NET ZERO CITIES
SGA2-NZC

Financing Carbon Capture, Utilization and Storage (CCUS)

The Swedish example

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Executive summary

Sweden is gradually positioning carbon capture, utilisation and storage (CCUS) to be a key pillar of its long-term climate strategy. CCUS technologies, which capture carbon dioxide from industrial sources or the atmosphere for permanent storage or utilization, are widely acknowledged to be critical to achieving net-zero emissions. Globally, over 1,000 CCUS projects have been announced, reflecting a growing urgency to meet the Paris Agreement's 1.5°C target.

In Sweden, 73 CCUS-related initiatives have been supported between 2009 and 2025, spanning research and development (R&D), feasibility assessments, pilot projects and early-stage commercial ventures. Yet only one, Stockholm Exergi's Bioenergy with Carbon Capture and Storage (BECCS) facility, has attained a final investment decision and entered the construction phase.

Despite this momentum, CCUS deployment remains fragmented. Most projects are in planning or feasibility stages, and costs remain a critical barrier. Total CCUS costs in Sweden are estimated to be between EUR 114–205 per tonne of CO2, with some cases exceeding EUR 300. These vary by capture technology, transport mode, interim storage and proximity to offshore sinks. While amine solvents and hot potassium carbonate are commercially mature, emerging alternatives such as ionic liquids may reduce costs in the future but currently remain at low readiness levels.

Public funding – roughly EUR 2.4 billion from the Swedish Energy Agency and the EU Innovation Fund – has been essential but primarily supports early-stage development. Commercial-scale deployment faces a significant financing gap. Private investment is constrained by high capital costs, long lead times and uncertainty around future carbon prices.

Stockholm Exergi's financing model demonstrates a viable path forward. By combining public grants, long-term carbon removal purchase agreements with corporate buyers like Microsoft and loans from the European Investment Bank and Nordic Investment Bank, the project secured the financial viability required for bankability. This blended approach shows that with robust policy support and revenue predictability, commercial CCUS is achievable.

CCUS will be essential for decarbonizing Sweden's hard-to-abate sectors, including power, refineries and process industries. With the right policy mix, Sweden can become a Nordic leader in negative emissions, contributing not only to national climate targets but also to European decarbonization efforts.

1 Introduction

With the introduction of the Paris Agreement goal to *limit anthropogenic global average warming to well below 2°C above pre-industrial levels and to pursue efforts to limit the warming increase to 1.5°C above pre-industrial levels* (UN, 2015), carbon dioxide removal (CDR) solutions have gained significant attention (Gasser et al., 2015; M. Smith Stephen et al., 2024). Carbon capture, utilization and storage (CCUS) is such a solution: it captures carbon dioxide (CO_2) from industrial processes (directly from the source of emission) or the atmosphere and then either utilizes it as a product or permanently stores the captured CO_2 in deep geological formations (Prado & Mac Dowell, 2023). CO2 can be captured at three points: pre-combustion, post-combustion and through oxy-fuel combustion (Hekmatmehr et al., 2024). Each capture option involves a range of technologies, which are at varying levels of readiness (Barlow et al., 2025; Hekmatmehr et al., 2024).

In essence, CCUS prevents CO_2 emissions from being released into the atmosphere during industrial processes, offering a method for decarbonising hard-to-abate sectors (Figure 1).[1] Studies have shown that it plays a critical role in sectors with few alternative mitigation options, including energy refineries and industries such as cement, iron, steel and chemical (IEA, 2023). The energy sector alone is projected to emit around 600 gigatons (GT) of CO_2 between 2023 and 2050 (IEA, 2023). Three deciding factors influence which CCUS technology is suitable for a given industry: 1) the source of CO_2 emissions, 2) the flue gas composition and 3) the conditions under which the flue gas operated (Hekmatmehr et al., 2024). Two CCUS solutions, bioenergy CCS (BECCS) and direct air capture with carbon storage (DACCS), are seen as novel CDR technologies with a medium level of technology readiness, high mitigation potential and the ability to store captured CO_2 for more than 3,000 years (M. Smith Stephen et al., 2024). DACCS captures CO_2 directly from the atmosphere and is particularly suited to addressing emissions that are released diffusely and for which locating a direct capture point is not feasible – for example, CO_2 emitted in the transport and agriculture sectors. A review of the field by Minx et al. (2018) shows that while BECCS dominates research and policy discourse, it is essential to consider other solutions, including DACCS, to hedge against technological and ecological uncertainty.

As of June 2025, 1,017 CCUS projects have been proposed or developed globally, 95% of which have been initiated since 2015 (IEA, 2025). Only 6% of them are close to being operational, and they are mostly located in North America (Table 1/ Figure 2). In Europe, the United Kingdom has initiated most CCUS projects (n=105). Challenges with deploying CCUS installations relate to, among others things, the technology readiness level (TRL) and planning permits (Babin et al., 2021; Buck, 2019; Chen et al., 2019). Projects have also been developed in isolation due to the sensitivity of project data and intense competition for limited funding. This lack of transparency has hindered collective learning (Ritala et al., 2015). Financing models and governance frameworks are increasingly recognized as central to the viability of CCUS deployment (Rogge & Johnstone, 2017). Recent scholars situate CCUS within the broader world of mission-oriented innovation (Mazzucato & Semieniuk, 2018), in which targeted public investment plays a catalytic role in shaping new industrial trajectories. This framing is particularly salient in countries like Sweden, where industrial decarbonisation is both a national goal and a source of competitive advantage (Zetterberg et al., 2021). To enable responsible and effective scaling of CCUS, Fajardy et al. (2019), for example, emphasize the importance of rigorous life-cycle assessments, transparent costing and region-specific policy frameworks. These considerations are critical in Sweden, where CCUS is being positioned as a cornerstone of the net-zero strategy.

1 We acknowledge that the framing of carbon removal as a neutral technological fix has been widely critiqued (Carton et al., 2020). These technologies are historically entangled with narratives of techno-optimism, and their deployment raises questions about intergenerational equity, political accountability and public legitimacy.

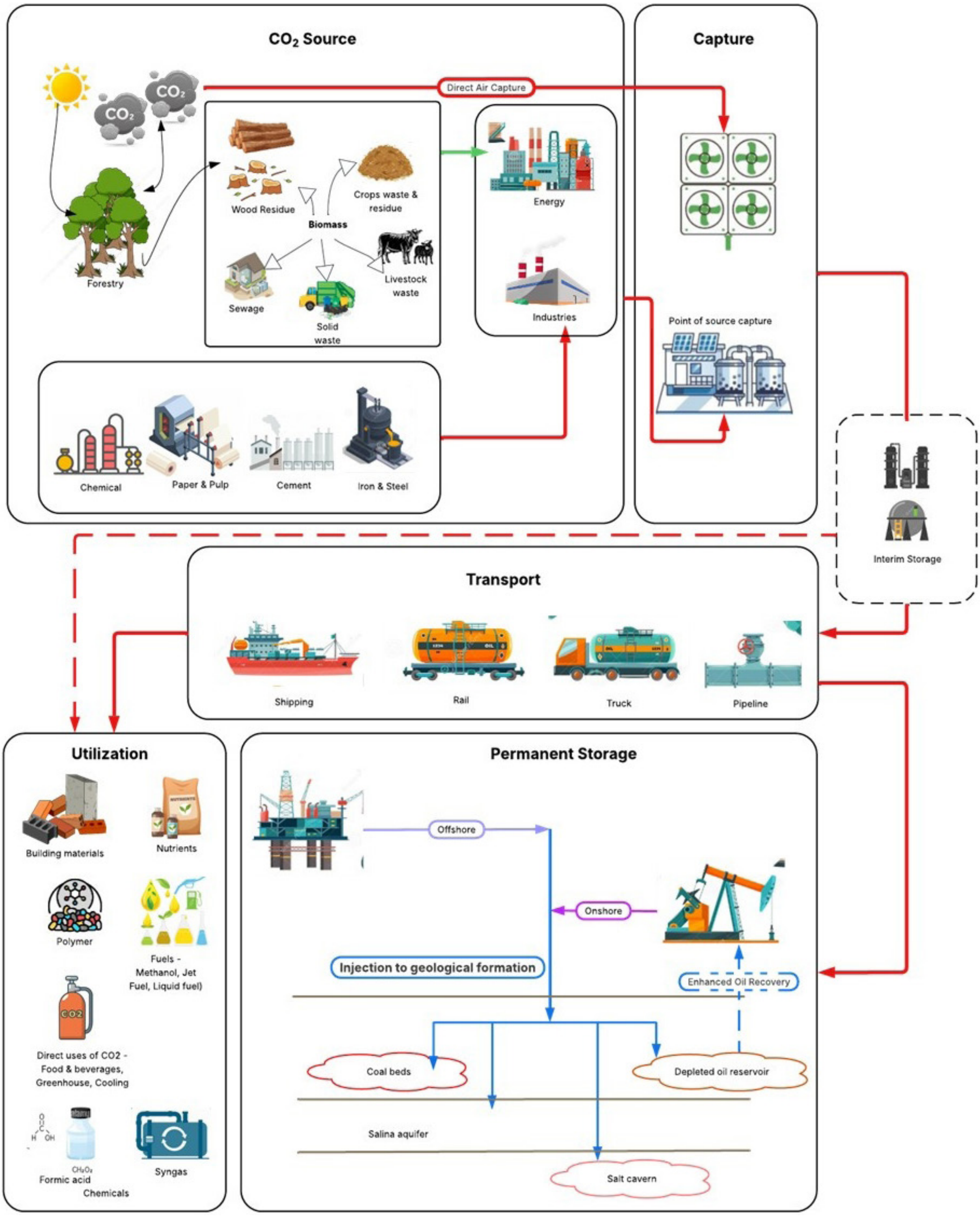


Figure 1. CCUS visualization

Source: Inspired by (Makepa & Chihobo, 2025) and (Mertens et al., 2024)

With this report, we aim to overcome some of these barriers by providing insight into the financial case for CCUS; we explore project funding, the role of public and private finance, and revenue models. We focus on Sweden, as there are 73 CCUS-related initiatives across different sectors and technology readiness levels (Energimyndigheten, 2025a; IEA, 2025)[2]. These include commercial, research and development, and pilot and demonstration projects between 2009 and 2025. A content analysis method was applied to extract and categorize financial and economic insights from each report (Krippendorff, 2004). First, we extracted project details from the Swedish Energy Agency's database using the following keywords: carbon capture storage, CCS, carbon capture utilization, CCU, carbon capture storage and utilization, CCUS, BECCS, and carbon capture, in both English and Swedish. Then, we analysed feasibility reports and project information published by each project to extract data on capturing technologies, technical specifications, energy portfolios, cost structures, transportation solutions, storage solutions, financing options and proposed business models.

Furthermore, the cross-case-comparison approach was used to identify patterns and differences across projects (Rihoux & Lobe, 2009). In addition to the Swedish Energy agency's database, we used CCUS project databases from the IEA, the Global CCS Institute and Clean Air Taskforce (CATF) to identify a broader set of projects worldwide, including transportation and storage projects. We then cross-compared some of those projects with Swedish projects to highlight key concerns related to technology, cost structures, financing and business models.

This report is structured as follows. Section 2 presents an overview of CCUS projects in Sweden; it explains the industries involved, project timelines, geographic distribution, CO_2 capture capacities, technology deployed, transportation systems, and storage methods and locations. In Section 3, we analyse and compare capital and operating expenditures (CAPEX & OPEX) across selected projects. Section 4 offers an in-depth discussion of financing structures, examining public and private sector contributions, funding mechanisms, financial risk assessments, future financial viability and potential revenue streams. Section 5 summarizes the key findings and offers recommendations for enhancing the financial viability of CCUS projects in Sweden.

2 Sweden's CCUS

2.1 Overview of the CCUS projects

To date, at least 73 carbon removal projects have been carried out in 30 different locations in Sweden (see Supplementary data, Figures 2–8 and Tables 1–9). The number of projects has increased significantly over the year. Close to half the projects (n=37) are in research and innovation and mainly concentrate on process optimization and energy efficiency. Feasibility studies (n=23) cover a wide range of sectors. The remaining 13 projects target commercial-scale deployment.

Around 40 industry actors, from waste (n=13), energy (n=10), transport and storage (3), hydrogen and chemical industries (n=3), cement (n=1), and paper and pulp (n=1) carried out these projects, oftentimes in collaboration with academic and scientific institutions, of which there were 12 that regularly participated. Bioenergy-sector CCUS seems highly feasible in Sweden: biomass contributes around 60% of renewable energy produced, with 80% of it originating from solid biomass and waste and

2 The IEA database contains only 20 CCUS projects in Sweden. We cross-checked whether the 20 IEA-identified cases appear in the energy agency's database. Additions were made to arrive at a complete dataset of 73 projects.

residues (IEA Bioenergy, 2024). Waste incineration generated 80% of the emission in the sector in 2023 while the electricity and district heating sector was responsible for 9% of Sweden's total emission in 2023 (Naturvårdverket, 2025a). Other EU countries, such as France and Germany, have more CCUS projects in the cement sector whereas Norway is more active in the chemical, hydrogen, iron and steel, and transport and storage sectors.

Most of the CCUS projects in Sweden are concentrated in the central and southern regions. Only a few projects have been developed in the north, in places such as Boden, Skellefteå, Umeå and Sundsvall. Västra Götaland county has eight projects, with four located around Gothenburg port. In Skåne, three of the four projects are located near Malmö port. Heidelberg developed its project in Gotland, where its cement factory is located. It also has direct access to the Baltic Sea. Port access for CO_2 transport is of strategic importance: direct access to a port provides a significant competitive advantage given the significantly lower transport and interim storage costs. Moreover, the clustering of projects near one another creates opportunities for shared infrastructure, further reducing cost and improving operational efficiency (see Section 2.4 on transportation and storage).

The capture capacities of the 27 CCUS projects[3] vary considerably. Heidelberg Cement has the largest planned capacity, targeting the capture of approximately 1.8 million tons of CO_2 annually. If successful, it could reduce Sweden's total CO_2 emissions by 4% (Heidelberg Materials, 2024). The second largest project, operated by Stora Enso in the pulp and paper sector, aims to capture around 1 million tonnes of CO_2 annually. The energy sector companies, such as Stockholm Exergi, Sysav, Mälerenrgi, Plagazi, Söderenrgi, Preem, Perstorp and E.ON plan to capture between 400 000–800 000 tonnes of CO_2 annually.

2.2 From the feasibility to implementation stage

Despite growing interest and extensive planning, Sweden has yet to establish a fully operational, large-scale commercial CCUS project. In 2025, Stockholm Exergi, with its BECCS plans, became the first company to reach a final investment decision (FID) and commenced construction.[4] Other front runners are Sysav in Malmö, Söderenergi in Stockholm, Öresundkraft in Helsinborg and Heidelberg Cement in Gotland.[5] These five projects have the potential to capture around 3.7 megatonnes (MT) of CO_2 by 2030. All projects are now in the FID-making phase (Energimyndigheten, 2025b). Overall, it took these frontrunners nearly six years to make their FIDs. An additional four years is anticipated before the projects are fully operational.[6] A further 10 feasibility studies and commercial-scale projects are still ongoing. For instance, Mälerenrgi conducted its initial feasibility study between 2020 and 2021 confirming the potential for CCUS implementation (Allmyr et al., 2021). A more detailed feasibility study followed in 2023, with plans to implement a pilot and demonstration plant in November 2024 and run it for three months (Mälarenergi Press, 2024). However, test results and outcomes have not yet been published. Similarly, Umeå Energi conducted their feasibility study between 2021 and 2023; the

3 Excluding infrastructure-related, cancelled, and research and innovation (R&I) projects.
4 Since first receiving funding in 2019, it has progressed through multiple phases of R&I studies, feasibility studies and pilot and demonstration projects.
5 Sysav appears in the Swedish Energy Agency in 2020, as does Söderenergi in 2020. Öresundkraft and Heidelberg Cement received funding as of 2021.
6 As Anderson and Peters (2016) caution, the extensive reliance on negative emissions in climate modelling has created a policy hazard, allowing governments to delay near-term mitigation while betting on future technological deployment. This underscores the need for a critical evaluation of what CCUS can realistically deliver within a given time frame.

company identified the potential for bio-CCS deployment but also highlighted unresolved technical and economic challenges (Umeå Energi AB et al., 2023). Sundsvall Energi is also waiting for the FID by 2025 (Borglund, 2024). The initial feasibility study, however, reported an overall negative net present value for its project (Lindberg & Durakovic, 2022). Boden Energi, operating in Sweden's northernmost region, has identified significant political and market-related risks. They concluded that CCS remains a high-risk investment and are looking to other larger players to demonstrate profitability (Unger et al., 2022).

Vattenfall AB's Hyskies project received funding in 2023 to produce electro-sustainable aviation fuel (eSAF). Initially they partnered with Shell, but Shell paused their collaboration, and later Vattenfall AB announced a slower-than-expected market maturation for eSAF. This affected Vattanfall's planned CCU project in Uppsala as well (Vattenfall Media Relations, 2025). The project AIR was jointly initiated by Perstrop and Uniper in 2022. The feasibility study result, however, did not fully align with Uniper's expected business model, and Uniper decided to withdraw from the project in 2024; Perstorp continues to develop it (EU, 2025b).

Our analysis of project maturity underscores the slow but deliberate progress of CCUS projects in Sweden. Even though many feasibility studies generally indicate the technical viability of implementing CCUS projects, they also reveal substantial financial, regulatory and market uncertainties, which slow down the investment decisions.

2.3 A focus on post-combustion

Most projects have focused on post-combustion technologies, including absorption technologies such as amine-based solvents (amines), hot potassium carbonate (HPC), chilled ammonia process (CAP) and ionic liquid as their capture option. Amines and HPC technologies are currently the most mature options: both are classified as having reached technology readiness level 9 – that is, as ready for normal commercial service (Bukar & Asif, 2024).

Stockholm Exergi, Sweden's leading BECCS project, selected HPC as its capture technology, as did Soderenergi. Amine technology, however, has become the preferred option due to its energy efficiency and its track record of deployment worldwide, including in Germany, Japan, the US, the UK and Brazil (Hekmatmehr et al., 2024). Therefore, many feasibility studies recommend it over HPC and CAP technologies. Feasibility studies of Falu Energi, Skövde Energi, Sysav, Vattenfall and Katarinfors recommended to evaluate amine technology as the most suitable (KKAB & Klimpo, 2023). Conversely, Nordkalk planned to utilize aqualung membrane technology (TRL 8), which requires less space and low capital, has a favourable energy balance and incurs lower operating cost (Aqualung, 2021; Nordkalk, 2023). The rest of the projects recommended further technical investigations (Allmyr et al., 2021). Projects were mainly concerned with energy efficiency, technical maturity and the ability to implement technology in existing plants (KKAB & Klimpo, 2023).

2.4 Assessment of transport and storage options

Transport and storage are critical components in the CCUS value chain, significantly influencing both overall project cost and economic feasibility. Distance to the port or storage hub, accessibility of different transportation modes and availability of sufficient infrastructure are the key factors considered in the feasibility studies (KKAB & Klimpo, 2023).[7] Our analysis indicates that, in Sweden, transport and storage cost accounts for approximately 30-45% of the total average cost of capturing one tonne of CO_2 in CCUS projects.

2.4.1 Land and water transport

For land transport, road, train and pipes are the most frequently discussed options.

- Road transport using trucks offers flexibility but raises concerns about emissions from diesel-powered truck fleets, which would negatively impact net carbon removals. Electrified truck fleets are emerging but remain limited in capacity (Allmyr et al., 2021). Moreover, because $CO_{2,}$ is by law categorized as a hazardous material, it cannot be transported through tunnels, requiring alternative routes (Allmyr et al., 2021).
- Electrified railroad transport, on the other hand, emits less and boasts widespread network, but currently available CO_2 wagons are built for a pressure of 15 bars and temperature of -25°C, which may require modification for port and storage demands (KKAB & Klimpo, 2023).
- Pipelines, therefore, are widely regarded as the most cost-effective option for large-scale movement; once they are constructed, they require significantly lower operational costs (Lindblom et al., 2024). However, they entail high capital investment, complex permitting processes and careful route consideration (Lindblom et al., 2024). Pipelines are built according to the form the CO_2 takes – liquid, gas or supercritical – each of which requires a different pressure and temperature range. Their feasibility is strongly linked to economies of scale and the development of shared infrastructure networks (KKAB & Klimpo, 2023).
- Shipping plays a vital role since most of the permanent storages are located in the North Sea (Lindblom et al., 2024). Since transporting CO_2 via the sea is new, a sufficient ship fleet to transport bulk CO_2 does not yet exist (DNV, 2025a).. Locating capture facilities in port vicinities offers a strategic advantage, as it enables the direct transport of CO_2 to permanent storage sites. In contrast, facilities situated further inland face higher logistical complexity and costs associated with additional transport requirements.

2.4.2 Interim and Permanent Storage

Storage is required on several occasions during CCUS processes, including in capture facilities and ports.

The size and type of interim storage depends on the daily capture rates and expected transport frequencies (KKAB & Klimpo, 2023). In the database, we found 17 port locations considered in different feasibility studies: Stockholm, Göteborg, Malmö and Gävle ports are situated in the most prominent locations. Västerås and Nörrköping are inland and provide easy access to Mälarenergi, E.ON and Teknisk verken. E.ON pointed out that cost savings can be achieved if the Nörrköping port is developed as a CO_2 hub with the involvement of other players as well (Corke et al., 2023). Some projects have their own ports – for instance, Preem in Lysekil port (Preem is also considering Göteborg as potential port) and Heidelberg in Slite. There are also plans to develop Göteborg and Malmö as CO_2 hubs. We found

7 CO_2 transportation is common in the food and beverages industry; however, CCUS requires comparatively higher resources for transportation (KKAB & Klimpo, 2023).

three projects for shared infrastructure, initiated by industry collaborations at Stockholm, Gothenburg and Malmö ports:

1. The feasibility study for the Stockholm project, project NICE, has been carried out in collaboration with Stockholm Exergi, Söderenrgi, Vattenfall, Heidelberg, Nordkalk and Plagazi. It is in the FID phase and is expected to facilitate and transport around 9 million tons of captured CO_2 per year (Boman et al., 2024).
2. The Gothenburg project, called CinfraCap, is initiated by Nordian Energi in collaboration with Gothenburg port, Preem, St1 and Renova (Jannasch et al., 2022). It is expected to store around 4 MT of CO_2 for onward transport. The current phase of this project (phase 3) will be completed in 2026 (Jannasch et al., 2022).
3. The third infrastructure project, CNetSS – Malmö CO_2 hub in Malmö, is a collaboration with Sysav, Copenhagen Malmö, E.ON, Nordian Energi and Uniper. It is expected to facilitate the transport of around 1.3 MT of captured CO_2 annually (Energimyndigheten, 2025b; Nordian Energi, 2022).

Around 20 permanent storage sites in the North Sea, including in Norway, Denmark, the UK and Iceland, are accessible to Sweden (Lockwood, 2023). Three projects are currently under construction: Northern Lights in Norway, NED in the UK and Greensand in Denmark. Most feasibility studies are targeting Northern Lights in Norway. Some feasibility studies consider onshore storage. Sweden is also exploring storage in the southern Baltic Sea (CNetSS project); however, the Helsinki Convention currently prevents this (Convention on the Protection of the Marine Environmnet of the Baltic Sea Area (Helsinki Convention), 1992).

3 Costs of CCUS

The cost of CCUS is a combination of capital expenditure (CAPEX), or investment costs to build the facility and infrastructure, and operational expenditure (OPEX), such as maintenance, transportation and storage fees. The unit cost can here be expressed as cost of CO_2 captured (total annualized cost of CCUS divided by captured CO_2) or cost of CO_2 avoided (total annualized cost of capture divided by captured CO_2 less emissions occurred during the process) (Barlow et al., 2025). Most of the feasibility studies use the cost of captured CO_2 since accurate emissions data to calculate the cost of avoided CO_2 is missing.

3.1 Capture cost

The choice of CCUS technology impacts energy requirements and CO_2 capture capacity and is therefore a key driver of both capital expenditure and operational costs (ZEP, 2011). In the database, we found several feasibility studies that compare two to three technologies on technical and cost analysis (Table 5).

Amines require an average CAPEX of around EUR 64–101 million and HPC requires around EUR 70–104 million. HPC is more capital-intensive technology since it requires more instruments and processes than amines do. For instance, HPC requires a compressor for the separation process of CO_2 which increases the CAPEX of the project (Baskaran et al., 2024). Ionic liquid technology requires a lower CAPEX of EUR 32–50 million. However, the TRL of the ionic liquids is between 4–5, i.e. development stages. As a result, the cost of this technology is more uncertain than other technologies (KKAB &

Klimpo, 2023). Another commonly considered technology is CAP, which by contrast, has the highest estimated CAPEX, ranging between EUR 103–183 million. This technology has a TRL of 6–7.

The main determinant of the OPEX is the energy requirements. Amines, especially Monoethanolamine (MEA) and HPC, require higher electricity than ionic liquids (Hekmatmehr et al., 2024).

In the dataset, the average cost of capture for HPC is around EUR 28–46 per tonne of CO_2 (tCO_2) while, for amines, it is between EUR 44–61/tCO_2. Even though HPC requires more electricity than amines, the operating cost of HPC is lower than that of amines, as HPC requires lower steam and generates more quality district heating during the process than amines do (Baskaran et al., 2024). Ionic liquids require lower energy consumption than other technologies and therefore incur lower OPEX at an average EUR 26–29/CO_2. Amine-based CCUS projects in the US incurred an average cost around EUR 50/CO_2, and ionic liquids cost around EUR 35/CO_2 (Hekmatmehr et al., 2024). However, some studies found that the operational cost for an amine-CCUS in South Korea is around EUR 35/CO_2 (Baskaran et al., 2024).

3.2 Transport and storage cost

3.2.1 Transport costs

Location, transport mode, carrying load and distance to permanent storage site are key drivers of cost. Given Sweden's well-developed railroad network, the Swedish projects mostly discussed railway transport. Costs are estimated at, on average, EUR 22–33/tCO_2. Road transportation with trucks is estimated at between EUR 13–26/tCO_2.

Shipping and pipeline transportation incur lower costs compared to trucks and trains because they operate at greater economies of scale(Friedmann et al., 2020; E. Smith et al., 2021). Shipping costs typically range between EUR 14–21/tCO_2 and pipelines cost around EUR 3–9/tCO_2. However, both are comparatively capital intensive and come with higher regulatory burdens (E. Smith et al., 2021). Some studies argue that truck and train transportation is suited for small-scale CCUS projects and that, for larger-scale implementation of CCUS, pipelines and shipping are essential (E. Smith et al., 2021). Global CCS institute's (GCCSI) transport cost report pointed out that onshore pipeline costs around EUR 1.5–5/tCO_2 while offshore pipeline costs around EUR 3.5–9.5/tCO_2 (ZEP, 2011). The IEA reports around EUR 1.7–11/tCO_2 for onshore pipeline (IEA, 2021). Further, shipping costs depend on the ships' transport capacity and distance, with costs ranging from EUR 11–16/tCO_2 (ZEP, 2011). To construct 1 kilometre of pipeline, EUR 1 million is needed. A designated CO_2 carrier vessel (7,500m^3) costs around EUR 50 million (Clarksons & CCSA, 2024).

3.2.2 Storage costs

Temporary storage requirements depend on the size of the facility, daily CO_2 capture rate and transport arrangements. Port handling fees for temporary storing and loading to the ships are additional costs. Temporary storages cost around EUR 4–6/tCO_2 in addition to requiring a capital expenditure in the range of EUR 3–5 million.

Most of the feasibility studies considered a reference price of EUR 11/tCO_2 as a port handling fee. Permanent storage costs range between EUR 20–50/tCO_2 for the projects in our dataset. Other studies found costs ranging from EUR 10–20/tCO_2 (IEA, 2021; ZEP, 2011); estimated storage costs around EUR 9–20/tCO_2 for US-based CCUS facilities (Baskaran et al., 2024).

3.3 Total cost of captured CO_2

Based on the available data of CCUS projects in Sweden, the average total cost of CCUS is around EUR 114–205/tCO_2. The lowest cost that was published was EUR 85/tCO_2 and the highest cost was EUR 300/tCO_2. The overall investment required is estimated to be around EUR 124–1300 million.

Many studies, industry reports and CCUS projects from other countries published comparable cost estimates. However, these costs vary substantially depending on the capture technology, the industrial sector, geological characteristics of the project location and other context-specific factors. As a result, CCUS projects display a wide range of cost outcomes (P. Smith et al., 2016).For Instance, the WBA reported that BECCS applied to combustion plant can range from EUR 74–244/tCO_2 whereas applications in bioethanol production, pulp mills, and other industries with high CO_2 concentrations can range from EUR 74-147 tCO_2 (IEA, 2021; WBA, 2024). A German study reported costs between EUR 70–150/tCO_2 for capturing CO_2 and transporting it via pipeline to offshore storage (CDRmare, 2023). DNV estimated costs in the range of EUR 85–255/tCO_2 for projects capturing CO_2 from low-concentrated sources, worst-case scenario (DNV, 2025b). Academic estimates range between EUR 127–297/tCO_2 (P. Smith et al., 2016). The cheapest CCUS project we found is the Moomba project in Australia. Given its location near an onshore storage site, the cost of carbon capture has been estimated to be as low as EUR 25/tCO_2 (Jacobs, 2024).

Cost estimates for BECCS vary widely, with Fuss et al. (2018) reporting a range of EUR 85-170CO_2 depending on the type of biomass, supply chain logistics and capture efficiency. Significant cost savings in BECCS systems can be achieved through integration with existing district heating networks and co-location with biomass-rich industrial clusters (Bui et al., 2018). Such synergies are particularly relevant in the Swedish context, where combined heat and power plants could host BECCS systems with minimal additional infrastructure. Zetterberg et al. (2021), for example, estimate BECCS costs in Sweden to be approximately EUR 90,9–118,18 per tonne, depending on site-specific conditions and access to transport infrastructure. However, Zhang et al. (2020) show that these costs can be significantly reduced through the use of indigenous biomass and co-location with district heating and combined heat and power plants. Their spatially explicit modelling highlights that leveraging domestic supply chains and strategically siting BECCS facilities can reduce capital and transport costs, thereby making national-scale deployment more feasible and cost effective. However, costs do not necessarily account for externalities such as land and water competition, which may significantly raise the effective social cost of deployment (Fuss et al., 2018). Fajardy and Dowell (2017) also caution that cost-based assessments may underestimate risks associated with resource inefficiency. In some configurations, BECCS systems could even result in net-positive emissions if upstream biomass supply and downstream energy losses are not carefully managed. They therefore recommend that costing models integrate full-life-cycle assessments to ensure climate efficacy.

4 Financing

Due to the high investment cost, high operational cost and uncertainty around the estimation (see Section 3), the financial viability of CCUS is oftentimes called into question (Honegger & Reiner, 2018; Singh et al., 2019). While policies and grants have been utilized (see Section 4.1), there remains a lack of consistent market-formation strategies (Kivimaa & Kern, 2016). A tangible market with predictable revenue streams and clearly defined assets, bankable contracts and obligations, and well-defined regulatory frameworks are key to developing favourable demand-side signals, build confidence and attract private investors into the CCUS industry (EU-CLIMA, 2025a).[8] This is consistent with transition studies that highlight that, without aligned policy, finance and infrastructure, emerging technologies struggle to overcome the “valley of death” (Markard et al., 2012). CCUS is no exception, requiring novel hybrid-governance mechanisms such as risk-sharing instruments, regulated offtake contracts and public guarantees to scale (Zetterberg et al., 2021). According to Nemet et al. (2018), financing CCUS requires a staged innovation system, combining early R&D funding, pilot demonstration grants and long-term offtake contracts. This approach mirrors historical support for renewables, whose cost has typically declined after sustained public support across TRLs.

Below, we first provide an overview of the public funding disbursed in Sweden, followed by insight into how private actors can support the financing of CCUS projects. We also detail how Stockholm Exergi has funded its installation.

4.1 Public funding

Sweden has established a supportive institutional framework for CCUS. The Swedish Energy Agency serves as the national centre for CCS, facilitating collaboration between industries and government authorities (Energimyndigheten, 2025c). It signed a bilateral agreement with Norway to enable the export of captured CO_2, addressing restrictions imposed by the London Protocol on transboundary CO_2 transport (Energimyndigheten, 2025c; Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 2009). It also signed a memorandum of understanding with Switzerland to investigate the possibility of trading negative emissions between two countries (Energimyndigheten, 2025c). Moreover, the possibility of implementing a net-zero-industry act to facilitate the injection capacity of CO_2 storage is being investigated (Energimyndigheten, 2025c).

Our analysis shows that Sweden has mobilized a significant volume of public funding to support the early-stage development of CCUS. In total, around EUR 2.4 billion has been granted to different projects, both through national and EU agencies:

- The Swedish Energy Agency has granted around EUR 2 billion for 88 CCUS initiatives through their Industry Leap program and reverse auction packages (Energimyndigheten, 2025b). In a reverse auction for CCUS or carbon removal, the government or a public agency offers to buy a certain volume of CO_2 reductions or removals, and interested suppliers (like BECCS operators or DACC companies) submit bids indicating the lowest price at which they are willing to deliver those reductions. The main state aid program has allocated EUR 3.22 billion via the reversed auction scheme to support BECCS projects especially. The program will cover the operational

8 An expert-group (which included experts from the EU, EIB, EIF and related industries) hosted by the EU’s Directorate-General for Climate Action discussed the potential for commercialization of CCUS and for unlocking affordable diverse financing options (EU-CLIMA, n.d., 2025a, 2025b).

cost of the CCUS projects for 15 years (Energimyndigheten, 2025c). The aid covers only biogenic CCS; biomass used in the process should be from sustainable sources; the capture capacity should be more than 50 000 tCO_2; and the project should be cost effective (Energimyndigheten, 2024), or between EUR 110–200/tCO_2 (Energimyndigheten, 2025c). Industry Leap is the other aid program offered through the energy agency; it supports research, feasibility studies and pilot and demonstration projects including CCUS (Energimyndigheten, 2025c).

- The Swedish Environmental Protection Agency granted around EUR 15 million for 2 CCUS projects through its Klimatklivet program. In total, it has awarded around EUR 1.7 billion for close to 27 500 projects related to CCUS, biochar and other CDRs (Naturvårdverket, 2025b).
- The EU Innovation Fund provided around EUR 433 million in grants to five Swedish CCUS projects.
- Other countries also allocate substantial funding to CCUS projects. Denmark, for example, allocated EUR 3.75 billion for a reverse auction scheme and has already granted around EUR 33 million (Energistyrelsen, 2024). EUDP, a Danish government agency, funded around EUR 43 million to CCUS projects in Denmark (EUDP, 2025). Norway allocated around EUR 240 million in 2024 for CCUS projects (CCUS Norway, 2024). Germany developed a EUR 5 billion grant scheme, of which it has already allocated EUR 2.8 billion (gasworld, 2025; Klimaschutz, 2024). The Netherlands allocated EUR 13 billion in 2022 for their SDE++ fund and have awarded around EUR 2.1 billion (IEA, 2022). Austria allocated around EUR 5 billion to RTI Pact to support research and development for climate projects, including CCUS (Carbon Gap, 2025). The UK allocated around EUR 28 billion in 2025 to CCUS projects (Department for Energy Security and Net Zero, 2025).

Despite these significant funding programs, a substantial financing gap remains. According to the dataset, research and development projects receive between 70–100% of their budgets as grants while feasibility studies and commercial-scale projects have been funded at a much lower level, covering only 8–64% of their total budgets (Energimyndigheten, 2025b). This leaves a gap of between 36–92%. Many argue that current policies remain primarily a technology push; they rely on CAPEX subsidies and research and development grants rather than on market pull mechanisms, which would create a stable demand for carbon removal (Olfe-Kräutlein et al., 2021; Von Stechow et al., 2011). Without demand-side policies, it remains difficult to attract long-term private financing and reach a proper commercialization stage (Oluleye & Ofori-Atta, 2025; Thielges et al., 2022).

4.2 Stimulating private investment

4.2.1 Guarantee facility

Guarantee facilities have been said to be essential for access to private debt financing (EU-CLIMA, 2025a). The EU has its InvestEU program, which provides a budget guarantee for its implementing partners, namely the European Investment Bank (EIB), and other national and international financial institutions. In turn, these institutions lend, invest or provide guarantees for the projects that do not have easy access to financing (EU, 2025c).

4.2.2 Revenue generation

Long-term CO_2 offtake agreements play a key role in ensuring stable revenue streams and providing access to affordable debt financing. Options include:

- Carbon credits. A carbon credit is a generic term for a tradable unit representing 1 tonne of CO_2e that has either been avoided (e.g. preventing deforestation), reduced (e.g. switching to renewables) or removed (e.g. through DACC or BECCS). They are a key tool in both voluntary and compliance-based carbon markets, such as the EU Emissions Trading System (EU - ETS) used to offset emissions or meet regulatory obligations. The EU-ETS is the world's largest carbon market and a cornerstone of the EU's climate policy. It aims to reduce greenhouse gas (GHG) emissions cost-effectively by putting a price on carbon through a cap-and-trade system. In a cap-and-trade system, regulators set an overall emissions cap and issue a corresponding number of allowances, each equal to one tonne of CO_2 equivalent (tCO_2e). Within the EU ETS, the supply of allowances declines annually and is projected to phase out by 2057(Rickels et al., 2020). At the end of each compliance period, firms must surrender allowances matching their verified emissions, with surplus allowances tradable and deficits requiring additional purchases (Rickels et al., 2020; The Monitoring and Reporting of Greenhouse Gas Emissions Pursuant to to Directive 2003/87/EC of the European Parliament and of the Council and Amending Commission Regulation (EU) No 601/2012, 2018). Article 12(3a) of the EU ETS Directive (Directive 2003/87/EC, amended 2009/29/EC) exempts captured and permanently stored CO_2 from surrender allowances. This incentive mainly applies to fossil fuel–based emissions, where CCS prevents additional CO_2 release. In contrast, CCS from biogenic sources, though capable of delivering net negative emissions, is not equally recognized (Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 Amending Directive 2003/87/EC so as to Improve and Extend the Greenhouse Gas Emission Allowance Trading Scheme of the Community (Text with EEA Relevance), 2009; Scheme for Greenhouse Gas Emission Allowance Trading within the Community and Amending Council Directive 96/61/EC, 2003). Höglund (2020) outlines concrete pathways for companies and individuals to fund negative emissions responsibly, emphasizing forward purchasing of removals, independent verification and long-term contracts to ensure permanence and additionality.
- Carbon removal certificate agreements with private companies. A carbon removal certificate represents the permanent removal of 1 tonne of CO_2 from the atmosphere, typically through engineered or nature-based CDR technologies. In addition to Stockholm Exergi (see Box 1), Söderenergi and Fabege have signed a letter of intent to sell their CDR to Fabege, securing a potential revenue stream beginning in 2030 (Söderenergi, 2025). A Swiss startup, Climeworks, raised over EUR 850 million in equity financing for its DACCS projects and entered into several CDR offtake agreements with SAP software solutions, NYK Line, British Airways, Tik Tok and TWO DRIFTERS Rum, proving the importance of industry collaboration (Climeworks, 2025). The EU Carbon Removal Certification Framework (CRCF) provides a voluntary certification system for permanent carbon removals (CDR) of atmospheric and biogenic CDR (The Geological Storage of Carbon Dioxide and Amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006, 2009).
- Tax incentives, such as the US Section 45Q tax credit, which provides USD 85/tonne for geologic storage and USD 60/tonne for CO_2 utilization (e.g. enhanced oil recovery). Developers can sell these credits to third parties (tax equity investors), creating upfront financing.

Fajardy et al. (2019) caution that public finance mechanisms for CDR certificates must be transparently linked to verified performance. Subsidies and procurement contracts should be conditional on stringent monitoring, reporting and verification (MRV) mechanisms to avoid rent-seeking and ensure cost effectiveness.

4.3 Recent developments

Given the importance of the market, several initiatives are under way, such as the integration of permanent and non-permanent CDR into the EU-ETS and development of the Industrial Decarbonization Bank and promoting carbon contracts for difference (CCfD). Increasingly, there are also roles available for new actors, such as insurance companies.

4.3.1 Integration of permanent and non-permanent CDR into the EU-ETS

The EU is currently exploring how to integrate CRCF-certified CDRs into the EU-ETS system (Blanchard, 2025). This will help to ensure the credibility and quality of CDR by avoiding greenwashing and providing verifiable removal (Carbon Market Watch, 2025). It will also facilitate investment by building confidence among investors (Makarchuk, 2025; Sultani et al., 2024). In addition, the EU is considering accounting for non-permanent CDR under EU-ETS. Unlike permanent CDR, non-permanent CDR such as carbon capture utilization needs to surrender its allowance. This under-incentivizes companies, such as waste incineration firms, to integrate CCU with CCS (Vermeulen et al., 2025).

4.3.2 The Industrial Decarbonization Bank and carbon contracts for difference

In February 2025, the EU introduced the Clean Industrial Deal to support competitiveness and resilience while accelerating the decarbonization of industries in Europe (EU, 2025a). It proposed an Industrial Decarbonization Bank (IDB), with funding of EUR 100 billion originating from the European Innovation Fund, EU-ETS revenue and a revision of Invest EU (EU, 2025a). The main financial instrument is the carbon contract for difference. CCfDs offer a guaranteed and stable revenue for investors. If the agreed price of the agreement is lower than the market carbon price, the government will pay out the difference. Conversely, if the agreed price is higher, the project has to pay back the difference to the government (Murfet, 2025; Richstein & Neuhoff, 2022). Investors will receive a guaranteed carbon price from this, and the investment will be de-risked (Richstein & Neuhoff, 2022). CCfDs could also reduce carbon prices and provide access to reasonable debt financing (Richstein & Neuhoff, 2022). Currently, a few European countries, including Germany (Climate Protection Agreement), Netherlands (SDE++), France (Contract for Difference), Denmark (CCUS Fund) and the UK (Industrial Carbon Capture Contracts) introduced CCfD-based CCUS support systems (Murfet, 2025).

4.3.3 Insurance companies

Insurance companies could also de-risk CCUS projects and provide access to affordable finance sources. The Global CCS Institute found that insurance firms could cover a variety of kinds of risk, including leakage, technological, political and regulatory, asset conditions and carbon price volatility (Smith, 2025). Leakage of captured CO_2 back to the atmosphere, for example, could lead to business interruption (Noussia et al., 2022). Coverage could reduce financial risk, thereby increasing investor confidence (Smith, 2025).

Several companies, including Ironshore, Marsh, Parhelion, Swiss Re and Zurich Insurance, have insured CCUS (IEAGHG, 2024). However, the main issue for these insurance providers is an availability of sufficient quantifiable data to estimate risks and losses (Noussia et al., 2022; Smith, 2025).

Box 1: An example – Stockholm Exergi

Stockholm Exergi is the first commercial scale BECCS facility that secured an FID, and it started construction in 2025. The expected total investment is around EUR 1.3 billion (Stockholm Exergi, 2025a). It is jointly owned by the City of Stockholm (50%) and Ankhiale (50%) (Stockholm Exergi, 2025a). It has around a 3000-km district heating system, which serves around 800 000 customers in Stockholm. In 2024, it reported a profit of EUR 45 million, before tax. It has a credit rating of BBB+ from S&P (Stockholm Exergi, 2025a). Since 2019, Stockholm Exergi has invested around EUR 3 million for their research and development and feasibility studies. They were granted around EUR 1.1 million through the Swedish Energy Agency (Energimyndigheten, 2025b).

To finance its BECCS installation, Stockholm Exergi is using a mix of public funding, a long-term offtake agreement and debt financing.

In terms of capital, they were awarded EUR 180 million from the EU Innovation Fund (Energimyndigheten, 2025b). The EIB granted them a loan of EUR 260 million, their first CCUS financing (EIB, 2025). The Nordic Investment Bank (NIB) granted them a 10-year loan of EUR 176 million (NIB, 2025). Furthermore, if its installation fulfils the requirements of their Green Bond Framework, they can utilize green bond financing (Stockholm Exergi, 2024). DC Advisory and ICECAPITAL elected financial advisors for Stockholm Exergi and recommended raising finance through a mix of bank loans and supranational loans (DC Advisory, 2025).

To cover OPEX, Stockholm Exergi has secured a reverse auction of over EUR 2 billion from the Swedish Energy Agency for 2028 to 2042 (Energimyndigheten, 2025b). It has also entered into an agreement with Microsoft and Frontier to sell permanent CDR certificates. They signed to deliver 5.8 million tons of captured CO_2 with Microsoft while with Frontier, they will deliver EUR 50 million worth of permanent CDR (Stockholm Exergi, 2025b).

This layered financing model, combining public funding, secured revenue streams from offtake agreements, and diverse debt instruments, allowed Stockholm Exergi to overcome initial bankability barriers. It also demonstrated that long term contractual agreements for carbon removals can create predictable cash flows, making the project more attractive to lenders and investors.

5 Conclusion

Sweden has made steady but gradual progress in developing CCUS as part of its broader decarbonization strategy. Since the first research initiatives in 2009, the country has funded at least 73 CCUS-related projects, ranging from early-stage research to feasibility studies and a limited number of commercial-scale developments. The most advanced project, Stockholm Exergi's BECCS facility, demonstrates that it is possible to achieve bankability through blended finance, combining public funding, long-term offtake agreements and supranational loans.

However, the overall pace of deployment remains slow due to technological, economic and market uncertainties. Only one project has reached a final investment decision (FID) and commenced construction; others are still in the planning, feasibility or early development phases. Higher operational and capital costs, limited infrastructure facilities, uncertain revenue models and weak market signals are a few of the key barriers in the CCUS industry. Utilization projects encounter greater challenges due to the immaturity of the utilization product market and lack of adequate recognition for non-permanent CDR.

Despite these challenges, CCUS will play a pivotal role in Sweden's path toward deep decarbonization, particularly for hard-to-abate sectors like energy, refineries and other industries (cement, iron and steel, pulp and paper). Sweden holds a unique advantage in bioenergy-based CCUS (BECCS) due to the country's strong renewable energy profile. By 2022, renewable energy accounted for 67% of Sweden's final energy consumption, with biomass contributing 60% of renewable energy production. This provides a robust foundation for BECCS projects, which can achieve negative emissions by capturing biogenic CO_2 from bioenergy and waste-to-energy plants. Shared infrastructure and clustering of projects significantly reduce transportation and storage costs. Enhanced risk-sharing mechanisms are essential to lower perceived project risks. This can be achieved through robust guarantee programs and insurance schemes. Government-backed guarantees are crucial for attracting private lenders to high-risk, uncertain sectors by sharing financial risks, thereby enabling access to lower-cost financing. In parallel, tailored insurance products for CCUS that covered leakage and operational and regulatory risks would make investments even safer. Standardizing such insurance solutions requires improved data collection from pilot projects to allow more accurate risk assessments and affordable coverage (Smith, 2025).

Targeted market policies are needed to support CO_2 utilization products. For example, the eSAF market remains immature, with many projects still economically unviable. Additionally, there is no established framework for identifying, measuring and accounting for non-permanent carbon dioxide removals generated by CCU projects. Policy reforms and market-focused studies are urgently needed to address these gaps, improve market readiness and identify emerging trends for CO_2 utilization products (Vermeulen et al., 2025).

Nevertheless, modelling by Rueda et al. (2021) shows that BECCS-heavy mitigation pathways expose countries to high cost volatility and technological lock-in. Cost-efficient and resilient pathways involve balancing BECCS with other CDR options such as DAC and afforestation. Therefore, Swedish climate strategy should maintain portfolio flexibility rather than focusing solely on large-scale BECCS deployment.

6 Tables and Figures

Region	Cancelled	Operational	Planned	Under construction	Total
Africa	1		5	1	**7**
South America		1	5		**6**
Europe	25	9	331	19	**384**
Middle East		3	17	4	**24**
North America	28	31	353	22	**434**
Asia Pacific	4	18	128	10	**160**
Unknown			2		**2**
Total	**58**	**62**	**841**	**56**	**1017**

Table 1. Database of IEA projects

Source: *IEA CCUS database*, 2025

Figure 2. Countries with CCUS projects

Source: *IEA CCUS database*, 2025

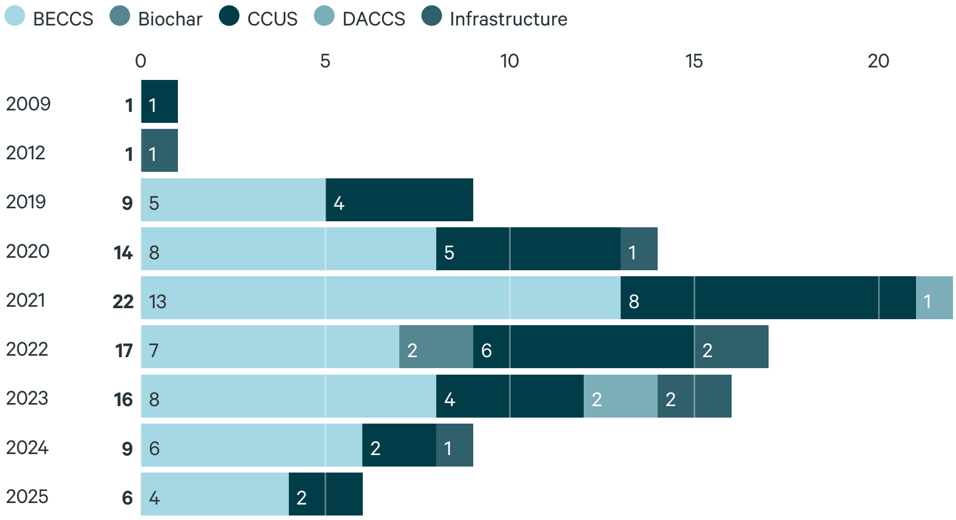


Figure 3. Number of projects initiated per year by type of technology

Source: *Energimyndigheten Projektdatabas*, 2025

Project Type	Number of Projects
Commercial	13
Feasibility Study	23
Research & Innovation	37

Table 2. Type of projects

Source: *Energimyndigheten Projektdatabas*, 2025

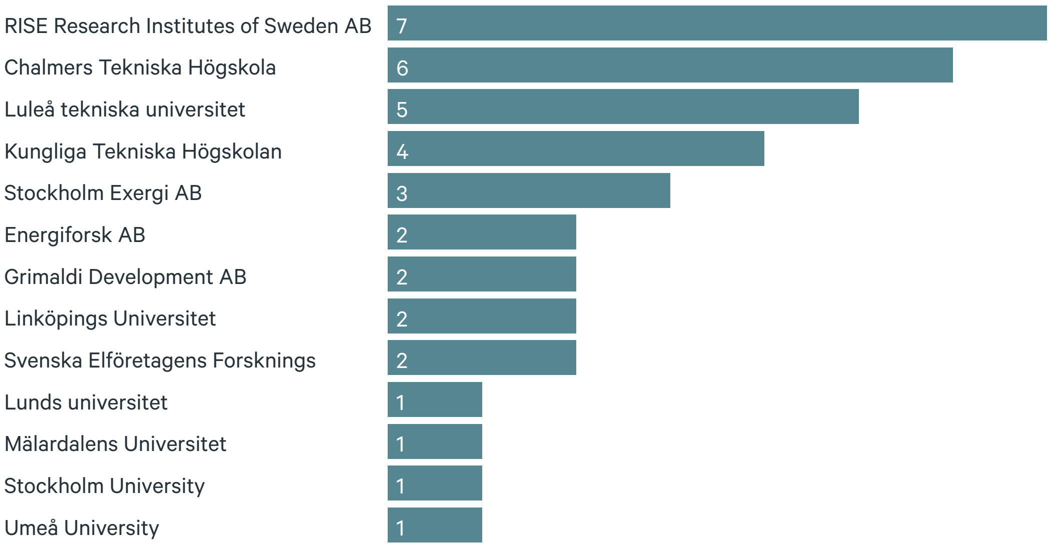


Figure 4. Research and innovation organizations

Source: *Energimyndigheten Projektdatabas*, 2025

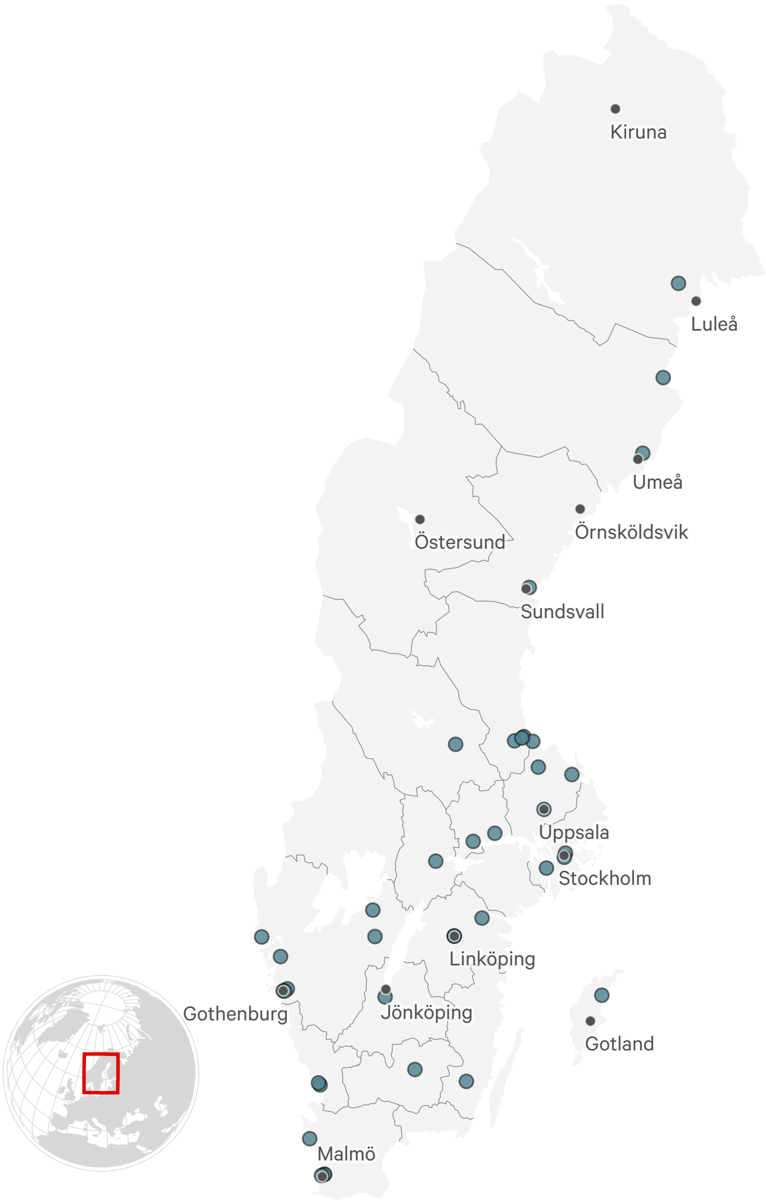


Figure 5. Locations

Source: *Energimyndigheten Projektdatabas*, 2025

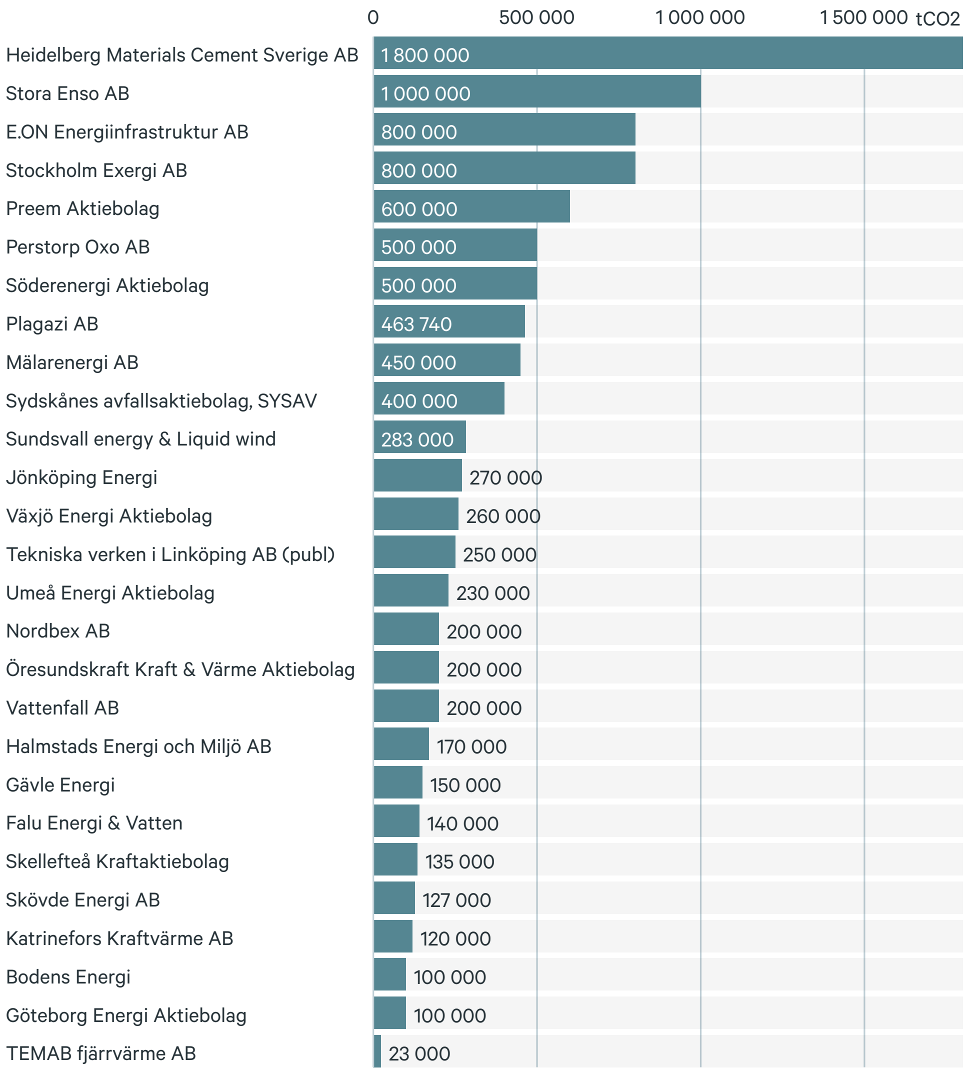


Figure 6. CO_2 capture capacities

Source: *Energimyndigheten Projektdatabas*, 2025

Figure 7. Project timelines

Source: *Energimyndigheten Projektdatabas*, 2025

Technology	Projects	TRL
Amine-based solvents	25	9
Hot potassium carbonate (HPC)	25	9
Chilled ammonia process (CAP)	11	6–7
Ionic liquids	2	4–5
Aqualung membrane	1	8–9

Table 3. Capture technologies

Source: *Energimyndigheten Projektdatabas*, 2025

	Port	Country	Projects
1	Göteborg	Sweden	7
2	Malmö	Sweden	5
3	Gävle	Sweden	5
4	Stockholm Norvik	Sweden	5
5	Nörrköping	Sweden	2
6	Narvik	Norway	1
7	Helsingborg	Sweden	1
8	Trondheim	Norway	1
9	Umeå	Sweden	1
10	Södertalje	Sweden	1
11	Västerås	Sweden	1
12	Halmstad	Sweden	1
13	Luleå	Sweden	1
14	Slite	Sweden	1
15	Lysekil	Sweden	1
16	Skellefteå	Sweden	1
17	Sundsvall	Sweden	1

Table 4. Connecting ports

Source: *Energimyndigheten Projektdatabas*, 2025

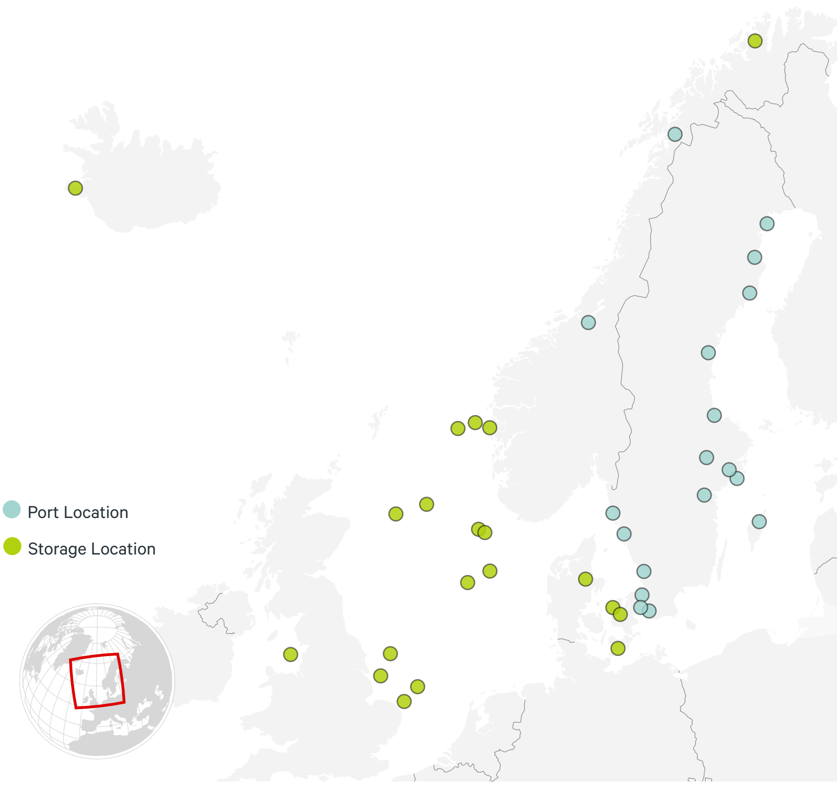


Figure 8. Storage locations and connection points

Source: (Clean Air Taskforce Database, [Europe Carbon Capture Project Map](#))

Technology	No. of projects	Average	Lowest	Highest
Amine-based solvents				
MEA	9	64,43-101,6	32.6	221
CESAR1	1	59	-	-
PSA/CRY	1	259	-	-
Hot potassium carbonate				
HPC FS	7	70,27-04.8	32	130
HPC ES	2	60-148,5	60	194
Ionic liquids	2	32,1-50	25.7	69.5
Chilled ammonia process	6	103-183,4	64	307
Overall		**65,9-133,6**	-	-

Table 5. Cost of capture – CAPEX (values are in million euros)

Technology	No. of projects	Average	Lowest	Highest
Amine-based solvents				
MEA	9	44,79 -61,79	15.5	85
CESAR1	1	50-78		
PSA/CRY	1	0	-	-
Hot potassium carbonate				
HPC FS	7	28,57-46,4	13	98.5
HPC ES	2	15-39	11	86
Ionic liquids	2	26,8-29	27	29.6
Chilled ammonia process	6	30-51	16	65
Overall		**32,5-50,9**	-	-

Table 6. Cost of capture – OPEX (values in EUR/tCO_2)

Category	Average	Lowest	Highest
Storage			
Temporary storage	4,1-6,28	3	10
Permanent storage	25	20	50
Port	11	0	0
Transport			
Truck	13-26	12	22
Train	22,5-33	7	65
Ship	14,2-21,6	7	55
Pipeline	3,7-9	1.5	15
Total transport cost	**51-64**	**33**	**77**

Table 7. Transport and storage cost (values in EUR/tCO_2)

Total cost of capture		
Average	€/tCO2	114.70 - 205.30
Lowest	€/tCO2	85
Highest	€/tCO2	300
Investment	MEUR	124 - 1300

Table 8. Total cost of capture

Source: *Energimyndigheten Projektdatabas (2025)*
Exchange rate, 1 EUR = 10 SEK

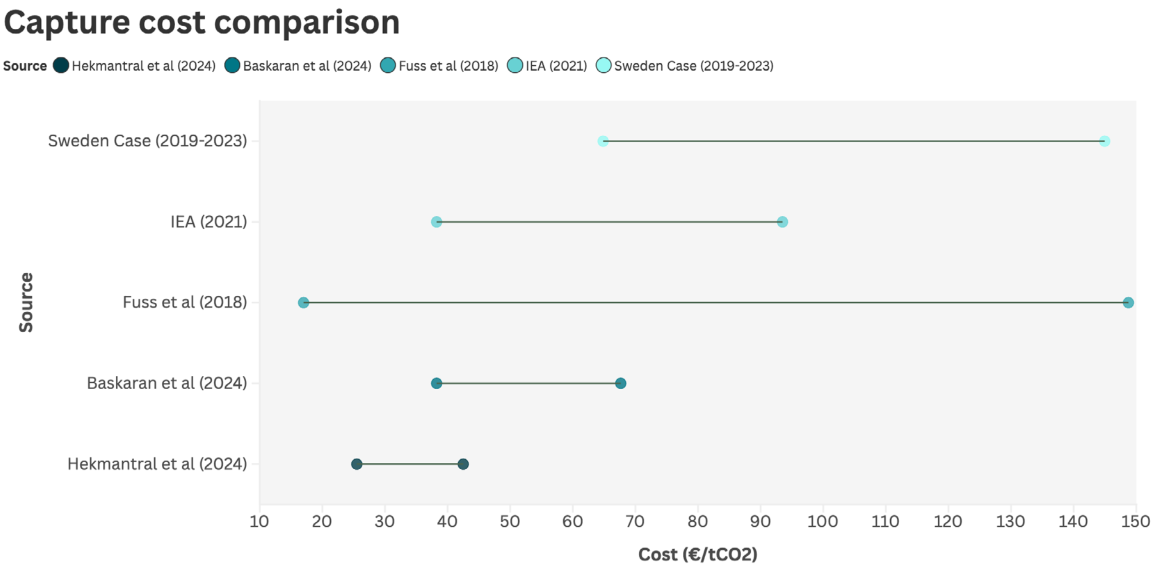


Figure 9. Capture cost comparison

Funder	Projects	Grant	Total project cost
Energy Agency	88	1,960,169,068	2,203,884,005
Innovation Fund	5	433,515,343	450,841,981
Klimatklivet	2	15,145,455	92,787,879
Total		**2,408,829,865**	**2,747,513,864**

Table 9. Financing through subsidies
(values in EUR, exchange rate EUR 1 = SEK 11)

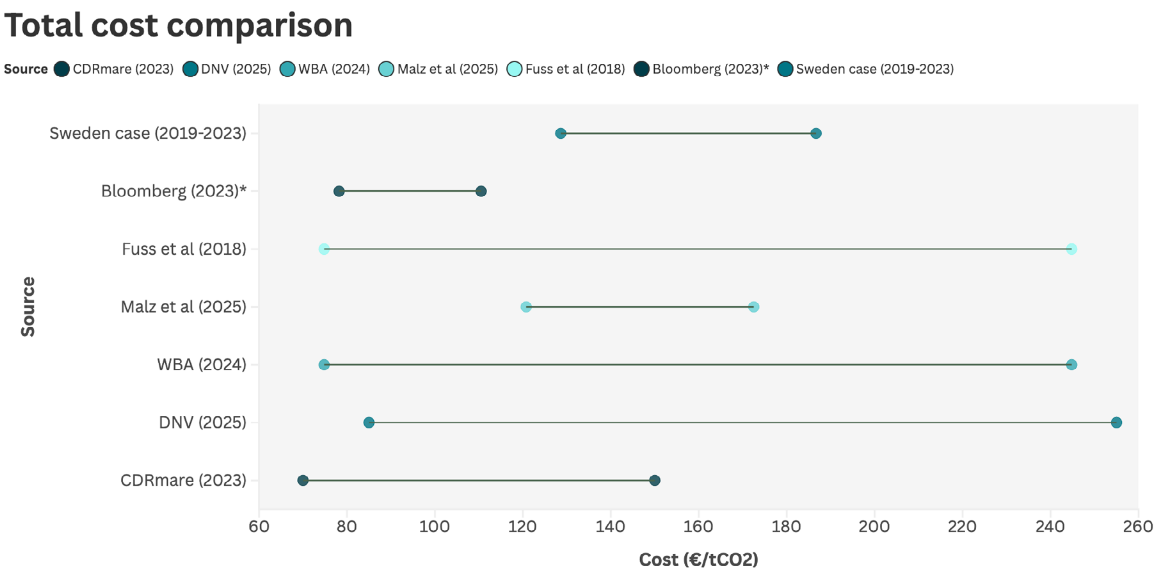
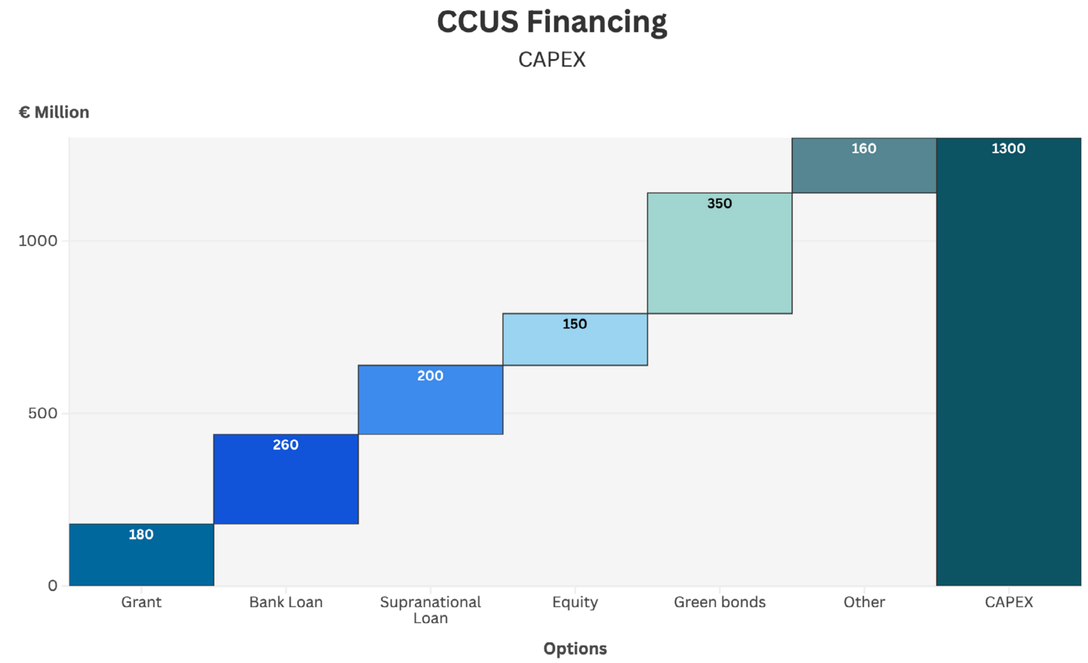
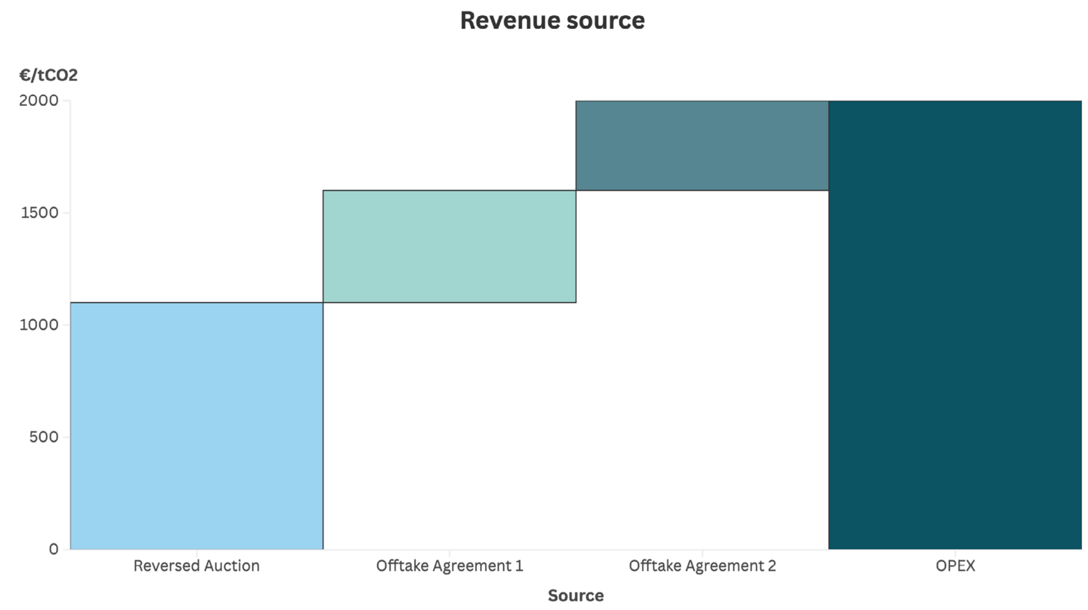


Figure 10. Total cost comparison

Source: *Energimyndigheten Projektdatabas (2025), Bloomberg (2023), Fuss et al. (2018), Malz et al. (2025), WBA (2024), DNV (2025), CDRmare (2023).*





*Bloomberg shows costs for CCS facilities near storage sites; for other sites, costs can be higher for 2 to 4 times.

Figure 11. Financing structure – Stockholm Exergi

Source: *Stockholm Exergi*, 2025, www.stockholmexergi.se.

Green bonds, other, revenue financing are hypothetical values used to demonstrate the chart.

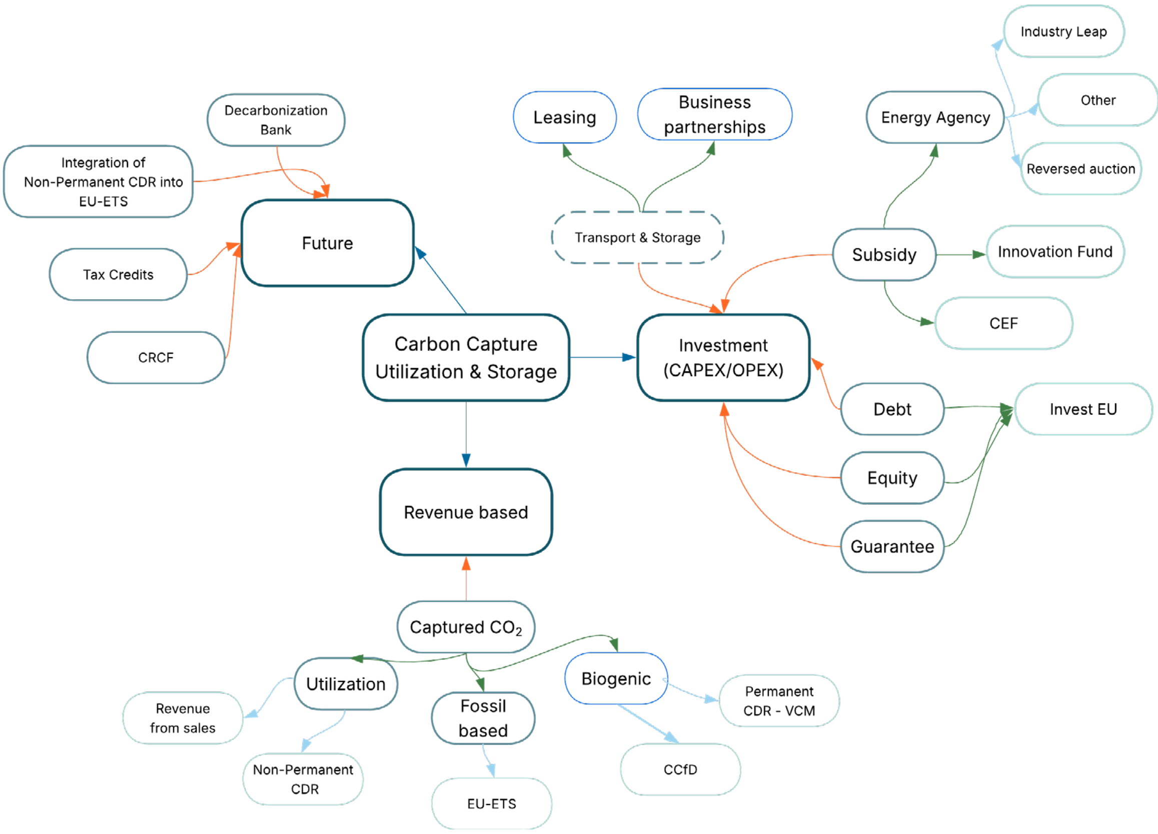


Figure 12. Summary of financing options

Source: *Energimyndigheten Projektdatabas*, 2025; EU-CLIMA, n.d., 2025a, 2025b

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Supplementary material

Appendix A: Project list

Company	Grant Amount	Grant Year	Grant category	Grant status	Location	Technology	Funded by	Grant %	Total Project cost	Other Source financed
	SEK								SEK	SEK
Chalmers Tekniska Högskola Aktiebolag	3,917,292	2019	Research & Innovation	Completed	Göteborg	BECCS	Energy Agency - Industriverket	39%	10,000,000.00	6,082,708.00
Chalmers Tekniska Högskola Aktiebolag	2,082,000	2020	Research & Innovation	Completed	Göteborg	BECCS	Energy Agency	66%	3,154,545.45	1,072,545.45
Chalmers Tekniska Högskola Aktiebolag	6,185,000	2021	Research & Innovation	Ongoing	Göteborg	DACCS	Energy Agency - Industriverket	69%	9,002,000.00	2,817,000.00
Chalmers Tekniska Högskola Aktiebolag	11,844,031	2021	Research & Innovation	Ongoing	Göteborg	CCUS	Energy Agency - Industriverket	100%	11,844,031.00	-
Chalmers Tekniska Högskola Aktiebolag	11,880,900	2022	Research & Innovation	Ongoing	Göteborg	Biochar	Energy Agency - Industriverket	85%	13,962,000.00	2,081,100.00
Chalmers Tekniska Högskola Aktiebolag	10,388,835	2023	Research & Innovation	Ongoing	Göteborg	DACCS	Energy Agency - Industriverket	74%	14,035,833.00	3,646,998.00
Energiforsk AB	1,812,000	2020	Research & Innovation	Completed	Stockholm	BECCS	Energy Agency - Industriverket	57%	3,178,947.37	1,366,947.37
Energiforsk AB	1,895,000	2021	Research & Innovation	Completed	Stockholm	BECCS	Energy Agency - Industriverket	70%	2,707,142.86	812,142.86
Grimaldi Development AB	7,090,000	2021	Research & Innovation	Completed	Nacka Strand	BECCS	Energy Agency	80%	8,862,500.00	1,772,500.00
Grimaldi Development AB	8,336,950	2024	Research & Innovation	Ongoing	Gärstad	BECCS	Energy Agency - Industriverket	53%	15,730,094.34	7,393,144.34
Kungliga Tekniska Högskolan	6,426,500	2020	Research & Innovation	Ongoing	Stockholm	BECCS	Energy Agency	90%	7,140,555.56	714,055.56
Kungliga Tekniska Högskolan	2,154,200	2021	Research & Innovation	Completed	Stockholm	BECCS	Energy Agency	88%	2,447,954.55	293,754.55
Kungliga Tekniska Högskolan	7,220,000	2022	Research & Innovation	Ongoing	Stockholm	BECCS	Energy Agency	91%	7,934,065.93	714,065.93
Kungliga Tekniska Högskolan	9,848,080	2024	Research & Innovation	Ongoing	Stockholm	BECCS	Energy Agency	92%	10,704,434.78	856,354.78
Linköpings Universitet	5,000,000	2021	Research & Innovation	Ongoing	Linköping	CCUS	Energy Agency - Industriverket	100%	5,000,000.00	-
Linköpings Universitet	830,728	2020	Research & Innovation	Completed	Linköping	CCUS	Energy Agency - Industriverket	100%	830,728.00	-
Luleå tekniska universitet	9,924,257	2020	Research & Innovation	Ongoing	Luleå	BECCS	Energy Agency - Industriverket	99%	10,024,502.02	100,245.02
Luleå tekniska universitet	5,600,000	2021	Research & Innovation	Ongoing	Luleå	CCUS	Energy Agency - Industriverket	90%	6,222,222.22	622,222.22
Luleå tekniska universitet	13,386,167	2023	Research & Innovation	Ongoing	Luleå	DACCS	Energy Agency - Industriverket	92%	14,550,181.52	1,164,014.52
Luleå tekniska universitet	8,828,497	2025	Research & Innovation	Ongoing	Luleå	BECCS	Energy Agency - Industriverket	98%	9,008,670.41	180,173.41
Luleå tekniska universitet	5,522,500	2020	Research & Innovation	Ongoing	Luleå	CCUS	Energy Agency - Industriverket	95%	5,813,157.89	290,657.89
Lunds universitet	6,201,784	2021	Research & Innovation	Ongoing	Lund	BECCS	Energy Agency - Industriverket	43%	14,422,753.49	8,220,969.49
Mälardalens Universitet	967,689	2019	Research & Innovation	Completed	Västerås	BECCS	Energy Agency	100%	967,689.00	-
RISE Research Institutes of Sweden AB	705,000	2019	Research & Innovation	Completed	Göteborg	CCUS	Energy Agency - Industriverket	100%	705,000.00	-
RISE Research Institutes of Sweden AB	2,709,127	2020	Research & Innovation	Completed	Göteborg	CCUS	Energy Agency	100%	2,709,127.00	-
RISE Research Institutes of Sweden AB	811,000	2020	Research & Innovation	Completed	Göteborg	BECCS	Energy Agency	82%	989,024.39	178,024.39
RISE Research Institutes of Sweden AB	2,962,270	2021	Research & Innovation	Completed	Göteborg	CCUS	Energy Agency - Industriverket	91%	3,255,241.76	292,971.76
RISE Research Institutes of Sweden AB	3,148,159	2023	Research & Innovation	Ongoing	Göteborg	BECCS	Energy Agency	100%	3,148,159.00	-
RISE Research Institutes of Sweden AB	7,605,491	2024	Research & Innovation	Ongoing	Göteborg	BECCS	Energy Agency - Industriverket	91%	8,357,682.42	752,191.42
RISE Research Institutes of Sweden AB	5,703,760	2021	Research & Innovation	Ongoing	Göteborg	CCUS	Energy Agency - Industriverket	69%	8,266,318.84	2,562,558.84
Stockholm Exergi AB	3,717,830	2020	Research & Innovation	Completed	Stockholm	BECCS	Energy Agency - Industriverket	32%	11,618,218.75	7,900,388.75
Stockholm Exergi AB	548,215	2023	Research & Innovation	Completed	Stockholm	BECCS	Energy Agency - Industriverket	36%	1,522,819.44	974,604.44
Stockholm Exergi AB	1,083,620	2024	Research & Innovation	Ongoing	Stockholm	BECCS	Energy Agency - Industriverket	25%	4,334,480.00	3,250,860.00
Stockholm University	9,975,000	2025	Research & Innovation	Ongoing	Stockholm	CCUS	Energy Agency - Industriverket	92%	10,842,391.30	867,391.30
Svenska Elföretagens Forsknings	2,000,000	2009	Research & Innovation	Completed	Stockholm	CCUS	Energy Agency	40%	5,000,000.00	3,000,000.00
Svenska Elföretagens Forsknings	1,880,000	2012	Research & Innovation	Completed	Stockholm	Infrastructure	Energy Agency	40%	4,700,000.00	2,820,000.00
Umeå University	7,725,265	2022	Research & Innovation	Ongoing	Umeå	BECCS	Energy Agency - Industriverket	74%	10,439,547.30	2,714,282.30

Company	Project	Grant Amount	Grant Year	Grant category	Grant status	Location	Technology	Industry	Expected CO_2 reduction	Funded by	Grant %	Total Project cost	Other Source financed
		SEK							t/CO_2			SEK	SEK
Bodens Energi		997,800	2021	Commercial	Completed	Boden	BECCS	Waste to energy	100000	Energy Agency	50%	1,995,600.00	997,800.00
E.ON Energiinfrastruktur AB		575,000	2022	Feasibility Study	Completed	Åby	BECCS	Waste to energy	800000	Energy Agency	50%	1,150,000.00	575,000.00
E.ON Energiinfrastruktur AB		835,000	2022	Feasibility Study	Completed	Malmö	BECCS	Bio-energy	800000	Energy Agency	50%	1,670,000.00	835,000.00
Falu Energi & Vatten	Smarter Falun	2,486,500	2022	Feasibility Study	Completed	Falun	BECCS	Waste to energy	140000	Energy Agency	50%	4,973,000.00	2,486,500.00
Future Eco North Sweden AB		11,197,973	2022	Feasibility Study	Ongoing	Harads	Biochar	Academia / Other		Energy Agency	70%	15,997,104.29	4,799,131.29
Gävle Energi & Billrud		9,200,000	2024	Feasibility Study	Ongoing	Gävle	BECCS	Bio-energy	150000	Energy Agency - Industriverket	50%	18,400,000.00	9,200,000.00
Gävle Energi		2,755,819	2022	Feasibility Study	Completed	Gävle Hamn	CCUS	Bio-energy		Energy Agency	50%	5,511,638.00	2,755,819.00
Göteborg Energi Aktiebolag	CinFraCap	11,222,000	2023	Commercial	Ongoing	Göteborg	Infrastructure	Bio-energy	100000	Energy Agency - Industriverket	40%	28,055,000.00	16,833,000.00
Halmstads Energi och Miljö AB		3,850,000	2023	Feasibility Study	Completed	Halmstad	BECCS	Bio-energy	170000	Energy Agency	50%	7,700,000.00	3,850,000.00
Heidelberg Materials Cement Sverige AB	Slite	12,666,747	2021	Feasibility Study	Completed	Gotland	CCUS	Cement & Concrete		Energy Agency	50%	25,333,494.00	12,666,747.00
Heidelberg Materials Cement Sverige AB	Slite	51,682,850	2022	Feasibility Study	Completed	Gotland	CCUS	Cement & Concrete		Energy Agency	50%	103,365,700.00	51,682,850.00
Heidelberg Materials Cement Sverige AB	Slite	238,234,896	2024	Commercial	Ongoing	Gotland	CCUS	Cement & Concrete	1800000	Energy Agency	50%	476,469,792.00	238,234,896.00
Jönköping Energi		2,911,500	2022	Feasibility Study	Completed	Jönköping	BECCS	Waste to energy	270000	Energy Agency - Industriverket	50%	5,823,000.00	2,911,500.00
Katrinefors Kraftvärme AB		1,554,500	2021	Feasibility Study	Completed	Mariestad	BECCS	Waste to energy	120000	Energy Agency	50%	3,109,000.00	1,554,500.00
Mälarenergi AB		447,500	2020	Feasibility Study	Completed	Västerås	BECCS	Waste to energy	450000	Energy Agency	50%	895,000.00	447,500.00
Nordbex AB		-	2023	Feasibility Study	Ongoing	Nybro	BECCS	Bio-energy	200000	Other			
Nordion Energi AB	CinFraCap	2,700,000	2022	Feasibility Study	Completed	Göteborg	Infrastructure	CO2 Transport / Storage	2000000	Energy Agency - Industriverket	50%	5,400,000.00	2,700,000.00
Nordion Energi AB	CNetSS	5,296,667	2024	Commercial	Ongoing	Göteborg	Infrastructure	CO2 Transport / Storage		Energy Agency - Industriverket	50%	10,593,334.00	5,296,667.00
Nordkalk AB	eLIMEnate	18,046,443	2023	Commercial	Ongoing	Köping	CCUS	Mineral	25%	Energy Agency - Industriverket	25%	72,185,772.00	54,139,329.00
Öresundskraft Kraft & Värme Aktiebolag	HICAS	2,773,152	2021	Feasibility Study	Completed	Helsinborg	BECCS	Waste to energy	200000	Energy Agency - Industriverket	49%	5,659,493.88	2,886,341.88
Öresundskraft Kraft & Värme Aktiebolag	HICAS	2,790,731	2022	Feasibility Study	Completed	Helsinborg	BECCS	Waste to energy	200000	Energy Agency - Industriverket	25%	11,162,924.00	8,372,193.00
Öresundskraft Kraft & Värme Aktiebolag	HICAS	33,613,937	2023	Commercial	Ongoing	Helsinborg	BECCS	Waste to energy	200000	Energy Agency - Industriverket	48%	70,029,035.42	36,415,098.42
Öresundskraft Kraft & Värme Aktiebolag	INNOZHERO	595,168,772	2025	Commercial	Ongoing	Helsinborg	BECCS	Waste to energy	200000	Innovation Fund	100%	595,168,772.00	-
Öresundskraft Kraft & Värme Aktiebolag	INNOZHERO	228,389,947	2025	Commercial	Ongoing	Helsinborg	BECCS	Waste to energy	200000	Energy Agency - Industriverket	8%	2,854,874,337.50	2,031,315,618.50
Perstorp Oxo AB		3,000,000	2019	Feasibility Study	Completed	Stenungsund	CCUS	Ethanol		Energy Agency	50%	6,000,000.00	3,000,000.00
Perstorp Oxo AB		1,852,000	2020	Feasibility Study	Completed	Stenungsund	CCUS	Ethanol		Energy Agency	50%	3,704,000.00	1,852,000.00
Perstorp Oxo AB	Project Air	294,990,955	2022	Commercial	Ongoing	Stenungsund	CCUS	Ethanol	500000	Energy Agency	19%	1,552,583,973.68	-
Perstorp Oxo AB	Project Air	1,067,000,000	2023	Commercial	Ongoing	Stenungsund	CCUS	Ethanol		Innovation Fund	69%	1,552,583,973.68	190,593,018.68
Plagazi AB		324,500,000	2024	Commercial	Ongoing	Gävle	CCUS	Hydrogen	463740	Innovation Fund	100%	324,500,000.00	-
Preem Aktiebolag		7,748,000	2019	Commercial	Completed	Lysekil	CCUS	Hydrogen / Ammonia	600000	Energy Agency	55%	14,087,272.73	6,339,272.73
Preem Aktiebolag	CinFraCap	1,231,498	2020	Feasibility Study	Completed	Göteborg	Infrastructure	CO2 Transport / Storage		Energy Agency - Industriverket	50%	2,462,996.00	1,231,498.00
Skellefteå Kraft		7,950,000	2,021	Feasibility Study	Completed	Skelleftea	BECCS	Waste to energy	135000	Energy Agency - Industriverket	50%	15,900,000.00	7,950,000.00
Skövde Energi AB		2,278,000	2,021	Feasibility Study	Completed	Skövde	BECCS	Waste to energy		Energy Agency - Industriverket	50%	4,556,000.00	2,278,000.00
Söderenergi Aktiebolag		788,800	2,020	Feasibility Study	Completed	Igelsta	BECCS	Waste to energy		Energy Agency - Industriverket	64%	1,232,500.00	443,700.00
Söderenergi Aktiebolag		2,518,500	2,021	Feasibility Study	Completed	Igelsta	BECCS	Waste to energy		Energy Agency - Industriverket	50%	5,037,000.00	2,518,500.00
Söderenergi Aktiebolag		12,352,401	2,023	Feasibility Study	Completed	Igelsta	BECCS	Waste to energy		Energy Agency - Industriverket	50%	24,704,802.00	12,352,401.00
Söderenergi Aktiebolag		74,650,650	2,024	Commercial	Ongoing	Igelsta	BECCS	Waste to energy	500000	Energy Agency	50%	149,301,300.00	74,650,650.00
Stockholm Exergi AB		1,914,200	2,019	Feasibility Study	Completed	Stockholm	BECCS	Bio-energy		Energy Agency - Industriverket	50%	3,828,400.00	1,914,200.00
Stockholm Exergi AB		4,345,000	2,019	Feasibility Study	Completed	Stockholm	BECCS	Bio-energy		Energy Agency - Industriverket	51%	8,519,607.84	4,174,607.84
Stockholm Exergi AB		1,980,000,000	2,021	Feasibility Study	Ongoing	Stockholm	BECCS	Bio-energy	800000	Innovation Fund	100%	1,980,000,000.00	-
Stockholm Exergi AB		20,275,000,000	2,025	Commercial	Ongoing	Stockholm	BECCS	Bio-energy	800000	Energy Agency	100%	20,275,000,000.00	-
Stockholm hamn AB	NICE	3,220,000	2,023	Feasibility Study	Completed	Stockholm	Infrastructure	CO2 Transport / Storage		Energy Agency - Industriverket	34%	9,470,588.24	6,250,588.24
Stora Enso AB		900,000	2,019	Feasibility Study	Completed	Skutskär	CCUS	Pulp & Paper		Energy Agency - Industriverket	50%	1,800,000.00	900,000.00
Stora Enso AB		354,856	2,020	Feasibility Study	Completed	Skutskär	CCUS	Pulp & Paper	1000000	Energy Agency - Industriverket	50%	709,712.00	354,856.00
Sundsvall energy & Liquid wind	Project Pheonix	962,761	2,021	Feasibility Study	Completed	Sundsvall	CCUS	Bio-energy	283000	Energy Agency - Industriverket	72%	1,337,168.06	374,407.06
Sydskånes avfallsaktiebolag, SYSAV		972,500	2,021	Feasibility Study	Completed	Malmö	CCUS	Waste to energy		Energy Agency	67%	1,451,492.54	478,992.54
Sydskånes avfallsaktiebolag, SYSAV	Skyzero	11,447,601	2,022	Commercial	Ongoing	Malmö	CCUS	Waste to energy	400000	Energy Agency	50%	22,895,202.00	11,447,601.00
Sydskånes avfallsaktiebolag, SYSAV		28,440,000	2,025	Commercial	Ongoing	Malmö	CCUS	Waste to energy	400000	Energy Agency	50%	56,880,000.00	28,440,000.00
Tekniska verken i Linköping AB (publ)		21,600,000	2,022	Commercial	Ongoing	Linköping	CCUS	Waste to energy		Klimatklivet	40%	54,000,000.00	32,400,000.00
Tekniska verken i Linköping AB (publ)		2,775,000	2,023	Feasibility Study	Ongoing	Linköping	CCUS	Waste to energy	13000	Energy Agency	50%	5,550,000.00	2,775,000.00
TEMAB fjärrvärme AB		2,251,500	2,023	Feasibility Study	Completed	Tierp	BECCS	Bio-energy	23000	Energy Agency - Industriverket	50%	4,503,000.00	2,251,500.00
Umeå Energi Aktiebolag		2,707,381	2,021	Feasibility Study	Completed	Umeå	BECCS	Bio-energy	230000	Energy Agency	50%	5,414,762.00	2,707,381.00
Vattenfall AB		1,050,500	2,019	Feasibility Study	Completed	Uppsala	BECCS	Waste to energy	200000	Energy Agency - Industriverket	63%	1,667,460.32	616,960.32
Vattenfall AB		145,000,000	2,022	Commercial	Ongoing	Forsmark	CCUS	Bio-energy		Klimatklivet	15%	966,666,666.67	821,666,666.67
Vattenfall AB - Hyskies	Hyskies	802,000,000	2,023	Commercial	On Hold	Forsmark	CCUS	Bio-energy	2700000	Innovation Fund	100%	802,000,000.00	-
Växjö Energi Aktiebolag	POSCLIMB	3,623,400	2,021	Feasibility Study	Completed	Växjö	BECCS	Bio-energy		Energy Agency - Industriverket	50%	7,246,800.00	3,623,400.00
Växjö Energi Aktiebolag	CNetSS	2,434,662	2,022	Feasibility Study	Completed	Växjö	Infrastructure	CO2 Transport / Storage		Energy Agency - Industriverket	50%	4,869,324.00	2,434,662.00
Växjö Energi Aktiebolag	POSCLIMB	6,276,900	2,023	Feasibility Study	Ongoing	Växjö	BECCS	Bio-energy	260000	Energy Agency	50%	12,553,800.00	6,276,900.00

NET ZERO CITIES
SGA2-NZC

Appendix B: Permanent storage locations

	Project ▲	Type	Country	Capacity (tCO2/annum)	Status
1	Acorn storage	Offshore	UK	10,000,000	In development
2	Bifrost	Offshore	Denmark	3,000,000	In development
3	Carbfix Coda Terminal	Onshore	Iceland	3,000,000	In development
4	Havstjerne Storage	Offshore	Norway	7,000,000	In development
5	Hewett Storage	Offshore	UK	20,000,000	In development
6	Luna	Offshore	Norway	5,000,000	In Development
7	Norne (Project Fyrkat)	Onshore	Denmark	8,000,000	In development
8	Norne (Project Trelleborg)	Onshore	Denmark	10,000,000	In development
9	Northern Endurance Partnership	Offshore	UK	27,000,000	Under construction
10	Northern Lights	Offshore	Norway	5,000,000	Under Construction
11	Orion	Onshore	UK	6,000,000	In development
12	Polaris Carbon Storage	Offshore	Norway	6,000,000	In development
13	Poseidon Storage	Offshore	Norway	5,000,000	In development
14	Project Greensand	Offshore	Denmark	8,000,000	Under construction
15	Ruby Storage	Onshore	Denmark	7,500,000	In development
16	Smeaheia	Offshore	Norway	10,000,000	In development
17	Spirit Energy	Offshore	UK	25,000,000	In development
18	Stenlille	Onshore	Denmark	500	In development
19	Trudvang Storage	Offshore	Norway	9,000,000	In development

Source: *Clean Air Task Force*, 2025