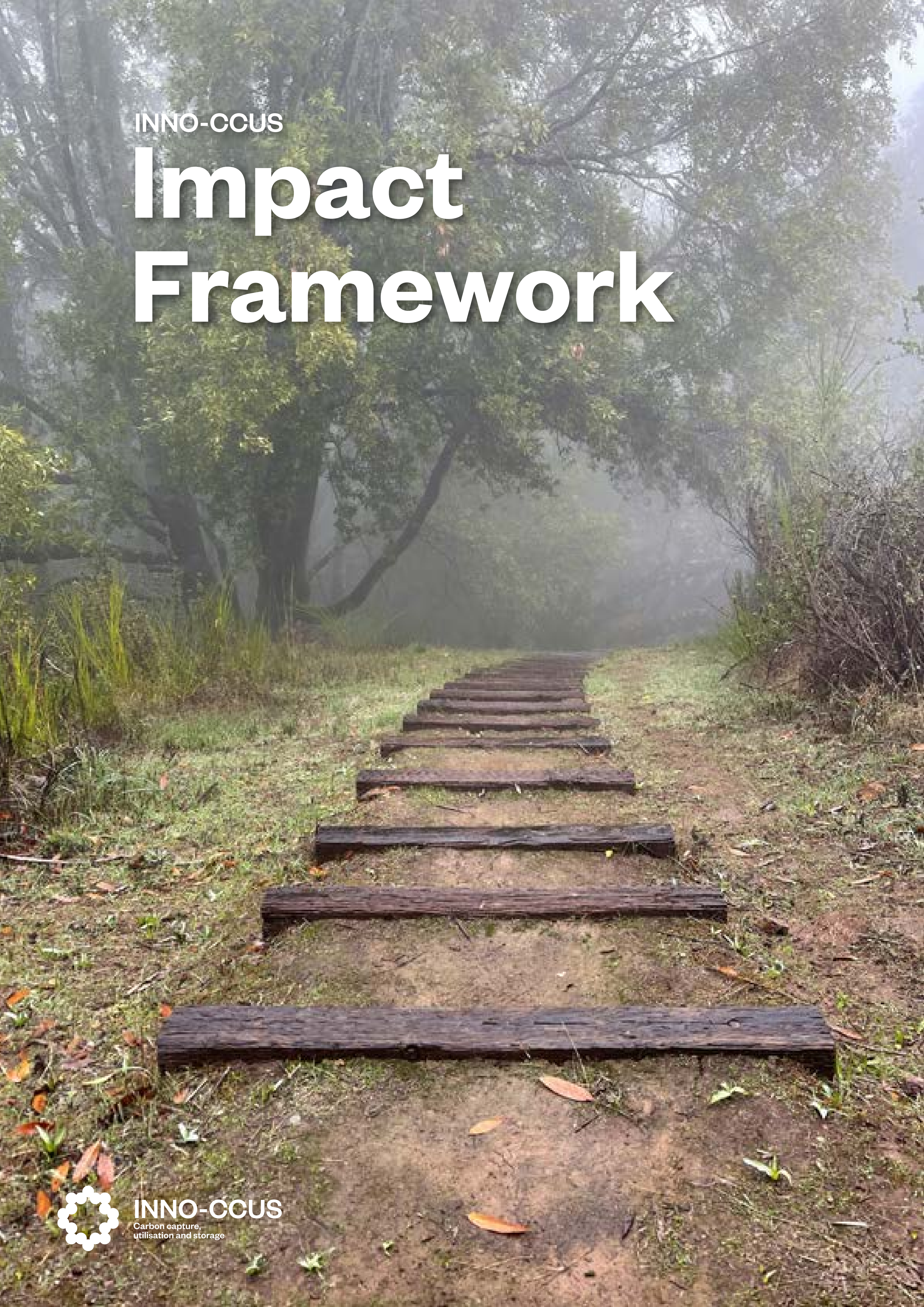
INNO-CCUS

Impact Framework



INNO-CCUS
Carbon capture, utilisation and storage

Contents

Introduction

The INNO-CCUS Impact Framework is the result of collective efforts across the INNO-CCUS's Board of Directors, supported by the Secretariat. The framework has been developed through a collaborative process involving interviews among partners and stakeholders, focused discussions, and several iterations.

Input from these processes has played a vital role in shaping the Impact Framework, helping to ensure broad ownership and strong alignment with the strategic direction of INNO-CCUS. The framework and the Danish CCUS roadmap are aligned, and together they guide the strategic priorities for INNO-CCUS. The overarching goal of the Impact Framework is to act as a dynamic strategic decision tool, iteratively updated as new insights and needs emerge. The Board and the Secretariat play a key role in its development and to maintain its relevance.

Background

Innovation Fund Denmark has developed an **Impact Framework for mission-oriented innovation** to address the complexity and unpredictability inherent in solving major societal challenges such as the green transition. Traditional evaluation approaches often fall short because they assume linear progress and fixed solutions. In contrast, missions require flexibility, continuous learning, and strategic adaptation.

The framework provides a structured yet dynamic approach for planning, monitoring, and evaluating mission progress. It is designed to:

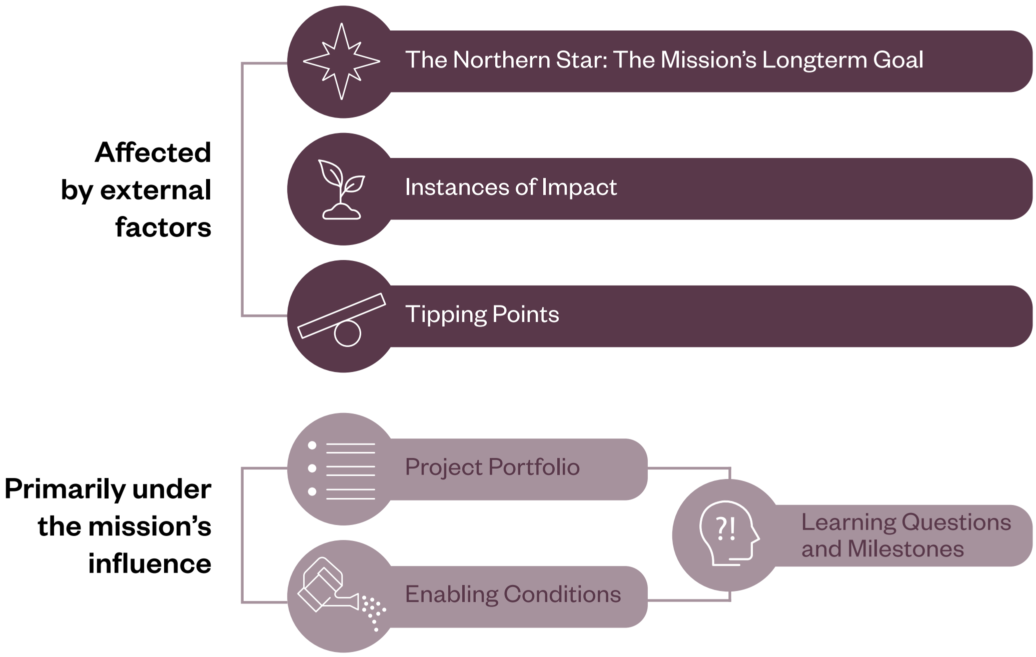
- **Connect long-term goals to concrete actions** by clarifying how projects and activities contribute to the mission's success.
- **Establish clear measurement points** that enable ongoing monitoring and documentation of progress.
- **Support continuous learning and adaptation,** ensuring strategies evolve in response to new insights and changing conditions.

The framework is built around six interconnected layers:

1. **The Northern Star** – the mission's overarching, time-bound goal.
2. **Instances of Impact** – early signals that the mission is moving in the right direction.
3. **Inflection Points** – critical moments that accelerate systemic change.
4. **Project Portfolio** – strategically selected projects aligned with mission priorities.
5. **Enablers for Change** – cross-cutting activities that create the conditions for success.
6. **Learning Questions and Milestones** – guiding inquiry and checkpoints to embed learning into decision-making.

This approach ensures that mission partnerships can navigate uncertainty while maintaining focus on their ultimate societal goals. By integrating strategic learning into every stage, the framework enables informed decisions, fosters collaboration across sectors, and strengthens the likelihood of achieving Denmark's ambitious climate targets.

Figure 1 - IFD Impact Framework chart



The Northern Star – The Mission's Long-Term Goal:
The Northern Star articulates an aspirational vision for what the mission seeks to achieve by 2050. It steers the collective effort, aligns stakeholders towards a shared purpose, and illustrates the societal transformation we aim for – even though some factors will remain beyond our control during the journey.

Instances of Impact:
Instances of impact serve as early evidence that our initiatives are having a tangible effect. These indicators are not predetermined; rather, they emerge in response to our Northern Star, chosen inflection points, and focus areas, as well as our learning inquiries. We identify instances of impact by continuously monitoring and evaluating activities within the selected domains.

Inflection points:
Inflection points signify major, identifiable shifts in systems, behaviours, or markets that advance us toward the Northern Star. Inflection points play a pivotal role in linking our overarching mission to the concrete actions we undertake.

Project Portfolio:
Within the project portfolio projects are linked to selected focus areas. These focus areas are dynamic and may be adapted over time depending on where our efforts and resources may contribute most to reaching the inflection point. Each focus area is connected to an inflection point and associated with a learning question. The project portfolio encompasses the set of initiatives and tasks designed to address those learning questions.

Enabling Conditions:
Enabling conditions form the backbone of the partnership. Examples include cultivating expertise and knowledge, promoting cross-disciplinary partnerships, fostering transparency, and upholding robust governance practices.

Learning Questions and Milestones:
Learning questions inform the selection of projects and the enabling conditions needed to advance. They clarify the knowledge gaps to reach an inflection point. Each question is matched with specific milestones, providing checkpoints for evaluating our progress over time.

How we interpret and apply the Impact Framework

The INNO-CCUS Impact Framework serves both as a long-term strategic anchor and as a tool for guiding concrete investment decisions. To support this dual purpose, it is structured into two complementary levels: a directional level and a portfolio-shaping level.

The directional level defines the long-term orientation of the mission. It consists of the Northern Star and the Inflection Points, which describe the systemic changes required for CCUS to contribute to Denmark's climate targets. These elements are intentionally stable, developed through stakeholder engagement, and endorsed by the INNO-CCUS Board of Directors, providing a shared and enduring reference point.

Within this level, Instances of Impact play a different role. While positioned alongside the directional elements, they are not fixed. Instead, they reflect emerging signals of progress and are updated over time to capture how the field evolves and how systemic change begins to materialise.

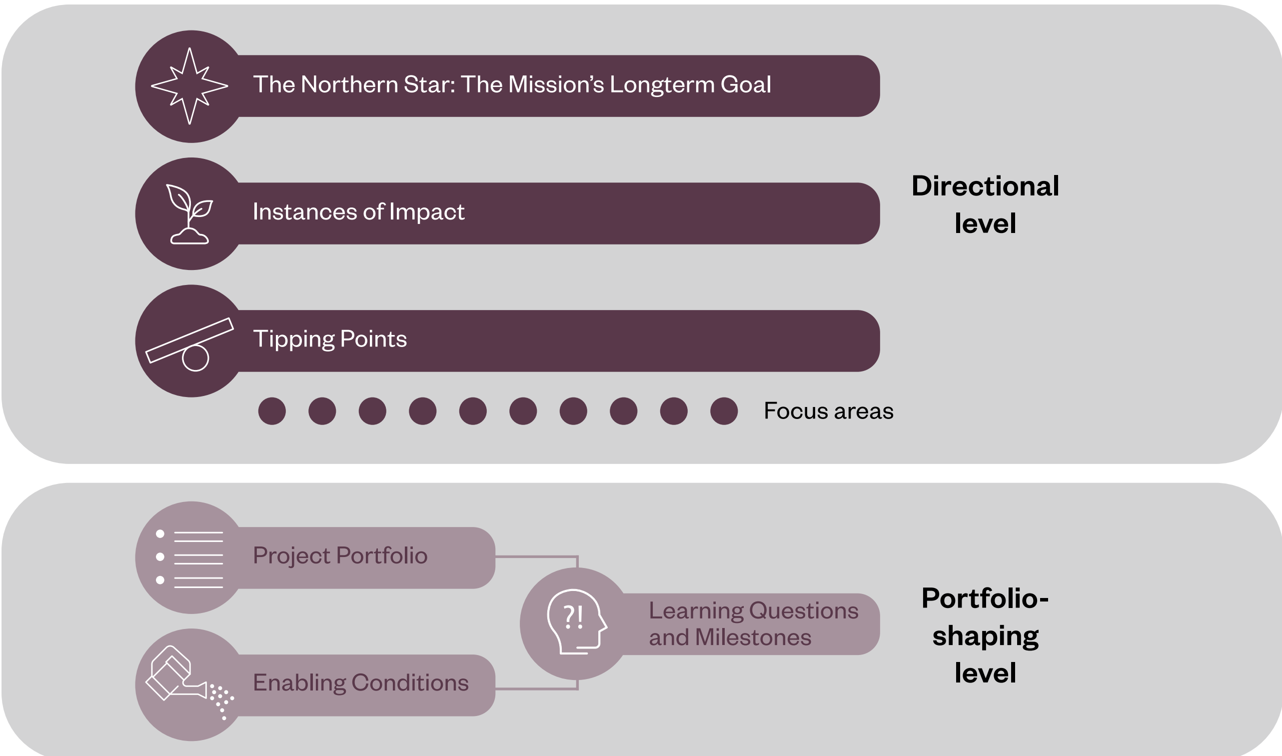
Focus areas translate the inflection points into concrete domains of action and indicate where INNO-CCUS will prioritise support for research and innovation over time, ensuring continuity across funding rounds.

The portfolio-shaping level translates this direction into concrete priorities, investments, and activities. It comprises the project portfolio, learning questions, milestones, and enabling conditions, and is inherently adaptive. This level is updated for each call for projects and reflects the specific priorities and knowledge gaps at that point in time.

Learning questions and milestones define what needs to be understood to progress towards the inflection points, while the project portfolio is designed to generate the necessary evidence. Enabling conditions, driven by the Secretariat, ensure coordination, knowledge sharing, and strategic learning across the portfolio.

Together, this structure allows INNO-CCUS to combine long-term consistency with continuous adaptation: the direction remains stable, while the pathway is refined through each call for projects.

Figure 1 - IFD Impact Framework chart



Executive summary: How we drive transformation

To achieve Denmark's ambitious climate targets, the mission-driven INNO-CCUS partnership acts as a catalyst for innovation and collaboration across sectors. Our mission is to accelerate the development and deployment of scalable, cost-effective carbon capture, utalisation, and storage solutions, to contribute to achieving the Danish Climate targets.

The INNO-CCUS Impact Framework was developed collaboratively through stakeholder input and iterative refinement. It aligns with the Danish CCUS Roadmap and Innovation Fund Denmark's missionoriented approach.

CCUS will contribute to a 70% reduction in greenhouse gas emissions by 2030, 82-85% by 2035 and net zero emissions by 2045 by facilitating technological development of upscaled cost-effective capture, storage and utalisation of captured carbon that supports widescale deployment.

Through extensive analysis and stakeholder engagement, we have identified three value chain-based, critical inflection points that will shape Denmark's CCUS journey. These inflection points represent strategic opportunities where targeted action can accelerate transformation within the related focus areas.

The Northern Star of INNO-CCUS
"Scalable, Cost- Effective Carbon Capture, Storage, and Utalisation"

Figure 2
Overview of inflection points and focus areas

CCS Inflection Point

CO_2 transport and geological storage remove the primary system bottleneck

CDR Inflection Point

CDR solutions mature to enable credible and scalable deployment

CCU Inflection Point

Captured carbon becomes competitive feedstock in industrial value chains

Enabling Conditions
The INNO-CCUS secretariat functions as the integrated coordination and governance unit of the partnership, combining operational delivery with strategic portfolio oversight. Through coordination across projects, institutions, and sectors, the secretariat supports alignment, learning, and progression across the CCUS value chain.

The enabling work of the secretariat is defined by five core conditions that underpin all activities:

- Cross-Sectoral Collaboration
- Authentic Engagement
- Inclusive, Transparent Governance
- Strategic Learning
- Capacity Building

In conclusion
Together, these elements establish the foundation for a mission driven partnership capable of steering Denmark's CCUS efforts toward long term impact. The following sections outline the full Impact Framework, detailing the Northern Star, inflection points, focus areas, and enabling conditions that guide our strategic direction.

The Northern Star

By 2050, we envision a carbon-neutral and regenerative, circular society. Within this future, INNO-CCUS has the overall goal: to be a main contributor to enable a 70% reduction in Denmark's greenhouse gas emissions by 2030, 82-85% by 2035, to achieve net zero by 2045 and net negativity in 2050.

INNO-CCUS serves as a catalyst in this transition. Cost-effective capture technologies and CO_2 infrastructure will enable hard-to-abate sectors with unavoidable process emissions to transcend their limitations. Nature-based and engineered capture technologies will work as efficient carbon removal paths. Secure storage technologies will contribute to emissions reductions, while the utalisation of CO_2 as a feedstock for valuable products contribute to a circular carbon economy.

In this future scenario, CCUS technologies and infrastructure has been upscaled and optimized to the point where market forces themselves drive its deployment. This includes a well-functioning legislative framework, including ETS and a market for carbon removals. Hence, the Northern Star of INNO-CCUS is a scenario, where carbon capture, storage and utalisation have been upscaled and become so cost-effective that it accelerates wide scale deployment.

The Northern Star of INNO-CCUS: Scalable, Cost- Effective Carbon Capture, Storage, and Utalisation

Instances of impact

Instances of impact show how combined efforts – ours and those across the CCUS field – are advancing scalable, cost-effective technologies. By identifying these potential instances, we observe some early examples of systemic impact, presented below. Since several of these activities began before INNO-CCUS launched in 2022, the initiative has not directly influenced all of them. Mentionable initiatives where INNO-CCUS has played a role is the Aalborg Portland ACCSION project to a great extent, and the Ørsted project to some extent. However, INNO-CCUS will monitor for similar instances of impact in the years ahead.

Significant investments in Denmark are driving the upscaling of CO_2 capture

The national fund for carbon capture and storage (CCS) provides 28.7 billion DKK for large-scale projects, while recent EU support – such as the 1.6 billion DKK grant for Aalborg Portland's ACCSION project – aims to enable major underground CO_2 storage. Additional investments in research, development, and infrastructure are building a complete value chain for CO_2 capture, transport, and storage.

Large Scale Capture and Removal in Commercial Context

A new agreement between Ørsted and Microsoft means that, from 2026, Microsoft will purchase 1 million tons of CO_2 removal from the straw-fired unit at the Avedøre Power Station. Ørsted has received 8 billion DKK in support from the Danish Energy Agency and will begin capturing 430,000 tons of CO2 per year starting 2026, which will be stored in Norway.

High Interest in Multi-Billion DKK Fund for CO_2 Capture and Storage

The Danish Energy Agency has received 16 applications from companies seeking support from the fund, which has a total allocation of 28.7 billion DKK. While the final number of funded projects will be smaller, the high number of applications signals strong demand and confidence in the development of CCS in Denmark. By the deadline in February 2026, two final offers was submitted.

Significant public commitment to policy and regulatory framework for accelerating and scaling up carbon capture and storage through pyrolysis and biochar

The Green Tripartite Agreement in Denmark (the first of its kind globally) is a first sign that carbon storage with biochar is being adopted as an instrument on a large scale within the agricultural sector in Denmark.

The INNO-CCUS project BIOCHASTA has, among others, led to a series of publications that directly and indirectly have impacted both Danish policy formation and EU policy development on scientific acceptance of biochar carbon storage as a valid and potentially very cost-efficient climate technologyIn the EU, the work of prof. Hamed Sanei (AU) and Henrik Ingemann Petersen (GEUS) e.g. ScienceDirect: " Assessing biochar's permanence: An inertinite benchmark" have significantly impacted policy frameworks (Supplementing Regulation (EU) 2024/3012) and is opening up the incorporation of biochar in the European Emissions Trading System (ETS). Utilisation of biochar in other contexts than for land application have also become more visible, among other things due to projects co-financed by INNO-CCUS.

Signs of Upscaling and Market Development in Geological CO_2 Storage.

The Greensand project is one of the most advanced market-driven CO_2 storage projects in Denmark. Partners include INEOS, Habour Energy and The Danish State Subsurface Resource Company (Nordsøfonden). In 2023, they completed the world's first cross-border, offshore CO2 injection, receiving CO2 from Belgium. Greensand is starting at 0.4 Mt/y, scaling toward 8 Mt/y by 2030.

CO_2 utalisation show beginning signs of commercialization

Some technologies (CO_2-to-methanol, CO_2-to-plastics, CO_2 to acetate) are reaching market entry. While Denmark is mostly in demonstration phases, commercial production of plastics and chemicals from CO_2 is already established in Germany (Covestro) and scaling in the Netherlands (Avantium), with strong support from EU programs. The Danish start-up AGAIN is starting up commercial production of acetic acid from CO_2.

These instances of impacts show that field of CCUS is transitioning from demonstration to large-scale, market-driven deployment of CCUS technologies.

Inflection Points

Inflection Points represent critical, tangible shifts in systems, markets, or societal behaviours that accelerate progress toward our Northern Star.

They serve as strategic anchors, connecting the overarching mission goal to the concrete work carried out in projects and partnerships. They help us prioritize efforts, allocate resources effectively, and maintain focus on the changes that matter most. By identifying and steering toward these points, we create a clear link between innovation activities and systemic transformation, ensuring that our contributions, alongside those of many other actors, collectively propel the green transition forward. The inflection points are:

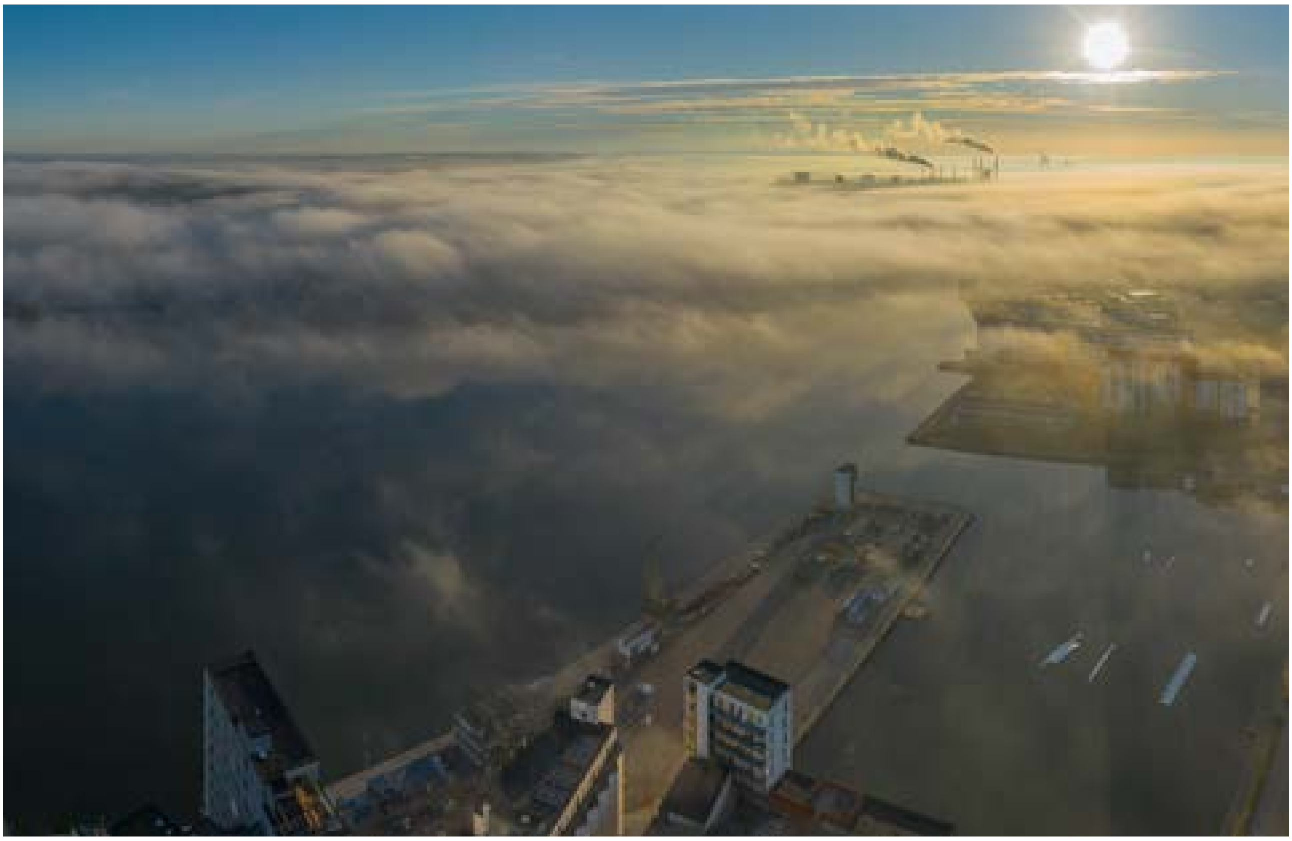
CO_2 transport and geological storage remove the primary system bottleneck (CCS)

CDR solutions mature to enable credible and scalable deployment (CDR)

Captured carbon becomes competitive feedstock in industrial value chains (CCU)

The path towards the North Star of INNO-CCUS progresses through these inflection points which describe a coherent and parallel CCS–CDR–CCU pathway.

This structure ensures that the inflection points reflect real system shifts across the CCUS value chain and remain closely aligned with the mission's focus on research, innovation, and enabling conditions for long-term impact.



CCS Inflection Point: CO_2 transport and geological storage remove the primary system bottleneck

The inflection point is reached when CO_2 transport and geological storage move from planning and uncertainty to committed, operational capacity. This includes final investment decisions on storage sites and associated infrastructure, supported by permitting, long-term responsibility frameworks, and operational readiness.

This inflection point addresses the main structural barrier in the CCS system. Cost or maturity of capture technologies is recognised as important, but on its own, this does not enable deployment, if access to storage and transport remains uncertain.

Once this bottleneck is removed, the entire CCUS system unlocks: CCU and CDR pathways can mature and scale because they can rely on predictable access to transport and permanent storage, enabling their respective inflection points to be reached.

The system shift is that CCS transitions from fragmented, project-specific development to an investable value chain where multiple pathways can scale in parallel.

The inflection point is anticipated in the 2030-2035 period, reflecting the combined progress needed for CO_2 transport and geological storage to shift from planning to fully operational, investmentready systems.

To reach this inflection point a wide range of needs within different domains will have to be fulfilled:

Technical Innovation needs

- **Secure and scalable geological storage:** Improved reservoir simulation models, laboratory standards, and risk assessments (leakage, injectivity, corrosion, well integrity) to ensure safe, largescale, longterm CO_2 storage.

- **Riskmanaged and flexible storage operations:** Modelling and testing of safe operational windows, including salt precipitation, injectivity limits, and wellbore management, enabling storage systems to handle varying CO_2 volumes, compositions, and temporal fluctuations.

- **Costeffective, highresolution monitoring and detection:** Advanced M&V technologies (satellites, drones, sensors, reservoir imaging) that reduce monitoring costs and enable efficient storage of fossil, biogenic, and naturebased CO_2.

- **Energyefficient CO_2 compression and conditioning:** Development of highthroughput, lowenergy compression technologies suitable for large and continuous flows.

- **Scalable and energyefficient CO_2 capture technologies:** Reductions in energy use, CAPEX/ OPEX, and solvent/sorbent degradation; improvements in CO_2 purity and capture rates; and demonstration of industrial scalability and digitalized control for higher reliability.

- **Innovative transport solutions for distributed emitters:** Modular, flexible transport concepts (truck, rail, smallvessel shipping, mobile CO_2 containers, standardized hubs) that reduce reliance on large pipelines and broaden participation across regions and sectors.

Societal Coupling Needs

- **Predictable policy, regulatory, and market frameworks:** Stable, technologyneutral regulation, predictable longterm permitting, clear valuechain responsibilities, harmonisation with EU frameworks, and a wellfunctioning EU ETS that provides reliable carbonprice signals for investment.

- **Credible certification and MRV for market integrity:** Robust public MRV and certification frameworks defining system boundaries, CO_2 quality, and capture efficiency, ensuring compatibility with compliance and voluntary markets and supporting investor confidence.

- **Practical guidance for authorities and developers:** Evidencebased tools and guidelines for planning, permitting, site selection, and stakeholder engagement, enabling transparent, timely decisions for capture facilities and storage infrastructure.

- **Public acceptance, legitimacy, and cocreation:** Researchbacked approaches to communication, transparency, and risk framing; models for meaningful involvement of communities, municipalities, and regional actors; and testing of engagement processes for onshore, nearshore, and offshore storage sites.

- **Societal integration at hub scale: Analysis of how CO_2** transport and storage align with regional development goals, including employment, industrial activity, environmental impact, and opportunities such as heat integration or reuse of existing infrastructure.

Value Chain Needs

- **Endtoend integration across capture, transport, and storage:** Coordination of CO_2 sources, conditioning, transport modalities, and storage sites to ensure predictable flows, reduce interface risks, and maximize shared infrastructure use.

- **Harmonised crossborder market access:** Regulatory and liability alignment to enable import/export of CO_2, supporting Denmark's (or the host country's) role as a European storage hub.

- **Clear and balanced risk allocation:** Standardized contractual frameworks, performance requirements, and CO_2 quality specifications that clarify responsibilities and reduce transaction costs across the value chain

- **Infrastructure readiness and system optimisation:** Timely availability of energy, pipeline, port, and hub infrastructure – integrated with industrial energy systems – to avoid bottlenecks and stranded assets.

- **Bankable, marketdriven business models:** Commercial structures that allow investment without longterm subsidies, including viable offtake contracts, pricing mechanisms, and revenue models for capture, transport, and storage services.

CDR Inflection Point: CDR solutions mature to enable credible and scalable deployment

This inflection point concerns the technological and regulatory maturity of carbon dioxide removal (CDR). It is reached when key CDR pathways, both capture-based and nature-based, progress from pilots and isolated demonstrations to credible, repeatable solutions that accelerates scaling.

This inflection point is characterised by reduced technological uncertainty, robust monitoring and verification approaches, and sufficient evidence of durability and performance to allow regulatory frameworks to be operationalised. The inflection point is not large-scale deployment or market take-off, but the transition from experimental development to scaled-up operational technologies that can be credibly integrated into climate policy instruments and long-term planning.

Once reached, CDR shifts from being a collection of promising options to a technically credible component of climate strategies, creating the foundation for subsequent market development and public procurement.

The timeframe for reaching this inflection point is between 2035-2040, by which CDR technologies and governance frameworks are expected to have matured sufficiently to support credible integration into climate policy and longterm planning.

To reach this inflection point a wide range of needs within different domains will have to be fulfilled.

Technical innovation needs

- **Development and demonstration of scaled-up and further scaleable technological solutions:** CDR technologies are often based on decentralized solutions. Pathways towards scaled-up and more centralized solutions must be developed and demonstration in practice.
- **Verification of Long-Term Storage Stability:** Evaluation of the permanence of carbon stored in soils, biomass, and biochar, providing evidence-based metrics on carbon durability.
- **Costefficient CDR solutions:** Reductions in energy requirements, CAPEX, and OPEX across engineered and naturebased CDR pathways, through improved process design, operational optimisation, and verification approaches that lower the cost per tonne of CO_2 durably removed.
- **Assessment of Carbon Storage Potential:** Assessment and documentation of carbon storage capacity in Danish terrestrial, coastal, and marine ecosystems (e.g., tons of captured carbon stored per area per year).
- **Development of Standardization Tools:** Development of robust monitoring, reporting, and verification (MRV) protocols that enable transparent tracking of carbon flows and storage permanence.

Societal coupling needs

- **Governance and certification frameworks for biological carbon storage:** Development of trusted public frameworks for certification, accounting, and commercialization of nature-based and biogenic carbon storage, aligned with land-use regulation, biodiversity objectives, and long-term stewardship requirements.

- **Public acceptance and landowner participation:** Research into societal acceptance of nature-based carbon storage, including landowner incentives, perceived trade-offs with food production and biodiversity, and willingness to engage in long-term management of carbon stocks.

- **Guidance for land-use and climate policy integration:** Research outputs provide practical guidance for policymakers and authorities on integrating nature-based carbon removal into land-use planning, climate policy, and rural development strategies.

- **Co-creation and local value generation:** Development and testing of co-creation models with landowners, municipalities, and local communities that support shared ownership, local economic value, and durable engagement over multi-decade time horizons.

Value chain needs

- **Credible, Standardised, and Scalable Carbon Accounting:** A harmonised framework that enables robust quantification, verification, and comparability of captured carbon removal across terrestrial, coastal, marine, and biochar pathways.

CCU Inflection Point: Captured carbon becomes competitive feedstock in industrial value chains

This inflection point is reached when captured carbon become a competitive source of carbon in selected industrial value chains, replacing fossil carbon as the default feedstock.

This inflection point reflects a reconfiguration of industrial carbon sourcing. It is reached when captured carbon, CO_2 conditioning and conversion technologies, and regulatory frameworks align such that captured carbon can be reliably sourced, qualified, and integrated into production processes.

The inflection point is not full substitution of fossil carbon, but when value chains for production of non-fuel products are intentionally designed around captured carbon as the primary feedstock.[1] At this stage, carbon utilisation pathways become structurally compatible with long-term climate objectives, and industrial carbon flows begin to reorganise accordingly.

Reaching this inflection point is projected for 2045, when the maturity of captured carbon supply systems, conversion technologies, and regulatory conditions enables industries to reorganize production processes around captured carbon as a primary carbon input.

To reach this inflection point a wide range of needs within different domains will have to be fulfilled.

Technical innovation needs

- **Development of flexible systems for conversion of CO_2:**
  Designing and demonstrating conversion technologies that can adapt to variable energy conditions and integrate CO_2 from diverse sources enables utilisation pathways that are viable across a wide range of industries and scales.

- **Accelerating Technology Maturation and Commercial Readiness:**
  Advancing CO_2 conversion processes from lab to demonstration scale while developing solutions that significantly reduce conversion costs will pave the way for commercially viable, industrial adoption.

- **Enhance Resource Utalisation and Material Substitution:**
  Quantification of carbon-based material substitution potential (e.g., percent reduction of emissions in the construction sector due to biochar use in building materials).

[1] Note that the use of the word of "carbon" in this chapter, all refers to this definition of captured carbon

Societal coupling needs

- **Market acceptance and willingness to adopt novel carbon-based products:**
  Research to understand factors influencing public and customer acceptance of carbon derived products, including perceptions of safety, quality, sustainability claims, and willingness to pay. This supports market uptake across sectors such as construction, chemicals, and materials.

- **Policy frameworks enabling demand creation:**
  Research outputs provide practical guidance for policymakers on how regulation, standards, and public procurement can stimulate early demand for carbon-based products, while ensuring transparency, credibility, and alignment with climate objectives.

- **Standards, labeling, and credibility of climate claims:**
  Development of evidence to support robust standards, product definitions, and labeling schemes that enable credible communication of climate benefits and avoid greenwashing, supporting trust among buyers and consumers.

- **System integration and local impacts:**
  Evidence-based strategies for integrating carbon utalisation facilities into existing industrial and energy systems in ways that minimize local disruption and maximize co-benefits, such as use of waste heat, industrial symbiosis, and compatibility with existing infrastructure.

Value chain needs

- **Expanding the Variety of carbon-based products:**
  Advancement of pathways that enable the transformation of CO_2 into high-value chemicals, platform molecules (such as acetate), and plastics, thereby supporting the expansion of sustainable, market-ready carbon-based products.

- **Integration with energy, CO_2 and carbon value chains:**
  Assessment and demonstration of end-to-end carbon capture, conditioning, transport, and use.

Figure 2
Overview of inflection points and focus areas

CCS Inflection Point

CO_2 transport and geological storage remove the primary system bottleneck

Focus areas:

- Transport solutions
- Geological storage
- Point Source Capture
- Direct Air Capture (secondary)
- Direct Ocean Capture (secondary)

CDR Inflection Point

CDR solutions mature to enable credible and scalable deployment

Focus areas:

- Direct Air Capture
- Direct Ocean Capture
- Ecosystem-based carbon removal
- Soil-based carbon removal
- Enhanced weathering and mineral-based removal
- Geological storage
- Point Source Capture (secondary)
- Transport solutions (secondary)

CCU Inflection Point

Captured carbon becomes competitive feedstock in industrial value chains

Focus areas:

- Point Source Capture
- Direct Air Capture
- Direct Ocean Capture
- Carbon conversion
- Carbon-based materials and products
- Transport solutions (secondary)

Project portfolio mapped against the Impact Framework

The INNO-CCUS portfolio covers a range of projects that have been selected through criteria supporting the overarching mission. The selections have been made in several iterations, and the current portfolio covers the two iterations that were carried out before the INNO-CCUS Impact Framework was completed.

The selection of relevant focus areas has been guided by the Danish CCUS Roadmap 2024, which provides a structured framework for identifying priority technologies and solutions. This roadmap outlines a comprehensive approach to carbon capture, utilisation, and storage, positioning it as a cornerstone of Denmark's green transition and a critical enabler for achieving climate neutrality.

The following section outlines the identified focus areas and links the current project portfolio to these. Projects can be linked to more focus areas and will be listed in each relevant area.

Transport solutions

Infrastructure and logistics solutions for moving captured CO_2 between capture sites, utilisation facilities, and storage locations, including pipelines, shipping, and intermodal solutions. Reliable and scalable transport is essential for enabling integrated CCUS value chains and reducing system-wide investment risk.

Existing projects within this focus area:

- **CASPER**
- **CCUS-INFRASTRUCTURES**
- **PAoCCUS**
- **CorroPro**

Geological storage

Permanent storage of CO_2 in subsurface geological formations such as saline aquifers and depleted oil and gas reservoirs. Geological storage is a critical enabler for large-scale CCS and CDR, providing long-term containment and underpinning confidence in the integrity of carbon management systems.

Existing projects within this focus area:

- **BOMS**
- **CarbonAdapt**
- **ChalkCO2RE**
- **CO2flow**
- **CO2RESHC**
- **CompReact**
- **INNO-SALT**
- **MONICO**
- **THERMOCO2WELL**
- **PAoCCUS**

Point Source Capture

Technologies that capture CO_2 from concentrated emission sources such as industrial plants, waste incineration, energy production, and biogenic processes. Point source capture provides access to large volumes of CO_2 and can serve different roles in the value chain, including supply for geological storage, utilisation in industrial processes, and capture-based carbon removal when combined with storage.

Existing projects within this focus area:

- **ASGREEN**
- **CapSim**
- **CASPER**
- **CORT**
- **Green Twins**
- **NEWCEMENT**
- **RD-BECCUS**
- **BioTechCCU**
- **LSICC**
- **VALCCAP**
- **CCUS-INFRASTRUCTURES**
- **RD-BECCUS**

Direct Air Capture

Technologies that capture CO_2 directly from ambient air using chemical or physical separation processes. DAC enables access to atmospheric carbon independent of emission sources and can support both carbon removal pathways (when combined with storage) and utilisation pathways based on non-fossil carbon feedstocks.

Existing projects within this focus area:

- **LSICC**
- **eDAC**

Direct Ocean Capture

Technologies that extract CO_2 from seawater, leveraging the ocean's natural buffering of atmospheric carbon. Direct ocean capture can provide an alternative source of atmospheric carbon and may contribute to both utilisation pathways and carbon removal, subject to environmental safeguards and system integration.

Existing projects within this focus area:

None.

CO_2 Conversion Pathways

Technological pathways that convert CO_2 into intermediate or final products through biological, chemical, or thermochemical processes. This focus area includes, but is not limited to, algae-based, enzymatic, electrochemical, and catalytic routes, and enables the integration of captured biogenic and atmospheric carbon into industrial value chains.

Existing projects within this focus area:

- **UC-DC**
- **RD-BECCUS**

Carbon-Based Materials and Products

Development of materials and products in which captured CO_2 replaces fossil carbon, including chemicals, polymers, fuels, and construction materials. This focus area supports the transition from fossil-based to carbon-based value chains and enables long-term storage of carbon in durable products where relevant.

Existing projects within this focus area:

- **CHARBUILD**
- **UC-DC**
- **BioTechCCU**
- **RD-BECCUS**

Ecosystem-Based Carbon Removal

Carbon removal through the restoration, management, or expansion of natural ecosystems such as forests, wetlands, and peatlands. These approaches leverage biological processes to remove CO_2 from the atmosphere and store it in biomass and soils, while delivering co-benefits for biodiversity and ecosystem services.

Existing projects within this focus area:

- **INNO4EST**
- **BlueOFS**

Soil-Based Carbon Removal

Practices and technologies that increase carbon storage in soils through biological processes and stable carbon forms. This includes soil carbon sequestration approaches and biochar, which can enhance long-term carbon storage while supporting soil health and agricultural resilience.

Existing projects within this focus area:

- **BIOCHSTA**
- **BioStore**
- **SIMPLY**

Enhanced Weathering and Mineral-Based Removal

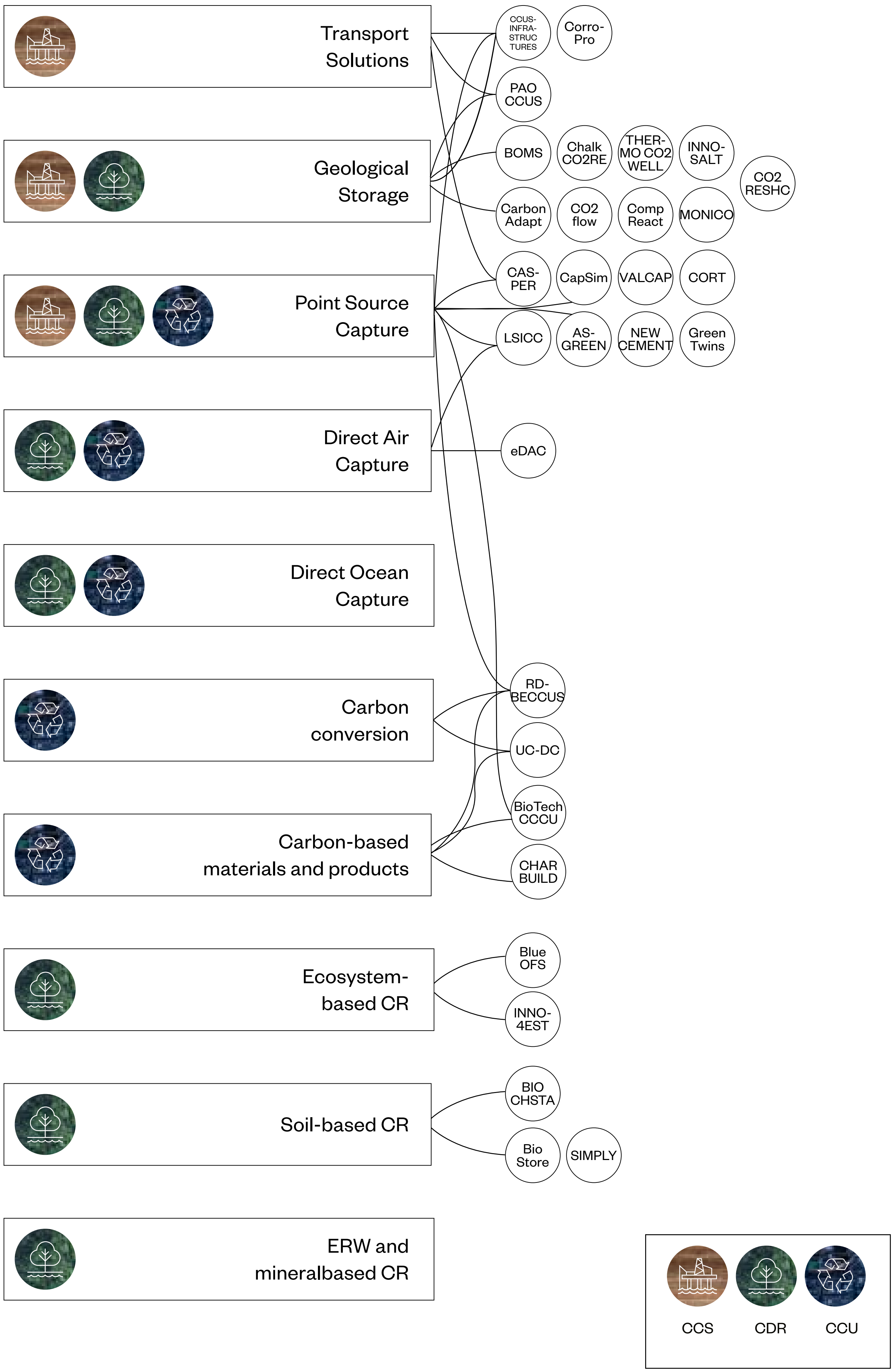
Carbon removal pathways based on the reaction of CO_2 with naturally occurring or engineered minerals to form stable carbonates. This focus area includes enhanced rock weathering and mineral carbonation and offers potential for permanent carbon storage with high durability, subject to scalability and environmental considerations.

Existing projects within this focus area:

None.

Summing up

The following diagram provides a visual overview of the three inflection points and the corresponding focus areas. It also highlights the projects within the portfolio that contribute to these strategic priorities, illustrating how INNO-CCUS drives systemic change across the CCUS value chain.



Transport Solutions
Geological Storage
Point Source Capture
Direct Air Capture
Direct Ocean Capture
Carbon conversion
Carbon-based materials and products
Ecosystem-based CR
Soil-based CR
ERW and mineralbased CR
CCUS-INFRA-STRUC TURES
Corro-Pro
PAO CCUS
BOMS
Chalk CO2RE
THER-MO CO2 WELL
INNO-SALT
CO2 RESHC
Carbon Adapt
CO2 flow
Comp React
MONICO
CAS-PER
CapSim
VALCAP
CORT
LSICC
AS-GREEN
NEW CEMENT
Green Twins
eDAC
RD-BECCUS
UC-DC
BioTech CCCU
CHAR BUILD
Blue OFS
INNO-4EST
BIO CHSTA
Bio Store
SIMPLY
CCS
CDR
CCU

Shaping the Project Portfolio

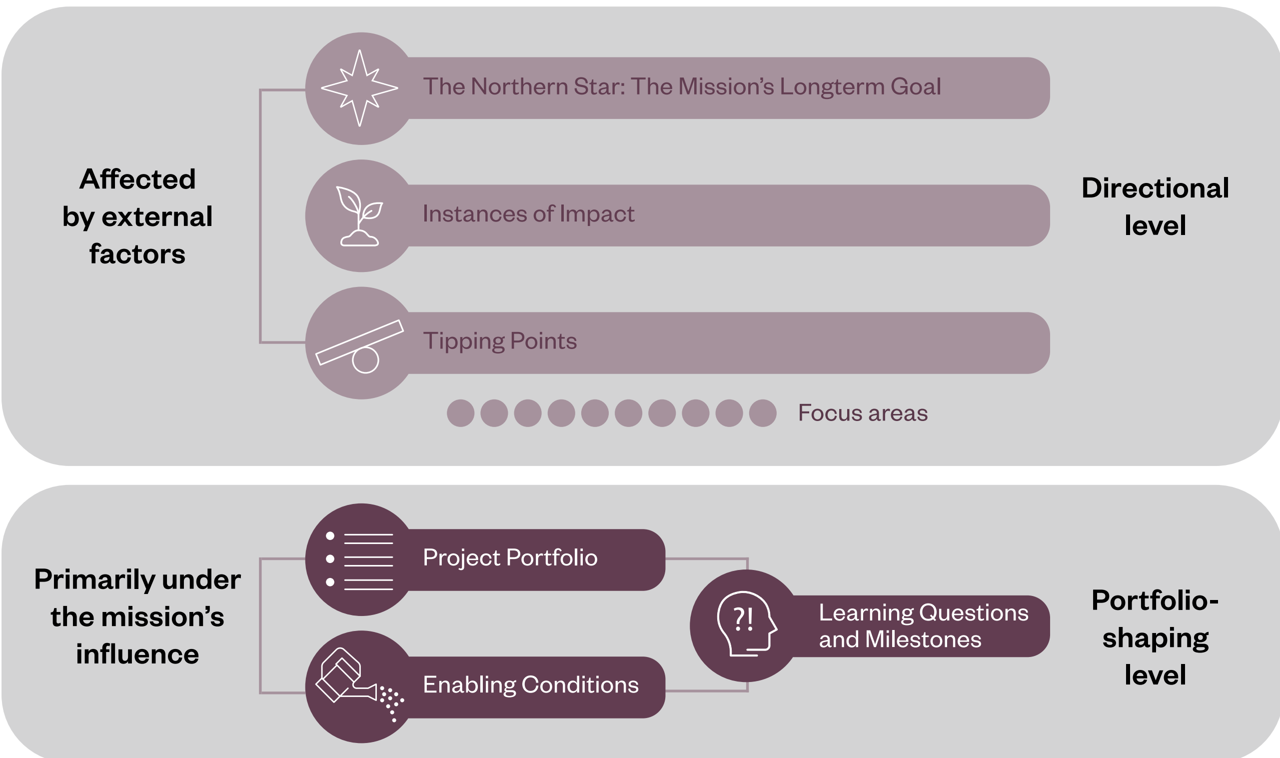
The following section presents the portfolio-shaping level of the Impact Framework.

The Impact Framework is our operating system for mission-oriented work. We anchor each funding round in the Northern Star and the three inflection points (CCS, CDR, CCU). Focus areas are selected against these inflection points, and projects are chosen to answer the most decision-critical learning questions. Evidence against milestones informs when to scale, pivot, or retire approaches.

A central part of using the framework is the learning questions and milestones, which translate the highlevel mission into concrete, testable progress markers for the project portfolio. The learning questions define what we must understand to move toward each inflection point, while the milestones define what progress should look like along the way. Together, they provide a structured way to monitor how technologies mature, how uncertainties are reduced, and where new strategic choices emerge. This ensures that each project meaningfully contributes to the system level changes the mission seeks to trigger.

Within this structure, the enabling conditions play a supportive, yet essential, role. They ensure that insights from the portfolio are captured, shared, and used to adjust direction when needed. Enabling conditions such as cross-sector collaboration, knowledge sharing, and strategic learning help connect the work across projects and maintain alignment with the CCUS Roadmap, without overshadowing the technology-focused efforts. In short, the enablers make it possible for learning questions and milestones to function as an active steering mechanism, not just a reporting tool.

Figure 1 - IFD Impact Framework chart



Learning Questions and Milestones for the Project Portfolio in Pool 5

The learning questions and milestones for the project portfolio of the Impact Framework outline how INNO-CCUS translates Denmark's long-term climate ambitions into targeted, mission-driven innovation efforts. They define the specific areas where learning, evidence generation, and technological progress are most critical for reducing uncertainty and accelerating deployment across the CCUS value chain. While the overarching Impact Framework provides a stable structure for mission-oriented innovation, these variable elements adapt for each application round to reflect emerging challenges, strategic priorities, and new insights from the project portfolio.

In this version for Pool 5, the project-shaping level identify the strategic learning questions and milestones for the portfolio that will guide the next phase of CCUS innovation in Denmark, ensuring that research, technology development, and cross-sector collaboration collectively address the most decisive barriers on the path toward scalable carbon capture, utilisation, storage, and removal solutions.

This version also specifies the enabling conditions that allow the mission to function effectively. These include the governance, strategic learning capacity, cross-sector collaboration structures, and knowledge sharing mechanisms that hold the project portfolio together and ensure alignment with the CCUS Roadmap. By strengthening these enabling conditions alongside the technological priorities, INNO-CCUS enhances its ability to adapt, steer investments, and accelerate the development of scalable CCUS solutions for Denmark.

Through open calls we invite applicants to respond to these learning questions in ambitious research and innovation projects that will strengthen and accelerate Denmark's journey toward scalable, cost-effective carbon capture, storage and utilisation.

Theme 1: Addressing current challenges in the CCS value chain

Uncertainty in storage capacity and lack of standardisation for shared CCS/CCU infrastructure pose significant challenges, hindering an interoperable CO_2 network for long-term deployment. A well-integrated CO_2 infrastructure, including geological storage sites, is essential for enabling CCS solutions to contribute as needed to Denmark's climate goals.

Parallel to addressing key issues within infrastructure and storage, energy efficient CO_2 capture from industrial point sources is a key component of Denmark's climate strategy. While first-generation capture technologies are being deployed, they face significant challenges in cost, energy efficiency, and adaptability - especially for smaller emitters and decentralised sources. Acceleration of the development of next-generation CO_2 capture technologies that enhance efficiency, reduce costs, and expand the range of viable capture solutions is needed.

The strategic learning questions listed below define some of the knowledge gaps that need to be addressed to unlock scalable CO_2 transport, storage, and capture solutions. Project applications under this theme must relate directly to one or more of these learning questions.

Projects must fall within TRL (Technology Readiness Levels) 3–8. Activities addressing technologies in the mid-TRL range (approximately TRL 4–7) are expected to be most relevant for this theme.

1.1. Where is the greatest potential for expanding Denmark's CO2 storage capacity, and how can geological assessments reduce uncertainty about site scalability and maturation?

While ~10 primary storage sites have been identified, their scalability remains uncertain. We invite project applications that contribute to expanding geological storage options, i.e. by assessing additional geological formations, advancing new methods for storage site development, advancing risk assessment, and injectivity modelling to de-risk investments and support long-term storage planning.

1.2. What are the key technical and regulatory requirements for establishing a harmonised and interoperable CO2 infrastructure in Denmark?

Variations in CO_2 purity affect pipeline integrity and storage performance, creating regulatory challenges. Projects addressing this learning question should work to support a unified CCS and CCU network that ensures interoperability, regulatory alignment, increasing investment certainty.

1.3. What are the key enablers for optimizing CO2 transport and storage through digital solutions and process integration?

Projects addressing this learning question should develop tools such as AI-driven models and digital twins to optimise CO2 transport networks, risk assessment, and injection planning. Real-time MRV solutions enhance transparency and safety, ensuring security across the value chain. By combining predictive analytics and process optimisation, projects enable optimised planning, cost efficiency, and infrastructure resilience.

1.4. How can CO2 capture processes be optimised to minimise energy consumption and improve efficiency?

CO_2 capture remains energy-intensive and costly, limiting its widespread adoption. This learning question explores advanced heat recovery, system optimisation, and integration with industrial energy streams to reduce energy consumption and operational costs. It also supports the development and maturation of next-generation capture technologies, such as low-energy solvent systems, solid sorbents, membrane-based separation, and cryogenic capture. By improving process efficiency and reducing reliance on chemical-intensive solutions, this initiative ensures a more sustainable and scalable approach to CO_2 capture.

1.5. How can modular and decentralised CO2 capture systems be designed to enable cost-effective deployment for smaller and mid-size emitters?

Decentralised emitters, such as bioenergy plants and waste incineration facilities, often face economic and logistical barriers to CO_2 capture. Project addressing this learning question should support the innovation and development of modular capture units, allowing flexible, scalable, and cost-efficient solutions for smaller point sources. Supporting technologies and innovations such as advanced process monitoring and digital or AI-driven control systems could be explored to optimise capture performance across diverse industrial settings, ensuring efficient operation and adaptability.

The milestones below suggest concrete, time bound outcomes related to defined the strategic learning questions.

Milestones

- **2027:** Pilot projects, focusing on energy efficiency and process optimisation in capture technologies. (Point Source Capture)

- **2028:** Demonstrate alternative capture technologies, possibly including solid sorbents, membrane separation, and cryogenic capture, at pilot scale to evaluate feasibility and cost reduction potential. (Point Source Capture)

- **2028:** Develop CO_2 purity and stream compatibility guidelines to support shared CCS and CCU infrastructure. (Transport solutions, Geological storage)

- **2029:** Complete geological storage site assessments to secure long-term storage capacity. (Geological storage)

- **2030:** Develop digital models and real-time monitoring solutions to optimise CO_2 transport and storage. (Transport solutions, Geological storage)

- **2030:** Scale towards industrial deployment of optimised solutions, ensuring broad adoption and integration with transport and storage networks. (Point Source Capture)

Theme 2: Maturing CDR solutions – scalable and verified nature-based carbon removal

Achieving Denmark's long-term climate targets requires credible and durable negative emissions. Denmark has significant potential to lead in biological and nature-based solutions (NbS) for CO_2 sequestration, a key component of the Danish CCUS Roadmap. This theme is prioritized in this call for its strategic importance in shaping future Danish ecosystems and carbon management strategies. With the Green Tripartite Agreement supporting afforestation, land-use transitions and nature restoration, projects under this theme can directly inform key decisions across these areas while also advancing broader NbS pathways such as biochar, soil carbon, and enhanced weathering.

For this call, focus is on the need to assess reduction potentials and sequestration timespans while also ensuring that nature-based sequestration is scientifically robust, economically viable, and positioned for integration into carbon markets and policy instruments. Projects submitted under this theme must have focus on carbon removal. This is summarised in the three strategic learning questions below.

Projects must fall within TRL 3–8. Activities addressing technologies in the mid-TRL range (approximately TRL 4–8) are expected to be most relevant for this theme.

1.1. How can nature-based carbon storage be optimised to enhance long-term stability and resilience?

To support the optimisation and scaling of NbS-based CO_2 storage, projects should deepen the understanding of biological system dynamics across diverse ecosystems, identifying key drivers of long-term carbon retention. Resilience must be considered beyond climate-related stressors, including land-use pressures, biodiversity interactions, and other systemic risks, to ensure sustainable and scalable carbon storage outcomes.

1.2. How can carbon sequestration in nature-based systems be accurately quantified, monitored, and verified?

Credibility of nature-based sequestration relies on robust measurement and verification systems. Projects should advance cost-effective, scalable, and reliable approaches for carbon stock assessment, with a focus on standardising verification protocols, improving documentation practices such as remote sensing, and enabling alignment with - or contributing insights relevant to - emerging certification frameworks, including the EU Carbon Removal Certification Framework.

1.3. What management practices and interventions can enhance CO2 uptake and storage in natural ecosystems?

To maximise carbon uptake, we invite project applications to investigate management strategies including species selection, genetic optimisation, and microbial interventions. Projects could also explore ecosystem-level practices to improve retention and enhance long-term sequestration efficiency across a range of NbS contexts.

The milestones below suggests concrete, time bound outcomes related to defined the strategic learning questions.

Milestones

- **2026:** standardised methodologies will be in place to quantify up to 3 MtPa from afforestation and biochar combined. (Ecosystem based, Soil based)

- **2028:** validated methods will ensure at least 90% of stored CO_2 is reliably verified for market and policy use. (Ecosystem based, Soil based)

Theme 3: Carbon based materials for circular technology innovation

As Denmark scales up CCUS, carbon storage in products offers a supplement to geological storage by integrating CO_2 into durable materials, with the dual purpose of ensuring long-term sequestration while reducing reliance on fossil-based carbon. This approach aligns with Denmark's decarbonisation and circular economy goals by enabling negative emissions and supporting CO_2 utilisation in industrial applications. However, significant research and innovation are needed to ensure material stability, process efficiency, and market viability before widespread industry adoption.

The aim of this theme is to advance research in CO_2-based materials, long-term carbon stability, and life cycle assessments (LCA) to close knowledge gaps. It addresses three key strategic learning questions as listed below.

Projects must fall within TRL 3–8. Activities addressing technologies in the mid-TRL range (approximately TRL 4–8) are expected to be most relevant for this theme.

3.1 How can CO_2-based materials be developed and scaled for long-term carbon storage?

Denmark must develop scalable and durable CO_2-derived materials for applications such as concrete, chemicals, polymers, and industrial feedstocks. Project applications addressing this learning question should focus on optimizing CO_2 conversion processes, enhancing biochar applications, and improving synthesis methods to ensure cost-effectiveness and scalability.

3.2 What factors influence CO_2 storage durability in materials, and how can storage conditions be optimised to prevent re-release?

To maximise long-term CO_2 retention, projects must address the key factors that affect storage stability. This includes optimizing material composition, improving carbon stabilisation mechanisms, and developing protective formulations that minimise degradation over time. Addressing these knowledge gaps will provide a scientific foundation for enhancing storage security and ensuring CO_2 remains sequestered under varying conditions.

3.3 How can life cycle assessment (LCA) and circularity models enhance the effectiveness of CO_2 utilisation?

To quantify carbon retention and environmental impact, project applications should develop LCA methods, circularity models and disposal strategies. These efforts will support certification and regulatory compliance, ensuring CO_2-derived materials contribute to net-negative emissions while optimizing reuse and disposal.

The milestones below suggests concrete, time bound outcomes related to defined the strategic learning questions.

Milestones

- **2028:** Launch pilot projects for CO_2-based materials, demonstrating durability and scalability. (Carbon based materials & products)

- **2030:** Establish LCA and certification models supporting transparency, regulatory alignment, and investor confidence. (CO_2 Conversion, Carbon based materials & products)

Enabling conditions

Alongside advancing CCUS technologies and solutions through collaborative research and innovation projects, INNO-CCUS strategically provides enabling conditions vital to delivering on the Danish CCUS Roadmap and Denmark's climate goals. These are critical to unlocking the full value from research and innovation funding and ensuring mission-driven transformation.

The Partnership Secretariat provides the foundation for strategic governance, project portfolio oversight, and administrative execution, ensuring that all activities are aligned with the revised CCUS Roadmap, the Impact Framework, and the partnership's strategic priorities. It plays a central role in enabling portfolio management, ensuring projects progress as planned, and maintaining financial sustainability, regulatory compliance, and knowledge-sharing infrastructure. Through this work the partnership can proactively identify gaps, manage risks, and guide investments toward the most impactful opportunities.

In the long term, this ensures the sustainability of Denmark's CCUS ecosystem by supporting international collaborations, enabling joint funding mechanisms, and capacity building through PhD exchanges and early-career researcher engagement. These elements are essential to sustaining Denmark's CCUS role and long-term research and industry competitiveness.

Each enabling condition supports a different aspect of the mission, from facilitating cross-sector collaboration and strengthening governance practices to ensuring transparent decision making and building capacity among researchers, companies, authorities, and other stakeholders. Together, they provide the scaffolding that allows the partnership to adapt to emerging technologies, changing market conditions, and new policy requirements.

The list below outlines the full range of enabling condition activities that the partnership management may carry out. Not all activities will be activated in every funding cycle; instead, priorities will be selected strategically for each round of Innovation Fund Denmark applications. This ensures that the enabling conditions remain flexible and responsive to the partnership's evolving needs, while still anchored in a long-term mission-oriented approach.

Cross-sectoral collaboration

- Partner and Conference Events
- Workshops, Seminars, and Networking Delegations and International Events
- Showcases and Project Visits
- Publications, Dissemination, and Digital Tools
- Other Events and Activities

Authentic engagement

- Engaging events and dialogue forums
- Decision-making and startup processes
- Strategy, learning, and materials

Inclusive, transparent governance

- Partnership agreement revised for clarity
- Impartiality rules published
- Project contracts updated
- Board info posted online
- Project changes inform learning
- Governance adjusted to IFD
- Procedures adjusted after recent calls
- Partners consulted on roadmap

Strategic Learning

- Annual project reports
- Dialogue with project leaders
- Portfolio analysis
- Mission Compass tool
- Learning from project changes
- Calls adjustment
- Events and workshops
- Roadmap updates
- ”State of CCUS” platform
- Peer learning network
- Partner feedback

Capacity Building

- State of CCUS publication
- Annual IFD reporting
- Semi-annual board reporting
- Impact data collection
- Partnership meeting
- CCUS Summit
- IFD applications
- Funding calls
- IEAGHG membership

- Advisory Board meetings
- Mission leadership training
- Coordinator training

Major convening events such as the Danish CCUS Summit and the INNO-CCUS Partnership Meeting, which alternate annually serves as essential forums for aligning priorities, sharing results, and strengthening collaboration among public and private partners. These events are key mechanisms for fostering portfolio-level synergies and building community around the shared mission.

A central focus of the secretariats activities is also to strengthen Denmark's international engagement in CCUS by supporting active participation in global research infrastructures and innovation networks. Through study trips, joint workshops, and sustained partnerships with organisations such as ECCSEL ERIC, Stanford University, and Alberta Innovates, the activity ensures that Danish CCUS efforts remain internationally connected and scientifically competitive. This includes INNO-CCUS's engagement in multilateral fora, bilateral collaboration mechanisms, and structured knowledge exchange.

In addition, key tools such as the Danish CCUS Roadmap and the Mission Compass are kept up to date and aligned with technological developments. By funding expert input and consultancy for analysis, design, and publication, the partnership can maintain its data-driven foundation for decision-making and long-term planning. These elements are essential for supporting a mission-driven innovation model and for delivering on the partnership's strategic priorities and identified inflection points.

Key enabling conditions:

- Roadmap & Mission Compass Updates: External consultancy and technical support for data analysis, roadmap revisions, to keep INNO-CCUS tools and publications aligned with the latest technological developments and communication strategy and design.

- CCUS Events & Dissemination: Organizing and hosting flagship events such as the Danish CCUS Summit, Biennial Partnership Meetings, project showcases, and thematic workshops to promote collaboration and knowledge-sharing.

- Knowledge & Communication Tools:Maintaining a searchable CCUS project database and a CCUS knowledge hub to ensure that research, policy insights, and best practices are easily accessible. Technical and design updates and revisions, publications and other materials.

- International Collaboration: Developing and sustaining global partnerships and knowledge exchange, including but not milited to ECCSEL ERIC, IEAGHG, Stanford School of Sustainability, and Canadian innovation programs such as Mitacs and Alberta Innovates.

In the long term, this ensures the sustainability of Denmark's CCUS ecosystem by supporting international collaborations, enabling joint funding mechanisms, and capacity building through PhD exchanges and early-career researcher engagement. These elements are essential to sustaining Denmark's CCUS role and long-term research and industry competitiveness.

The following activities ensures that INNO-CCUS can maintain and execute its mission-enabling functions effectively. It provides the resources needed to deliver key events, operate essential digital tools, and engage internationally – all critical for ensuring visibility, alignment, and impact.

Major convening events such as the Danish CCUS Summit and the INNO-CCUS Partnership Meeting, which alternate annually serves as essential forums for aligning priorities, sharing results, and strengthening collaboration among public and private partners. These events are key mechanisms for fostering portfolio-level synergies and building community around the shared mission.

A central focus of the secretariats activities is also to strengthen Denmark's international engagement in CCUS by supporting active participation in global research infrastructures and innovation networks. Through study trips, joint workshops, and sustained partnerships with organisations such as ECCSEL ERIC, Stanford University, and Alberta Innovates, the activity ensures that Danish CCUS efforts remain internationally connected and scientifically competitive. This includes INNO-CCUS's engagement in multilateral fora, bilateral collaboration mechanisms, and structured knowledge exchange.

In addition, key tools such as the Danish CCUS Roadmap and the Mission Compass are kept up to date and aligned with technological developments. By funding expert input and consultancy for analysis, design, and publication, the partnership can maintain its data-driven foundation for decision-making and long-term planning. These elements are essential for supporting a mission-driven innovation model and for delivering on the partnership's strategic priorities and identified inflection points.

Key Milestones

- 2026: Mission Compass fully implemented as a dynamic tool for portfolio management and decision-making.
- 2026: Strengthened international collaboration through Denmark's active participation in ECCSEL ERIC and expanded engagement with European and North American initiatives.
- 2027: Launch of the CCUS Knowledge Hub, enhanced data analytics for tracking technological development, updated Roadmap, and full implementation of the Mission Compass.
- 2028: Evaluation and refinement of partnership activities to ensure continued alignment with national and international climate targets

About this publication
This first edition of INNO-CCUS Impact framework is developed and published by INNO-CCUS - supported by Innovation Fund Denmark.

Photos: Shutterstock & Unsplash
Layout and design: AMN Design Studio / annemettenygaard.dk

INNO-CCUS
Kemitorvet 207
Building 206
2800 Kgs. Lyngby
www.inno-ccus.dk