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Independent Project Assurance with Stockholm Exergi: A Case Study

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Executive summary: from ambition to action

In March, 2025, the Stockholm Exergi bioenergy with carbon capture and storage (BECCS) project crossed a threshold that only a handful of carbon dioxide removal (CDR) projects have ever reached: a final investment decision (FID) backed by public subsidy and private offtake commitments. What was an ambitious concept is now an active construction project, with a target to begin capturing carbon dioxide (CO₂) by late 2028.

Getting there required more than good engineering and climate ambition. It required building trust between a Swedish district heating utility building a first-of-a-kind (FOAK) carbon project at a scale the world has never seen (Stockholm Exergi) and a global technology company counting on the outcome (Microsoft), supported by an independent project assurance advisor with a mandate to ask hard questions and propose actionable solutions (Carbon Direct).

This is the story of that collaboration.

Key takeaways

- **A landmark for CDR at scale:** The Stockholm Exergi BECCS project achieved its FID in March 2025. Designed to capture approximately 800,000 tonnes of biogenic CO₂ per year, it is one of the largest planned BECCS facilities globally.
- **Independent project assurance builds buyer confidence:** Carbon Direct served as Microsoft's independent technical advisor from March 2022 through mid-2025, and provided project assurance services. This work enabled Microsoft to commit as the project's anchor offtaker of 500,000 net tonnes of CDR credits per year.
- **Collaboration, not just oversight:** The engagement spanned technical de-risking, organizational development, and regulatory navigation. This collaboration demonstrated that the relationship between buyer, advisor, and developer can be a genuine partnership.
- **A replicable model for the CDR industry:** The layered project assurance approach—combining third-party engineering evaluation, independent benchmarking, and buyer-focused advisory—provides a robust model for advancing large CDR projects.

The project at a glance

Stockholm Exergi, jointly owned by the City of Stockholm and Ankiale (a consortium of pension funds), provides heat to roughly 800,000 residents and operates the world's largest biomass-fired combined heat and power plant at Värtan in central Stockholm. The project plans to retrofit the plant with carbon capture and sequestration (CCS) technology. This will involve bolting a carbon capture system onto the existing facility, using the hot potassium carbonate (HPC) capture process. This process has been used in industry for decades but has never been applied to biomass flue gas at this scale. Once captured, the CO₂ will be liquefied on-site and shipped to Northern Lights' storage hub in Norway for permanent geological storage beneath the North Sea.



Figure 1. Rendering of the carbon capture plant and loading dock at the Värtan site. Source: Stockholm Exergi.

HPC is a proven technology, and the energy efficiency of the project's design is exceptional. HPC's operating temperatures are well aligned with district heating needs, so heat generated during the carbon capture process feeds directly back into Stockholm's heating network and is not wasted. However, the technology has only been tested on flue gas at a small scale. The pilot project at the Värtan site validated the core process at a scale of roughly 1.5 tonnes of CO₂ per day. Scaling to full commercial operation (approximately 3,000 times larger than the pilot) is an enormous engineering challenge.

Microsoft, drawing on technical advice from Carbon Direct, initially committed as the anchor offtaker for 3.33 million tonnes over 10 years. At the time, this was the world's largest permanent CDR deal. Microsoft re-engaged Carbon Direct in December 2023 to provide independent project assurance through FID and into early construction. Based partly on Microsoft's initial commitment, the Swedish Energy Agency (SEA) awarded over kr20 billion (approximately US\$2.2 billion) in subsidies for the project, through its first reverse auction for biogenic CCS in January 2025. In May

2025, the agreement with Microsoft was expanded to more than 5 million tonnes, or approximately 500,000 net tonnes per year, a powerful vote of confidence following FID.

"Microsoft's extended commitment in 2025 was the final piece of the FID puzzle. Reaching the FID for Beccs Stockholm, after more than 400,000 engineering hours of preparatory work, marked a historic landmark for Stockholm Exergi."

—Erik Rylander, Commercial Director CDR, Stockholm Exergi

Why independent project assurance matters

Project assurance is a structured discipline developed for capital-intensive industries such as nuclear power and heavy infrastructure, where the cost of a failed investment can run into the billions. The premise is straightforward: any team deeply invested in building something will, inevitably, develop blind spots because the people closest to a project unconsciously normalize the risks that they are diligently working to manage. An independent project assurance advisor exists to provide a view from outside: one that is technically credible enough to challenge engineering assumptions, but commercially aware enough to translate those challenges into terms a buyer or board can act on. Although project assurance is standard practice in major infrastructure projects, it is a new discipline as applied to industrial CDR projects.

The Stockholm Exergi engagement was a test of whether the discipline could be adapted to this new asset class and clarified how it should be adapted to be genuinely useful. A 500,000-tonne annual offtake commitment is a very material financial and reputational bet on infrastructure that does not yet exist. Microsoft retained Carbon Direct as an independent, technically expert set of eyes to scan for risks the Stockholm Exergi team might be too close to the project to see and to translate complex engineering realities into language that business decision-makers could act on.

Over 18 months, the Carbon Direct team attended benchmarking interviews, conducted site visits, and delivered plain-language quarterly reports that translated interwoven technical, economic, commercial, organizational, and political risks into actionable insights for Microsoft. The work was collaborative and built on a structured dialogue between advisor, buyer, and developer that was aimed at maximizing the project's value—ultimately adding benefits beyond just reaching FID.

"Carbon Direct's assurance work built on their thorough, prior derisking and gave us a time-series sense of how Exergi was retiring development risk. That analysis underpinned our decision to step up from 325,000 tonnes/year to 500,000 tonnes/year."

—Phil Goodman, Carbon Removal Portfolio Director, Microsoft

Proving the technology

Carbon Direct's first task was to pressure test the project's technology choice. Stockholm Exergi selected the HPC capture technology in 2018 after engaging with 34 different technology suppliers. Carbon Direct independently reviewed the scoring methodology Stockholm Exergi used for selection, to ensure the decision was sound and to bring fresh perspective to a decision the team had been developing upon for several years.

Carbon Direct concluded that HPC was the right choice. However, as with any FOAK application, the path from validated chemical process to industrial-scale operation requires careful engineering. Exergi commissioned a technology pilot, which confirmed the feasibility of the core process with a series of experiments between 2019 and 2023. Scaling from the original lab-scale demonstrator to full commercial operation (by a factor of roughly 3,000) introduced all kinds of design challenges. These challenges included adapting equipment to handle biomass flue gas at volumes never previously attempted, meeting stringent CO₂ purity specifications for permanent geological storage, and ensuring that performance observed at pilot scale translates reliably to the full-scale plant.

Carbon Direct worked closely with Exergi to pressure-test how pilot data informed engineering decisions, identify where additional conservatism or refinements may be needed, and understand whether appropriate mitigations were in place to avoid scale-up risks—all of which strengthened the project's technical foundation ahead of FID.

Carbon Direct also facilitated a valuable connection by introducing Stockholm Exergi to the Boundary Dam CCS project team in Canada—the world's first commercial-scale, post-combustion CCS facility—for a frank discussion of operational lessons learned from the Boundary Dam project.

This exchange prompted rigorous internal review of the gas clean-up design for Stockholm Exergi, with the project team evaluating additional particulate control measures informed by Boundary Dam's operational experience. This kind of cross-project learning is rare in the world of CCS, considering the limited years of commercial post-combustion operation. The exchange underscored the value of looking beyond individual project boundaries. A key factor here was Stockholm Exergi's openness to the involvement of an independent project assurance provider who brings a broad awareness of industry trends and lessons learned, and whose job is to broker important conversations.

A core function of independent project assurance is not to second-guess a developer's conclusions, but to test whether the process that produced them was rigorous and to bring an awareness of lessons from comparable projects that the developer's team may not have otherwise had considered.

Building delivery capability

A second function of assurance is asking not just whether the technology works, but whether the team assembled to advance that technology has the right organizational capabilities to deliver a project of the planned scale and complexity. These are very different questions, and developers building a FOAK facility are often better equipped to answer the first than the second.

Stockholm Exergi is one of Europe's leading district energy companies, providing heat to about 800,000 residents and operating one of the world's largest biomass-fired combined heat and power plants. That track record of operational excellence and public service is precisely what makes the BECCS project credible. But delivering a FOAK capture facility at this scale demands a different set of project management skills, those that are required for megaproject construction. Carbon Direct identified this gap early in the engagement, recommending that Stockholm Exergi

complement its deep technical expertise with dedicated capabilities in complex project management.

In May 2024, Stockholm Exergi engaged a dedicated project management office that brought the appropriate megaproject practices to bear: structured work packages, formal cost reporting, and risk register management fit for an international contractor base. As with all teams that must rapidly grow their organizational capacity, there were challenges with integration, but the trajectory and outcome was unmistakably positive. By FID, the project had restructured from an engineering design model to an execution-focused structure across multiple construction lots.

Carbon Direct's role was to flag integration gaps early and track their resolution, while acknowledging that Exergi's on-site staff and its new project management partners were always the best informed stakeholders. This is a crucial distinction: the advisor supports the project's success by making risks visible, not by micromanaging the response. This approach gave Stockholm Exergi space to build its own capabilities and maintained Microsoft's confidence in the project through providing transparency and high-level situational awareness.

The value of layered assurance

A cornerstone of the engagement was Carbon Direct's recommendation to introduce independent, third-party project benchmarking. This practice is routine in industrial and infrastructure megaprojects but not yet common in CDR. At Carbon Direct's recommendation, the project's progress was assessed against an industry database of comparable capital projects, evaluating readiness across design, cost, schedule, and execution planning.

The findings were encouraging and instructive in equal measure. The project was broadly in line with other large CCS projects at a similar stage, but the assessment also identified areas where Exergi could strengthen the project's risk provisions and cost estimate maturity ahead of FID. These findings gave Stockholm Exergi actionable areas to focus on and gave Microsoft confidence that risks were being surfaced in time to be addressed effectively.

Critically, the benchmarking outputs were oriented toward the developer instead of the buyer. This is where Carbon Direct's translational role proved essential. The team contextualized the findings in real time to Microsoft, and assessed the interdependence of technical benchmarks and commercial risk. Neither the benchmarking nor the advisory alone would have been sufficient to support project progression to FID.

"Any single perspective is brittle. Assurance from Carbon Direct combined our own expertise with Exergi's technical depth, Microsoft's core requirements, industry benchmarks, and lived experience from analogous projects. The result was decision-making robust enough to stand up to the hardest questions."

—A.J. Simon, Senior Director of Industrial Decarbonization at Carbon Direct.

Counting carbon correctly

The Stockholm Exergi BECCS project is co-funded. Sweden's government will subsidize it through a reverse auction and expects to count removals from the project toward the country's climate

targets, while corporate buyers like Microsoft purchase CDR credits for their own climate goals. Can both claim climate benefit from the same tonne? If not communicated correctly, the answer risks creating confusion about responsibility for climate action.

To clarify the integrity of the solution, Carbon Direct drew a critical distinction for Microsoft early in the engagement between dual accounting and double counting of carbon credits. Dual ledger accounting, or tracking the same removal in two parallel systems, each serving a different purpose, is legitimate and unavoidable in the context of corporate and national emissions inventories.¹ However, double counting, where two different parties to the Paris Agreement (i.e., two different nations) each claim the same physical tonne as a means to reach their respective nationally determined contributions, is not allowed and must be carefully avoided. Getting this wrong or communicating it poorly, particularly on a co-financed project, could erode confidence across the entire voluntary carbon market.

In June 2024, the Swedish Energy Agency published its reverse auction rules and resolved the immediate question. Voluntary carbon market sales are explicitly permitted alongside the subsidy. Buyers must contractually agree that credits contribute to Sweden's climate goals and cannot fulfill another country's targets without an Article 6 corresponding adjustment. Carbon Direct assessed the double-counting risk between Sweden and the USA as virtually non-existent.

Because the City of Stockholm holds a 50% ownership stake and has its own territorial net-zero target, clarity of claims methodology and communications was important to all parties. Carbon Direct identified the separate and distinct claims of each of Microsoft, Stockholm Exergi, and city stakeholders to outline how corporate, municipal, and national claims could be communicated clearly and consistently. For the CDR industry, the Swedish framework offers an early and workable model for how public subsidy and private offtake can coexist without compromising environmental integrity.

Looking ahead

While independent project assurance has existed in mature capital markets for decades, the Stockholm Exergi engagement demonstrated that the discipline is fully transferable to CDR projects. When done well, it protects not only buyer interests but the project itself: surfacing risks the developer can fix, building the organizational muscle the project needs, and creating the trusted information environment in which billion-dollar commitments are possible.

As more CDR projects reach the megaproject scale where billions of dollars and corporate reputations are at stake, independent project assurance will shift from a nice-to-have to an absolute necessity—much as independent engineering reviews are already standard in project-financed infrastructure. The layered model demonstrated here, where third-party benchmarking is combined with buyer-focused advisory, offers a template that future CDR investments can adopt and adapt to their needs.

¹ Microsoft. 2024. CDR Accounting: Transparently structuring corporate claims to reconcile with national goals. [accessed 2026 Apr 16]. <https://cdn-dynmedia-1.microsoft.com/is/content/microsoftcorp/microsoft/msc/documents/presentations/CSR/Microsoft-CDR-Accounting-Claims-FY24.pdf>

The organizational lessons learned here are also broadly applicable. Investors and offtakers will increasingly assess not just a project's technology and carbon accounting methodology, but whether the developer's organization is equipped to deliver a megaproject. Further, the CDR industry will need to develop standardized frameworks for construction-phase assurance, recognizing that FID is just one milestone to reach in assessing project risks, with many others possible during execution and operation.

Carbon Direct's assurance engagement with Microsoft on Stockholm Exergi's BECCS project models a way of working—one in which ambition is matched by rigor, and where trust between buyer, advisor, and developer is built on both optimism and *evidence*. If the CDR industry is to deliver on the promise of gigatonne-scale removal, it will need many more projects like this one as well as the independent project assurance infrastructure to match.

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About Carbon Direct

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