

Securing investments in CO₂ pipeline networks and CO₂ underground storage facilities

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Abbreviations

Abbreviation	Full term
BAFU	Federal Office for the Environment (Bundesamt für Umwelt / FOEN)
BAK Economics	Basel Working Group for Business Cycle Research
BEIS	UK Department for Business, Energy and Industrial Strategy
BBB+	Investment-grade credit rating (BBB Plus)
CAPEX	Capital Expenditure
CEF-E	Connecting Europe Facility – Energy
CCfD	Carbon Contract for Difference
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilisation
CHF	Swiss Franc
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
CTP	Climate Target Pathway
DACCS	Direct Air Carbon Capture and Storage
DENA	Deutsche Energie-Agentur (German Energy Agency)
DESNZ	UK Department for Energy Security and Net Zero
DETEC	Federal Department of the Environment, Transport, Energy and Communications
EBN	Energie Beheer Nederland
EC	European Commission
EPC	Engineering, Procurement and Construction
EOR	Enhanced Oil Recovery
ETS	Emissions Trading System
EU	European Union
EUA	European Union Allowance
FID	Final Investment Decision
GSP	Government Support Package
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre
LC	Letter of Credit
LCCC	UK Low Carbon Contract Company
MRV	Monitoring, Reporting and Verification
NAO	UK National Audit Office
NEP	Northern Endurance Partnership
NET	Negative Emission Technologies
NZIA	Net-Zero Industry Act
OPEX	Operating Expenditure
RAB	Regulated Asset Base
RVO	Rijksdienst voor Ondernemend Nederland (Netherlands Enterprise Agency)
SCA	Supplemental Compensation Agreement

SCOR	Société Commerciale de Réassurance
SDE++	Stimulering Duurzame Energieproductie en Klimaattransitie
SFOE	Swiss Federal Office of Energy
SPV	Special Purpose Vehicle
Swiss Re	Swiss Reinsurance Company Ltd
TSA	Transport and Storage Agreement
TRI	Transport and Storage Regulatory Investment
TSC	Transport and Storage Company
TEN-E	Trans-European Networks for Energy
UK	United Kingdom
US	United States of America
WACC	Weighted Average Cost of Capital

Executive summary

Background and objectives

Switzerland has committed to net-zero greenhouse gas emissions by 2050. Because roughly one-quarter of today's emissions originate in hard-to-abate sources such as waste incineration, cement manufacturing, and other parts of industry, carbon capture and storage (CCS) and negative emission technologies are indispensable complements to direct emission reductions. Federal estimates imply that around 7 MtCO₂ will need to be captured, transported, and permanently stored each year by 2050. Since domestic geological storage potential is limited, at least in the short-term, an efficient system will depend on a national CO₂ pipeline network connected to foreign transport routes and storage sites. To enable this, the Federal Council is preparing a CCS/NET framework law and a revised CO₂ Act, due to be submitted by end of 2026.

Even with carbon pricing and emitter-level support such as Carbon Contracts for Difference (CCfDs), specific risks along the CO₂ transport and storage (T&S) chain may continue to deter private investment. This study provides a structured overview of how those investment risks could be hedged in Switzerland under a policy framework assumed to be in place from around 2031. It works from the premises that T&S infrastructure is privately built and operated, that a harmonised framework law and market regulation are in place, that emitter-level financing instruments exist, and that the system scales rapidly towards roughly 7 Mt/year captured, transported, and stored by 2050. These political and institutional boundary conditions have been presupposed for this study and were not further investigated. The analysis addresses three questions:

1. Which residual risks could still discourage investment in the ramp-up phase and in a mature market;
2. which of these can be covered by private markets versus where state-backed mitigation is justified by market failure; and
3. which concrete hedging instruments are suitable for Switzerland, at what indicative cost.

The study draws on Swiss and international literature, including comparable Swiss studies on thermal and hydrogen networks, and on interviews with emitters, network and storage operators, financial institutions, and regulators. The results of this study are therefore primarily of a qualitative nature.

Investment characteristics and the risk landscape

CO₂ T&S infrastructure is highly capital-intensive, long-lived (30–50+ years) and exhibits strong economies of scale, with pipelines accounting for around 30% of total system costs and tending towards natural-monopoly structures. Current full-chain CCS costs (broadly CHF 219–339/tCO₂) remain well above carbon allowance prices, leaving a financing gap; total (primarily private) investment of CHF 11–21 billion is estimated by 2050. A defining feature is that the upside for T&S investors is inherently capped, whereby revenues depend on policy, regulated pricing and subsidies rather than open-market competition, while downside exposure can be substantial. Investors therefore place a premium on downside protection and contractual certainty before committing capital.

The study groups risks into five categories (planning, financial and commercial, legal, political, and technical) and assesses each by probability, impact, and insurability. A central finding is that **operational and technical risks tend to be at least partially insurable, whereas risks rooted in systemic market structure, policy uncertainty or coordination failure are generally not**. The most material uninsurable risks are planning and interdependency risk (the “chicken-and-egg” problem of capture, transport and storage having to advance in parallel, amplified in Switzerland by dependence on cross-border infrastructure); regulatory risk, particularly ETS carbon-price volatility, which is the core determinant of revenue viability; public-acceptance and permitting risk, heightened by Switzerland's federal, direct-democratic system; and technological obsolescence. Many of these risks have the effect of either escalating costs, delaying projects, or simply making projects unfeasible.

Transport incidents can be well covered by conventional insurance, while storage carries insurable short-term operational risks but uninsurable long-term, post-closure leakage liability that ultimately requires some form of public backstop.

Availability of hedging instruments and lessons from comparable cases

For most short-term risks, the availability of hedging instruments in Switzerland is already very good. A mature commercial market, including active Swiss players such as Swiss Re and Zurich, offers private insurance, parent-company and public-sector guarantees, letters of credit, performance bonds, ring-fenced and escrow accounts, take-or-pay contracts and regulated-return mechanisms, and even post-closure leakage cover is beginning to emerge. As a later entrant, Switzerland can also expect to benefit from instruments maturing in neighbouring markets. There is therefore little need for the federal government to provide these instruments directly.

Counterparty (default) risk on the emitter side is similarly manageable. The two dominant Swiss emitter groups can secure their obligations through familiar means: cement is dominated by Holcim, whose balance sheet and investment-grade ratings make parent-company guarantees highly effective, while waste-incineration plants — typically owned by cantons or municipalities — benefit from implicit or explicit public guarantees. Nonetheless, significant political risk can arise if a federal guarantee wouldn't support such projects to ensure costs are shared more evenly across the entire benefitting group. A long-duration CCfD on the emitter side would, in any case, substantially reduce residual default risk.

Experience from comparable sectors and countries reinforces these conclusions. The SFOE thermal-networks study shows that volume-loss and large pre-investment risks are best addressed by guarantees, with the state backstopping the portion of risk that markets cannot bear; the SFOE hydrogen study points to subsidies, guarantees and conditional loans, and stresses EU-law compatibility. In the Netherlands (Porthos and Aramis), the state secures demand through subsidies, provides pre-FID guarantees, takes a direct ownership role and absorbs long-term storage liability. The United Kingdom enables private T&S investment through a Regulatory Asset Base (RAB) model combined with a Government Support Package that places long-tail leakage and stranded-asset risk on the public balance sheet, alongside CCfD-type support for emitters. The principal lesson for Switzerland is that, alongside CCfDs on the emission side, a well-designed regulated-return framework, plus targeted public support for long-term storage risk, can mobilise private investment without direct state equity. Switzerland's reliance on foreign storage makes detailed cross-border agreements an additional necessity.

Where federal action is required

The study's central conclusion is that risk hedging for Swiss CO₂ T&S infrastructure is, for the most part, already well provided for by commercial markets and by the project owners themselves. The **decisive gap lies less in missing hedging products than in enabling actions that only the Confederation can take**. Four are recommended:

1. **Revenue support for capture projects**, often delivered through **Carbon Contracts for Difference**. CCfDs (or other forms of revenue support) are the most frequently cited missing piece: they make the capture business case investible at current carbon prices, stabilise emitter revenue against ETS volatility and, in turn, underpin the long-term T&S agreements on which network investment depends. They carry a high short-term budgetary cost but are otherwise efficient and effective.
2. **Coordination and organisation of ventures**. Active government involvement in aligning partners, projects, subsidies and permits reduces overall cost substantially. It can bring together final investment decisions, construction schedules, permitting and other milestones across dispersed emitters and pipeline developers. It is a low-cost way to defuse interdependency ("chicken-and-egg") risk and avoid much higher overall societal cost.
3. **Detailed, binding cross-border agreements**. Agreements with sufficient operational precision, including on liability for leakage and ETS surrender, monitoring obligations, and

chain-of-custody, are essential. The June 2025 Switzerland–Norway agreement is significant progress; further detail is needed along the Basel–North Sea corridor.

4. **A regulated asset base (RAB) framework** for the scale-up phase. When T&S operators hold a quasi-natural-monopoly position, a RAB framework secures efficient investment. Switzerland has applicable experience from electricity, though its federal structure (cantonal subsurface competence) and the small scale of the network call for a lighter, flexible design during ramp-up.

The first action carries a significant budgetary burden, at least in the short term; the other three are inexpensive for the federal budget but high-impact.

Hedging long-term storage liabilities and indicative costs

Beyond these enabling actions, the one residual risk that markets cannot fully absorb is long-term, post-closure storage liability, because insurers cannot reliably price high-impact, very-low-probability events over century-scale horizons. In the beginning, this risk will most likely be hedged by the storing countries. Nonetheless, Swiss government would need to prepare for possible national storage as well. The study sets out three options for this: a public backstop (closely aligned with the EU CCS Directive and administratively simple); an industry-pooled fund; and a three-tiered model layering private insurance, an industry pool and a public backstop, as used for nuclear liability. The three-tiered model scores highest on effectiveness and efficiency and limits moral hazard, but is administratively demanding; a simpler public backstop may suffice if total liabilities are small.

Combining academic estimates for the three main liability components (surrendering carbon allowances, corrective and remediation measures, and environmental damages) yields an indicative long-term storage liability cost. This cost is calculated as **CHF 0.4–1.1 per tonne of CO₂ stored**, far below other costs in the CCS chain. For the foreseeable 1-2 decades, most Swiss CO₂ would be likely stored in Dutch and Norwegian sites, where long-term liability is assumed by those states; the volumes destined for any domestic Swiss storage before 2050 are small. The anticipated cost to the Swiss state of assuming this liability, even via a direct public backstop, is therefore expected to be very small. Where costs are recovered, the study briefly notes several options that should be calibrated to the polluter-pays principle.

Conclusion

Switzerland enters the CO₂ transport and storage domain with a deep commercial risk-hedging market and the benefit of international precedent. The priority for the Confederation can therefore be to **establish revenue support (via CCfDs), coordination, cross-border agreements, and regulated-return frameworks that make private investment bankable**. For the narrow but genuine gap of long-term storage liability, the federal government can consider a backstop at a cost expected to be very modest.

Zusammenfassung

Ausgangslage und Zielsetzung

Die Schweiz hat sich verpflichtet, bis 2050 Netto-Null-Treibhausgasemissionen zu erreichen. Da rund ein Viertel der heutigen Emissionen aus schwer vermeidbaren Quellen stammt – Kehrlichtverwertungsanlagen (KVA), Zementproduktion und weitere Industriebereiche –, sind die CO₂-Abscheidung und -Speicherung (Carbon Capture and Storage, CCS) sowie Negativemissionstechnologien (NET) unverzichtbare Ergänzungen zu direkten Emissionsminderungen. Schätzungen des Bundes zufolge müssen bis 2050 jährlich rund 7 Mio. t CO₂ abgeschieden, transportiert und dauerhaft gespeichert werden. Da das inländische geologische Speicherpotenzial zumindest kurzfristig begrenzt ist, wird ein effizientes System auf ein nationales CO₂-Pipelinennetz angewiesen sein, das an ausländische Transportrouten und Speicherstandorte angeschlossen ist. Um dies zu ermöglichen, erarbeitet der Bundesrat ein CCS-/NET-Rahmengesetz sowie eine Revision des CO₂-Gesetzes, die bis Ende 2026 vorgelegt werden sollen.

Selbst mit einer CO₂-Bepreisung und Unterstützung auf Ebene der Emittenten wie Carbon Contracts for Difference (CCfD) können entlang der CO₂-Transport- und Speicherkette (T&S) spezifische Risiken fortbestehen, die private Investitionen hemmen. Die vorliegende Studie gibt einen strukturierten Überblick darüber, wie sich diese Investitionsrisiken in der Schweiz absichern liessen, unter einem politischen Rahmen, der ab rund 2031 als gegeben angenommen wird. Sie geht von den Prämissen aus, dass die T&S-Infrastruktur privat errichtet und betrieben wird, dass ein harmonisiertes Rahmengesetz und eine Marktregulierung vorliegen, dass Finanzierungsinstrumente auf Ebene der Emittenten bestehen und dass das System rasch auf rund 7 Mio. t pro Jahr an abgeschiedenem, transportiertem und gespeichertem CO₂ bis 2050 skaliert. Diese politischen und institutionellen Rahmenbedingungen wurden für die vorliegende Studie vorausgesetzt und nicht weiter untersucht. Die Analyse behandelt drei Fragen:

1. Welche Restrisiken könnten Investitionen in der Hochlaufphase und in einem reifen Markt weiterhin hemmen;
2. welche davon lassen sich über private Märkte abdecken und wo ist demgegenüber eine staatlich gestützte Absicherung durch Marktversagen gerechtfertigt; und
3. welche konkreten Absicherungsinstrumente eignen sich für die Schweiz, zu welchen indikativen Kosten.

Die Studie stützt sich auf schweizerische und internationale Literatur, einschliesslich vergleichbarer Schweizer Studien zu Wärme- und Wasserstoffnetzen, sowie auf Interviews mit Emittenten, Netz- und Speicherbetreibern, Finanzinstituten und Regulierungsbehörden. Die Ergebnisse dieser Studie sind daher in erster Linie qualitativer Natur.

Investitionseigenschaften und Risikolandschaft

CO₂-T&S-Infrastruktur ist ausgesprochen kapitalintensiv, langlebig (30 bis über 50 Jahre) und weist ausgeprägte Skaleneffekte auf; Pipelines machen rund 30 % der gesamten Systemkosten aus und tendieren zu natürlichen Monopolstrukturen. Die heutigen Kosten einer vollständigen CCS-Kette (grob CHF 219–339/tCO₂) liegen weiterhin deutlich über den Preisen für Emissionsrechte, womit eine Finanzierungslücke verbleibt; der gesamte, überwiegend private Investitionsbedarf bis 2050 wird auf CHF 11–21 Mrd. geschätzt. Ein prägendes Merkmal ist, dass das Ertragspotenzial von T&S-Investoren naturgemäss gedeckelt ist: Die Erlöse hängen von der Politik, von regulierten Preisen und von Subventionen ab und nicht vom Wettbewerb auf offenen Märkten, während das Verlustrisiko erheblich sein kann. Investoren messen deshalb dem Schutz vor Verlusten und der Vertragssicherheit einen hohen Wert bei, bevor sie Kapital binden.

Die Studie gliedert die Risiken in fünf Kategorien (Planung, Finanzen und Kommerzielles, Recht, Politik und Technik) und beurteilt jede nach Eintretenswahrscheinlichkeit, Auswirkung und

Versicherbarkeit. Ein zentrales Ergebnis ist, dass **betriebliche und technische Risiken tendenziell zumindest teilweise versicherbar sind, während Risiken, die in der systemischen Marktstruktur, in politischer Unsicherheit oder in Koordinationsversagen wurzeln, dies in der Regel nicht sind.**

Die bedeutendsten nicht versicherbaren Risiken sind das Planungs- und Interdependenzrisiko (das «Henne-Ei-Problem», bei dem Abscheidung, Transport und Speicherung parallel vorankommen müssen und das in der Schweiz durch die Abhängigkeit von grenzüberschreitender Infrastruktur verstärkt wird); das Regulierungsrisiko, insbesondere die Volatilität des CO₂-Preises im Emissionshandelssystem (EHS), die massgeblich über die Tragfähigkeit der Erlöse entscheidet; das Risiko der öffentlichen Akzeptanz und der Bewilligungen, verschärft durch das föderale und direktdemokratische System der Schweiz; sowie technologische Obsoleszenz. Viele dieser Risiken bewirken, dass Kosten steigen, Projekte sich verzögern oder Vorhaben schlicht nicht realisierbar werden. Transportunfälle lassen sich mit konventionellen Versicherungen gut abdecken, während bei der Speicherung versicherbare kurzfristige Betriebsrisiken bestehen, jedoch eine nicht versicherbare langfristige Leckagehaftung nach Stilllegung, die letztlich eine Form staatlicher Rückfallgarantie erfordert.

Verfügbarkeit von Absicherungsinstrumenten und Erkenntnisse aus vergleichbaren Fällen

Für die meisten kurzfristigen Risiken ist die Verfügbarkeit von Absicherungsinstrumenten in der Schweiz bereits sehr gut. Ein reifer kommerzieller Markt mit aktiven Schweizer Akteuren wie Swiss Re und Zurich bietet private Versicherungen, Garantien von Muttergesellschaften und der öffentlichen Hand, Akkreditive, Erfüllungsgarantien, zweckgebundene Konten und Treuhandkonten, Take-or-Pay-Verträge sowie regulierte Renditemechanismen; selbst eine Deckung von Leckagen nach Stilllegung beginnt zu entstehen. Als späte Einsteigerin kann die Schweiz zudem damit rechnen, von der Reifung entsprechender Instrumente in den Nachbarmärkten zu profitieren. Es besteht daher wenig Anlass, dass der Bund diese Instrumente direkt bereitstellt.

Das Gegenpartei- bzw. Ausfallrisiko auf Seiten der Emittenten ist ähnlich beherrschbar. Die beiden dominierenden Schweizer Emittentengruppen können ihre Verpflichtungen mit vertrauten Mitteln absichern: Die Zementbranche wird von Holcim dominiert, deren Bilanz und Investment-Grade-Ratings Muttergesellschaftsgarantien hochwirksam machen, während Kehrrechtverwertungsanlagen – in der Regel im Eigentum von Kantonen oder Gemeinden – von impliziten oder expliziten staatlichen Garantien profitieren. Gleichwohl kann ein erhebliches politisches Risiko entstehen, wenn eine Bundesgarantie solche Vorhaben nicht so unterstützt, dass die Kosten gleichmässiger über die gesamte begünstigte Gruppe verteilt werden. Ein langfristiger CCfD auf Emittentenseite würde das verbleibende Ausfallrisiko ohnehin deutlich reduzieren.

Erfahrungen aus vergleichbaren Sektoren und Ländern bestätigen diese Schlussfolgerungen. Die BFE-Studie zu thermischen Netzen zeigt, dass Mengenausfall- und hohe Vorleistungsrisiken am besten über Garantien adressiert werden, wobei der Staat jenen Teil des Risikos auffängt, den die Märkte nicht tragen können; die BFE-Studie zu Wasserstoff verweist auf Subventionen, Garantien und bedingte Darlehen und betont die Vereinbarkeit mit dem EU-Recht. In den Niederlanden (Porthos und Aramis) sichert der Staat die Nachfrage über Subventionen, gewährt Garantien vor der endgültigen Investitionsentscheidung, beteiligt sich direkt am Eigentum und übernimmt die langfristige Speicherhaftung. Das Vereinigte Königreich ermöglicht private T&S-Investitionen über ein Regulatory-Asset-Base-Modell (RAB) in Kombination mit einem staatlichen Unterstützungspaket, das langfristige Leckage- und Stranded-Asset-Risiken in die öffentliche Bilanz überführt, ergänzt um CCfD-artige Unterstützung für Emittenten. Die wichtigste Lehre für die Schweiz lautet, dass neben CCfD auf der Emissionsseite ein gut ausgestalteter regulierter Renditerahmen sowie eine gezielte staatliche Unterstützung für das langfristige Speicherrisiko private Investitionen mobilisieren können, ohne direkte staatliche Kapitalbeteiligung. Die Abhängigkeit der Schweiz von ausländischen Speicherstandorten macht detaillierte grenzüberschreitende Vereinbarungen zusätzlich erforderlich.

Handlungsbedarf auf Bundesebene

Die zentrale Schlussfolgerung der Studie ist, dass die Risikoabsicherung für die Schweizer CO₂-T&S-Infrastruktur grösstenteils bereits durch kommerzielle Märkte und durch die Projektträger selbst gut

abgedeckt ist. Die **entscheidende Lücke liegt weniger bei fehlenden Absicherungsprodukten als bei ermöglichenden Massnahmen, die nur der Bund ergreifen kann**. Vier werden empfohlen:

1. **Erlösunterstützung für Abscheidungsprojekte**, häufig über **Carbon Contracts for Difference**. CCfD (oder andere Formen der Erlösunterstützung) sind das am häufigsten genannte fehlende Element: Sie machen den Business Case der Abscheidung bei den heutigen CO₂-Preisen investitionsfähig, stabilisieren die Erlöse der Emittenten gegenüber der EHS-Volatilität und untermauern damit die langfristigen T&S-Verträge, auf die Netzinvestitionen angewiesen sind. Sie verursachen kurzfristig hohe Budgetkosten, sind im Übrigen aber effizient und wirksam.
2. **Koordination und Organisation der Vorhaben**. Eine aktive Rolle des Staates bei der Abstimmung von Partnern, Projekten, Fördermitteln und Bewilligungen senkt die Gesamtkosten erheblich. Sie kann endgültige Investitionsentscheide, Bauprogramme, Bewilligungsverfahren und weitere Meilensteine über verstreute Emittenten und Pipelineentwickler hinweg zusammenführen. Sie ist ein kostengünstiger Weg, das Interdependenzrisiko («Henne-Ei-Problem») zu entschärfen und weit höhere gesamtgesellschaftliche Kosten zu vermeiden.
3. **Detaillierte, verbindliche grenzüberschreitende Vereinbarungen**. Vereinbarungen mit hinreichender operativer Präzision, namentlich zur Haftung für Leckagen und zur Abgabe von EHS-Emissionsrechten, zu Monitoringpflichten sowie zur lückenlosen Nachverfolgbarkeit des CO₂, sind unerlässlich. Das Abkommen zwischen der Schweiz und Norwegen vom Juni 2025 ist ein bedeutender Fortschritt; entlang des Korridors Basel–Nordsee ist weitere Konkretisierung nötig.
4. **Ein Regulated-Asset-Base-Rahmen (RAB)** für die Hochlaufphase. Nehmen T&S-Betreiber eine quasi natürliche Monopolstellung ein, sichert ein RAB-Rahmen effiziente Investitionen. Die Schweiz verfügt über einschlägige Erfahrung aus der Elektrizitätswirtschaft; ihre föderale Struktur (kantonale Zuständigkeit für den Untergrund) und die geringe Netzgrösse sprechen jedoch für eine leichtere, flexible Ausgestaltung während des Hochlaufs.

Die erste Massnahme ist zumindest kurzfristig mit einer erheblichen Budgetbelastung verbunden; die drei übrigen sind für den Bundeshaushalt kostengünstig, aber wirkungsstark.

Absicherung langfristiger Speicherhaftungen und indikative Kosten

Über diese ermöglichenden Massnahmen hinaus ist die langfristige Haftung nach Stilllegung eines Speichers das einzige Restrisiko, das die Märkte nicht vollständig absorbieren können, da Versicherer Ereignisse mit hoher Schadenwirkung und sehr geringer Eintretenswahrscheinlichkeit über jahrhundertelange Zeithorizonte nicht verlässlich bepreisen können. Zunächst wird dieses Risiko höchstwahrscheinlich von den Speicherstaaten getragen. Dennoch müsste sich der Bund auch auf eine mögliche inländische Speicherung vorbereiten. Die Studie legt dazu drei Optionen dar: eine staatliche Rückfallgarantie (eng an der EU-CCS-Richtlinie ausgerichtet und administrativ einfach); einen von der Branche gespeisten Haftungsfonds; sowie ein dreistufiges Modell, das private Versicherung, Branchenfonds und staatliche Rückfallgarantie übereinanderlegt, wie es bei der Kernenergiehaftung angewandt wird. Das dreistufige Modell schneidet bei Wirksamkeit und Effizienz am besten ab und begrenzt Fehlanreize, ist administrativ jedoch anspruchsvoll; eine einfachere staatliche Rückfallgarantie kann genügen, wenn die Gesamthaftung gering bleibt.

Die Kombination von Schätzungen aus der wissenschaftlichen Literatur für die drei wesentlichen Haftungskomponenten (Abgabe von Emissionsrechten, Korrektur- und Sanierungsmassnahmen sowie Umweltschäden) ergibt indikative Kosten der langfristigen Speicherhaftung. Diese Kosten werden auf **CHF 0,4–1,1 pro gespeicherter Tonne CO₂** beziffert und liegen damit weit unter den übrigen Kosten der CCS-Kette. In den absehbaren ein bis zwei Jahrzehnten dürfte der grösste Teil des Schweizer CO₂ in niederländischen und norwegischen Speichern eingelagert werden, wo die langfristige Haftung von diesen Staaten übernommen wird; die für eine allfällige inländische Speicherung vor 2050 vorgesehenen Mengen sind gering. Die erwarteten Kosten für den Schweizer Staat aus einer Übernahme dieser Haftung, selbst über eine direkte staatliche Rückfallgarantie,

dürften daher sehr gering ausfallen. Für die Anlastung der Kosten nennt die Studie kurz mehrere Optionen, die am Verursacherprinzip auszurichten sind.

Fazit

Die Schweiz betritt das Feld des CO₂-Transports und der CO₂-Speicherung mit einem tiefen kommerziellen Markt für Risikoabsicherung und dem Vorteil internationaler Präzedenzfälle. Die Priorität des Bundes sollte deshalb darin liegen, **Erlösunterstützung (über CCfD), Koordination, grenzüberschreitende Vereinbarungen und regulierte Renditerahmen zu schaffen, die private Investitionen bankfähig machen**. Für die enge, aber reale Lücke der langfristigen Speicherhaftung sollte der Bund eine staatliche Rückfallgarantie prüfen, zu Kosten, die voraussichtlich sehr gering bleiben.

Résumé exécutif

Contexte et objectifs

La Suisse s'est engagée à atteindre l'objectif de zéro émission nette de gaz à effet de serre d'ici à 2050. Environ un quart des émissions actuelles provient de sources difficiles à décarboner, telles que les usines d'incinération des ordures ménagères (UIOM), la production de ciment et d'autres branches de l'industrie ; le captage et le stockage du CO₂ (CSC) ainsi que les technologies d'émission négative (NET) constituent dès lors des compléments indispensables aux réductions directes d'émissions. Selon les estimations de la Confédération, quelque 7 Mt de CO₂ devront être captées, transportées et stockées de manière permanente chaque année d'ici à 2050. Le potentiel de stockage géologique national étant limité, du moins à court terme, un système efficace dépendra d'un réseau national de conduites de CO₂ raccordé aux itinéraires de transport et aux sites de stockage situés à l'étranger. Pour rendre ce développement possible, le Conseil fédéral prépare une loi-cadre sur le CSC et les NET ainsi qu'une révision de la loi sur le CO₂, dont la soumission est prévue d'ici à fin 2026.

Même avec une tarification du carbone et un soutien au niveau des émetteurs tel que des contrats carbone pour différence (Carbon Contracts for Difference, CCfD), des risques spécifiques tout au long de la chaîne de transport et de stockage du CO₂ (T&S) peuvent continuer à dissuader l'investissement privé. La présente étude offre une vue d'ensemble structurée de la manière dont ces risques d'investissement pourraient être couverts en Suisse, dans un cadre politique supposé en place à partir de 2031 environ. Elle part des prémisses selon lesquelles les infrastructures de T&S sont construites et exploitées par des acteurs privés, une loi-cadre harmonisée et une régulation du marché sont en place, des instruments de financement destinés aux émetteurs existent, et le système monte rapidement en puissance pour atteindre quelque 7 Mt/an captées, transportées et stockées d'ici à 2050. Ces conditions-cadres politiques et institutionnelles ont été posées comme hypothèses pour la présente étude et n'ont pas fait l'objet d'un examen plus approfondi. L'analyse traite trois questions :

4. quels risques résiduels pourraient encore dissuader l'investissement durant la phase de montée en puissance et sur un marché mature ;
5. lesquels de ces risques peuvent être couverts par les marchés privés et, à l'inverse, dans quels cas une couverture adossée à l'État se justifie par une défaillance de marché ; et
6. quels instruments de couverture concrets conviennent à la Suisse, et à quel coût indicatif.

L'étude s'appuie sur la littérature suisse et internationale, y compris des études suisses comparables consacrées aux réseaux thermiques et à l'hydrogène, ainsi que sur des entretiens menés avec des émetteurs, des exploitants de réseaux et de sites de stockage, des établissements financiers et des autorités de régulation. Les résultats de cette étude sont dès lors principalement de nature qualitative.

Caractéristiques de l'investissement et paysage des risques

Les infrastructures de T&S du CO₂ sont fortement capitalistiques, de longue durée de vie (30 à plus de 50 ans) et présentent de fortes économies d'échelle ; les conduites représentent environ 30 % des coûts totaux du système et tendent vers des structures de monopole naturel. Les coûts actuels d'une chaîne CSC complète (de l'ordre de 219 à 339 CHF/tCO₂) demeurent nettement supérieurs au prix des quotas d'émission, ce qui laisse subsister un déficit de financement ; l'investissement total, essentiellement privé, est estimé à 11–21 milliards de CHF d'ici à 2050. Une caractéristique déterminante tient à ce que le potentiel de gain des investisseurs en T&S est intrinsèquement plafonné : les revenus dépendent des politiques publiques, de tarifs régulés et de subventions plutôt que de la concurrence sur un marché ouvert, alors que l'exposition aux pertes peut être considérable. Les investisseurs accordent dès lors une prime à la protection contre les pertes et à la sécurité contractuelle avant d'engager des capitaux.

L'étude regroupe les risques en cinq catégories (planification, financiers et commerciaux, juridiques, politiques et techniques) et évalue chacune d'elles selon la probabilité, l'impact et l'assurabilité. Un constat central est que **les risques opérationnels et techniques sont généralement assurables au moins en partie, tandis que les risques qui tiennent à la structure systémique du marché, à l'incertitude politique ou à des défauts de coordination ne le sont en règle générale pas**. Les risques non assurables les plus significatifs sont le risque de planification et d'interdépendance (le problème dit de « la poule et l'œuf », le captage, le transport et le stockage devant progresser en parallèle, amplifié en Suisse par la dépendance à l'égard d'infrastructures transfrontalières) ; le risque réglementaire, en particulier la volatilité du prix du carbone dans le système d'échange de quotas d'émission (SEQE), déterminant central de la viabilité des revenus ; le risque d'acceptation par la population et d'obtention des autorisations, accentué par le système fédéral et de démocratie directe de la Suisse ; et l'obsolescence technologique. Nombre de ces risques ont pour effet soit de renchérir les coûts, soit de retarder les projets, soit simplement de les rendre irréalisables. Les incidents de transport peuvent être bien couverts par l'assurance conventionnelle, tandis que le stockage comporte des risques d'exploitation à court terme assurables, mais une responsabilité de fuite à long terme, après fermeture, non assurable, qui exige en dernier ressort une forme de garantie publique de dernier recours.

Disponibilité des instruments de couverture et enseignements tirés de cas comparables

Pour la plupart des risques à court terme, la disponibilité d'instruments de couverture en Suisse est déjà très bonne. Un marché commercial mature, comprenant des acteurs suisses actifs tels que Swiss Re et Zurich, propose des assurances privées, des garanties de sociétés mères et du secteur public, des lettres de crédit, des cautions de bonne exécution, des comptes cantonnés et sous séquestre, des contrats take-or-pay et des mécanismes de rendement régulé ; une couverture des fuites après fermeture commence même à émerger. Entrée plus tardive dans la filière, la Suisse peut en outre escompter bénéficier de la maturation de ces instruments sur les marchés voisins. Il n'y a donc guère lieu que la Confédération fournisse ces instruments directement.

Le risque de contrepartie (défaut) du côté des émetteurs est tout aussi maîtrisable. Les deux principaux groupes d'émetteurs suisses peuvent garantir leurs obligations par des moyens éprouvés : la branche du ciment est dominée par Holcim, dont le bilan et les notations « investment grade » rendent les garanties de société mère très efficaces, tandis que les usines d'incinération des ordures ménagères, généralement détenues par des cantons ou des communes, bénéficient de garanties publiques implicites ou explicites. Un risque politique significatif peut néanmoins apparaître si une garantie fédérale ne vient pas soutenir de tels projets de manière à répartir les coûts plus équitablement sur l'ensemble du groupe des bénéficiaires. En tout état de cause, un CCfD de longue durée du côté des émetteurs réduirait sensiblement le risque de défaut résiduel.

L'expérience de secteurs et de pays comparables conforte ces conclusions. L'étude de l'OFEN sur les réseaux thermiques montre que les risques de perte de volume et de préfinancement important sont le mieux traités par des garanties, l'État assumant en dernier ressort la part du risque que les marchés ne peuvent porter ; l'étude de l'OFEN sur l'hydrogène met en avant les subventions, les garanties et les prêts conditionnels, et insiste sur la compatibilité avec le droit de l'UE. Aux Pays-Bas (Porthos et Aramis), l'État sécurise la demande par des subventions, octroie des garanties avant la décision finale d'investissement, prend une participation directe et assume la responsabilité de stockage à long terme. Le Royaume-Uni rend l'investissement privé en T&S possible par un modèle de base d'actifs régulés (Regulatory Asset Base, RAB) combiné à un paquet de soutien gouvernemental qui place le risque de fuite à horizon long et le risque d'actifs échoués au bilan de l'État, parallèlement à un soutien de type CCfD pour les émetteurs. Le principal enseignement pour la Suisse est que, aux côtés de CCfD du côté des émissions, un cadre de rendement régulé bien conçu et un soutien public ciblé sur le risque de stockage à long terme peuvent mobiliser l'investissement privé sans participation directe de l'État au capital. La dépendance de la Suisse à l'égard de sites de stockage étrangers rend en outre nécessaires des accords transfrontaliers détaillés.

Domaines nécessitant une action de la Confédération

La conclusion centrale de l'étude est que la couverture des risques des infrastructures suisses de T&S du CO₂ est, pour l'essentiel, déjà bien assurée par les marchés commerciaux et par les porteurs de projets eux-mêmes. La **lacune décisive tient moins à l'absence de produits de couverture qu'aux actions habilitantes que seule la Confédération peut entreprendre**. Quatre sont recommandées :

5. **Soutien aux revenus des projets de captage**, souvent au moyen de **contrats carbone pour différence**. Les CCfD (ou d'autres formes de soutien aux revenus) sont l'élément manquant le plus fréquemment cité : ils rendent le modèle d'affaires du captage finançable aux prix actuels du carbone, stabilisent les revenus des émetteurs face à la volatilité du SEQUE et, partant, sous-tendent les contrats de T&S de longue durée dont dépend l'investissement dans le réseau. Ils représentent une charge budgétaire élevée à court terme, mais sont par ailleurs efficaces et efficaces.
6. **Coordination et organisation des projets**. Une implication active de l'État dans l'alignement des partenaires, des projets, des subventions et des autorisations réduit sensiblement le coût global. Elle permet de faire converger décisions finales d'investissement, calendriers de construction, procédures d'autorisation et autres jalons entre des émetteurs dispersés et des développeurs de conduites. C'est un moyen peu coûteux de désamorcer le risque d'interdépendance (« la poule et l'œuf ») et d'éviter un coût social global bien supérieur.
7. **Accords transfrontaliers détaillés et contraignants**. Des accords suffisamment précis sur le plan opérationnel, notamment quant à la responsabilité en cas de fuite et à la restitution des quotas du SEQUE, aux obligations de surveillance et à la traçabilité de la chaîne de possession, sont indispensables. L'accord Suisse–Norvège de juin 2025 constitue un progrès notable ; un degré de détail supplémentaire est nécessaire le long du corridor Bâle–mer du Nord.
8. **Un cadre de base d'actifs régulés (RAB)** pour la phase de montée en puissance. Lorsque les exploitants de T&S occupent une position de quasi-monopole naturel, un cadre RAB sécurise un investissement efficient. La Suisse dispose d'une expérience transposable dans l'électricité, même si sa structure fédérale (compétence cantonale sur le sous-sol) et la taille modeste du réseau plaident pour une conception plus légère et flexible durant la montée en puissance.

La première mesure représente une charge budgétaire significative, du moins à court terme ; les trois autres sont peu coûteuses pour le budget fédéral, mais à fort impact.

Couverture des responsabilités de stockage à long terme et coûts indicatifs

Au-delà de ces mesures habilitantes, le seul risque résiduel que les marchés ne peuvent absorber entièrement est la responsabilité de stockage à long terme, après fermeture, les assureurs n'étant pas en mesure de tarifier de façon fiable des événements à impact élevé et à probabilité très faible sur des horizons séculaires. Dans un premier temps, ce risque sera très probablement couvert par les pays de stockage. La Confédération devrait néanmoins se préparer à l'éventualité d'un stockage national. L'étude expose trois options à cet effet : une garantie publique de dernier recours (étroitement alignée sur la directive CSC de l'UE et simple à administrer) ; un fonds mutualisé financé par la branche ; et un modèle à trois niveaux superposant assurance privée, fonds de branche et garantie publique de dernier recours, à l'image du régime applicable à la responsabilité nucléaire. Le modèle à trois niveaux obtient les meilleurs résultats en matière d'efficacité et d'efficience et limite l'aléa moral, mais il est exigeant sur le plan administratif ; une garantie publique plus simple peut suffire si les responsabilités totales demeurent faibles.

La combinaison des estimations issues de la littérature scientifique pour les trois principales composantes de la responsabilité (restitution de quotas d'émission, mesures correctrices et de remise en état, et dommages environnementaux) conduit à un coût indicatif de la responsabilité de stockage à long terme. Ce coût est chiffré à **0,4–1,1 CHF par tonne de CO₂ stockée**, très en deçà des autres coûts de la chaîne CSC. Pour la ou les deux décennies à venir, l'essentiel du CO₂ suisse serait vraisemblablement stocké sur des sites néerlandais et norvégiens, où la responsabilité à long terme

est assumée par ces États ; les volumes destinés à un éventuel stockage national avant 2050 sont faibles. Le coût attendu, pour l'État suisse, de la reprise de cette responsabilité, même par une garantie publique directe, devrait donc être très modeste. S'agissant du recouvrement des coûts, l'étude évoque brièvement plusieurs options, qui devraient être calibrées sur le principe du pollueur-payeur.

Conclusion

La Suisse aborde le domaine du transport et du stockage du CO₂ avec un marché commercial de la couverture des risques bien développé et le bénéfice de précédents internationaux. La priorité de la Confédération devrait donc être d'**établir un soutien aux revenus (via des CCfD), une coordination, des accords transfrontaliers et des cadres de rendement régulé qui rendent l'investissement privé bancable**. Pour la lacune étroite mais réelle que constitue la responsabilité de stockage à long terme, la Confédération devrait envisager une garantie de dernier recours, à un coût qui devrait rester très modeste.

1 Introduction

1.1 Background and policy context

Backed by IPCC¹ scientific consensus, climate change is recognised as the human-driven, long-term alteration of Earth's climate systems, primarily caused by greenhouse gas emissions that trap heat and accelerate global warming. Achieving net-zero emissions is essential to limit global temperature rises to, preventing extreme weather, rising sea levels, and irreversible ecological damage.

In the global effort to mitigate the effects of climate change, Carbon Capture and Storage (CCS) has been recognised as a critical measure, particularly for addressing hard-to-abate emissions. This technology should not be viewed as a substitute for rapid emissions reductions, but as a necessary complement for hard-to-abate sectors and for achieving net-zero by 2050. These measures are vital for capturing emissions that cannot be entirely avoided, such as certain industrial process emissions, and storing them permanently to mitigate their environmental impact.²

In this context, Switzerland has also committed to achieving climate-neutrality by 2050. Switzerland's long term climate targets require the large-scale development of CO₂ capture, transport, and permanent storage³. While CO₂ can currently be moved by truck, rail or ship, an efficient long term-system will require a national CO₂ pipeline network integrated with foreign networks.⁴ To support this development, the Federal Council is preparing a CCS/ negative emissions technologies (NET) framework law and a revised CO₂ Act, to be submitted by end of 2026.⁵ These will define harmonised rules for planning, constructing and operating CO₂ pipelines and underground storage facilities, drawing parallels with existing regulation of natural gas pipelines and waste disposal sites.

The expansion of CCS/NET involves significant costs for investments in facilities and their operation.⁶ Even with CO₂ pricing and market based- instruments for negative emissions, investment incentives for transport and storage infrastructure may remain insufficient. Financing solutions at the emitter level, such as carbon contracts for difference (CCfDs)⁷, can address some gaps⁸. However, certain risks along the CO₂ transport and storage chain may continue to discourage private investment. Switzerland already applies risk hedging mechanisms in analogous sectors (e.g. thermal networks under the Climate and Innovation Act), where the state intervenes only if a defined risk materialises. This assignment builds on earlier BAFU work on CO₂ infrastructure regulation and Swiss studies on hydrogen and thermal networks to provide clarity on how similar approaches could support the CCS/NET system.

¹ IPCC (Accessed 26/05/2026). Available at: <https://www.ipcc.ch/about/>

² IPCC, (2023). [IPCC Sixth Assessment \(AR6\) Synthesis Report](#).

³ [CO₂ capture and storage \(admin.ch\)](#); [Climate change: Federal Council approves report on the expansion of negative emission technologies \(admin.ch\)](#).

⁴ ARAMIS (2021). [CO₂NET – Rough design and cost estimate for a CO₂ collection network in Switzerland – basic data](#).

⁵ FOEN (2025). [Bundesrat befasste sich mit Klimapolitik nach 2030](#).

⁶ BAFU & DENA (2023). [Carbon Capture & Storage \(CCS\) Kostenschätzung für ein CCS-System für die Schweiz bis 2050](#).

⁷ Carbon Contracts for Difference are instruments that guarantee a fixed price for avoided carbon emissions. They are aimed at providing financial support by covering the gap between a reference CO₂ price (e.g., the EU ETS price) and a guaranteed strike price. This is meant to address uncertainty in case carbon price are too low to make for a competitive business case for industry.

⁸ Polynomics, Frontier Economics, BAK Economics, VISCHER (2024), [Optionen zur Regulierung von CO₂-Pipelines und CO₂-Untergrundspeichern in der Schweiz](#).

1.2 Objectives of the study

The objective of this assignment is to develop a structured overview of how investment risks in CO₂ pipelines and CO₂ underground storage could be hedged in Switzerland under a 2031 policy framework.

This study maintains some **important assumptions, as consulted with BAFU, throughout the analysis:**

- Transport and storage infrastructure is privately built and operated;
- A national CCS/NET framework law would provide harmonised rules for planning, construction, operation and decommissioning;
- Market regulation ensures non-discriminatory access and prevents market abuse;
- Emitter-level financing instruments exist, for example in the form of CCfDs, and cover capture investments *and the procurement of transport and storage services*;
- By 2050, all major plants in Switzerland capture CO₂ for permanent storage. In other words, the system is assumed to scale up rapidly to operate with around 7 Mt/year⁹ captured, transported, and stored.

Within this context, the following key questions were considered:

1. Which residual risks—in both the ramp-up phase and in a mature market—could still discourage investment in CO₂ transport and storage?
2. To what extent can these risks be covered privately (e.g. insurance) vs. where is state-backed risk mitigation justified due to market failure?
3. What concrete risk hedging instruments are suitable for Switzerland and what are their indicative costs and benefits?

The results will support ongoing federal work on the CCS/NET framework law and the revision of the CO₂ Act.

1.3 Scope and assumptions

In terms of scope, the study focuses on the scaling period starting 2031 up to 2050. The study works on the premise that after 2030 a regulatory framework is in place ensuring the capture of CO₂ by Swiss emitters for CCS. This framework includes all the five elements listed above.

The geographic scope of the analysis focuses on Switzerland while acknowledging that CO₂ storage is likely to take place outside of Switzerland. Furthermore, international examples are examined to draw appropriate lessons and identify best practices that could be taken up by Switzerland.

1.4 Structure of the report

This report contains six chapters and additional annexes. The report is structured as follows:

1. **Executive summary**
2. **Chapter 1:** Introduction
3. **Chapter 2:** CO₂ Transport and Storage Infrastructure: Context and Challenges
4. **Chapter 3:** Analytical Framework and Methodology
5. **Chapter 4:** Investment Risks and Rationale for Public Intervention
6. **Chapter 5:** Review of Risk-Hedging Instruments

⁹ This amount includes an estimated 2 Mt/year of captured biogenic CO₂.

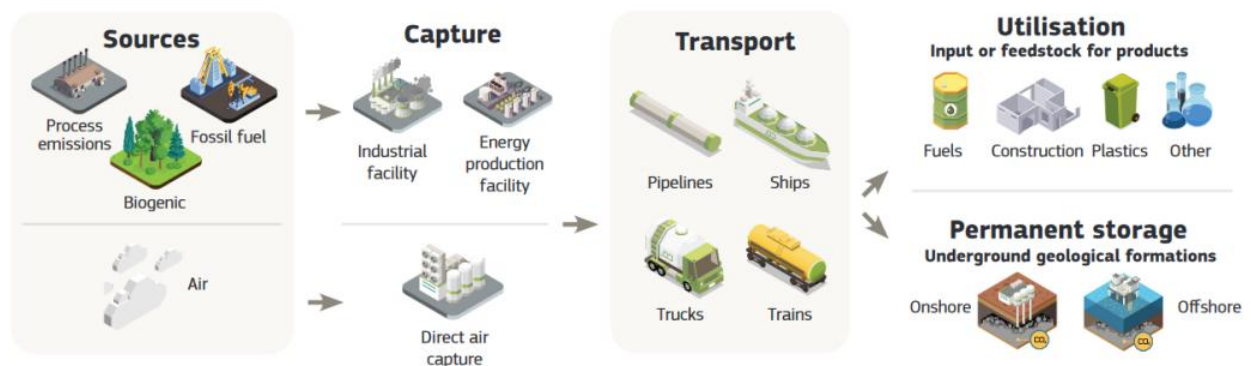
7. **Chapter 6:** Conclusions and Policy Recommendations

2 CO₂ Transport and Storage Infrastructure: Context and Challenges

2.1 Role of CO₂ transport and storage in climate neutrality

The term CCS comprises a chain of technologies, with each of the steps, capture, transport, storage, containing several technological alternatives. In addition to storing the CO₂ underground, the molecule can also be utilised for producing fuels or to make building materials through mineralisation, in which case the term Carbon Capture and Utilisation (CCU) is applied. Most CCU applications, such as synthetic fuels or plastics, are short-term, given that recycled carbon is quickly re-released into the atmosphere. Furthermore, there are significant energetic requirements to convert CO₂ into products. Thus, CCU is expected to make a much smaller contribution to climate change mitigation and is not the focus of this study.^{10, 11} CCS, on the other hand, is considered indispensable for sectors such as cement, steel, chemicals, and waste-to-energy, where process emissions cannot be fully avoided.

Figure 2-1 European Commission schematisation of CCS and CCU (source: EC, 2024¹²)



A schematic of the different steps involved in CCS (and CCU – see above) chain is shown in Figure 1-2 and briefly explained below:

- **Capture** involves the extraction of CO₂ emissions from various sources (process, fossil fuels, or biogenic when referring to industrial and energy production facilities and air when referring to direct air capture) to concentrate this to enable its safe and cost-effective transport, permanent storage or utilisation. Before the CO₂ can continue its journey downstream of the value chain it needs to undergo **purification**¹³ to prevent corrosion issues during transport and geological reservoir degradation. In addition, CO₂ buffer storage (also known as interim storage) acts as a temporary storage in the CCS chain in order to allow for continues industrial capture and smaller-scale/batch-based transportation methods.¹⁴
 - Direct air capture (DACCS), currently at quite early stage, involves capturing the CO₂ directly from air. DACCS is considered a negative emissions technology (NET).

¹⁰ IEA (n.d.). [CO₂ Capture and Utilisation](#).

¹¹ For Switzerland specifically, see, for example: Swiss Government. (2020) [Energieperspektiven 2050+](#).

¹² EC (2024). [Towards an ambitious Industrial Carbon Management for the EU](#).

¹³ Sala, L. et al. (2024). [Comparison and optimization of CO₂ purification units for CCS applications](#).

¹⁴ IEAGHG (2023). [Components of CCS Infrastructure – Interim CO₂ Holding Options](#).

- **Transport** involves the movement of captured CO₂ from the capture sites to the storage or utilisation locations. Typically, compression and/or liquefaction of the captured CO₂ are precursors to the transportation step by **pipeline or ship** respectively;
- **Permanent storage** of CO₂ in **onshore and offshore underground geological formations** so as not to enter the atmosphere under normal use of the product for a period of at least several centuries.

In the European Union (EU), The European Commission's (EC) climate strategies, including the Green Deal Industrial Plan¹⁵ and the Net-Zero Industry Act (NZIA)¹⁶, recognise CCS as an essential technology to achieve climate neutrality. However, CCS deployment has been slow and continues to be insufficient to meet climate goals due to high costs and complex infrastructure needs.¹⁷ In other European countries the role of CCS in supporting climate goals has also been recognised. For example, Norway¹⁸ has more than 25 years of experience with CCS while in the United Kingdom (UK), CCS has been classified as a necessary technology for meeting the legally binding net-zero target by 2050.¹⁹

While key technologies of the CCS value chain – capture, transport, and storage – are already commercially available, their current implementation scale is insufficient to meet long-term climate goals. According to the latest IEA CCUS projects database, 50 CCS/CCU projects are operational worldwide, capturing, transporting, storing and/or utilising CO₂. However, many of these projects were not initially developed for climate mitigation. Instead, they primarily serve commercial interests, such as selling CO₂ for enhanced oil recovery (EOR) in the United States.

In the EU, the 2009 **CCS Directive** establishes a comprehensive legal framework for the environmentally safe geological storage of carbon dioxide within the European Union. Its primary purpose is to prevent environmental and health risks while enabling CCS as a viable climate mitigation tool. The CCS Directive is also relevant for countries outside the EU, like Norway. The Norwegian regulatory framework for CCS is heavily influenced by the CCS Directive. The Directive is implemented in Norwegian law primarily through the Storage Regulations (Regulations on the Use of Subsea Reservoirs on the Continental Shelf for the Storage of CO₂ and on the Transport of CO₂ on the Continental Shelf).²⁰ The UK, transposed the EU CCS Directive and retained it with amendments following Brexit. The country's main legislative framework is the Storage of Carbon Dioxide (Amendment) (EU Exit) Regulation 2022²¹, operating mainly alongside the Energy Act 2023²².

Although the EU CCS Directive focuses primarily on storage, it interacts with transport through its link to the **Emission Trading System (EU ETS)**²³. The ETS is the key instrument that provides economic incentives for CCS projects through putting a price on carbon dioxide emissions. Outside of the EU various countries have also adopted a similar system or CO₂ transported to a permitted storage site can be considered “not emitted” under the ETS, provided that chain-of-custody is verified. Three non-EU countries are also full participants to the EU ETS, they are: Iceland, Liechtenstein and Norway. The EU and Switzerland linked their respective ETS in 2020.²⁴ The Swiss policy and regulatory context is described in more detailed in the following section. The UK's ETS is also a ‘cap-and-trade’ system however it has different caps, rules, and sectoral timelines. While currently they operate

¹⁵ EC. [The Green Deal Industrial Plan](#).

¹⁶ EC. [The Net-Zero Industry Act: Accelerating the transition to climate neutrality](#).

¹⁷ Kazlou, T., Cherp, A., & Jewell, J. (2024). [Feasible deployment of carbon capture and storage and the requirements of climate targets](#). Nature Climate Change, 14(10), 1047-1055.

¹⁸ GCCSI (2023). [CCS Commercial and Regulatory Frameworks Enabling CCS Progress in Norway and Europe](#).

¹⁹ UKCCS (n.d.), [CCS Explained](#).

²⁰ HJORT (2024). [The Regulatory Framework for CCS](#).

²¹ UK Government (2022). [The Storage of Carbon Dioxide \(Amendment\) \(EU Exit\) Regulations 2022](#).

²² UK Government (2023). [Energy Act 2023](#).

²³ EC. [The Net-Zero Industry Act: Accelerating the transition to climate neutrality](#)

²⁴ Swiss Government (2024), [Linking Swiss and EU emissions trading](#).

independently, the UK and EU have reached a political agreement to eventually link their two systems²⁵. In the EU, apart of the money raised via the ETS is reinvested in the **Innovation Fund**,²⁶ which finances large-scale CCS and CCU projects. Since 2020, a total of 41 Innovation Fund-backed projects, representing over €5 billion in funding, have been committed to advancing industrial carbon management. Together, these projects support up to 18.6 million tonnes per year of CO₂ capture capacity for CCS, equivalent to around 37% of the CO₂ injection capacity target set under the **Net-Zero Industry Act** (NZIA), as well as up to 11.7 million tonnes per year of CO₂ injection (storage) capacity, corresponding to 23% of the NZIA target.²⁷ Furthermore, in November 2023, the EC adopted its first Union list of **Projects of Common Interest** (PCIs)²⁸ and **Projects of Mutual Interest** (PMIs)²⁹ under the revised **Trans-European Networks for Energy (TEN-E) Regulation**,³⁰ which included 14 CO₂ transport network projects. Recognising the significance of CCS technologies, the **Green Deal Industrial Plan** actively promotes their development as a cornerstone of the EU's climate neutrality objectives. The European Commission is also in the process of developing a market regulation for CO₂ transport and storage activities.

Next to developing storage sites, advancing CCS requires developing the necessary infrastructure to link CO₂ emitting sources to carbon storage or usage sites. To expand CCS deployment in Europe, a robust transportation system relying – mostly – on pipelines and ships is necessary to connect CO₂ emitters with storage sites and large users. While in the very short term, the projects will mostly be point-to-point, they will then develop into national and regional networks, focusing on areas near emission sources, potential large users and storage facilities. On the potential future development of such European network, the Joint Research Centre (JRC) has recently published a study on network outlook scenarios and potential investment needs.³¹ This study projects the potential connections of the CO₂ network based on main emitters and known CO₂ storage capacity. Figure 1-1 below reports one of the scenarios to 2040 based on CTP targets. While not intended as a projected future development of the network, these results can help inform future network planning initiatives in an effort to shape the emerging CO₂ transport and storage infrastructure.

²⁵ EP (2025), [Linking the EU and UK emissions trading systems](#).

²⁶ EC, [Innovation Fund](#).

²⁷ EC (2025), [REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL on the implementation of the Innovation Fund in 2024](#).

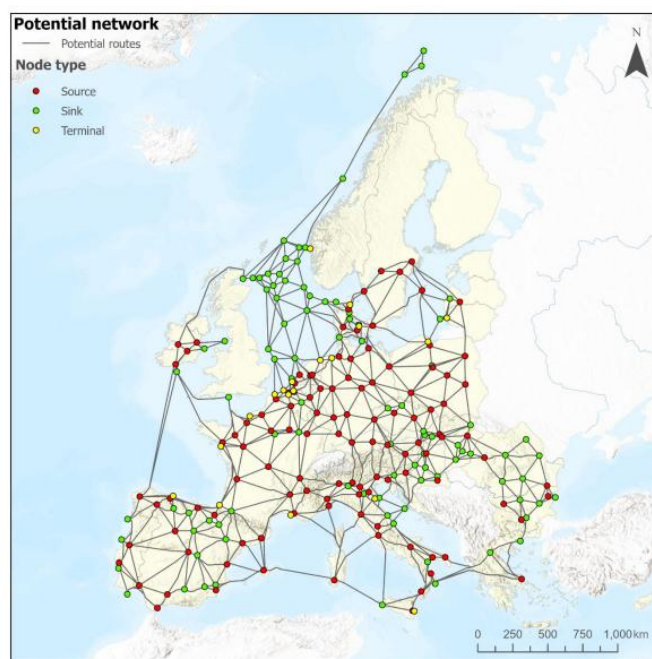
²⁸ EC, [Projects of Common Interest and Projects of Mutual Interest](#).

²⁹ Ibid.

³⁰ EC, [Trans-European Networks for Energy](#).

³¹ JRC(2024), [Shaping the future CO₂ transport network for Europe](#).

Figure 2-2 Network of potential CO₂ routes based on CTP 2040 emissions targets (source: JRC, 2024)



A significant barrier to CCS deployment is the current **lack of access to storage capacity**, discouraging emitters from investing in capture technologies. This includes limited availability of “proven” storage as well as the CO₂ transportation infrastructure to connect emitters to permanent stores. This refers to the so-called “chicken and egg” dilemma: while transport and storage developers hesitate to invest in infrastructure without guaranteed CO₂ supply, emitters are reluctant to invest in capture technologies without available transport and storage infrastructure.

2.2 Overview of the Swiss policy and regulatory context

2.2.1 Long-term climate strategy of Switzerland

Switzerland has committed to achieving net-zero greenhouse gas emissions by 2050. The policy framework is anchored in successive revisions of the **Federal Act on the Reduction of CO₂ Emissions**³² (CO₂ Act for short) and the **Climate and Innovation Act**³³, targeting two main objectives: achieving at least –50% emissions by 2030 (vs. 1990), and reaching net-zero by 2050.

Switzerland's decarbonisation pathway combines both:

- i. deep emissions reductions across sectors (energy efficiency, electrification, renewable energy), and
- ii. deployment of CCS and negative emissions technologies (NETs) to address residual emissions.

The strategy recognises that residual emissions from hard-to-abate sectors - notably waste incineration, cement, and parts of industry - will persist even under ambitious mitigation policies. CCS is framed not as a substitute but as a complementary measure for emissions that are technically or economically difficult to eliminate. These residual emissions are estimated at roughly one-quarter of current emissions by 2050, necessitating large-scale deployment of CCS and NETs. According to

³² Swiss Government. [Federal Act on the Reduction of CO₂ Emissions](#).

³³ Swiss Government. [Climate and Innovation Act](#).

federal estimates, Switzerland will need to *capture and store domestic point-source emissions of around 7 MtCO₂ (incl. 2 Mt biogenic CO₂) annually by 2050*.³⁴

2.2.2 CCS role in the CO₂ reduction plan until 2050

The role of CCS in supporting the 2050 net-zero goal is detailed in the **2022 Federal Council report on CCS and NETs**³⁵. The roadmap explicitly highlights that CCS and NETs are indispensable for achieving net-zero and even net-negative emissions beyond 2050. The report discusses various governance, competence, and market design considerations, including the need to de-risk investments, and the cantonal competence over CO₂ transport and storage infrastructure regulation.

The deployment of CCS is envisioned based on a two-phase strategy for CCS and CO₂ infrastructure development:

Phase 1: Pioneering phase (up to 2030)

This phase focuses on **technology validation and early infrastructure development**:

- Deployment of first large-scale CCS and NET demonstration projects in Switzerland.
- Development of capture at key point sources (e.g., waste incineration plants).
- Initial CO₂ transport solutions, primarily via:
 - Pilot pipelines, and/or
 - Export logistics (rail/ship) to foreign storage sites, reflecting limited domestic storage capacity.
- Establishment of support mechanisms.

The current legal framework is mostly considered sufficient for this early stage.³⁶

Phase 2: Scaling-up phase (2030–2050)

The second phase envisages **system-wide deployment at scale**:

- Expansion of CCS to all major emitting installations.
- Development of integrated CO₂ transport networks, likely including:
 - Dedicated pipeline systems within Switzerland, and
 - Cross-border pipeline or shipping infrastructure for export.
- Large-scale CO₂ storage, primarily:
 - Abroad (e.g., North Sea storage sites), due to limited domestic capacity, and
 - Potentially limited onshore storage in Switzerland (subject to geological feasibility).

No comprehensive legal framework yet exists for this phase, particularly for: CO₂ pipeline infrastructure, long-term liability for storage, and cross-border transport governance. For this phase, lessons drawn from the by then-available information on market developments and market outcomes can be adapted to the regulatory framework for a 'mature market'. The measures in this phase should aim to ensure the functioning of the market, for example by placing greater emphasis on preventing market power and addressing natural monopoly issues.³⁷

³⁴ Polynomics, Frontier Economics, BAK Economics, VISCHER (2024), [Optionen zur Regulierung von CO₂-Pipelines und CO₂-Untergrundspeichern in der Schweiz](#).

³⁵ Swiss Government (2022). [Carbon capture and storage \(CCS\) and negative emission technologies \(NETs\)](#).

³⁶ Swiss Government (2022). [Carbon capture and storage \(CCS\) and negative emission technologies \(NETs\)](#).

³⁷ Polynomics, Frontier Economics, BAK Economics, VISCHER (2024), [Optionen zur Regulierung von CO₂-Pipelines und CO₂-Untergrundspeichern in der Schweiz](#).

Structural constraints for the deployment of CCS persist in Switzerland. One of them is uncertainty around domestic geological storage capacity as the underground has not been well explored. Secondly, a federal system where cantons control subsurface planning, complicates the development of national CO₂ transport and storage infrastructure while no national regulations on CO₂ pipelines and underground storage and no long-term financing solutions for the CCS chains exist to date.

The Federal Council aims to accelerate the expansion of CO₂ capture and storage with a new framework law that harmonises the rules for the development of the necessary CO₂ pipelines and underground storage facilities. The Federal Council will thereby implement the Motion 24.4256 'National Regulation on the Separation, Transport and Storage of CO₂'. In addition, measures in the CO₂ Act after 2030 are intended to increase investment security for CO₂ capture and storage, for example through targeted financial support.³⁸

2.3 Investment characteristics of CO₂ pipelines and storage facilities

2.3.1 CCS infrastructure: key characteristics and routing in Switzerland

CO₂ transport and storage infrastructure exhibits distinct investment characteristics that are particularly relevant in the Swiss context. CO₂ transport and storage use facilities and mechanical and chemical processes that are rather well-understood and whose supply chains are somewhat mature. However, many projects are implemented in a first-of-a-kind situation, with unexpected delays or cost escalations possible.

CCS systems require **high upfront capital investment** for: pipeline construction, compression and transport infrastructure, and storage site development. In Switzerland, pipelines alone account for around 30% of total system costs, underlining their financial significance.

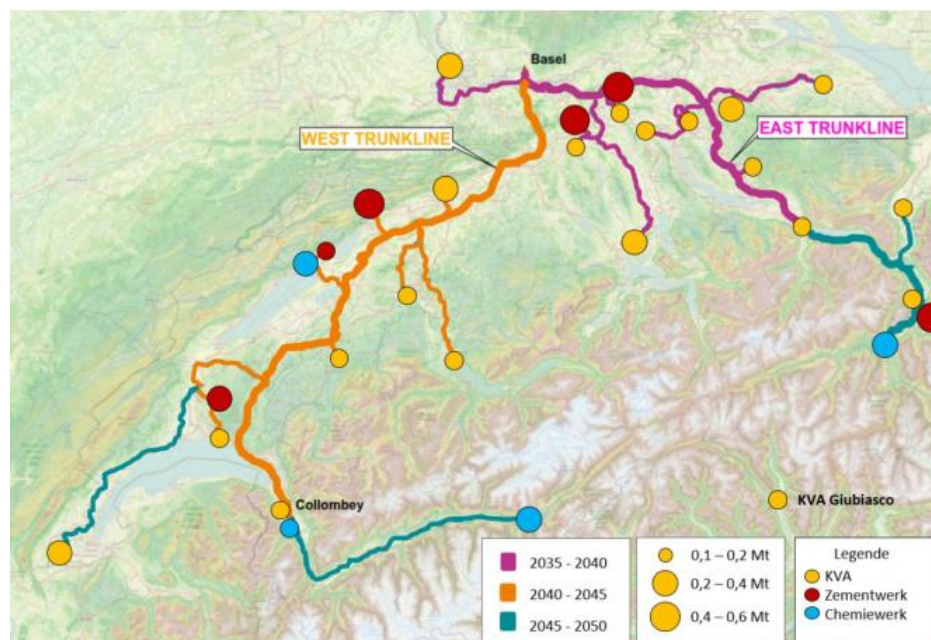
CO₂ pipelines exhibit strong **economies of scale**. Unit transport costs decrease as volumes transported per time period increase. This represents a challenge in particular for early-stage projects which face high per-unit costs due to underutilised capacity, where infrastructure must often be built ahead of demand. Organizing emitters into **CCS hubs** and development of 'trunk' pipelines transporting large volumes can help to reduce transport costs significantly.

CCS pipeline **networks tend toward natural monopoly structures**, given their high fixed costs, low marginal costs, and limited duplication efficiency. This implies a need for regulatory oversight or public involvement, especially in a less centralised federal system like Switzerland. Optimizing the network connection is an important consideration to optimize volumes and minimise the costs of the pipeline. A study has examined the potential pipeline system routing for Switzerland³⁹. The study identifies 32 large emitters in Switzerland (identified as point sources emitting over 100,000 tons/y of CO₂). The proposed routes within Switzerland, assume connection to a long transmission pipeline outside of Switzerland that will deliver the CO₂ to a selected, final sequestration site outside of the country. The figure below, shows one option for CCS infrastructure rollout in Switzerland.

³⁸ BAFU (n.d.). [Bundesrat befasste sich mit Klimapolitik nach 2030](#)

³⁹ Saipem (2020). [CO₂ Collection Network Conceptual Study – Pipeline system Routing Study](#).

Figure 2-3 Proposed rollout plan for CCS network in Switzerland⁴⁰



CO₂ pipelines and storage facilities are long-lived assets (30–50+ years). The longevity of these assets has an implication for investors, who face significant risks related to **demand uncertainty** (e.g. dependent on CCS deployment rates) as well as **policy and regulatory uncertainty** (notably in Switzerland's still-developing legal framework). An additional source of uncertainty relates to **cross-border dependency risks**. In the case of Switzerland, these risks are very present due to reliance on foreign countries for storage. CO₂ long-term storage is particularly less well-known, as very few storage basins in the world have transitioned into the long-term post-closure phase.

2.3.2 Indicative costs of CSS with focus on Switzerland

Reported CCS cost ranges are wide but consistently high: numerous studies indicate lower-end estimates of around Swiss Francs (CHF) 64/t, while upper-end values often reach CHF 184–230/t, depending on plant characteristics, capture complexity, transport distance, geological conditions, and project scale⁴¹. Analyses such as the Clean Air Task Force (CATF) mapping exercise illustrate a typical European range of CHF 64–230/t, highlighting the substantial variability across sectors and locations.⁴² In comparison, as of mid-March 2026, EU ETS carbon allowance (EUA) prices fluctuated around CHF 60–61/t (€65–€66/t). The average allowance price for the preceding six months (September 2025–February 2026) was CHF 73/t (€79/t).⁴³ The Swiss Emissions Trading System (Swiss ETS) allowance prices generally trade in parity with the EU ETS due to their linked systems.⁴⁴

A recent study analysed CCS investment and operating costs for 2030 and 2050 in the context of Switzerland.⁴⁵ The reported costs for CO₂ transport and storage are shown in the table below. It is important to mention that the transport costs in 2030 are based on transport via rail is assumed since pipeline infrastructure is not expected to be developed by that time. In 2050, a pipeline network is expected to exist. In the case of the low estimate, the availability of storage facilities within Switzerland

⁴⁰ Polynomics, Frontier Economics, BAK Economics, VISCHER (2024), [Optionen zur Regulierung von CO₂-Pipelines und CO₂-Untergrundspeichern in der Schweiz](#).

⁴¹ In Switzerland, overall costs, can be expected to be higher due to lack of domestic storage and longer distances to third-country storage sites.

⁴² CATF (2023). [Mapping the cost of carbon capture and storage in the EU](#).

⁴³ EC. [Auctioning of Allowances](#).

⁴⁴ Swiss Government (2025). [Emissions Trading](#).

⁴⁵ BAK Economics and Dena (2025). [CCS and CCUS in Switzerland: Study Highlights Need for Action](#).

is assumed. For the medium bandwidth, CO₂ is expected to be transported to Italy in 2050, and for the high bandwidth to Germany. These estimates are all highly uncertain and depend on various specific assumptions, detailed further in the cited study.

Table 2-1 Cost ranges assumed for CO₂ transport and CO₂ storage in 2030 and 2050 for Switzerland (in CHF/tCO₂)⁴⁶

Value chain element	Timeline	Low estimate	Medium estimate	High estimate
Transport	2030	159	159	219
	2050	50	95	103
Storage	2030	60	90	120
	2050	11	14	29

Financing gap

There is thus a large financing gap for CCS to become economically viable in Switzerland. According to estimates, CCS in Switzerland will require CHF 11–21 billion in investments by 2050 (including OPEX)⁴⁷. The study conducted by BAK and DENA also finds that for 2030, there is a large funding gap between the projected ETS prices and the calculated abatement costs. Due to lower abatement costs and rising ETS prices, the funding gap decreases significantly by 2050.

Thus, current cost levels imply that CCS infrastructure is not commercially viable without support mechanisms. The study identifies Carbon Contracts for Difference (CCfDs) as a particularly promising support tool, as they can cover not only capital and operating expenses but also transport and storage costs.⁴⁸

Considerations on cost structure and policy design implications

The estimated breakdown of cost-share across the CCS value chain and share of capex for each value chain element is listed below:

- Capture: 64% of costs (CAPEX share 28%)
- Pipeline transport: 34% (CAPEX share 46%)
- Storage: 1–3% (but very capital-intensive: 68% CAPEX)

Overall, CCS is capital-intensive upfront, but operational costs dominate long-term system economics. However, from this breakdown it is apparent that capture is more OPEX-heavy whereas pipelines are CAPEX-intensive. This has implications for policy design. The capture part of the value chain is expected to be more sensitive to efficiency and innovation, whereas the transport part will have a higher sensitivity to financing conditions. This distinction is crucial when aligning policy instruments with cost drivers. This is summarised in the table below.

Table 2-2 Cost Drivers and implications for policy design per CCS value chain element

CCS Segment	Key Cost Driver	Policy design logic
Capture	OPEX, innovation	Market-based / private
Pipelines	CAPEX, financing	Regulated / public-oriented
Storage	CAPEX (small share)	Case-dependent

⁴⁶ Ibid.

⁴⁷ Ibid.

⁴⁸ Ibid.

3 Analytical Framework and Methodology

This short chapter covers some methodological aspects for the analysis in the following chapters. The chapter first reviews methodology as applied for determining and structuring the risks for CO₂ transport and storage infrastructure. Next, assessment criteria for risk hedging instruments is presented. Lastly, data sources and stakeholder interactions are described in more detail.

3.1 Framework for risks

The risk classification presented in Chapter 4 is based on a structured qualitative risk assessment framework commonly used in studies on hydrogen infrastructure, natural gas systems, and carbon management technologies. Risks are primarily categorised based on the root cause of the risk, and are divided among: *planning risks*, *financial and commercial risks*, *legal risks*, *political risks*, and *technical risks*.

The identification and definition of risk categories were developed through a targeted literature review of CCS, hydrogen and other energy infrastructure studies, as well as policy and industry reports from institutions such as the IEA, Global CCS Institute, Swiss federal government, and the European Commission. This ensured consistency with established classifications of planning, financial, commercial, legal, political, and technical risks used in energy transition infrastructure assessment.

Building on this foundation, risks were further adapted to reflect the specific institutional and geographical conditions of Switzerland, in particular its reliance on cross-border transport routes and foreign geological storage sites. This allowed the assessment to capture both domestic regulatory and political constraints and externally determined risks originating from EU regulatory frameworks and international storage infrastructure.

Finally, each risk was evaluated in terms of probability, impact, and insurability to enable a structured comparison of risk profiles and to highlight which risks can be mitigated through insurance markets versus those requiring contractual, regulatory, or public policy solutions. A qualitative scoring (High/Medium/Low) was followed.

3.2 Assessment criteria for risk-hedging instruments

The assessment criteria for each risk-hedging instrument are set to give a comprehensive comparison of all instruments. Such a comparison would be necessarily qualitative, as the instruments are in various cases not established enough to identify sufficiently precise quantitative values for comparison.

Criteria include:

- Effectiveness: to what extent does the instrument support the build-out of infrastructure?
- Efficiency: does the instrument achieve the lowest costs for its level of effectiveness? How significant are the deadweight losses with its application?
- Equity: to what extent does the instrument redistribute costs to those who should not cover them (e.g., polluter pays principle)?
- Flexibility and adaptability: how flexible is the instrument as the CO₂ transport and storage market develops? Would it be stuck in usefulness in earlier stages, or remain applicable until equilibrium market conditions? Would it be valuable in certain market conditions (e.g., ETS prices)?
- Compatibility with (potential) EU law: to what extent would the instrument be compatible with possible EU law?

- Administrative ease: to what extent are the administrative needs for its implementation already available in the federal government? How much might they need to be expanded if the solution is pursued?

These criteria will each be assessed on a 5-point Likert scale (from “very poor”, to “very good”)

3.3 Data sources and stakeholder input

This study’s analysis relies on two sources of input. First, a literature grounds the analysis based on the experiences and investigations conducted both in the Swiss case and in similar countries with similar CO₂ and other infrastructural plans. Second, stakeholder input validates and complements the understanding of risks and their hedging instruments.

Literature review

The literature review included the in-depth review of various sources. The review method chosen for each was different, depending on the category:

- Literature focusing on CO₂ infrastructural developments in Switzerland was used to build and test the understanding of the CCS chain in Switzerland. These studies informed what was the current status and future plans for CCS infrastructure. These sources were primarily used to inform Chapters 0,2, and 4
- Literature focusing on non-CO₂ infrastructure in Switzerland. This literature complemented the first group of literature by providing both crucial contextual information about the regulation and operation of similar infrastructure in Switzerland, together with insights on the application of these regulations and operations to the case of CO₂ transport and storage. This literature was primarily used in Chapter 5, and to a lesser extent in Chapter 4.
- Literature on CO₂ infrastructure outside of Switzerland. This literature covered:
 - The various approaches and lessons learned of other regions. The analysis here was comparative, considering the possible application to Switzerland and lessons that may be relevant for the Swiss federal government.
 - Risk hedging instruments used for CO₂ (and other) infrastructure. This strand of literature covered the potential risks and their risk hedging instruments for CO₂ infrastructure. Analysis of these sources also was comparative, aiming to understand how these hedging instruments would be applied in Switzerland.

These sources were used for Chapters 4. And 5.

- Online sources (web pages, blog posts, news articles, etc.) covering specific information, such as availability of insurance products or specific volumes of investments, etc., were used throughout the study.

Stakeholder interaction

In addition to literature review, various key-stakeholders were interviewed. The main goal of these interviews was to validate the risks and the risk hedging instruments. In addition, a secondary intention was to understand any surrounding information that would be important to consider in the analysis of possible government interventions for risk hedging instruments, and broadly in the CO₂ infrastructure domain.

For this purpose, an interview guide was developed and approved by the client. The interview guide aimed for 60-minute interviews with a broad range of stakeholders. The interviews were primarily carried out in a semi-structured format, where the interview was slightly adjusted to best accommodate the expertise of the interviewee. Interviews were held online via Microsoft Teams.

The stakeholders interviewed were chosen broadly to represent diverse viewpoints on risk hedging for CO₂ transport and storage investments. Intended interviewees included transport (pipeline) operators, industry associations relevant for carbon capture, financial institutions (including

insurance providers), and operators of other infrastructure similar to CO₂ transport and storage and those of other countries. The list of interviewees was reviewed and validated by the client before contact was initiated by us. Overall, the vast majority of interviewees reacted positively and attended interviews, providing suitable inputs for the study.

The interviewee's inputs were integrated into the literature review throughout the study. The commercial interests of stakeholder views were also considered in the integration of the interviewee inputs throughout the study. Where relevant, interviewee's inputs have been used to validate specific assertions. Interviewees have to the extent possible been kept confidential.

4 Investment Risks and Rationale for Public Intervention

4.1 Definition of risks

The risks for CO₂ transport and infrastructure developments in Switzerland are categorised based on the identified or likely root cause of the risk. These categories include *planning risks*, *financial and commercial risks*, *legal risks*, *political risks*, and *technical risks*.

4.1.1 Planning risks

Inter-dependency risks stemming from different interlocking projects (cascading delays and counterparty). CCS projects depend on multiple interlinked components (i.e. capture facilities, transport infrastructure, storage sites, and cross-border agreements) being delivered simultaneously. Delays by one project partner can create cascading delays across the value chain, disrupt CO₂ flows, and undermine project bankability. They can also significantly impact the financial security of CO₂ projects, reducing or delaying revenues at critical times. This risk is particularly pronounced in Switzerland, where projects depend on foreign transport and storage providers. Moreover, timing mismatches between domestic capture projects and the development of cross-border pipelines, shipping routes, or storage hubs create a high risk of underutilised assets and delayed revenues.

4.1.2 Financial and commercial risks

Cost escalation risk. First-of-a-kind CCS projects face significant capital cost uncertainty due to evolving designs, limited domestic experience, supply chain constraints, and inflation in construction and energy markets. Likewise, financial market developments, particularly on WACC, risk-free interest rates, and foreign exchange rates, introduce uncertainty for project costs. Higher-than-expected CAPEX can materially weaken project economics, especially in Switzerland where project volumes are relatively small.

Counterparty risk: Refers to the exposure each party bears if another does not hold up to its expected obligations. The transport and storage (T&S) operator faces revenue collapse if a major emitter defaults or goes insolvent (often called “**default risk**”), or otherwise exits or reduces volume. An emitter can be left with stranded volumes and ETS liabilities if its sole transporter or storage operator fails. This is amplified by the thinness of the CO₂ market in Switzerland (little alternative supply/demand), so defaulting counterparties are hard to replace, especially for 15+ year contract tenors.

4.1.3 Legal risks

EU legal framework (including carbon price developments). Swiss CCS is influenced by EU regulatory developments because of the Swiss ETS linkage and dependence on EU transport and storage infrastructure. Carbon price volatility or insufficient ETS prices, significantly driven by EU and national policymaking, may undermine project revenues. Other changes in EU CCS regulation, transport rules, or liability frameworks may affect project feasibility due to the cross-border dimension.

Swiss federal legal framework. Swiss CCS deployment depends on long-term policy support, including subsidies, carbon contracts for differences, or recognition of stored CO₂ under climate policy. Delays, policy reversals, or insufficient support mechanisms could weaken investment incentives and reduce demand. Switzerland currently has limited domestic CCS regulation, particularly regarding transport rights, permitting, storage responsibility, and long-term liability, while expecting to develop a full package of CCS regulation by 2030 (i.e. the start of the time period for this study). Regulatory uncertainty, combined with cantonal permitting processes, may delay projects or create legal uncertainty for investors.

Cross-border interconnections. The need for Switzerland to export CO₂ across border and store in foreign sites creates interdependency risks. Uncertainty about the pass-through of specific costs, how long-term risks (such as leakage risks) are handled across borders, and other elements create some regulatory risks.

4.1.4 Political risk

CCS projects may face opposition from local communities, NGOs, or cantonal authorities due to concerns about safety, environmental impacts, industrial infrastructure, or perceived prolongation of fossil-based industries. In Switzerland's federal system, local opposition can significantly delay permitting or lead to project cancellation.

4.1.5 Technical risks

Transport. Transport risks include pipeline rupture, shipping accidents, truck or rail incidents, and temporary interruptions caused by technical failures, weather events, or human error. Such events can create safety hazards, operational downtime, and reputational damage.

Storage. Storage risks relate to leakage, migration of CO₂ outside the storage formation, induced seismicity, or monitoring failures over long periods. Long-term liability remains particularly uncertain for Swiss projects relying on foreign storage sites, as responsibility may ultimately require public guarantees or international agreements⁴⁹.

Lastly, **exploration risk** refers to the uncertainties involved with exploration activities in the subsurface layers for potential CO₂ storage basins in Switzerland. A potential CO₂ storage site can also prove unsuitable after geological investigation due to insufficient storage capacity, inadequate injectivity, poor containment characteristics, or unexpected geological conditions. This may result in additional development costs, project delays, or the need to identify alternative storage locations.

CO₂ stream conditioning: impurities such as water, SO_x, NO_x, CO, hydrocarbons, and mercury can cause corrosion and other major problems for transport and storage infrastructure. The specific pressure-temperature profile of the CO₂ stream must also be aligned between different operators (or specific assets included to adjust between different profile).

Technological obsolescence. Investments in early transport or capture technologies may become obsolete as larger pipeline networks, alternative capture technologies, or competing decarbonisation solutions emerge. This may lead to stranded assets or lower-than-expected utilisation over time. This risk is different across different transport and capture modes (e.g., higher for pipelines and lower for repurposable technologies such as rail carriages and road vehicles).

4.2 Risk landscape under the Swiss regulatory framework

Under Switzerland's current and anticipated policy framework (characterised by ambitious net-zero by 2050 targets, a national CO₂ Act, and a Swiss ETS linked to the EU ETS) the CCS risk landscape remains complex, interconnected, and unevenly distributed across project stages and stakeholders. Importantly, **individual risks cannot be assessed in isolation**, as they are interdependent and reinforce one another. For example, regulatory delays can trigger coordination failures across the value chain, which in turn can lead to cost overruns, delayed revenues, counterparty bottlenecks, and ultimately undermined project bankability. Similarly, uncertainty around future CO₂ volumes may affect infrastructure sizing decisions, which then influences both financial viability and long-term operational risks. In practice, CCS projects are therefore exposed not to isolated risks, but to chains of correlated risks that can amplify each other across the capture, transport, and storage system.

⁴⁹ Under the EU ETS and the EU CCS Directive, responsibility for stored CO₂ in a storage site permitted under the EU CCS Directive rests with the storage operator, with long-term responsibility transferring to the competent Member State in accordance with the Directive. Additional bilateral arrangements are generally only required for offshore storage to ensure compliance with the London Protocol.

The willingness of investors, operators, and public authorities to accept these interconnected risks depends on the expected upside. In conventional infrastructure or commodity markets, higher expected margins may justify significant technical, financial, or market risks, creating risk appetite. In CCS, however, the upside is inherently limited: revenues are largely driven by public policy, regulated carbon pricing, subsidies, or cost-recovery mechanisms rather than open market competition, meaning profit potential is capped while downside exposure can remain substantial. Furthermore, upside considerations imply an existing market, but the absence of a mature CCS market results in lower risk appetite. This is partly why actors place greater emphasis on downside protection, contractual certainty, and public risk-sharing mechanisms before committing capital.

This is particularly relevant when distinguishing between the **pre-FID phase** (i.e. where uncertainty, optionality, and coordination risks predominate) and the **post-FID phase**, where capital becomes committed and operational, while long-term liability risks become more prominent. This distinction, alongside the distinction between **ramp-up market phase vs mature market phase**, need to be integrated in the analysis and assessment of risks for CCS.

4.2.1 Planning risks

Planning risks are high in the pre-FID phase, where CCS projects depend on multiple interlocking investments reaching financial closure and operational readiness simultaneously. These risks generally fall in what can be called interdependence risks. Capture facilities, transport networks, storage sites, all adjacent infrastructure, and regulatory progress must all progress in parallel, often across multiple jurisdictions and counterparties. In early CCS markets, conventional risk mitigation and **risk hedging instruments are difficult to apply** because no liquid market yet exists for transport or storage services. As a result, investment decisions are heavily exposed to interdependency risk: delays, bottlenecks, or withdrawal by one actor can trigger cascading delays across the chain and prevent other projects from reaching FID. This has been observed in major European CCS clusters, where multiple industrial projects must commit simultaneously to justify shared infrastructure⁵⁰. For Switzerland, these risks are amplified by dependence on foreign transport and storage infrastructure. Timing mismatches between Swiss capture investments and the availability of cross-border pipelines, shipping routes, or certified storage sites are likely and lead to prolonged underutilisation of domestic assets even after FID has been taken.⁵¹

4.2.2 Financial and commercial risks

Financial risks concern uncertainties affecting the cost of financing, investment returns, and the overall economic performance of CCS projects in Switzerland. Because CCS infrastructure is highly capital-intensive and requires substantial upfront investments with long payback periods, projects are particularly exposed to rising interest rates, inflation-driven CAPEX increases, refinancing risks, and higher operating costs. These risks are amplified by the fact that Switzerland is still in the early stages of CCS deployment, with many projects relying on emerging business models and public support mechanisms under the Climate and Innovation Act. In addition, Switzerland currently lacks large-scale domestic geological storage capacity and is expected to rely heavily on cross-border CO₂ transport and storage agreements with countries such as Norway and Denmark. Dependence on international transport and storage infrastructure may create additional cost uncertainties related to transport tariffs, storage fees, exchange rates, and evolving bilateral agreements. Furthermore, changes in market conditions or policy frameworks could lead to asset impairment risks for transport and intermediate storage infrastructure.⁵²

⁵⁰ Wesche, J., & Steen, M. (2026). [What does it take for large-scale CCS projects to reach final investment decision? Evidence from Porthos in the Netherlands](#). *International Journal of Greenhouse Gas Control*, 151, 104590.

⁵¹ Polynomics, Frontier Economics, BAK Economics, VISCHER (2024), [Optionen zur Regulierung von CO₂-Pipelines und CO₂-Untergrundspeichern in der Schweiz](#).

⁵² Swiss Government (2022). [Carbon capture and storage \(CCS\) and negative emission technologies \(NETs\)](#).

Commercial risks relate to uncertainties affecting the operational viability and revenue stability of CCS projects due to changes in market conditions, contractual relationships, technology developments, or customer behaviour.⁵³ In the Swiss early-stage CCS market, infrastructure is expected to serve a relatively limited number of concentrated industrial emitters, particularly cement plants and waste-to-energy facilities. Reductions in captured CO₂ volumes caused by industrial relocation, facility closures, lower industrial production, bankruptcy, or the adoption of alternative decarbonisation pathways can significantly reduce infrastructure utilisation and revenues. Additional commercial risks arise from delays in developing cross-border CO₂ transport networks, underutilised transport or storage capacity, and uncertainties surrounding future demand for carbon storage services. Competition from alternative mitigation options including electrification, material substitution, energy efficiency improvements, hydrogen-based processes, or negative emission technologies, may further reduce demand for CCS over time. These risks can weaken the long-term business case for CCS and increase the likelihood of stranded infrastructure assets.

4.2.3 Legal risks

Legal and regulatory risks are central throughout the CCS project lifecycle but are particularly critical before FID, when investors require confidence in the long-term policy and regulatory environment. Given the current absence of large-scale domestic storage options, Swiss CCS projects are especially exposed to regulatory developments at both the Swiss and European levels, as well as to the legal complexities associated with cross-border CO₂ transport and storage.

Swiss CCS is strongly influenced by **EU regulatory developments**. Switzerland's emissions trading system is linked to the EU ETS, while future Swiss CCS projects are expected to rely heavily on European transport and storage infrastructure. Consequently, carbon price volatility or persistently low ETS prices may undermine project revenues and weaken investment incentives. In addition, changes to EU CCS legislation, cross-border transport rules, monitoring and verification requirements, or storage liability frameworks could affect the feasibility and economics of Swiss projects by altering the regulatory conditions under which CO₂ is transported and permanently stored.⁵⁴

At the federal level, CCS deployment depends on the establishment of a stable and predictable Swiss regulatory framework. Long-term investment decisions may rely on policy support mechanisms such as subsidies, carbon contracts for difference, or the further embedding and advancing of CO₂ storage as a constitutive element of the broader Swiss climate strategy. Delays in implementing these measures, policy reversals, or insufficient support could reduce project viability and investor confidence. Regulatory uncertainty is heightened by the fact that Switzerland is still developing key elements of its CCS framework, including rules governing CO₂ transport infrastructure, permitting procedures, storage responsibility, and long-term liability. Although a comprehensive regulatory package is expected by around 2030, uncertainty regarding its final design may delay investment decisions and increase financing costs.

A third category of risk arises from **cross-border interconnections**. Because Swiss CO₂ will likely need to be transported through multiple jurisdictions and stored in foreign reservoirs, projects depend on coordinated legal and commercial arrangements across national boundaries. Uncertainty regarding the allocation and pass-through of transport and storage costs, the treatment of long-term risks such as leakage liability (as pertaining to the ETS Directive and CCS Directive)⁵⁵, and the interaction of

⁵³ Risk hedging for thermal networks, Federal Office for Energy

⁵⁴ Federal Office for the Environment (FOEN)(2025). [Carbon capture, removal and storage](#).

⁵⁵ Under the EU ETS, liability for CO₂ leakage from a storage site permitted under the EU CCS Directive rests with the storage site operator, irrespective of the origin of the CO₂. Accordingly, this also applies to CO₂ imported from Switzerland and stored in an EU-permitted geological storage site. The storage operator is responsible for monitoring, reporting and, where applicable, surrendering allowances for any leaked CO₂ under the EU ETS. Following transfer of responsibility under the EU CCS Directive, long-term responsibility passes to the competent Member State, subject to the conditions laid down in the Directive.

different regulatory regimes can create significant interdependency risks. Disputes or regulatory changes affecting any part of the international value chain may delay projects, increase costs, or undermine contractual arrangements that are essential for project viability.⁵⁶

4.2.4 Political risks

Political and public acceptance risks can affect projects at every stage but are often most critical before FID, when permitting, site selection, and stakeholder engagement determine whether projects can proceed. CCS infrastructure (including capture facilities, pipelines, shipping terminals, compression stations, or potential storage sites) may face opposition from local communities, NGOs, or cantonal authorities due to safety concerns, environmental impacts, land use conflicts, or perceptions that CCS prolongs industrial emissions instead of accelerating structural decarbonisation. In Switzerland, these risks can be more pronounced due to the country's decentralised governance model and strong local participation in planning decisions. Public opposition can significantly delay permitting, increase development costs, or lead to project cancellation, thereby undermining financing assumptions and increasing coordination risks across the wider CCS chain. Switzerland's federal structure further increases permitting risk,⁵⁷ as cantonal approval procedures and political acceptance may differ significantly across regions.⁵⁸ Moreover, induced seismicity has been a significant factor for public opposition to similar geothermal projects in the past (although also a very minor risk). This history demands more detailed sub-surface basin characterisation to alleviate public concerns.⁵⁹

4.2.5 Technical risks

Technical risks become increasingly relevant after FID, as liabilities materialise once CCS assets are constructed and operational. In the Swiss context, these risks are further amplified by the anticipated reliance on cross-border CO₂ transport and foreign storage infrastructure, which increases both operational complexity and exposure to external jurisdictions.

Transport risks include pipeline rupture, shipping incidents, truck or rail accidents, equipment failure, operational downtime, and temporary interruptions caused by technical malfunctions, force majeure events, or human error. These events can lead to safety hazards, environmental damage, financial losses, and reputational harm. These risks are actively mitigated through regulatory requirements, safety standards, damage prevention measures, emergency response planning, and integrity management systems. Given Switzerland's reliance on cross-border transport corridors, such risks may also be affected by system interdependencies across multiple jurisdictions and operators. Interviewees have highlighted that CO₂ pipeline performance risks are broadly comparable to gas transport, whereby existing Swiss inspection practice makes pipeline leaks very rare.

Storage risks relate to the long-term integrity of geological storage sites, including potential CO₂ leakage, migration outside the intended storage formation, induced seismicity, and failures of monitoring or verification systems over extended time horizons. For Switzerland, many storage sites are expected to be located abroad, meaning that long-term monitoring responsibilities and liability arrangements fall outside national jurisdiction. In the further future with in-land underground

⁵⁶ Global CCS Institute (2024). [Global Status of CCS 2024](#).

⁵⁷ Public opposition can significantly delay or complicate the permitting and development of CO₂ transport infrastructure (particularly pipelines) and geological storage sites, increasing development costs, delaying investment decisions, or leading to project cancellation. Even assuming that a nationally harmonised permitting framework is in place after 2030, project-specific permitting timelines and outcomes may still be affected by local acceptance and legal challenges, creating coordination risks across the wider CCS chain. Switzerland's federal structure may further exacerbate these risks, as political acceptance and implementation of permitting procedures can vary across cantons.

⁵⁸ ZEP (2024). [Key enablers and hurdles for CCS and CCU projects](#).

⁵⁹ Swiss Seismological Service (n.d.). [Geothermal energy & induced earthquakes](#).

storage, seismicity risks would be important to consider (but are quite difficult to assess given limited knowledge on subsurface status, mentioned in the next paragraph).

Switzerland has had very limited historical exploration and sampling activities for oil and gas resources, resulting in comparatively limited knowledge of deep subsurface structures relative to regions such as the North Sea. Interviewees have verified that Swiss storage potential is geologically plausible (due to deep aquifers) but as of yet unproven. This data scarcity increases uncertainty and risk in the exploration, characterisation, and development of potential geological CO₂ storage sites in Switzerland. Similar challenges are also observed in other subsurface uses, such as geothermal energy projects (e.g. the St. Gallen geothermal project). To date, storage considerations have primarily focused on saline aquifers in the Molasse Basin and structures in the Folded Jura.

According to current federal assessments, Switzerland's best-case domestic CO₂ storage potential is in the order of around 3 Mt CO₂ per year by 2050, while projected domestic demand for geological storage is higher (approximately 7 Mt CO₂ per year).⁶⁰ This indicates that domestic storage capacity alone is unlikely to fully meet long-term national demand under net-zero pathways, implying continued reliance on access to established storage sites abroad, particularly in the North Sea region, at least in the medium term. **CO₂ stream quality and conditioning** requirements: impurities such as water, SO_x, NO_x, CO, hydrocarbons, and mercury can cause corrosion, phase instability, and other integrity issues that may compromise transport and storage infrastructure. Ensuring safe operation therefore requires strict specification of CO₂ quality and continuous monitoring. In addition, pressure and temperature conditions must be aligned across different operators and system segments. Where systems operate under different design parameters, additional compression, conditioning, or buffering infrastructure may be required to enable compatibility and avoid operational disruptions.

Technological obsolescence⁶¹ represents a structural long-term risk for early CCS investments. Capture, transport, and conditioning technologies deployed in early phases may become less competitive as larger integrated pipeline networks develop, alternative capture technologies emerge, or competing decarbonisation pathways gain prominence. This can result in stranded assets or lower-than-expected utilisation over time. The degree of exposure varies across transport and capture modes: fixed, large-scale infrastructure such as pipelines is particularly exposed due to long asset lifetimes and limited flexibility, whereas other systems, such as rail or road-based transport, may retain greater adaptability and residual value.

4.3 Assessment of probability, impact, insurability, and market failures

The risk assessment presented in Table 1 summarises the analysis of the risk landscape of CCS infrastructure, addressing each risk based on its impact, probability and insurability. As described in the previous section, CCS risk includes organisational, financial, regulatory, and physical risks, each differing significantly in terms of probability, potential impact, and insurability. A starting point of the analysis is that **risks arising from operational and technical events tend to be at least partially insurable**, whereas **risks driven by systemic market structures, policy uncertainty, or strategic coordination failures are generally uninsurable** through conventional insurance mechanisms. This distinction is particularly relevant for CCS projects, whose economic viability depends on long asset lifetimes, stable policy frameworks, and complex chain coordination. Below an overview of the analysis presented in the table.

4.3.1 Planning risks

Planning risks primarily stem from the strong interdependence between the different components of the CCS value chain, namely capture, transport, and storage infrastructure. Because these assets

⁶⁰ Swiss Government (2022). [Carbon capture and storage \(CCS\) and negative emission technologies \(NETs\)](#).

⁶¹ Hong, W. Y. (2022). [A techno-economic review on carbon capture, utilisation and storage systems for achieving a net-zero CO₂ emissions future](#). Carbon Capture Science & Technology, 3, 100044.

are developed and operated by different actors, project success depends on precise timing of commissioning schedules, contractual alignment, and operational reliability across the entire chain. The analysis indicates both a **high probability and high impact for coordination failures**, as delays or underperformance by a single actor may disrupt the entire system and undermine project bankability. Similarly, the risk associated with insufficient transport, storage, or operational capacity is assessed as highly probable and highly impactful, reflecting the mismatch between the pace of capture project development and infrastructure deployment (i.e. the “chicken and egg” dilemma).

From an insurance perspective, both risks are **non-insurable**. This is due to the fact that they arise from systemic dependencies and strategic infrastructure planning rather than from accidental, random loss events. Insurers generally require risks to be independent, quantifiable, and sufficiently diversified across portfolios. Coordination failures in CCS instead exhibit strong correlation across projects and may affect entire clusters simultaneously, making them unsuitable for traditional risk transfer mechanisms.⁶² As a result, mitigation of organisational risks relies primarily on contractual arrangements, phased infrastructure development, and public coordination mechanisms rather than insurance products.

4.3.2 Financial and commercial risks

Cost escalation risks in CCS projects are assessed as medium to high probability, reflecting the combination of relatively mature underlying technologies with first-of-a-kind project implementation, supply chain constraints, and inflationary pressure on materials and construction costs. These factors can lead to higher-than-expected capital expenditures and operating costs, thereby reducing overall project returns and potentially affecting financing viability. The impact is considered high, as cost overruns directly affect project bankability and can undermine investment decisions prior to or after FID. From an insurability perspective, this risk is partially insurable, as elements of construction-related cost overruns can be mitigated through EPC contracts, fixed-price arrangements, contingency planning, and project insurance products.

Counterparty risks are assessed as low to medium probability for Swiss capture facilities, reflecting relatively stable industrial counterparts, but potentially medium to high for transport and storage providers due to their capital intensity and emerging market structures. The impact is high, as default or financial distress of key CCS chain participants can significantly disrupt cash flows, increase financing costs, and threaten the viability of integrated CCS networks. From an insurability perspective, these risks are only partially insurable. While some exposure can be mitigated through contractual arrangements, revenue hedging mechanisms, and long-term offtake agreements, CCS revenue streams are often considered highly uncertain by financial markets and may fall outside standard insurance or hedging products, particularly given their dependence on carbon prices and policy frameworks.

4.3.3 Legal risks

Regulatory risks emerge as some of the most critical and least insurable threats to CCS deployment. Carbon price volatility under the ETS and uncertainty regarding continued public support or subsidy schemes are both assessed as high-impact risks with medium to high probabilities. Since carbon pricing and subsidy regimes directly determine revenue generation and investment incentives for CCS projects, changes in policy frameworks can fundamentally alter project economics.

These risks are categorised as non-insurable because they originate from political and regulatory decision-making rather than physical or operational events. Insurers are generally unable to underwrite risks linked to sovereign policy choices, fiscal priorities, or political cycles, especially when such changes can simultaneously affect entire sectors. Consequently, regulatory risks represent a major residual exposure for investors and lenders. Their mitigation depends largely on long-term

⁶² Global CCS Institute (2025). [INSURANCE FOR CARBON CAPTURE AND STORAGE – STATE OF THE MARKET](#).

policy commitments, carbon contracts for difference, regulatory stability, and public-private partnership frameworks rather than private insurance markets.

4.3.4 Political risks

Political and public opposition to CO₂ transport infrastructure, storage sites, or industrial decarbonisation projects can lead to permitting delays, reputational challenges, or outright project cancellation. Similar to regulatory and organisational risks, public acceptance risks are generally not insurable⁶³. Their management therefore depends on stakeholder engagement, transparent communication, and early community involvement.

4.3.5 Technical risks

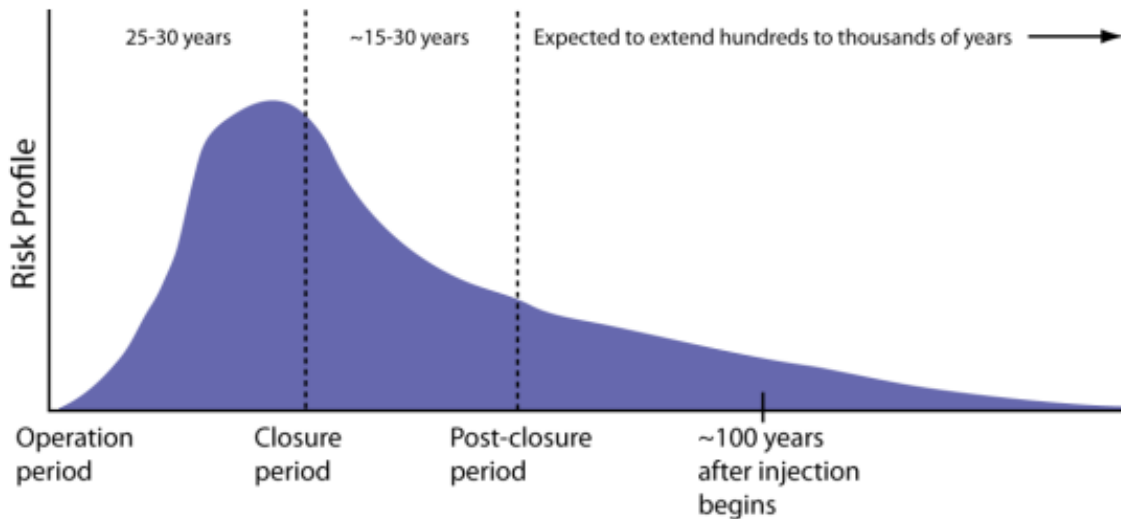
Transport risks are assessed as low probability, reflecting mature engineering standards and the relatively well-understood properties of CO₂ in transport applications. Nevertheless, the impact is considered medium, as incidents such as pipeline ruptures, shipping accidents, or operational failures in truck and rail transport can lead to safety hazards, temporary downtime, and reputational damage. From an insurability perspective, these risks are fully insurable through operational, engineering, and liability insurance products, as they correspond to well-defined, accidental loss events with established risk models. It is however worth mentioning that pipeline rupture can be more severe, in terms of impact, in valleys versus in flat plains. Thus, earlier phases of CO₂ pipelines in Switzerland would likely be at similar severity as other ruptures on plains, whereas later buildouts in valley regions can be more severe.⁶⁴

Storage risks are assessed as low to very low probability, assuming appropriate site selection, construction quality, and long-term monitoring practices. However, the impact is medium, as potential leakage or containment failure could trigger ETS credit surrender obligations, environmental remediation costs, and reputational consequences. These risks are only partially insurable: short-term operational leakage events may be covered under existing insurance frameworks, but long-term leakage and post-closure liabilities are generally uninsurable.

Exploration risk for storage is assessed as high probability in the Swiss context, given the data scarcity on sub-surface geology. Nonetheless, impact is very small, as most CO₂ is to be stored in well-characterised foreign storage sites, particularly in the North Sea region. Delays in site development, permitting, or capacity expansion abroad could still postpone Swiss CCS projects and disrupt the wider value chain (but would fit under other risk categories). The exploration risk is generally non-insurable, as it relates to uncertainty in sub-surface geology and is a general risk with such projects rather than identifiable insurable loss events.

⁶⁴ Schulman, N., Reding, N., Cox, B., Schneider, J., & Ogle, R. (2025). [Consequence Analysis of the Satartia Carbon Dioxide Release](#). In 2025 Spring Meeting and 21st Global Congress on Process Safety. AIChE.

Figure 4-1: Timing and severity of storage leakage risks. Source: Energy Policy Institute (2011)⁶⁵



CO₂ stream conditioning risks are assessed as medium probability, reflecting dependence on capture technologies and the availability of appropriate purification and conditioning infrastructure. The impact is considered low, as issues such as impurities or mismatched pressure and temperature specifications would primarily require additional conditioning or adjustment facilities, resulting in limited incremental costs rather than systemic disruption. These risks are partially insurable, as quality specifications can be addressed through contractual arrangements between capture, transport, and storage operators, although uncertainty remains during early ramp-up phases of CCS value chains.

Technological obsolescence is assessed as medium probability, driven by the rapid evolution of capture technologies, transport systems, and broader decarbonisation pathways. The impact is high, as early investments in CCS infrastructure risk becoming stranded or significantly underutilised if more efficient or competitive alternatives emerge. This risk is considered non-insurable, as it results from structural technological change and market evolution rather than accidental, insurable events.

Higher exploration and development uncertainty in Switzerland may make domestic storage projects less attractive than investments in established storage hubs such as the North Sea, but this should be seen as a competitiveness challenge rather than a definitive show-stopper.

⁶⁵ Energy Policy Institute (2011). [Analysis of liability regimes for carbon capture and sequestration: a review for policymakers](#).

Table 4-1 Risk analysis matrix (risks categories with high probability and high impact are highlighted in red)

Category	Risk	Probability (high/medium/low)	Impact (high/med/low)	Commercially hedgeable (yes/no/partially)
Planning risks	Inter-dependency	High: multiple interlinked capture, transport, and storage assets must align	High: delays or failure of one actor can disrupt entire CCS chain and bankability.	No: systemic coordination failures cannot be insured
	Cross-border interdependency	High: Switzerland's CCS chain is inherently dependent on exports to other countries.	Very high: lack of sufficient development downstream of Switzerland can completely undermine the CCS plan.	No.
Financial and commercial risks	Cost escalation	Medium/High: Well-understood technologies but first-of-a-kind implementations, supply chain constraints, inflationary pressure	High: significantly impacts project returns and financing viability	Partially: EPC contracts, contingencies, and insurance provide some coverage. First-of-a-kind design-related escalations and financial market dynamics (e.g., causing OPEX inflation) are not entirely insurable, if at all.
	Counterparty risks	Low/Medium: default risk of Swiss capture facilities low, but risks of T&S companies may be medium/high	High: increases financing burden	Partially: revenue hedging possible via commercial offers and contractual obligations. Revenue streams of CO ₂ projects are however very high risk and may be rejected from usual financial instruments.
Legal risks	EU legal framework (e.g., ETS price volatility)	High: ETS prices and policy frameworks are inherently volatile	Very high: core determinant of CCS revenue viability	Partially: ETS volatility can be covered by contractual obligations, but is very expensive. Other legal framework details are not hedgeable.
	Swiss federal legal framework	Medium: dependent on political cycles and fiscal priorities.	Medium: Can delay commissioning and escalate costs; can impact investments and cause asset stranding.	No: policies are generally not hedgeable.

Category	Risk	Probability (high/medium/low)	Impact (high/med/low)	Commercially hedgeable (yes/no/partially)
			Assessment assumes suitable legal framework is set up by 2030.	
Political risks	Public acceptance and permitting challenges	Medium: Swiss direct democracy system could make contestations possible	High: susceptible to delay or prevent project implementation	No: social acceptance risks are mostly not insurable
Technical risks	Transport (pipeline, ship, truck, rail)	Low: engineering standards reduce likelihood; CO ₂ is a well-understood material.	Medium: safety incidents, downtime, reputational damage	Yes: covered by operational and liability insurance
	Storage (leakage, etc.)	Low/Very low: depends on proper site selection, construction and operational choices, and monitoring	Medium: ETS credit surrenders, environmental damage liability, remediation costs	Partially: short-term leakage can be insured; long-term leakage is not insurable and requires some form of a backstop
	Exploration risk for storage	High: Swiss sub-surface geology is not well-understood, given a lack of prior (energy industry) exploration.	Low: The vast majority of Swiss CO ₂ is planned to be stored in North Sea basins, which are well-characterised storage sites. Nonetheless, conditional on off-shore storage remaining viable post-2040, the risk of lack of discovery of suitable underground Swiss storage is less severe.	No: uncertainty over resource availability and project development is not insurable
	CO ₂ stream conditioning	Medium: dependent on capture technologies and conditioning facilities	Low: would require further conditioning facilities, which would only add minor costs.	Partially: conditioning needs can be specified in contracting, though unclarity remains during ramp-up phase.
	Technological obsolescence	Medium: rapid evolution of capture, transport, and decarbonisation technologies	High: risk of stranded or underutilised assets.	No: structural technological change is not insurable

5 Review of Risk-Hedging Instruments

This chapter reviews and assesses the risk-hedging instruments for the main risks in CO₂ transport and storage. The study first reviews experience from other sectors, particularly thermal networks and hydrogen networks, and also experiences from other countries implementing CCS chains. The analysis then focuses on risk-hedging for CO₂ T&S in Switzerland, reviewing risk-hedging instruments that are offered commercially for these projects. The study narrows down on which risks are not hedged commercially, but must be hedged for a successful implementation of the CCS chain post-2030. Different options for public intervention for risk hedging in these areas are explored, the costs of which are elaborated based on academic studies. The chapter ends by giving various other important actions by the government that could (indirectly) de-risk CO₂ T&S infrastructural projects.

5.1 Experience from other sectors

Risk-hedging practices during the build-out of other network infrastructure can be instructive for that of CO₂ infrastructure. Which specific risks exist, and also which risk hedging instruments are best-placed, are quite unique to each set of network infrastructure and can depend on various factors in the infrastructure. Our understanding is that the most applicable forms of network infrastructure for this case, namely roll-out of CO₂ transport and underground storage in the Swiss case, are those where:

- The infrastructure supports continuous trade of a commodity.
- The transport buildout has some similarities to those of other (existing) infrastructure.
- The infrastructure is based upon well-understood mature technologies with limited economies of scale.
- The marginal cost of transporting and storing a unit of the networked commodity is far lower than the average cost (i.e. CAPEX and fixed operational costs dominate the cost structure).
- The infrastructure build-out involved a transitory period during which build-out took place and volumes traded were uncertain and/or limited.
- The infrastructure build-out has happened in recent decades or is yet to happen (i.e. build-outs more than 5-6 decades ago would not be sufficiently relevant).
- The build-out was conducted in Switzerland, or a region with similarity to the regulatory and economic status of Switzerland.

The ideal comparative sector would be one which is most similar across these factors to CO₂ transport and storage. The sectors most relevant for this type of build-out would thus be network infrastructure for other energy vectors, particularly thermal energy and hydrogen. A significant and specific characteristic for CO₂ networks is that there is no demand side for CO₂ (contrary to heat and hydrogen). The market thus depends on political will to drive demand, and primarily aligned via targets of carbon reductions for industrial and other actors.

5.1.1 Thermal networks

One of the primary studies relevant for this context is that on thermal networks in Switzerland. A 2021 study commissioned by the SFOE details the risks and related hedging instruments for investments in heating and cooling networks. Similar to the CO₂ context, the study highlights that thermal networks face both risks that can be hedged on commercial markets, but also includes some risks which are not hedgeable on commercial markets (some of which may require public intervention). The relevance of unhedgeable risks is especially large for projects undertaken by smaller energy suppliers, such as those of municipalities.

Based on responses from stakeholders, the study identifies the main risks as:

- Lack of coordination in the development of thermal networks
- Volume loss on both supply and demand sides (loss of customer or heating/cooling source)
- High risk for large CAPEX investments.

The study considers the first risk as not requiring direct risk-hedging, as it is not a “financial risk” per se of project investments. Actions for the public bodies in this regard relate to considerations for subsidy schemes and other steering measures to improve coordination in the development of these networks.

The second and third risks are, however, considered risks for investments and could benefit from public intervention. Risks regarding volume loss on the supply and demand side can be resolved by both (public) guarantees and (commercial) insurance. Public involvement in both is seen as necessary, as commercial insurances require backstops on uncontrollable risks (i.e. guarantees from the government for the portions of the risks that are not controllable and thus not commercially viable). While guarantees are administratively simple, they may require more initial budgetary involvement than insurance backstops. However, insurance backstops would be more complex, and the overall preference is expressed for a guarantee.

The study also discusses specific details on each risk hedging mechanism:

- For volume loss risks, the study considers **minimum contract periods** as a waiting period for hedging to materialize, and with a **maximum period** until which it takes place. The study also considers **which specific volumes are considered in scope** (lost heat generation capacity, lost waste heat extraction infrastructure, size and usage of lost customer connections, etc.)
- For large pre-investment risks, the study mentions setting the right **milestone for triggering guarantee** (expiry of letter of intent, commissioning deadline, etc.), and which **portion of the capital costs** would be insured.

5.1.2 Hydrogen networks

The development of hydrogen networks also has many common elements with CO₂ infrastructure. Both networks require development of a transport backbone, mainly via pipelines, together with supply and demand nodes at various points. Both networks are also rather nascent, with few and in some cases outdated regulations applying to their build-out and operation. While some differences exist between the two, leading to nuances when comparing their application of risk hedging instruments, these similarities create some common ground for applying similar practices.

In hydrogen networks, a recent study by Swiss Economics (2025) for the SFOE details securing investments in hydrogen infrastructure. Many of the risks identified for this infrastructure are highly similar to that of CO₂ infrastructure:

- Volume risk (on the demand and supply side, but also for transport across to other countries)
 - Tied to this, price risk is also identified in case volumes are underwhelming, causing average tariff prices to remain high and deflate further ramp-up of transport and demand.
- Financing or bankability risk: the lack of sufficient credibility for commitment by banks (such as visible future cashflows, creditworthy customers, etc.)
- Construction risk: large upfront capex for a rather novel build-out with high cost uncertainty
 - Connected to this, high sunk cost risks.
- Regulatory risks regarding the ongoing development of EU market design for hydrogen.
 - In the case of state support, public-sector risk also exists for financial losses if ramp-up is underwhelming and/or credit-worthiness is overestimated.

The study maps specific risk hedging instruments to each risk category, some of which are discarded due to moral hazard, worsening uncertainty for stakeholders, and distributional concerns. The main remaining suggestions for risk hedging instruments by the federal government include:

- Subsidies and/or one-off grants in the early stages of projects (planning phase). These options are seen as accelerating delivery while requiring clear interest and co-engagement with key actors (particularly municipalities and cantons).
- One-time equity purchases within a fund for the infrastructure.
- Conditional low-interest loans
- Guarantee to (private bank) loans
- Convertible bonds.

A key factor for the hedging support options for hydrogen is compatibility with EU laws. This would be particularly important for some suggested solutions to relax some of the rules impacting the build-out of hydrogen infrastructure (e.g., on tariff/access, unbundling, use of public land, tax exemptions). Given the recently developed hydrogen regulatory framework in the EU, this was seen as unlikely and some options have been reconsidered. For CO₂ infrastructure, the EU is currently developing a regulatory framework which after adoption will help the Swiss government to guide their policies.

For hydrogen, some key differences exist when considering risks for the infrastructure build-out. The main difference is that the ramp-up of hydrogen infrastructure is built upon the assumption that the energy vector may otherwise be the best option for decarbonizing some hard-to-abate sectors. A key assumption here is that hydrogen would be more affordable than alternative abatement measures. While the CO₂ infrastructure buildout faces similar concerns, the alternatives in this case are generally believed to be less economically feasible, and thus CO₂ infrastructure faces less concerns about volume risk due to this specific cause. CO₂ transport does however face enhanced volume risk due to the viability of some alternatives in some cases, for example road and rail transport⁶⁶, when compared against hydrogen. Lastly, the well-documented and mature technologies employed for CO₂ infrastructure greatly reduce uncertainties regarding technical performance and costs versus far more uncertainty in similar areas on hydrogen infrastructure (pipelines, valves, conditioning infrastructure, storage, etc.).

5.2 International experiences

The Netherlands

The Netherlands currently maintains two flagship projects in the CO₂ transport and storage domain. The Porthos project is the earlier and more concentrated system, aiming to transport 2.5 Mtpa 15 years from a limited set of industrial emitters into depleted, nearby offshore gas reservoirs. The more recent Aramis project is the next generation system, structured as a more open-access backbone with initial capacity of 7.5 Mtpa (scaling to 22 Mtpa) including shipping terminals and multiple offshore storage sites. Although initially developed by private companies, both projects are now fully owned by public companies. These projects have developed from a longer history of experimentations in the CO₂ infrastructure domain in the Netherlands over the prior decades.

These two projects have somewhat different types of risk-hedging following their differing timelines and individual situations, and are thus described in turn. We note however, that there are also some similarities between the used instruments, including public ownership models, T&S agreements, LCs, guarantees, and regulated requirements, and long-term risks being absorbed by the Dutch government.

The Porthos project is an earlier project that was impacted more by risks associated with being first-of-its-kind in the Netherlands. It thus received generous governmental support. On the customer

⁶⁶ and marine transport, which is not in consideration for Switzerland.

side, the Dutch government supports (via SDE++ subsidies) the demand for carbon transport and storage and secures it for a 15-year period. On the infrastructure (or supply) side, various types of support were provided from various sources (e.g., RVO for preparatory studies, state loan, plus other support from the Commission)⁶⁷. The Dutch state also provided a €176 million guarantee for 80% of Porthos's pre-investments while the Council of State case on the project's nitrogen emissions was ongoing (which lapsed when the ruling was finalised).

Despite these costs, expectations for the project's overall costs to the Dutch state budget have been positive. Tax revenue from the project's operations is expected to compensate for Dutch state funding.⁶⁸ Moreover, the SDE++ mechanism may also turn out to be far less impactful than the €2.1b notional size, as ETS prices increase (which remains nonetheless highly dependent on EU and national regulatory developments).

The Porthos project tackles long-tail leakage risks with both private and public contributions. Porthos collects fees contributing to an insurance package that covers leaks 20 years after injection, during the transition period. Porthos then also covers monitoring costs for the State for 30 years. Full liability transfers to the state after the 20-year transition period, with the expectation of "very low" leakage probability likely remaining within the government's own cost efficiency standards.⁶⁹ Nonetheless, a rigorous quantification of leakage risk over the long term has not been published. The most cited estimate, i.e. the €1b to €30b range provided by the Dutch Court of Audit⁷⁰ are bounding heuristics to compare these costs versus the profitability and cost efficiency standards of the Dutch government, and not a direct calculation of the upper and lower bounds of risk exposure.

The Aramis project is a more recent project building on the experience from Porthos. The project's ownership structure was initially a 4-way public-private joint venture (TotalEnergies, Shell, Energie Beheer Nederland (EBN), Gasunie), but in April 2025 the two oil majors withdrew from the pipeline portion and the Dutch government committed an additional €639 million to allow EBN and Gasunie to continue as a 50:50 public owner-operator of the trunk infrastructure. Shell and Total remain in the storage joint ventures and as commercial storage offtakers.⁷¹ In addition to this state support, Aramis received a €124 million grant from the Commission's CEF-E fund, plus €45 million for related research, and other support via the SDE++.

An important difference between Dutch projects and potential Swiss ones is the involvement of the state as an indirect owner in some infrastructure. In Dutch projects, various entities that are state-owned become involved, some directly. Energie Beheer Nederland (a wholly state-owned company), for example, is directly invested into both projects, such as via a statutory 40% stake on all storage licenses. While this greatly increases the involvement and costs for the state in the projects, it allows a more active role that can also provide the early-stage absorption of risk in a more comprehensive manner. For various reasons, this difference in ownership limits the lessons applicable from the Dutch case for Switzerland's development of CO₂ transport and storage infrastructure.

Some lessons that can be drawn from Dutch developments include:

- Consideration of a CCfD to stabilise price developments on the emitter side (indirectly securing demand for transport and storage).
- Potential guarantees for (some or all of) investment exposure before FID, particularly during the scale-up phase of the infrastructure.

⁶⁷ Porthos (n.d.). [Will Porthos receive subsidy for this project?](#)

⁶⁸ Netherlands Court of Audit (2024), [Carbon storage under the North Sea](#).

⁶⁹ Netherlands Court of Audit (2024), [Carbon storage under the North Sea](#).

⁷⁰ Netherlands Court of Audit (2024), [Carbon storage under the North Sea](#).

⁷¹ [Aramis \(2025\)](#). Aramis takes next step towards investment Decision.

- Particular attention should be paid to the transport part of the infrastructure, where low margins can cause private actors to take slow or even backwards steps (as happened with the Aramis project).
- Long-term liability of storage could be directly taken over or otherwise supported or coordinated by the state.

The United Kingdom

The UK's approach to CO₂ transport and storage began with two false starts that eventually developed into real investments and projects. A 2007 demonstration and a 2015 commercialisation competition were cancelled or downsized, mainly due to the insufficient de-risking of investments by the state. The National Audit Office concluded in both cases that the Department for Energy Security and Net Zero (DESNZ) had pushed too much risk onto private developers, which made bids unaffordable, and that the State would need to bear more of the risk, particularly long-tail CO₂ storage risk.⁷² The current programme is the explicit policy response. In October 2021, DESNZ (then BEIS) selected two Track-1 clusters (8.5 MtCO₂/yr combined), HyNet (north-west England and north Wales) and the East Coast Cluster (Teesside-Humber, served by the Northern Endurance Partnership, or NEP). Acorn (Scotland) and Viking (Humber) followed as Track-2. The Track-1 transport and storage networks reached financial close in December 2024, and start-up is scheduled for 2028.⁷³ The UK aims to reach 20-30 MtCO₂/yr by 2030, which the NAO assessed might be difficult to achieve.⁷⁴

The UK system is thus heavily publicly organised. Funding is provided through channels that eventually lead to direct expenditure from the treasury together with consumer levies.

The main instrument used to return revenue for investments is a regulatory asset base approach called the Transport and Storage Regulatory Investment (TRI). The private transport and storage companies (TSCs) are set a specific rate of return on the overall value of assets they operate and own, including various other expenditures, adjusted for novelty of projects and other factors. This rate of return is ensured via regulated tariffs for users. An additional support mechanism also tops up any shortfalls on short-term (quarterly) basis, reconciling annually.

The main de-risking element in the UK system is the "Government Support Package" (GSP). The GSP explicitly targets the main risks that existed with earlier competitions and provides indemnification for TSCs in risks where commercial insurance is lacking. For example, a Discontinuation Agreement gives the Secretary of State the right to terminate support once specified thresholds are reached (stranded-asset or unsustainable-payout scenarios), with the TSC entitled to a "discontinuation compensation" sized to cover its outstanding debt and equity. In effect, the GSP places the long-tail leakage, cross-chain and stranded-asset risks on the public balance sheet, which was recommended by the NAO after the second competition collapse.

The most prominent example of this hedging is that of CO₂ leakage risk from storage sites. A Supplemental Compensation Agreement includes also the cost of replacement ETS allowances for leaked CO₂. Initially, during operation for at least 20 years post-closure, the TSCs remain responsible for leakages and their monitoring needs, after which the SCA provides support on top of what private insurance offers. Following this, supervision may be transferred to the government, which then covers the liability.

On the emitter's side, a CCfD-like instrument secures prices for industrial and waste carbon capture projects, which indirectly reduce risks for the counterparty in T&S services.

The main concerns raised about the UK system are the significant costs, and how they are distributed. The Public Accounts Committee's February 2025 report flags that a) DESNZ has not published a credible mechanism for sharing upside back to consumers or taxpayers if carbon prices outperform

⁷² National Audit Office (2017). [Carbon Capture and Storage: the second competition for government support](#).

⁷³ Department for Energy Security and Net Zero (2025). [UK carbon capture, usage and storage \(CCUS\)](#).

⁷⁴ National Audit Office (2024). [Carbon Capture, Usage and Storage programme](#).

expectations or if projects out-deliver on capture, b) three-quarters of the funding falls on bill-payers, c) the £34 billion contingent liability is large relative to the £21.7 billion commitment, and d) capture-rate performance in international precedents has often fallen below design specification, meaning subsidies could be paid against tonnages that are not actually achieved.^{75,76} A secondary concern, raised by the NAO, is the complexity itself: the TRI requires Ofgem, DESNZ, LCCC, and several private counterparties to run interdependent contracts simultaneously, which has already produced multi-year delays in negotiation and a real risk that Track-1 build-out misses 2030 capacity targets.⁷⁷

The UK's case stands similar to the Swiss case in the lack of the state's direct involvement with equity in the T&S infrastructure. A suitable and well-reasoned RAB framework together with suitable side-supporting mechanisms (for regular revenue balancing and for de-risking long-term storage risks) have allowed for private T&S investment to materialise in the UK. Switzerland can likewise set up similar mechanisms in the early stages, accompanying similar CCfDs to support the capture side. Moreover, some specific details of the UK regime, such as those in the design of long-term storage risk hedging and the setup of the RAB, can be informative for the Swiss case. A significant difference to consider, however, is the importance of foreign storage sites for the Swiss case, requiring detailed international agreements with precision on operational matters, such as the specifics of liabilities for long-term leakage risks.

5.3 Summary of lessons and key points for Swiss CO₂ transport and storage

The prior analysis on experiences from other sectors and from other countries in the CO₂ T&S sector reveals some important insights.

First, for most other countries, national governments have taken a significant role in coordinating and even directly supporting CO₂ T&S infrastructure. The UK government has direct involvement through its GSP, which provides various support types, but also through overseeing an RAB framework. The Dutch government has taken on an even larger role, investing (via intermediary institutions) directly into T&S projects and otherwise playing significant roles in coordinating stakeholders. A similar example exists in Denmark as well, where the government directly oversees infrastructural planning and provides various other coordination and regulatory activities. The reasons for these very active roles are numerous, and relate to various direct and indirect de-risking and cost-reducing for CO₂ T&S projects.

Second, all countries have implemented some form of support for the emission side. This action has been not only to support the emitters' business cases, ensuring projects are realised, but also to indirectly de-risk T&S projects by giving more certainty on future revenue flow. Both the UK and the Netherlands have opted for CCfDs as the main manner of achieving this support. These schemes have involved significant volumes of support, to ensure sufficient impact on T&S operators' volume risks.

Third, the specific contexts of each country have led to a different mix of hedging instruments from the public sector. Broadly:

- Some of the project risks that are not commercially hedged (as identified in Chapter 4) are left un-hedged; it is implicitly expected that project developers absorb these exposures in return for higher returns.

⁷⁵ Parliament UK Public Accounts Committee (2025). [Carbon Capture, Usage and Storage](#).

⁷⁶ There are however some disagreements on this; for example an academic piece describes various errors in this reasoning: Imperial College London (2025), [Public Accounts Committee report on CCS is full of errors and misconceptions](#).

⁷⁷ National Audit Office (2024). [Carbon Capture, Usage and Storage programme](#).

- Most countries have opted for some form of government backstop on long-term storage liabilities. This risk has been found to be detrimental to T&S business cases, requiring direct governmental intervention.
- Some countries have provided additional guarantees to support T&S investments, or other similar investments. These include governmental guarantees on revenue, pooled funds for revenue stability (sometimes as an amortisation fund), guarantees on solvency of injectors for T&S contracts, etc.

5.4 Risk hedging instruments for CO₂ transport and storage in Switzerland

While CO₂ transport and underground storage have sometimes different types of risk, we consider both together in the analysis below. This is for two reasons. First, the risk hedging instruments used across both stages of the carbon chain are somewhat overlapping. Second, in practice, many ongoing projects combine CO₂ transport and indefinite storage services, leading to a holistic risk management approach.

Hedging options for CO₂ underground storage risks can be broadly divided based on whether the risk is applicable in the short-term or in the long-term. Short-term risks relate to those existing during construction, operation, and closure, and during a waiting period after closure. In many jurisdictions, following this waiting period after closure, risks are transferred to a different party (such as the government). The combination of these steps normally takes about 30-50 years.

In the following text, risk hedging instruments are presented in order of a CO₂ project's life. First, the instruments applied during the construction, operation, and decommissioning phase are discussed. The post-decommissioning waiting period is then discussed together with long-term risks following the waiting period.

Short-term risks

Short-term risks have become well-defined in some jurisdictions based on extended use for EOR. Thus, various commercial offers have existed for their coverage. Such instruments include private insurance, letters of credit, performance bonds, trust funds, and escrow accounts.

Private insurance transfers defined risks from the project sponsor to an insurer in exchange for premiums. Insurance can cover construction delays, equipment failure, environmental impairment, accidental leakage events, induced seismicity, well integrity failures, (other) third-party liability, business interruption, cybersecurity risk, and directors' liability. Insurance reduces downside exposure for lenders and equity investors, although insurers often exclude long-tail regulatory or unquantifiable storage permanence risks. Premium pricing depends heavily on reservoir characterisation, monitoring quality, applied engineering standards, and regulation. As an example, the Dutch Porthos project use insurance plus backstop group guarantees and a financial provision⁷⁸, and the European Commission explicitly recommended that insurance and parental guarantees cover temporary-operation obligations after permit withdrawal. Swiss institutions, such as SwissRE, are particularly active in this area.⁷⁹

Parent company guarantees are corporate credit-support instruments in which a financially stronger parent entity contractually guarantees the obligations of a project subsidiary or special-purpose vehicle (SPV). These guarantees are especially common and useful in the early stages of CO₂ transport and storage infrastructure, as many developing companies in Europe are often thinly-capitalised subsidiaries or SPVs of larger infrastructural operations by big players that would otherwise lack sufficient standalone creditworthiness. The guarantee effectively substitutes the balance-sheet strength of the parent for that of the SPV, thereby hedging counterparty and

⁷⁸ Netherlands Court of Audit (2024) [Carbon storage under the North Sea](#).

⁷⁹ Swiss Re Institute (2021). [The insurance rationale for carbon removal solutions](#).

insolvency risk during development, construction, operation, and in some cases decommissioning. European CCS regulators commonly accept parent guarantees as part of the “financial security” required under the EU CCS Directive, particularly for obligations relating to monitoring, remediation, permit compliance, and closure. In commercial structures, parent guarantees are also used to secure throughput commitments, transport-and-storage tariffs, and EPC obligations. Their main advantage is capital efficiency: unlike escrowed cash or funded reserves, they do not immediately immobilise liquidity. They can however impact the parent’s credit quality, which is why regulators often require periodic reassessment, minimum credit standards, replacement triggers, or supplemental security if the guarantor weakens financially. Interviewees have verified that in practice, parent company guarantees are one of the most common and important financial-assurance instruments in current European CCS infrastructure.

Similar to this, some publicly-owned infrastructure can be implicitly or explicitly guaranteed via an **public-sector guarantee**. In the case where this infrastructure acts as quasi-public critical infrastructure with monopoly operation, financial markets view them with “implicit sovereign” support that puts a backstop on default or insolvency. For some projects, they may nonetheless require explicit guarantees, which are often provided via the parent organisation through political and legislative channels (instead of financial ones), which are often cheap in financial terms but can cost political capital and delays. Such guarantees can arrive from national governments, along with regional and municipal bodies. In Switzerland, implicit guarantees can be illustrated by waste incineration plants, where the primary ownerships are municipal or cantonal governments. Waste plants also can have access to explicit municipal or cantonal guarantees, offering highly secure hedging in cases where such costs become necessary.

Letters of credit (LCs) are bank-issued guarantees that assure counterparties payment if the project company fails to perform contractual obligations. LCs are widely used in transport-and-storage agreements, tax credit monetisation structures, EPC (engineering, procurement, and construction) contracts, and carbon offtake arrangements. For example, a CO₂ storage operator may require an emitter shipping CO₂ into the network to post an LC guaranteeing minimum throughput payments. Similarly, regulators may require financial assurance via LCs to ensure funds are available for site closure or remediation. Economically, an LC substitutes bank creditworthiness for project-company creditworthiness, thereby lowering counterparty risk without immediately tying up collateral cash. As an example, in the UK, LCs are suggested as an instrument for users of the transport network to hedge revenue (or volume) risks for the network operator.⁸⁰

Performance bonds are surety instruments typically issued by insurers or surety providers guaranteeing completion or contractual performance by a contractor or operator. EPC contractors building compression, storage, or pipeline infrastructure may post performance bonds to guarantee timely completion, capacity achievement, or engineering specifications. If the contractor defaults, the bond compensates the project owner or finances replacement performance. These instruments are especially important in first-of-a-kind carbon infrastructure where technology execution risk is elevated. Unlike insurance, which transfers risk broadly, performance bonds specifically address non-performance risk tied to contractual obligations. While these bonds are an explored option for CO₂ infrastructure, in Europe they play a less significant role compared to other instruments.

“Ring-fenced” accounts or funds (or “**trust funds**” in the Anglo-American legal tradition⁸¹) are legal structures holding dedicated assets for future liabilities or obligations. In CO₂ projects, ring-fenced funds are frequently discussed for long-term stewardship and post-closure monitoring liabilities. Governments or project sponsors may contribute over the operating life of the project into a managed

⁸⁰ Department for Business, Energy, and Industrial Strategy (2022). [Carbon Capture, Usage and Storage An update on the business model for Transport and Storage](#).

⁸¹ Trust funds in the Anglo-American sense have a slight distinction that the fund is managed by a trustee with fiduciary duties. In European ring-fenced accounts, ownership and governance may still lie with the operator, whereas significant regulatory and contractual restrictions nonetheless lead to a somewhat similar risk hedging profile.

fund that finances future monitoring, remediation, well plugging, or compensation costs after injection ceases. The key economic purpose is intertemporal risk smoothing: future obligations are prefunded during revenue-generating years rather than left uncertain decades later. These structures also reassure regulators and local stakeholders that liability management survives bankruptcy or ownership transfer. CO₂ Infrastructure in the UK, for example, is explicitly using ring-fenced decommissioning funds for obligations and risks associated with closure and post-closure of transport and storage.⁸² Similar funds also exist for nuclear decommissioning and waste in Switzerland.⁸³

Escrow accounts are similar segregated accounts administered by an independent third party that temporarily holds funds until predefined contractual conditions are met. Compared with trust funds, escrow accounts are usually shorter-term and transaction-specific rather than perpetual liability-management vehicles. Escrow arrangements are thus used during acquisitions, tax-credit transfers, construction milestones, carbon credit issuance, or decommissioning assurance. For example, parties may place milestone payments into escrow pending verification that a storage site achieved certified injection volumes or MRV (monitoring, reporting, and verification) compliance. Escrow mechanisms reduce settlement and execution risk because neither party fully relies on the other's future behaviour.

Some specific instruments also secure expectations about CO₂ revenues and costs. The common method for funding monopoly network infrastructure in Europe, based on returns on **Regulatory Asset Bases**, serve as form of regulated but hedged returns for infrastructural investors, providing a regulated but predictable return on their invested capital. **Take-or-pay contracts** are long-term agreements where a buyer (e.g., CO₂ emitter) commits to pay for a minimum volume of service (transport or storage capacity), regardless of whether it is fully used. If the service is not used, the payment is still due. Other instruments in this area are also relevant, though mainly for entities different from transport and storage operators; **Carbon Contracts for Difference** provide multi-year fixed prices for emitters, giving a reliable value for their carbon allowances versus the volatile and risk-prone ETS market.

The availability of hedging instruments for most short-term risks is very good in Switzerland. Switzerland is particularly well-developed in terms of its commercial market for risk-hedging and insurance instruments for infrastructure investments. This quality extends to some extent to the CO₂ infrastructure market as well, where offers are expected to continue to mature and expand in liquidity up to 2030. Many offers (such as those of Swiss RE and Zurich noted earlier) already provide risk-hedging during various stages of a project's lifetime, and even post-closure leakage risks are beginning to be covered to a noticeable (albeit incomplete) extent. Likewise, a benefit of Switzerland's later entrance into the CO₂ infrastructure domain is benefitting from lessons learned from other countries. Other markets would likely pass on risk-hedging options across borders as the 2030 framework becomes adopted and infrastructural developments begin scaling. Thus, while the government could improve coordination and reduce the impact of "chicken and egg problems", there is little direct role necessary to provide specific risk hedging instruments throughout these stages of CO₂ infrastructure development.

In this regard, in Switzerland, some demand (or volume) risk is already hedged. The requirement for 100 ktCO₂/yr capture for waste incinerators already creates an initial impetus for development of downstream infrastructure. Further demand/volume is required to meet the needs of downstream infrastructure in the post-2030 framework. These are relevant on the emission side (thus out of scope) and are briefly mentioned in Subsection 5.4.3. More importantly, initial planning risk in the ramp up phase remains a major hurdle that likely cannot be taken without further government action. The

⁸² Department for Business, Energy, and Industrial Strategy (2022). [Carbon Capture, Usage and Storage An update on the business model for Transport and Storage](#).

⁸³ Swiss Federal Office of Energy. (2025). [Decommissioning and waste disposal funds](#).

form and volume of this intervention heavily depends on the effectiveness of policy instruments and coordination to reduce these planning risks.

Box 5-1: Emitter default risk and related hedging instruments.

A significant risk for CO₂ transport and storage actors exists regarding the **default risk** of emitters. These CO₂ capture facilities usually secure their obligations to CO₂ T&S companies via **parent organisation guarantees** or other forms of guarantees, within a hedging stack including other hedging instruments (mentioned earlier). In the Swiss case, two main emitters drive downstream considerations, with different types of guarantees needed:

- For cement manufacturing, parent company guarantees are often the most important form of hedging. Holcim is overwhelmingly the dominant actor in this area, and its comparatively massive balance sheet and credit ratings provides excellent risk coverage. On one side, the size of likely capture projects would be negligible on Holcim's overall balance sheet (CHF 34 bn as of FY2025). Second, Holcim maintains very high credit ratings at Moody's (Baa1) and Fitch (BBB+) with both outlooks being stable.¹ Holcim's primary listing has been relocated to the US stock market, so some cross-border enforcement questions may exist.
- Waste incineration plants are often owned by cantonal or municipal governments, which require a differing guarantee process with different costs. These plants are often seen as quasi-public critical infrastructure with monopoly operation, with "implicit sovereign" support that can be considered more secure than a BBB+ credit-backed parent company guarantee. Otherwise, waste plants can have access to explicit municipal or cantonal guarantees, offering highly secure hedging that costs political or bureaucratic hurdles rather than financial ones. The question can however remain whether the backstop for such guarantees should be provided by the federal government instead, considering the targets originate at the federal level, and the likelihood of diverse political oppositions within municipal/cantonal systems.

It is worth noting that default risks are already severely reduced by a CCfD (possibly 15+ years duration) supporting revenue streams for the counterparties of T&S companies. The residual default risk surviving this implicit hedge can in practice be substituted by other instruments, which more efficiently target the specific residual risks. The main residual in this case would be permanent plant failure or insolvency. While highly unlikely, such risk would require bridging support rather than long-term revenue support, and would be well-supported by rolling guarantees, surety bonds, letters of credit covering only a few months to 1-2 years of revenue.

The short duration of such an instrument would be sufficient in a mature market, but less so in the ramp-up phase. T&S companies would be highly dependent on very few emitters supplying regulated revenue, and the default or delayed commissioning of one emitter can greatly diminish the T&S company's financial balances. Nonetheless, such costs can still be recovered through specific instruments, such as front-loaded guarantees (i.e. guarantees that diminish in value over time) sized to the termination payment, delayed liquidated damages (damages for delayed achievement of injection milestones), capacity reservation charges (covering fixed costs independent of flow), among others. These types of guarantees can be a bit more expensive than the aforementioned parent guarantees in the aforementioned mature market scenario. Nonetheless, the costs for these guarantees may also be folded into the strike prices bid under CCfDs (insofar as the support rules allow for this), and can thus be either scrutinised on a case by case basis as part of a larger capture plant package (likely during the ramp-up phase) or within competitive auctions (in a mature market).

Post-closure waiting period and long-term risks

During the waiting period following infrastructure closure, specific instruments cover costs for monitoring and liabilities. As mentioned earlier, in the EU, a ring-fenced decommissioning fund or similar restricted reserves are used for this purpose. These funds cover monitoring and liabilities

during this period, though may also be combined with coverage of earlier stages (e.g., decommissioning). This is for example the case with the UK's decommissioning fund structure.⁸⁴

Long-term risks and their associated hedging options are those past the waiting period following closure. Such risks are often "long-tail" (discussed further in the prior section) and require differing instruments for hedging. Long tail risks are not yet suitably known for sufficient risk management by commercial parties. This is primarily due to a mix of high uncertainty on the likelihood of leakage, and high uncertainty on the magnitude of the effects (see e.g., discussion on Porthos project in Section 5.2 **Error! Reference source not found.**). The lack of commercial offers for hedging long-term storage liabilities has been highlighted by the interviewees; while tenors for insurance offers grow, they remain far from offering the tenors necessary for long-term storage. In practice, for Switzerland's captured CO₂, these risks are mainly passed on, considering that the final storage takes place in Dutch and Norwegian storage basins with their specific liability models for leakage risks.

Nonetheless, discussion here focuses on long-term storage risks for underground storage that may be commissioned post-2030s directly in Switzerland. For these assets, while ring-fenced funds can to some extent cover these risks, they may require state intervention for hedging. This is discussed further in Sub-section 5.4.1.

Summary

To summarise, risks for CO₂ transport and storage infrastructure in Switzerland are covered by different parties. Many risks are coverable by commercial third parties, via insurance offers, letters of credit, or other instruments. Other risks are not covered by third parties, but should be covered by the project owner itself given the nature of risk management with infrastructural projects and the expected rate of return. Returns do not justify the extent of some risks, however, where three types of actions may be needed:

- Direct uptake of the liability by the government (at cost).
- Indirect uptake of the liability of the risk by the government, as the main barrier relates to a different part of the CCS chain. (e.g., improving emitter revenue reliability by providing stable support).
- Other actions that directly reduce risk, but do not have traditional costs and do not involve direct uptake of any risks (e.g., improving interdependency risks through high-level coordination activities).

Our analysis of risks, related hedging instruments, and potential additional action is shown in Table 5-1.

Table 5-1: Summary of hedging instruments available per risk and potential additional action.

Risk	Hedgeable	Hedging instrument	Additional action?
Interdependency risks	No	-	High-level coordination
Cross-border interdependency	No	-	Development of cross-border agreements
Cost escalation	Yes	Commercial insurances; Performance bonds; contractual terms (fixed-price EPC contracts); contingency reserves / escrow accounts	Not needed
Counterparty risks	Partially	Parent organisation guarantees; letters of credit; bank guarantees; escrow accounts;	CCfDs

⁸⁴ Department for Business, Energy, and Industrial Strategy (2022). [Carbon Capture, Usage and Storage An update on the business model for Transport and Storage](#).

Risk	Hedgeable	Hedging instrument	Additional action?
EU legal framework	Partially	Contractual obligations (regarding ETS prices)	CCfDs
Swiss legal framework	No	-	Not needed
Public acceptance	No	-	Not needed
Transport	Yes	Private insurance; performance bonds; warranties; reserve accounts.	Not needed*
Storage	Partially	Private insurance; ring-fenced decommissioning funds;	Long-term storage risk hedging
Exploration risk for storage	No	-	Not needed
CO ₂ conditioning	Partially	Performance bonds; warranties; private insurance; letters of credit / bank guarantees	Not needed
Technological obsolescence	No	Insurance (limited)	RAB framework

*: contingent on sufficient demand support for capture plants reducing volume risks.

5.4.1 Additional risk hedging options developed by public bodies

The EU's regulatory structure allows for hedging of long-term risks in the EU to be passed on to other entities, such as governmental bodies. In the EU, this rule is covered in Article 20 of the CCS Directive, which describes a financial contribution paid to a competent authority (during earlier stages) to fund the authority's long-term duties for monitoring, corrective measures, potential ETS surrenders (in case of leakage), and environmental liabilities. While these rules are controversial, this offers a (at least) 30-year coverage of long-tail risk for public authorities stewarding these sites. Such a **coverage of long-term risks by the public sector** may also be an option for the Swiss federal government.

Such a fund can thus be gathered throughout the operation of a set of CO₂ infrastructure. The collection can be performed at the point of injection of CO₂ into a storage site, or earlier at the point of injection of CO₂ into the pipeline network. In the case of cross-border flows, specific agreements would be needed to ensure liability is distributed correctly, and funds are gathered in the right proportion. The fund can also be limited to specific liability events, such as those not covered by existing commercial offers⁸⁵, leaving the fund as an additional "layer" on top of the existing commercial insurance. The coverage of these risks via the public sector can however be controversial, as it creates a moral-hazard problem. If the storage operator is shielded from tail risk by a state backstop, site-characterisation and monitoring incentives weaken.⁸⁶

In a case where multiple entities in an industry contribute to such funds, they are called "**industry-pooled funds**". Such funds are common structures in US states with CO₂ infrastructure where multiple operators may exist. In the Swiss case, such an industry-pooled fund can cover the relevant liabilities in the long-term via funds gathered from operators of transport and storage facilities. Governance of the fund may be via a collective arrangement of the participating members, via an independent trust, or via public-private structures (i.e. with direct regulatory supervision).

An alternative approach is a **three-tiered liability model** that has been previously used for nuclear energy plants.⁸⁷

⁸⁵ SCOR (2024). [SCOR Syndicate leads carbon capture and storage insurance facility](#).

⁸⁶ Handler, B., Littlefield, A., Patton, L., Peticari Pesci, N. G., Ayaburi, F., Kulkarni, S., & Shah, D. (2024). [Locked Up for the Long Term: Risk Mitigation and Liability Assumption in the Geological Storage of CO₂](#).

⁸⁷ Aldrich et al (2011). [Analysis of Liability Regimes for Carbon Capture and Sequestration: A Review for Policymakers](#).

In the first tier, CO₂ projects are required to take commercial insurance (or some other form of private backup) for liabilities related to the sites involved, for a specific amount and a specific duration. This can be for example via existing commercial offers, such as that from Howden/SCOR.⁸⁸

A second tier can become activated if a large-scale (and low likelihood) liability event occurs and the first insurance's payouts are depleted. This second tier is an industry-pooled fund. Other backstops must be considered while the industry-pooled fund is being built up (likely during the operation of CO₂ infrastructure) so that a gap in coverage does not remain.

The third tier is governmental backing of liabilities after this fund becomes depleted. The third tier thus is activated only in cases where multiple high impact and low likelihood events occur in a short timespan, causing a third backstop to be necessary. The amount of activation of this backstop thus depends on how large the first two tiers are set to, i.e. the maximum amount of liability that is set under each tier.

The three-tiered model has a few benefits in application to CO₂ infrastructure. First, it creates clear responsibilities for both individual infrastructure operators and for the industry as a whole. The share of these insurances can be tailored to increase or decrease the responsibility of each, depending on the specific needs of the insurance. Second, it saves a second tier for potential long-tail risks of large-scale disasters with low likelihood. Moreover, the first two tiers can cover earlier stages of CO₂ long-term risks, which cover higher but better understood risk, while the third tier covers later risks (lower but less understood). Connected to this, the three-tiered model also greatly reduces (but does not fully eliminate) the moral hazard mentioned earlier with public backstops, as the operator becomes more responsible for risks with very similar nature to that covered by the third layer (public backstop).

5.4.2 Evaluation against criteria

Hedging instrument	Effectiveness	Efficiency	Equity	Flexibility	Compatibility w/ EU law	Administrative ease
Public backstop	++	+/-	+/-	+/-	++	++
Industry pooled funds	+	+	+/-	+/-	+/-	+
Three-tier liability model	++	++	+	+	+/-	-

The assessment of each hedging instrument is discussed separately below.

Public backstop

Coverage of the long-term risks by the public sector as a state backstop would be effective, but not ideal. The public sector is highly effective at taking on such long-term liabilities with very low-probability but possibly high impact risks. Transferring such risk to public bodies is however inefficient, as a moral hazard exists for passing on costs from private activities to the public sector. The transfer may also be inequitable, depending on how the cost are recovered. A significant connected problem is that calibration for such instruments remains difficult (discussed further in the costs estimates section) and setting fund sizes would involve either more extensive monitoring and risk assessments, or other administrative burdens, or otherwise a less accurate calibration (reducing efficiency). Inaccuracies on the lower bound (i.e. undercounting costs) would also overburden future generations, impacting the equity criterion.

⁸⁸ SCOR (2024). [SCOR Syndicate leads carbon capture and storage insurance facility](#).

Such an instrument would be designed and codified into law at an early stage. Thus, future developments of market conditions or of changes to ETS price levels would not be significantly and timely reflected in its design, considering the pace of legislative processes. Nonetheless, on the timespans envisioned for its relevance, it can be considered somewhat flexible and reactive to market developments.

The EU compatibility of this option would be excellent, as this is precisely the model envisioned via the EU CCS Directive.

Industry-pooled fund

The industry-pooled fund resolves some of the issues with the public-sector backstop, while maintaining a few challenges of its own. First, a fund mutually-gathered via industry participants can be a similarly effective gatherer of funds. However, the possibility for some participants to reduce payments due to unexpected events (defaults or insolvency) can create some shortfalls in the expected funds. The direct connection between payments by industry participants and the fund can slightly improve efficiency compared to the state backstop, while some concerns would nonetheless remain. The mechanism maintains similar flexibility as the state backstop option. Monitoring the pooled fund to ensure suitable operation, particularly suitable scale considering the expected liabilities, may be very slightly more administratively complex than the state backstop.

This option is not directly EU-compatible, but can be considered as an “equivalent” financial security scheme under some flexibility by the CCS Directive.

Three-tiered model

The three-tiered model combines the various benefits of the previous options, while increasing the complexity of the instrument. The instrument remains effective at hedging long-term storage risks, but its effectiveness depends strongly on how well the specific scopes and parameters of each instrument are set. This scoping would be a highly taxing administrative activity (albeit with good precedent in Switzerland, such as for the nuclear industry). Nonetheless, the opportunity for efficiency here remains very high. Equity remains ensured by allowing the state to only carry the additional risk on top of what the industry pool and insurance have already covered, to the extent to which they are most efficient and effective and capable in covering them. The option would be also optimally flexible in future market developments, as they can be rapidly translated into insurance premia and somewhat rapidly into the industry-pooled fund's management.

Similar to industry-pooled funds, this options would be considered as an equivalent scheme under the CCS Directive.

5.4.3 Other federal government actions reducing risks for investments

In addition to the hedging instruments suggested earlier, some other actions by the federal government can greatly improve the business case for CO₂ transport and storage. Many of these possibilities can come from the post-2030 regulatory framework, expected to be in development in the latter half of the 2020s. These actions are either not identifies as hedging instruments per se, or are hedging instruments but do not directly impact the CO₂ transport and storage areas (they are, for example, impacting CO₂ emitters which then indirectly can impact transport and storage downstream).

Carbon CfDs and other demand-boosting regulations

Swiss emitters require revenue certainty over a 15-to-20-year horizon to credibly commit to a long-dated take-or-pay TSAs. This would be required by North Sea operators. The SDE++ (Netherlands), Klimaschutzverträge (Germany), Danish CCUS Fund, and UK ICC contract all play exactly this role and have been the proximate driver of cross-border TSA signings. Switzerland's revised 2025 CO₂ Act treats stored CO₂ as not emitted under the linked ETS but contains no revenue-support instrument. While obligations provide direct demand pressure, the high revenue risks leave some economic inefficiency due to inefficient actions by emitters.

Overall, CCfDs are the most-cited missing piece in Switzerland's support of CO₂ infrastructure. Inclusion of CCfDs not only subsidises carbon capture to the extent to which it is necessary, but also reduces the volatility on revenue for carbon capture projects. Designed well, they can be both effective and efficient support instruments on the carbon capture side. Further downstream in transport and storage, they would also significantly improve confidence in long-term agreements for network access. In an ideal scenario, ETS prices would remain high enough for major emitters to only benefit from the volatility and long-term-risk reductions of the CCfD contract, while the majority of the CCfD's costs would be recovered. In such a scenario, the government would only play a long-term risk hedging role, a role for which it is most efficiently suited.

CCfDs do however have some downsides. Setting up CCfDs and carrying out the payments, settlements, and other procedures require significant administrative burden, both on the emitters' side and on the federal government's side. Such an up-front cost would be more prohibitive for smaller entities. Considering the Swiss case, namely its two main emitting industries, such a concern is less significant, but may require further investigation.

While the design elements of a CCfD are out of the scope of this study, our analysis highlights some relevant aspects for their design:

- Ramp-up phase: The CCfD should be designed in such a way to allow for different procedures and outcomes during the ramp-up phase. This is especially necessary given the higher risks that T&S operators face during this period. CCfDs in this time period might benefit from having higher budgets, allowing for more cost elements to be included in the contract, providing longer durations of revenue support, and also setting stricter adherence protocols for milestones (higher penalties, stricter review in case of delay, etc.). Moreover, earlier rounds of CCfDs could benefit heavily from allowing for a declining compensation for some cost elements.
- Support duration: CCfD revenue support duration should also consider the revenue concerns of the downstream T&S operators, and ensure that sufficient duration is considered. At least 15 years would be necessary in this regard, and possibly longer tenures would be even more appropriate.
- Costs elements included: consider which costs elements must be included in the CCfD, and organise the strike price build-up based on the preferred categorisation scheme. An example could be separating CAPEX (and setting a regulated return on it), OPEX, and T&S operation charge, while ensuring that hedging instrument costs are adequately included in CAPEX and/or OPEX categories.
- Revenue backstop on T&S costs: Consider whether a revenue backstop on the T&S operation portion of costs would be wise. Such security can, as mentioned earlier, be priced into the Swiss emitters' CCfDs via existing avenues for guarantees. Nonetheless, if a public support role is explored, this instrument is a possible implementation of it.
- Indexation: ensure suitable indexation elements, considering that part of the CCS chain may be exposed to Eurozone inflation, and not Swiss inflation.

Box 5-2: Amortisation accounts for CCS

By covering costs of the whole CCS chain via CCfDs, the government also de-risks demand risk for transport and storage providers. The CCfD can act somewhat as an amortisation account, whereby the costs of CO₂ T&S service are covered expensively in earlier CCfDs, and then is gradually declining for future CCfDs.

An alternative, also suggested by interviewees, is to set up an explicit amortisation account, similar to what has been done for hydrogen networks in Germany. This account would top up revenue for T&S companies during the early years while demand from capture plants is lacking, and recover revenue later (with some interest) as demand increases and fills the T&S companies' capacities. The risk of demand not materialising in the future would mainly fall on the government's shoulders,

while some (as in the German case) can be shared with the T&S operators (in the German case, 24%). Thus, the amortisation account can allow for a significant share of demand risks to be covered via smoothing the temporality of revenue.

There are however multiple reasons why this approach has not been adopted for hydrogen networks in other countries. First and foremost, administrative costs for such an instrument are high, and must be justified by the scale of the transport network and its economic activities. As a comparison, the intended CAPEX for the German core hydrogen network is almost an order of magnitude higher than that intended for the CO₂ transport network in Switzerland (within the BAK/Dena study)⁸⁹. Second, depending on the share of risk that is given to T&S operators for coverage of the account's volume, significant moral hazard can exist. Moreover (such as in the Swiss context), no viable institution may already exist for its administration and budgeting (as a doppelgänger of the German KfW). Budgeting can be especially relevant for Switzerland, ensuring that the account remains separate from the federal balance sheet. Overall, most other countries, including the Netherlands, France, and Belgium, have opted for other instruments for their hydrogen networks. The cited studies also indicate how such an approach was not included for Switzerland for its hydrogen backbone⁹⁰ and possibly reconsidered for CO₂ networks⁹¹.

In the case of CO₂ T&S, amortisation accounts may simply be less effective compared to other instruments. The CCS chain's main ongoing issue is CO₂ price averages and volatility, both of which are best supported by a CCfD. While an amortisation account helps to de-risk T&S operators, its action is overall less impactful than a CCfD. Moreover, the intended de-risking can to some extent be covered by the CCfD (as is done with the SDE++ in the Netherlands) or is often better covered by other instruments (such as the RAB framework in the UK). Guarantee schemes have also been implemented for similar infrastructure, more efficiently than would be for an amortisation account. Overall, no country has so far adopted an amortisation account for CO₂ T&S de-risking.

Lastly, when applied to Switzerland, an amortisation account may be insufficient for its intended goal. The German hydrogen network is mainly internal, and the amortisation account serves primarily the main trunklines (rather than distribution networks). Thus, an amortisation account in the country's own boundaries could cover this specific transport operator's risks quite well. For Swiss CO₂, some risks and quite some costs remain downstream of the Swiss transport company, especially in the earlier years, which cannot be covered by a nationally-bounded amortisation account. A multi-country amortisation account is possible, but further complexifies the administration and worsens moral hazard concerns. In addition, multi-modal transport is likely for at least some portion of time and location in the Swiss case, further lowering the effectiveness of an amortisation account and creating competitiveness issues.⁹²

Initial CCfD awards may be for limited volumes during the ramp-up phase. This limited award would fundamentally undermine the main benefit that CCfDs would have for reducing T&S investment risks – while slightly reducing inefficiencies in investments. On one hand, awarding CCfDs at levels well below the needed nominal capacities of pipelines would dramatically worsen volume risk (in the short run) and stranded asset risk (in the long run) for T&S investors (primarily within interdependency and counterparty risks). Moreover, spreading T&S costs over less CO₂ would lead to higher per-tCO₂ prices for emitters, which would pass on as higher CCfD prices. On the other hand, awarding fewer CCfDs would always result in the most efficient projects, on a €/tCO₂-captured basis, being awarded. Overall, the negative impacts of limiting volume appear far higher than the positive impacts, as mentioned

⁸⁹ BAK Economics & dena, for BAFU (2023), [Carbon Capture & Storage \(CCS\): Kostenschätzung für ein CCS-System für die Schweiz bis 2050](#)

⁹⁰ Swiss Economics (2025). [Absicherung von Investitionen zur Integration der Schweiz in das europäische Wasserstofftransportnetz](#).

⁹¹ Polynomics (2024), [Optionen zur Regulierung von CO₂-Pipelines und CO₂-Untergrundspeichern in der Schweiz](#).

⁹² Polynomics (2024), [Optionen zur Regulierung von CO₂-Pipelines und CO₂-Untergrundspeichern in der Schweiz](#).

by various interviewees. Significant limit on the award of CCfDs could potentially be a total showstopper for reaching the 2050 CCS targets.

In addition to CCfDs, the government may also set other regulations to improve the demand for CO₂ transport and storage services, thus improving reliability of operators' revenue streams. A significant option in this regard is setting obligations. Obligations on waste incineration plants for CO₂ capture can be extended further, especially considering part of their services are a public good provided through regulated monopolies.

Ensuring equitable distribution of the burden of these obligations would be important. Some waste incineration plants would find a full CCS plan cheaper than others, while the benefits are a national matter and their distribution is thus equal across the country. This can create competitiveness concerns for the portion of waste incineration plant activities that are not considered as a public service. An area for federal government support could be the higher costs of some waste incinerators. These costs can be (partially or wholly) socialised across the CCS chain, within this specific class of emitters, or via specific levies upon all emitters.

Coordination and/or organisation of ventures

Coordination among the various actors involved in the stakeholder domain would be a significant yet resource-efficient contribution by the Swiss federal government. The ongoing chicken-and-egg problem with the various dispersed emitters and specific planners for transport and storage projects can be resolved by central coordination of activities. Relevant activities include alignment of FIDs, construction schedules, permitting, and operative timelines and milestones. It does *not* imply that the government should get involved in commercial decisions and this coordination can go side-to-side with private build of transport and storage projects. Switzerland's forecasts for the limited deployment of the storage system until 2050 tempers the need for coordination on storage, yet significant coordination remains needed for the various waste incineration and larger cement emitters with the potential developers of pipelines exporting to EU countries. The initial assumption of a privately-funded build-up and indirect role in coordinating funding for such projects limits the applicability of coordination experiences from other countries (namely the UK and Dutch cases). Benefits in this regard would require Switzerland's federal government to favour a more active role in the CO₂ system. This was also highlighted as a significant need by stakeholders, who missed the more active coordinating role played by governments in other European countries.

Detailed cross-border agreements

The Swiss dependence on (downstream) cross-border transport and storage of CO₂ requires more detailed and binding cross-border agreements. A detailed agreement between Norway and Switzerland (signed June 2025) provides significant progress in this regard⁹³. Nonetheless, binding state-level agreements, detailed on the operational layer, are also needed within and downstream of the Basel to North Sea pipeline. Interviewees have also highlighted that this is especially important for operational matters, including specifications for liability in leakages (particularly surrendering of EU ETS allowances), monitoring obligations, documentation of chain-of-custody, among others. These agreements would greatly reduce regulatory risks which are otherwise unhedgeable via a traditional risk management framework (i.e. within commercial offers). State-level agreements make definable the risks that can be allocated cross-chain in commercial agreements. For example, clarity on leakage liability allocation between jurisdictions along the transit corridor to the North Sea would clarify the underwriting of insurers for leakage risks (e.g., by allowing for knock-for-knock or back-to-back indemnity clauses due to bounded exposure).

⁹³ Swiss Federal Office for the Environment. (2025). [Agreement between the Swiss Confederation and the Kingdom of Norway on cross-border cooperation on carbon capture, utilisation and storage and carbon dioxide removal](#).

Exploring a regulated return framework and its alternatives

A framework for regulating returns on infrastructural investments is especially relevant in cases where, among others:

- Infrastructure investments require long-term revenue certainty, and bear much of the market risk.
- The upstream and/or downstream contractors are limited, i.e. there is limited liquidity in the eyes of the infrastructure operator in terms of potential customers.
- Competition for the specific service offered is difficult or non-existent, e.g., in cases where a natural monopoly exists due to technical limitations.

In the scale-up phase (post-2030) of the CO₂ chain's development, transport and storage operators would have a quasi-natural-monopoly status over their services. Studies of potential waterway, rail, or road transport of CO₂ emphatically signal that costs are rarely, if ever, competitive with pipelines, especially at higher volumes and distances. A regulated asset base (and its relevant processes and monitoring frameworks) is thus necessary to ensure the right amount of investment is made by operators. This remains relevant for pipeline networks and can be relevant if the Molasse Basin storage site becomes developed. This would align closely with similar setups in the UK (Transport and Storage Regulatory Investment model)⁹⁴ and Belgium (Flanders).

While necessary, instruments for securing CO₂ revenue for T&S operators require a nuanced consideration. T&S operators would be most confident with investments when take-or-pay contracts are set with long durations (often 15+ years) and firm capacities with major capture plants. Such contracts greatly reduce their stranded asset risk. For the CO₂ system in Switzerland, these concerns are less prevalent due to the natural monopoly status of a potential CO₂ pipeline (and associated storages). Nonetheless, an emitter under Swiss law (particularly the Cartel Act) remains capable of bringing ex-post challenges to 15-year contracts with T&S operators, creating some legal risk for T&S operators. While small, this concern is worth considering as well for securing revenue streams for T&S operators. A full RAB framework (as a specific form of regulating returns) can pre-empt long-term commitments while protecting third-party emitters, by setting a regulated return for the T&S operator. Alternatively, as is done in the Dutch case, ex-ante clearance of capacity commitments can arrive from the competition regulatory authority well in advance of the contracted start dates.

RAB frameworks can also reduce the risk of future technological obsolescence of currently installed T&S infrastructure by specific provisions targeting stranded asset risks. Such provisions would adjust capital recovery mechanisms. An example is setting depreciation profiles on an accelerated trajectory (versus the design lifespan of infrastructure), providing cost recovery before novel technologies can make earlier infrastructure obsolete. This method can suitably compensate assets at risk of stranding, but also front-loads investment costs onto tariffs (to which a T&S network that is ramping up volume is particularly sensitive). In addition, the RAB's price controls can be flexible, adjusting the valuing of the asset base and retiming cost recovery as technology changes over time. It is worth noting however that the risk-reduction of RAB frameworks should also be viewed from the opposite perspective: in the further future, they are protective of obsolescent infrastructure versus competitive novel technologies.

Focusing on these other cases, there are some where a regulated return framework is not used. The Netherlands, for example, relies on bilateral contracts, while access rights are grounded in competition law. Porthos, currently active, is a fully public transport-and-storage joint venture operating as an open-access utility, with EBN discharging a statutory role under the Mining Act. There is no regulated tariff methodology, so the operator sets fees and cross-chain risk is carried through private 15-year take-or-pay contracts. The emitter side is de-risked separately through a CCfD (an SDE++ operating subsidy). Where operators wish to jointly market capacity, competition concerns are

⁹⁴ Department for Energy Security & Net Zero (2026). [Carbon capture, usage and storage \(CCUS\): Ensuring fair access to CO₂ infrastructure \(accessible webpage\)](#).

addressed ex ante by the Authority on Competition and Markets: in June 2022 it cleared the Aramis joint-marketing initiative (5 Mtpa, ~20% of pipeline capacity) as exemptible under Art. 6(3) of the Dutch Competition Act and Art. 101(3) TFEU, ahead of the contracts taking effect. Thus, Netherlands' state-owned entities (particularly EBN) are heavily involved (including through direct ownership of T&S operators) and directly safeguard public interest.

In Denmark, tariffs are negotiated by users while access remains non-discriminatory by law. Nonetheless, Danish law (mainly the Act on Pipeline Transport of CO₂)⁹⁵ sets various rules on operations, including specific published ranges for tariffs, while the government directly oversees investment planning (dimensioning of pipelines, for example). Every CO₂ network plan must be approved by the Ministry for Climate, Energy and Utilities, so transparent negotiated access, rather than a regulated return, is used to ensure competitive behaviour during ramp-up. Public-interest protection is through ownership; the Danish state, via Nordsøfonden, holds a 20% stake in every CO₂ storage licence. As capture projects must present a full transport-and-storage value chain when bidding for the DEA-administered CCUS subsidy, cross-chain risk is allocated between the parties rather than absorbed (and then separately priced) by a regulator.

France illustrates a third, explicitly adaptive alternative to a RAB.⁹⁶ The energy regulator CRE mid-2024 report stated that CCS infrastructure should not be regulated immediately due to its nascency. Capture would be left to competition, and collection pipelines are placed under negotiated third-party access with transparency and non-discrimination obligations overseen by CRE, allowing emitters to self-organise within hubs. Crucially, the CRE recommends legislating now the standby option to switch the genuinely monopolistic segments, namely trunk transport pipelines, liquefaction terminals, and storage, to regulated third-party access with regulator-set tariffs, to be activated case by case. For Switzerland, this "regulate-if-and-when-needed" design aligns with the BAFU study's preference for lighter regulation during ramp-up (general competition law or minimum standards first) with sector-specific tariff and access regulation held in reserve for a later phase. Sequencing is a practical caveat, since France can prepare a unified national regulator by statute, whereas Switzerland would first need a federal competence over CO₂ pipelines before an equivalent standby power could be created.

Switzerland's federalised system does complicate the application of a regulated return framework. Competencies related to the planning and operation of infrastructure are currently cantonal, requiring a new foundation for federal action, as has been done with electricity transport. Also, the recent BAFU-commissioned study⁹⁷ highlights that a sufficiently flexible framework is necessary during the ramp-up stage, given its uncertainties. The new CCS framework act is expected to satisfy this need, harmonising regulations for CO₂ T&S. In addition, a smaller number of economic actors on a comparatively small CO₂ network are likely not needing the full regulatory mechanism needed for the oversight on operation of far larger and more numerous economic actors in a larger network (in the case of electricity).⁹⁸ Thus, a lighter regulatory framework at the beginning might be more suitable, but must reflect and consider the various risks otherwise hedged by RAB frameworks within other mechanisms. Volume and revenue risks for T&S companies could be transferred to the emitters' side and resolved in CCfDs, which are assumed in this study to be active by 2030. Coordination risks would be better resolved via coordination initiatives (mentioned earlier). Market competition issues would stay relevant, particularly in later years, and require one of the other approaches to be explored further.

⁹⁵ Danish Energy Agency (n.d.). [Political agreements and applicable legislation](#).

⁹⁶ CRE (2024). [Rapport de la CRE sur le cadre de régulation des infrastructures d'hydrogène et de dioxyde de carbone](#).

⁹⁷ Polynomics, Frontier Economics, BAK Economics, VISCHER (2024), [Optionen zur Regulierung von CO₂-Pipelines und CO₂-Untergrundspeichern in der Schweiz](#).

⁹⁸ Polynomics, Frontier Economics, BAK Economics, VISCHER (2024), [Optionen zur Regulierung von CO₂-Pipelines und CO₂-Untergrundspeichern in der Schweiz](#).

5.5 Cost estimates and economic implications for long-term storage liability

Cost estimates for long-term storage risks have not reported on precise methodologies and figures. As two examples, in the two international experiences reviewed earlier, the costs of long-term storage risks are not precisely calculated. Both in the UK and Dutch cases, governmental overtaking of long-tail leakage risks was based on very uncertain maximum-exposure values, and not based on a quantified loss distribution, such as might be done via Monte Carlo methods applied to a specific risk profile. For example, in the UK case, Parliament has been given a maximum-exposure number (the £34 billion umbrella) and verbal assurances about probabilised exposure.⁹⁹ This is partially due to the difficulty of assigning the value of lost ETS allowances, where prices are heavily tied to future regulatory developments that remain currently uncertain.

In the UK case, the government mentions that “Independent technical analysis commissioned by Government shows very high long-term containment confidence (4) with a typical project expected to retain over 99.9% of injected CO₂ over a 125-year period. Minor leak rates have a low probability of occurring whereas major leak rates have a very low probability of occurring. Therefore, the likelihood of damage to the marine ecosystem is considered to be very low...”¹⁰⁰.

In the Dutch case, the Dutch Court of Audit report from 2024¹⁰¹ is the most-cited estimate. As mentioned earlier, the risk of leakage over the long term has not been rigorously quantified, i.e. the €1b to €30b range are bounding heuristics to compare these costs versus the profitability and cost efficiency standards of the Dutch government, and not a direct calculation of the upper and lower bounds of risk exposure.

Considering the lack of specific risk profiles and liability/damage profiles to calibrate a Monte Carlo model, this study uses existing academic literature to bring together a comprehensive cost estimate. The leakage liabilities of future long-term storage of CO₂ mainly consist of:

1. Costs of surrendering carbon credits: This would require recovery of carbon credits at the cost at the time of surrender.
2. Costs of corrective and remediative actions, which are actions taken to resolve leakage issues and ensure full remediation of the storage basin's integrity.
3. Costs of environmental liabilities: This covers compensable harm to groundwater, ecosystems, protected habitats and third parties, distinct from the climate cost. Such costs would cover CO₂ leakage both above ground and below ground (e.g., in aquifers), seismicity events, etc.

Academic studies exist of each cost element:

1. Surrendering carbon credits: Wifling (2020) calculates the potential future costs of CO₂ leakage in Europe in terms of exposure to ETS credit recovery costs. The author calculates ETS potential prices for 2030 and 2100, assuming prices stabilise by 2100 at a very high level (following the IPCC (2014) median prices for AR5 2°C, an extremely ambitious scenario). These price levels are set at USD 80 /tCO₂, growing to USD 1867 /tCO₂ on an assumed 4.5% discount rate, implying a very high-cost case for the future costs for surrendering carbon credits. On this basis, Wifling calculates the fund size for well-managed storage sites, reaching a specific USD/tCO₂ value (converted to CHF/tCO₂ based on current conversion rates), based on storage in 2030 vs in 2100.

⁹⁹ UK Parliament Hansard / DESNZ (2024). [Carbon Capture, Usage and Storage Track 1 – Contingent Liabilities](#).

¹⁰⁰ UK Parliament and UK Government (2026). [Pause UK offshore CO₂ storage projects and conduct full safety and legal review](#).

¹⁰¹ Netherlands Court of Audit (2024), [Carbon storage under the North Sea](#).

2. Corrective/remediative actions: Due to the further development of the US market, the most robust analysis on this topic follows from this region. Handler et al (2024) relies on US EPA Class VI financial responsibility data to calibrate a Monte Carlo model of Class VI wells, finding costs for corrective actions for storage leaks both during operations (very early) and in the long term.
3. Environmental liabilities: Peters et al. (2017) operates under a worst-case scenario, assuming all leakage-pathway permeabilities are extremely high. The modelling produced only minor system effects, and the authors conclude the realistic-case impact is essentially negligible. Nonetheless, extremely unlikely events in the tail are possible here with higher liabilities but can often be handled by pollution-legal liability insurance.

Based on these methods, costs for each category are:

1. Surrendering carbon credits: Fund needed to compensate storage-related costs should gather CHF 0.20 per stored tonne in 2030 to about CHF 0.8–1.0 /tCO₂ stored by 2100.
2. Corrective/remediative actions: Costs are roughly CHF 0.14 /tCO₂ stored during operations, falling below CHF 0.10 /tCO₂ in the post-injection long-term-stewardship phase as reservoir pressure declines.
3. Environmental liabilities: negligible (likely < CHF 0.05 /tCO₂).

Combining these values, we reach a range of **CHF 0.4 to 1.1 /tCO₂ stored**. Compared to the other costs of CCS, this is a very low value.

The costs of CO₂ long-term storage may not necessarily be borne by the Swiss government. At least for some years, the final storage sites for captured Swiss CO₂ would remain those connected to Dutch and Norwegian projects. The long-term risks of these projects are taken up by the Dutch and Norwegian actors (mainly via the state). Later, some captured CO₂ may be stored in Swiss storage basins. Estimates for the quantities sent to these basins up to the 2050 limit of this analysis are very small, however. Thus, the anticipated cost for the Swiss state of taking on such obligations, even directly via a public backstop, are considered to be negligible.

This study does not directly estimate what portion of these costs may be divided between the three suggested options for risk-hedging of long-term storage liabilities. In the case of the public backstop and industry-pooled fund cases, the volumes assigned to these instruments is rather clear. In the case of three-tiered liability schemes, the amounts and tenors taken up by each instrument would be highly dependent on various factors that may be currently difficult to predict. These include the extent (volume and tenor) of private insurance offers and the (regulatory) decision of how much of the residual liability should rest within an industry-pooled fund versus a public backstop. Detailing the design of a three-tiered liability scheme would be better performed within later stages of the regulatory framework.

Cost recovery mechanisms

While the costs are considered to be rather small or even negligible, some comments on possible cost recovery follow. To ensure full satisfaction of all principles, particularly the equity (fairness) principle, cost recovery must be performed such that the costs are recovered proportional to the responsibility of each stakeholder in the chain. In this regard, the main payments should thus arrive from those whose captured CO₂ is stored, proportional to how much is stored. This idea of proportionality was also shared by interviewees.

In this context, explicit cost recovery can be performed through various means, including:

- A regulated surcharge per ktCO₂ injected into any storage falling under the backstop. This is the simplest option, but may not directly reflect the difference in leakage risks between different storage sites. This (and the next) option are quite similar to common cost recovery mechanisms for nuclear and landfill waste.

- A regulated surcharge per ktCO₂ injected into a specific storage basin. This option can be more efficient and equitable. However, it requires specific understanding of leakage risk between different storage sites, and can thus be unfeasible.
- A regulated surcharge per ktCO₂ captured or emitted. While disjointed from the actual injection, and thus less efficient, it creates a very simple mechanism that can be directly charged at the source.
- Setting a mandate for the transport and/or storage company to recover certain costs on a per-year basis. This leaves the final charge structure to the relevant company. This option is the most administratively simple for the government, but may require additional regulatory monitoring activities to ensure equity and efficiency.

A full analysis of these and other possible cost recovery mechanisms may be needed at a later stage to identify the most suitable option.

6 Conclusions

6.1 Summary of key insights

This study analysed the risks for CO₂ transport and storage infrastructure in Switzerland and highlighted where hedging instruments' unavailability requires government action. Our study described first the general risks for CO₂ transport and storage, focusing on the Swiss context. The study then aligns each risk with a risk-hedging instrument, identifying both areas where risk hedging is not active (i.e. risks would be absorbed by the investors in return for profits) and areas where risk hedging should be active but is not available (due to missing commercial offers for risk hedging instruments). The study also investigated the circumstances surrounding the CO₂ transport and storage topic in Switzerland, identifying various other key actions that are necessary to support a dynamic and effective CCS chain. The study refined and verified this analysis via interviews with the primary stakeholders in Switzerland and other relevant EU countries.

The study's primary finding is that risk hedging in the Swiss case for this infrastructure is already well in place. Some residual risks remain, particularly that of long-term storage liabilities. Nonetheless, **the main missing piece for this CO₂ infrastructure are actions that are needed from the central government which are not directly risk-hedging offers**. Rather, these actions either support CO₂ upstream (in capture projects) or are otherwise coordinating or oversight actions with little cost (i.e. no direct hedging of risk exposures). The primary actions were described in detail in Subsection 5.4.3 and include:

1. Setting up revenue support for CO₂ capture projects, best done via a Carbon Contracts for Difference.
2. Coordination and/or organisation of ventures.
3. Cross-border agreements with sufficient legal standing and operational detail.
4. Exploring the possibilities for a regulated return framework for infrastructure operation.

The first action, CCfDs, aligns with one of the most-reported comments from stakeholders: the CCS chain is not investible with current market rates for carbon. Extra support is needed not just for improving the average price received by the capture plants, but also for stabilising ETS revenue and divorcing it from political impulses. This is especially needed in the earlier stages of CCS build-up, as ETS revenue may grow and stabilise in the coming years as global attention to climate change continues to grow. While efficient and effective, it must still be underlined that CCfDs will maintain a very high budgetary burden for the federal government, at least for the short term.

Unlike CCfDs, the latter three actions are cheap for the federal budget. Coordinating the development of capture, transport, and storage infrastructure will immensely improve timing risks, if it can effectively prevent various possible delays from causing revenue risks for various infrastructure operators. Likewise, cross-border agreements can have a great impact on clarifying expectations for downstream transfer of CO₂ to the North Sea basins. Lastly, a regulated return framework has experience within other network infrastructure in Switzerland, and can be applied here with some revisions. While oversight on this framework has some administrative burden, it can greatly improve clarity for both the capture side and the transport and storage side. The importance of these actions were also much highlighted by interviewees.

It is important to consider that this study's findings were based on multiple assumptions, listed earlier in Chapter 1.

6.2 Recommended risk-hedging approaches

In addition to these measures, the government may prefer to take a role in hedging long-term storage risk. These long-term risks are often not commercially insurable, as insurance providers cannot adequately model and thus price high-impact but very low probability risks. 3 different options have

been proposed in this study, each with pros and cons. Overall, the flexibility of the three-tiered approach, layering private insurance, industry-funded pools, and a public backstop, may be worth the administrative complexity in the long run. In practice, however, a simpler public backstop might be sufficient and avoid administrative hassles if the total liabilities are sufficiently small.

The costs for these risks in the long-term have also been calculated based on academic studies. Given the nascency, long-term storage risks are not well-calculated in prior literature. Thus, a calculation based on summing potential liabilities from carbon credit surrenders, corrective and remediation measures, and environmental damages was done. This calculation showed that the overall cost of long-term storage of CO₂ is well-covered with a surcharge of CHF 0.4-1.1 /tCO₂ stored. This amount is well below currently-discussed costs for the full CCS supply chain. The study also briefly discussed various options for the recovery of these costs.



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