_2 pipeline infrastructure**, particularly if there is government funding involved. This would help to ensure that infrastructure development meets the goals of the region and the needs of CCS deployment in Alberta.

While the RFA primarily focused on access to CO_2 pipelines, Alberta is also considering open access requirements for CO_2 storage hubs. In May 2021 the government of Alberta issued a statement announcing that it would be introducing a competitive process to encourage the development of strategically located storage hubs. The government plans to issue CO_2 storage rights via a competitive process, with the intention that prospective operators will "ensure open access to the hub, provide fair service rates, and account for carbon offsets or future credits".

Facilitating shared storage infrastructure

As with shared CO_2 transport infrastructure, the development of shared storage infrastructure can help catalyse CCUS investment opportunities across a range of industrial applications and regions. It can improve the economics of storing CO_2 by reducing unit costs through economies of scale, as well as reducing commercial risk and enabling business models whereby CO_2 storage is developed and operated by specialised entities.

Frameworks should outline steps for third-party access to shared storage infrastructure, while taking into account the technical requirements for receiving and storing the CO_2.

Global examples and approaches

In the European Union, the CCS Directive requires member states to ensure that potential operators can obtain "fair and open" access to CO_2 storage sites in a non-discriminatory manner. Much like its stipulations for access to shared CO_2 transport networks, the directive has in place provisions for access that are determined by reasonable availability of capacity and technical requirements.

In Norway, national regulations derived from the CCS Directive provide a comprehensive regulatory framework for CO_2 transport and storage. This framework includes several provisions that seek to clarify co-ordinated storage development and third-party access of the site:

- **Co-ordination of CO_2 storage**: the framework notes that if a subsea storage reservoir extends across multiple licence holders, or into another country's jurisdiction, the affected parties must submit for approval an agreement on how they will co-ordinate transport, injection and storage activities.
- **Third-party access**: the relevant authority can allow third parties to access and use CO_2 storage sites if it determines that such shared use is "not an unreasonable impediment" to the licensee's own storage needs. The licensee that owns the storage facility may refuse third-party access if it determines that there is a lack of capacity to take on the additional CO_2. However, the relevant authority is allowed to intervene and instruct the licensee to increase the site's capacity if it is economically justifiable or if the third party will pay for the necessary capacity increases, so long as the capacity addition does not adversely affect the rest of the storage site.
- **Specifications for access**: in order for third parties to take advantage of the capacity in a shared storage facility, the CO_2 flow must have certain specifications that are "reasonably certain" to be compatible with the technical requirements of the storage facility and location.
- **Operator risk and profit**: the framework empowers the relevant authority to ensure that storage of CO_2 is implemented with the consideration of resource management and that the owner of the facility is afforded a reasonable profit, e.g. based on investment and risk.

Chapter 6
Other key and emerging issues

Treatment of technology-based carbon dioxide removal (CDR) solutions

Most CCUS frameworks focus on CO_2 abatement and not necessarily removal. Yet, reaching net zero emissions by 2050 will almost certainly require some level of technology-based carbon dioxide removal (CDR). CDR refers to capturing CO_2 from the atmosphere, either directly or indirectly, and storing it. CDR can offer a solution for legacy emissions and support net-negative emissions across the energy system in the long term. There are several approaches to CDR:

- **Nature-based solutions** include afforestation and reforestation that repurpose land use by growing forests where there was none before or re-establishing a forest where one existed in the past. Other examples include peatland and coastal restoration.
- **Enhanced natural processes** include land management approaches that increase the carbon content of soil through modern farming methods and ocean fertilisation. Many of these approaches are in the research and development phase and further studies are needed to understand their costs, risks and trade-offs. Other examples include enhanced weathering and the use of biochar.
- **Technology-based solutions** include capturing CO_2 from bioenergy and directly from the air (DAC) and permanently storing it (BECCS and DACS).

Many of the legal and regulatory issues outlined in this handbook, as well as those covered under traditional environmental assessment and permitting procedures, could apply to DACS and BECCS technologies. That said, as more countries and companies consider CDR options to reach net zero goals, it is important for policy makers to consider how frameworks could support or hinder deployment.

For example, BECCS and DACS are discussed in the context of “geoengineering”, that is, a deliberate and large-scale manipulation of an environmental process that affects the earth's climate, in an attempt to counteract the effects of global warming. The Convention on Biological Diversity adopted a non-binding decision in 2012 inviting parties and others to ensure (with some exceptions and until certain conditions are met) that no geoengineering activities take place. It is therefore important for national legislation or international protocols to clearly distinguish between geoengineering approaches such as solar radiation modification and technology-based carbon removal via BECCS and DACS.

Technology-based CDR should also be considered in the context of climate change measures or legislation. For example, in the European Union the recently-launched Fit for 55 package aims to revise the bloc’s climate, energy and transport-related legislation to align current laws with its 2030 and 2050 climate goals. The package includes a proposal to revise the regulation on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry. While land-based CDR is explicitly mentioned in the package, technology-based options such as BECCS and DACS have not been included yet.

Regulatory issues for CDR technologies focus on how frameworks can ensure robust accounting and certification of CO_2 removals. Key considerations include:

- **Transparent and consistent life cycle assessment methodologies** are needed to verify that more CO_2 has been removed than emitted from CDR operations.
- **Accounting frameworks** for CDR must be adjusted to consider the potential for reversal or re-release of CO_2.
- **Double counting** is a potential issue when multiple frameworks may overlap.

A regulatory framework for carbon removal certification

In December 2021 the European Commission published its Sustainable Carbon Cycles Communication, a proposed action plan on how nature- and technology-based carbon removals can help the European Union reach its net zero by 2050 climate target.

The communication calls for a regulatory framework for the certification of carbon removals that integrates with European Union compliance frameworks. The certification and accounting framework should provide "sufficient guarantees" of the duration of CO_2 storage, the quality of measurements and the management of carbon leakage. This is to be supported by scientifically robust requirements for quality, monitoring standards, reporting protocols and verification means.

The framework leaves open various governance options ranging from a single, centralised European Union system to a more decentralised structure involving public authorities and private bodies to support the framework's implementation.

As part of this initiative, the European Union intends to propose a regulatory framework for the accounting and certification of carbon removals. In addition, it aims to establish a European Union standard for monitoring, reporting and verifying GHG emissions and carbon removals at farm or forest holding level, as well as for captured fossil, biogenic or atmospheric CO_2 that is transported, processed, stored and potentially re-emitted to the atmosphere.

Interactions with other surface and subsurface resources

Issues to consider in relation to potentially overlapping resource interests include:

- Coexistence of CO_2 storage authorisations and existing authorisations relating to other uses of the subsurface (e.g. oil and gas production, geothermal energy production).
- Conflict resolution in the event that disputes arise in authorising subsurface activities.
- Potential competition with seabed real estate.

One emerging issue is the potential interaction between CCUS projects and offshore wind energy installations. Offshore wind platforms that are fixed to the seabed can increase the challenges in visualising, characterising and monitoring potential CO_2 storage sites. Several risks may result from the development of offshore wind and CCUS projects in similar locations:

- **Lack of clarity**: it remains unclear how issues such as the overlap of development planning, promotion, standards alignment, liabilities and dispute mitigation would be handled.
- **MMV survey interaction**: CCUS projects require robust MMV surveys, which may interact with offshore wind infrastructure.
- **Direct physical impact**: overlapping projects can result in the increased risk of impacts to physical infrastructure or personnel.
- **Infrastructure blocking seabed access**: the physical infrastructure of a pre-existing project can block access to the seabed and can modify requirements for new projects.

Frameworks should address competition and conflict between CCUS operators and other parties by putting in place the necessary co-ordination and communication channels to address potential real estate issues.

Interactions with other resources can also play a complementary role, especially with regard to the reuse of existing oil and gas assets for CCUS purposes. Oil and gas infrastructure, such as trunk pipelines, offshore platforms and site facilities, are broadly similar to the infrastructure needed for the transport and storage of CO_2. Utilising these existing assets, particularly offshore infrastructure, leaves room for potential cost savings for CCUS projects if that existing infrastructure can be reused or repurposed once it has reached the end of its commercial life for oil and gas extraction. While the feasibility of reusing oil and gas infrastructure for CCUS should be determined on a project-by-project basis, changes to legal and regulatory frameworks can provide general guidance on how to support this transition. Existing regulations covering decommissioning liability and well abandonment procedures are prime targets for evaluation.

Global examples and approaches

In Victoria (Australia), the relevant minister cannot approve an injection and monitoring plan unless satisfied that, among other things, use of the relevant formation for CO_2 injection and storage will not present a significant risk of contaminating or sterilising other resources in the licence area.

In the European Union, member states retain the right to give priority to any other use of the underground, and must give due consideration to other energy-related options, including options strategic to energy security or the development of renewables.

In Louisiana, any reservoir that is producing or capable of producing oil, gas, condensate or other commercial minerals in paying quantities cannot be subject to CO_2 storage activities, unless all owners in the reservoir have agreed to those activities. In addition, no reservoir can be used for CO_2 storage unless either:

- All volumes of oil, gas, condensate, salt or other commercial minerals in the reservoir capable of being produced in paying quantities have been produced, or
- The reservoir has a greater value or utility for CO_2 storage than for the production of the remaining volumes of oil, gas, condensate or other commercial minerals, and at least three-quarters of the owners of the reservoir have consented to such use in writing.

In Texas, a CO_2 storage facility permit may be issued if the applicant has demonstrated, among other things, that CO_2 injection and storage will not endanger or injure any existing or prospective oil, gas, geothermal or other mineral resource, or cause waste. Proper safeguards must also be in place to ensure that underground drinking water and surface water sources are protected from CO_2 migration or displaced formation fluids.

In the United Kingdom, concerns have been raised over the potential conflict between offshore wind energy installations and the development of CO_2 storage sites in the North Sea. Existing regulatory frameworks do not yet account for such seabed real estate competition, although relevant authorities have created a forum to identify the challenges and opportunities associated with the co-location of CCUS and offshore wind. In April 2021, the Crown Estate, Crown Estate Scotland and the Oil & Gas Authority released a study that recommended a proactive review of any potential overlap between offshore wind projects and CCUS projects and performing site characterisation activities for CO_2 storage in the areas prior to any offshore wind development. The study called for the creation of an overarching committee (comprised of various regulatory authorities and representatives from industry) to co-ordinate and implement this review.

Reuse of oil and gas infrastructure for CCUS in the United Kingdom

In the United Kingdom, relevant authorities are evaluating what changes need to be made to existing oil and gas legislation in order to promote the reuse of existing infrastructure for CCUS purposes. In 2019 regulators launched a consultation to help gather information and opinions on ways to facilitate the deployment of CCUS at scale by identifying the existing opportunities and barriers to the reuse of infrastructure for CO_2 transport and storage. After receiving feedback from industry, academia and individuals, the government published a summary of the responses:

- **Trunk pipelines and depleted oil and gas reservoirs have the greatest reuse potential**. Respondents noted that the reuse of trunk pipelines, which can often be hundreds of kilometres long, could result in significant time and cost savings for CO_2 transport infrastructure. However, many trunk pipelines remain in operation and their decommissioning timeline may not match the timescale needed to deploy CCUS technologies. Regarding the subsurface, respondents agreed that depleted oil and gas reservoirs could allow for more accurate modelling of CO_2 injection and storage given that the subsurface geology has already been well characterised.
- **The benefits of reuse need to be balanced against potential concerns regarding historic wells**. Decommissioned and abandoned wells may not be suitable for reuse for CO_2 injection. In this regard, there may also be a lack of data and technical records on the condition of the well and the way in which it was plugged. Respondents noted that decommissioning costs are likely to increase due to the higher standards required to minimise the risk of CO_2 leakage and need for additional monitoring.
- **There is a lack of clarity in the legal and regulatory framework regarding the transfer of assets**. Regulations require previous oil and gas asset owners to be liable for the costs associated with decommissioning infrastructure. However, it is unclear how these obligations will fit into existing frameworks if assets are intended to be transferred for reuse. Respondents were supportive of a suggestion that the relevant authority's power to remove decommissioning obligations on previous asset owners be expanded to allow for the smooth transfer of infrastructure to a CCUS project. Existing frameworks would need to clarify the status of decommissioning obligations and the eligibility requirements for removing them.

The relevant authority intends to work with other regulators to review the existing oil and gas framework, including whether new guidance or amendments are needed to encourage the reuse of oil and gas infrastructure to support CCUS projects.

Transitioning from CO_2-EOR to dedicated storage

The process of injecting CO_2 into existing oil fields is a well-known enhanced oil recovery (EOR) technique; the addition of CO_2 increases the overall pressure of an oil reservoir, forcing the oil towards production wells. The CO_2 can also blend with the oil, improving its mobility and so allowing it to flow more easily. As a by-product of enhanced recovery, some CO_2 remains trapped in the subsurface. Over the lifetime of a CO_2-EOR project, much of the injected CO_2 is retained in the reservoir.

The use of CO_2 for EOR has formed the basis of early CCUS deployment, especially in the United States, where natural gas processing plants in Texas began to capture CO_2 in the 1970s and 1980s and supply it to local oil producers for EOR operations.

Many existing oil and gas frameworks already have in place specific regulatory requirements for CO_2-EOR. However, the focus of these regulations is not on long-term CO_2 storage. Instead, regulations for CO_2-EOR tend to assume that CO_2 injection will end and producing wells will be decommissioned, plugged and abandoned after CO_2-EOR operations have ceased.

Existing legal and regulatory frameworks generally do not provide a clear pathway to transition from CO_2-EOR to dedicated storage operations. Yet these depleted reservoirs could be an attractive option for CO_2 storage given they will be well understood and characterised by the operators and have relevant CO_2 infrastructure in place. While in principle there are no major technological challenges in converting EOR operations to dedicated CO_2 storage operations, frameworks would need to clarify additional monitoring and verification requirements for dedicated storage, which would go beyond the requirements for CO_2-EOR operations in most jurisdictions. This would help track any unintended CO_2 migration and leakage that may not have been considered during CO_2-EOR operations.

Over time, as CO_2-EOR operations come to a close at some sites and the need for CO_2 storage grows, it may be important for CCUS legal and regulatory frameworks to clarify a clear transition pathway to permanent geological storage.

Global examples and approaches

In the United States, CO_2-EOR entails specific reporting requirements, such as obligations for calculating and reporting relevant CO_2 volumes and other data, monitoring and quality assurance and control. These regulations fall under the UIC Class II well requirements, which are not tailored to the long-term storage of CO_2 as under the UIC Class VI requirements for geological storage. The current framework does not easily allow for the transition from a Class II well to a Class VI well for permanent CO_2 storage. In 2014 the EPA published a two-page memorandum specifying key principles in transitioning from Class II to Class VI, although more detailed guidance or changes to the framework may be needed in order facilitate a transition to permanent storage.

In the European Union, CO_2-EOR is not directly included in the CCS Directive as a standalone activity. However, the directive may cover CO_2-EOR operations where the project is "combined with geologic storage of CO_2", given the levels of incidental CO_2 storage from EOR activities. The general wording of CO_2-EOR in the framework leaves it open to interpretation as to which CO_2-EOR projects may actually qualify under the directive, raising several legal points over what should count as geological storage of CO_2. For example, does incidental CO_2 storage during EOR operations count? Or does this only apply to CO_2-EOR projects that transition to permanent storage following the termination of production operations?

In the case where a CO_2-EOR project intends to transition to permanent storage, the project must retrospectively undertake the geotechnical assessments required for site evaluation and other activities in order to comply with the directive. Even if these requirements are met, the CO_2-EOR operator is not necessarily guaranteed to receive a CO_2 storage licence given the directive's level playing field requirements that allow other parties to apply for the storage exploration permit.

CCUS-ready requirements

If left unmitigated, today's power and industrial plants could generate more than 600 GtCO_2 until the end of their technical lives. This is almost 17 years' worth of global energy sector emissions in 2021. The fact that many industrial and power facilities can have technical lives of 40 or 50 years (or more) underscores the need to avoid locking in new emissions-intensive infrastructure.

Retrofitting CCUS can provide a strategic solution to reduce emissions from some existing power and industrial plants. CCUS-ready requirements should be considered in situations where new emissions-intensive plants are planned, but are unable – for commercial or technical reasons – to be immediately fitted with CCUS and where alternative (e.g. renewable energy) solutions are not available. This will involve assessment of the technical feasibility of retrofitting capture to the installation, as well as access to CO_2 transport and storage. These factors should be taken into consideration at the time of design and construction of a facility.

In a report to the G8 Muskoka Summit in 2010, the IEA and Carbon Sequestration Leadership Forum identified several essential requirements that represent the minimum criteria that should be met before a facility could be considered CCUS-ready:

- Carry out a site-specific study in sufficient engineering detail to ensure the facility is technically capable of being fully retrofitted for CO_2 capture, using one or more choices of technology that are proven or whose performance can be reliably estimated as being suitable.
- Demonstrate that retrofitted capture equipment can be connected to the existing equipment effectively and without an excessive outage period and that there will be sufficient space available to construct and safely operate additional capture and compression facilities.
- Identify realistic pipeline or other route(s) to storage of CO_2.
- Identify one or more potential storage areas that have been appropriately assessed and found likely to be suitable for safe geological storage of projected full lifetime volumes and rates of captured CO_2.
- Identify other known factors, including any additional water requirements that could prevent installation and operation of CO_2 capture, transport and storage, and identify credible ways in which they could be overcome.
- Estimate the likely costs of retrofitting capture, transport and storage.
- Engage in appropriate public engagement and consideration of health, safety and environmental issues.

Annex: Model regulatory text

Definitions and terminology

1. **Baseline survey** means the collection of storage site data before injection commences, to help identify any possible effects of storage during or after injection.
2. **Closure authorisation** means an authorisation granted by the relevant authority.
3. **Closure period** means the period between cessation of injection activities at a storage site and the granting by the relevant authority of a closure authorisation for the storage site.
4. **Corrective measures** means measures taken to address significant leakage, unintended migration or other irregularity at a storage site.
5. **Corrective measures plan** means the plan to be provided as part of a storage authorisation application, as updated from time to time in accordance with the requirements of this framework.
6. **CO_2 enhanced oil recovery** refers to the injection of CO_2 in oil reservoirs contributing to the extraction of crude oil.
7. **CO_2 plume** means the volume of CO_2 dispersing or dispersed in the subsurface.
8. **CO_2 stream** means the CO_2 and other allowed substances injected into a storage site.
9. **Decommission** means the dismantling and removal of injection facilities following cessation of injection activities at a storage site and the restoration of a storage site as required by the relevant authority prior to the granting by the relevant authority of a closure authorisation.
10. **Eminent domain** refers to the power of the government to acquire private property and convert it into public use.
11. **Environmental impact assessment** means a process consisting of:
    a. the preparation of an environmental impact assessment report by the developer,
    b. the carrying out of consultations,
    c. the examination by the competent authority of the information presented in the environmental impact assessment report and any supplementary information provided, and any relevant information received through the consultations,
    d. the reasoned conclusion by the competent authority on the significant effects of the [CCS] project on the environment, taking into account the results of the examination referred to in point (iii) and, where appropriate, its own supplementary examination, and

e. the integration of the competent authority's reasoned conclusion into any of the decisions.

12. **Exclusive economic zone** has the meaning given in the United Nations Convention on the Law of the Sea.
13. **Explore or exploration** means activities undertaken to locate and assess the suitability of prospective storage sites.
14. **Exploration authorisation** means an authorisation granted by the relevant authority.
15. **Exploration facilities** means temporary surface equipment required for exploration.
16. **Exploration period** means the period between the granting by the relevant authority of an exploration authorisation and either:
    a. the granting by the relevant authority of a storage authorisation, or
    b. expiry or earlier termination of the exploration authorisation.
17. **Injection facilities** means surface installations required to undertake injection activities at a storage site.
18. **Leakage** means the unintended release of CO_2 from a storage complex.
19. **Migration** is the movement of CO_2 within a storage complex.
20. **Monitoring, measurement and verification plan** refers to a plan with the following objectives:
    a. Demonstrate CO_2 inventory accuracy to ensure the reported CO_2 stored will comply with regulations and protocols.
    b. Ensure containment to demonstrate the security of CO_2 storage and to protect human health, groundwater resources, hydrocarbon resources and the environment.
    c. Ensure conformance to indicate the long-term effectiveness of CO_2 storage by demonstrating actual storage performance is consistent with expectations about injectivity, capacity and CO_2 behaviour inside the storage complex.
21. **Operation period** means the period between the granting by the relevant authority of a storage authorisation and the cessation of injection activities at a storage site.
22. **Operator** means the holder or holders of an exploration authorisation or a storage authorisation for a storage site.
23. **Overburden** means the geological matter between the storage complex and the surface projection of the storage complex.
24. **Post-closure period** refers to the period from the granting by the relevant authority of a closure authorisation.

25. **Post-closure plan** means the plan to be provided as part of a storage authorisation application, as updated from time to time in accordance with the requirements of this framework.
26. **Primary cap-rock formation** means the impermeable layer of rock overlying a primary storage formation.
27. **Primary containment system** means a primary storage formation together with a cap-rock formation.
28. **Primary storage formation** means the permeable geological strata in a storage complex where the CO_2 stream is injected.
29. **Project** means a proposed storage site, a storage site and any activities undertaken in the project period.
30. **Project period** means the exploration period, operation period and closure period.
31. **Relevant authority** means a government entity or an entity appointed by a government entity from time to time, which is responsible for the administration of this framework or aspects of this framework.
32. **Remediation measures** means measures taken to rectify any damage resulting from significant leakage, unintended migration or other irregularity in a storage site.
33. **Risk assessment** means the process of risk identification, risk analysis and risk evaluation. The risk assessment shall comprise, inter alia, the following:
    a. Hazard characterisation.
    b. Exposure assessment.
    c. Effects assessment.
    d. Risk characterisation.
34. **Secondary cap-rock formation** means any impermeable layer of rock overlying a secondary storage formation.
35. **Secondary containment system** means a secondary storage formation, together with a secondary cap-rock formation.
36. **Secondary storage formation** is a permeable geological stratum in a storage complex overlying a primary containment system.
37. **Site characterisation** means a part of the site selection process and consists of a detailed evaluation of at least the area of review of one or more candidate sites for CO_2 sequestration to confirm and refine containment integrity, sequestration capacity and injectivity estimates. Site characterisation provides basic data for initial predictive modelling of fluid flow, geochemical reactions, geochemical effects, risk assessment, and monitoring measurement and verification programme design.

38. **Store or storage** means the injection and intended permanent containment of a CO_2 stream into a storage complex to prevent the CO_2 from reaching the atmosphere.
39. **Storage authorisation** means an authorisation granted by the relevant authority.
40. **Storage complex** refers to the primary containment system and any secondary containment systems.
41. **Storage site** means a storage complex, overburden, the surface projection of the storage complex and injection facilities.
42. **Unintended migration** means movement of CO_2 outside of a storage complex.

Storage resource assessment and authorisation (model text)

Authorisation of storage site exploration activities

1. It is prohibited to explore for a potential storage site without an exploration authorisation.
2. An exploration authorisation application must:
    a. define a fixed area that is intended for exploration,
    b. define the methods and techniques intended for exploration, providing evidence of any authorisations required to undertake those methods and techniques, and
    c. include any other information required by the relevant authority.
3. An exploration authorisation:
    a. allows the operator to perform the exploration as specified in the authorisation,
    b. grants the operator the sole right to explore for potential storage sites in the area as specified in the exploration authorisation, and
    c. has a fixed duration.
4. Where appropriate, monitoring of injection tests may be included in the exploration permit.
5. The relevant authority shall ensure that the procedures for the granting of exploration permits are open to all entities possessing the necessary capacities and that the permits are granted or refused on the basis of objective, published and non-discriminatory criteria.
6. The relevant authority may withdraw an exploration authorisation on the terms specified in the authorisation.
7. If the duration of an exploration authorisation is insufficient to enable the operator to carry out the exploration as specified in the exploration authorisation, the operator may apply to the relevant authority for an extension of the exploration authorisation.

Regulating site selection and characterisation activities

1. A site characterisation process as required by the relevant authority must be undertaken in respect of a proposed storage site.
2. The results of the site characterisation process must be submitted as part of a storage authorisation application.
3. To be a suitable storage site, the site characterisation process must indicate that a proposed storage site:
    a. has sufficient storage capacity for the intended quantity of CO_2 to be stored,

   b. has sufficient injectivity for the intended rate of CO_2 injection, and
   c. is free of faults, fractures, wells or other features that are likely to allow unintended migration.

4. When conducting site selection and characterisation activities, operators shall apply the precautionary principle in relation to significant risks.
5. A proposed storage site is not suitable where the site characterisation process indicates that it poses significant:
   a. risk of unintended migration,
   b. risk of leakage,
   c. environmental risks,
   d. health risks, or
   e. risk to other resources.
6. Where the location of a proposed storage site would result in the existence of more than one storage site in the same primary storage formation, the potential interaction of the sites (including but not limited to interaction of CO_2 plumes and pressure interactions) must be such that both sites will meet, or continue to meet, the requirements of this section.

Authorisation of storage activities

1. It is prohibited to operate a storage site without a storage authorisation.
2. A storage authorisation application must include:
   a. proof of the technical competence of the applicant,
   b. the results of the site characterisation process for the proposed storage site including the location and areal extent of the storage site,
   c. the site model developed from the results of the site characterisation process, including an assessment of the anticipated security of the storage site,
   d. the total quantity of CO_2 to be stored, the composition of CO_2 streams, the injection rates and pressures, and the location of proposed injection facilities,
   e. a description of measures to prevent significant leakage, unintended migration or other irregularities in the storage site,
   f. a proposed monitoring plan,
   g. a proposed corrective measures plan,
   h. a proposed closure plan,
   i. a proposed post-closure plan,
   j. an environmental impact assessment,
   k. a health and safety emergency response plan,
   l. proof of the financial security of the applicant, and
   m. any other information required by the relevant authority.

3. In considering applications for a storage authorisation, the relevant authority will:
    a. have regard to the potential impact of issuing a storage authorisation on existing or potential users or uses of the subsurface, and
    b. give the holder of an exploration authorisation for a proposed site priority, where a storage authorisation is to be issued.
4. If the relevant authority considers, based on the information provided by a storage authorisation applicant, that there is a risk that the applicant's financial security may be insufficient to cover potential costs associated with a project during the project period, including without limitation potential costs associated with:
    a. undertaking corrective measures,
    b. undertaking remediation measures,
    c. decommissioning and rehabilitating a storage site during the closure period, or
    d. potential liabilities associated with the storage site,

    the relevant authority may:

    e. require the applicant to implement and maintain a financial security mechanism, including without limitation by way of insurance, trust fund or equivalent mechanism, until transfer of responsibility to the relevant authority, or
    f. impose or have imposed on the applicant levies or fees for the duration of the project period in order to cover such costs.
5. A storage authorisation authorises the operator to develop the storage site, store CO_2 and undertake activities incidental to CO_2 storage as specified in the storage authorisation.
6. During the operation period and closure period the operator must continue to refine and update the site model developed from the results of the site characterisation process to reflect ongoing monitoring results and other operational data.
7. During the operation period the operator must continue to refine and update the closure plan to reflect ongoing activities undertaken under the storage authorisation.
8. A storage authorisation must be reviewed if there is significant leakage, unintended migration or other irregularity in the storage site.
9. An operator must inform the relevant authority if it intends to cease injection activities under a storage authorisation. Once injection activities have ceased, the operator must not recommence injection activities without authorisation from the relevant authority.

10. Injection activities under a storage authorisation must cease:
    a. when the total quantity of CO_2 to be stored, as set out in the storage authorisation, has been reached,
    b. if the operator informs the relevant authority that it intends to cease injection activities under a storage authorisation, on a date advised by the operator, or
    c. when required by the relevant authority including due to significant leakage, unintended migration or other irregularity in the storage site.
11. A storage authorisation ends when the relevant authority issues a closure authorisation.

Measurement, monitoring and verification (model text)

1. A monitoring plan must be submitted as part of a storage authorisation application.
2. The monitoring plan must outline a monitoring programme and monitoring methods sufficient to:
    a. continue the baseline survey for the storage site until injection commences,
    b. monitor the injection facilities, the storage site (including the CO_2 plume) and the surrounding environment,
    c. compare the ongoing monitoring results with the baseline survey for the storage site,
    d. compare the actual behaviour of the storage site with the anticipated behaviour of the storage site based on the results of the site characterisation process and monitoring results,
    e. detect and assess significant leakage, unintended migration or other irregularity in the storage site,
    f. quantify, as required by the relevant authority, the volumes of CO_2 associated with significant leakage or unintended migration,
    g. detect migration of CO_2,
    h. detect significant adverse effects on the surrounding environment, and
    i. assess the effectiveness of any corrective measures taken.
3. Monitoring of a storage site must be based on the site-specific monitoring plan as approved by the relevant authority.
4. Monitoring results must be reported to the relevant authority periodically for review, as required by the relevant authority.
5. The relevant authority may require that a monitoring plan be updated to take account of:
    a. changes to the assessed risk of leakage,
    b. changes to the assessed risk to the environment,
    c. changes to the assessed risk to human health,
    d. new scientific knowledge, and
    e. improvements in best available technology.

Storage site inspections (model text)

1. The relevant authority may undertake routine and non-routine inspections of a storage site or any other site relevant to a project.
2. In undertaking inspections, the relevant authority may access any site that has been, or is being, used in connection with a project including third-party property. Inspections may include:
    a. exploration facilities,
    b. visits to injection facilities,
    c. assessment of injection activities,
    d. assessment of monitoring operations and compliance with the storage site's monitoring plan as approved by the relevant authority, and
    e. access to all relevant records.
3. Inspections may commence when an exploration authorisation has been granted and may continue until transfer of responsibility to the relevant authority, if relevant.
4. Frequency of inspections may vary, increasing if there is significant leakage, unintended migration or other irregularity in the storage site.
5. Following each inspection, the relevant authority shall prepare a report on the results of the inspection. The report shall evaluate compliance with the relevant regulations and indicate whether or not further action is necessary. The report shall be communicated to the operator concerned and shall be publicly available in accordance with relevant legislation within two months of the inspection.

Operational liabilities and financial security (model text)

Liability during the project period

1. During the project period, the operator is responsible for any liabilities for damage caused by the project, including but not limited to:
    a. damage to the environment,
    b. damage to human health,
    c. damage to other resources,
    d. damage to third-party assets,
    e. the cost of corrective measures required to limit the extent of the damage, and
    f. the cost of remediation measures associated with the damage.

Corrective measures and remediation measures

1. Where significant leakage, unintended migration or other irregularity occurs, the operator must immediately notify the relevant authority.
2. The operator must undertake:
    a. any corrective measures, as determined by the relevant authority, to protect:
        i. the environment;
        ii. human health;
        iii. other resources; and
        iv. third-party assets, including as set out in the operator's corrective measures plan as approved by the relevant authority; and
    b. any remediation measures, as determined by the relevant authority.
3. The relevant authority may itself undertake corrective measures or remediation measures at any time, including at the cost of the operator, while responsibility for the storage site resides with the operator.
4. The operator must update the corrective measures plan to reflect any lessons learnt after undertaking any corrective measures.

Site closure and post-closure processes (model text)

Authorisation for site closure

1. During the closure period, the operator:
    a. must undertake the following activities in accordance with the requirements of this framework:
        i. monitoring of the storage site and reporting monitoring results to the relevant authority,
        ii. any corrective measures,
        iii. any remediation measures, and
        iv. any other activities as set out in the operator's closure plan as approved by the relevant authority.
    b. must, at the operator's cost, decommission the storage site to the satisfaction of the relevant authority; and
    c. remains liable for damage caused by the storage site in accordance with the terms of this framework.
2. A closure authorisation application must include:
    a. evidence to the satisfaction of the relevant authority that:
        i. there is no significant risk of future leakage or other irregularity in the storage site, and
        ii. the storage site has been decommissioned as required by the relevant authority;
    b. a statement of operations conducted at the storage site during the project period, including:
        i. the quantity of CO_2 stored;
        ii. a report on the behaviour of the storage site as compared to the anticipated behaviour of the storage site, based on the results of the site characterisation process and ongoing monitoring results over the operation period and closure period, and information relevant to the operator's analysis of that information;
        iii. the anticipated migration pathway or pathways of the CO_2 in the post-closure period;
        iv. the short- and long-term consequences of any migration; and
        v. a revised post-closure plan, including the operator's suggestions for the approach to be taken to monitoring the behaviour of the CO_2 in the post-closure phase;

   c. a description of the location, condition, plugging procedures and any integrity testing results for every well that has been or will potentially be affected by the storage site;
   d. a description of the decommissioning and rehabilitation activities undertaken during the closure period; and
   e. any other information required by the relevant authority.
3. If specified in a storage authorisation, the relevant authority may require:
   a. a minimum period to elapse between cessation of injection and issue of a closure authorisation; and
   b. that an operator make a financial contribution to the relevant authority's anticipated or potential costs associated with the storage site in the post-closure period.

Liability during the post-closure period

1. Subject to the terms of this section, where a closure authorisation has been issued for a storage site, responsibility for the storage site transfers to the relevant authority.
2. On transfer of responsibility for a storage site to the relevant authority, the relevant authority assumes:
   a. Responsibility for any liabilities for damage caused by the storage site, including but not limited to:
      i. damage to the environment;
      ii. damage to human health;
      iii. damage to other resources;
      iv. damage to third-party assets;
      v. the cost of corrective measures required to limit the extent of the damage; and
      vi. the cost of remediation measures associated with the damage;
   b. responsibility for:
      i. monitoring the storage site;
      ii. undertaking any corrective measures; and
      iii. undertaking any remediation measures;
3. In the post-closure phase, an operator remains responsible for any liabilities for damage caused by a storage site if that damage results from fault or negligence of the operator during the project period.

Financial assurances of long-term site stewardship

1. The relevant authority may:
    a. require an operator at any time during the project period to implement and maintain to the satisfaction of the relevant authority a financial contribution mechanism, including without limitation by way of trust fund or equivalent mechanism; or
    b. impose or have imposed on an operator levies or fees, to contribute to, or cover the relevant authority's anticipated or potential costs associated with the storage site in the post-closure period.

Abbreviations and acronyms

BECCS	bioenergy with carbon capture and storage
CCS	carbon capture and storage
CCUS	carbon capture, utilisation and storage
CDR	carbon dioxide removal
CO_2	carbon dioxide
CP	contracting party
DAC	direct air capture
DACS	direct air capture with CO_2 storage
EIA	environmental impact assessment
EOR	enhanced oil recovery
EPA	Environmental Protection Agency
ETS	Emissions Trading Scheme
GHG	greenhouse gas
ICCS	Illinois Industrial Carbon Capture and Storage Project
IMO	International Maritime Organization
JCCS	Japan CCS Co., Ltd
LCFS	Low Carbon Fuel Standard
MMV	measurement, monitoring and verification
PCI	project of common interest
RFA	Regulatory Framework Assessment
UIC	Underground Injection Control
UNCLOS	United Nations Convention on the Law of the Sea

Units of measure

Gt	gigatonne
km	kilometre
Mt	million tonnes

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