Heidelberg Materials

Lessons Learned Edmonton CCS Project

2022-2025

Heidelberg Materials

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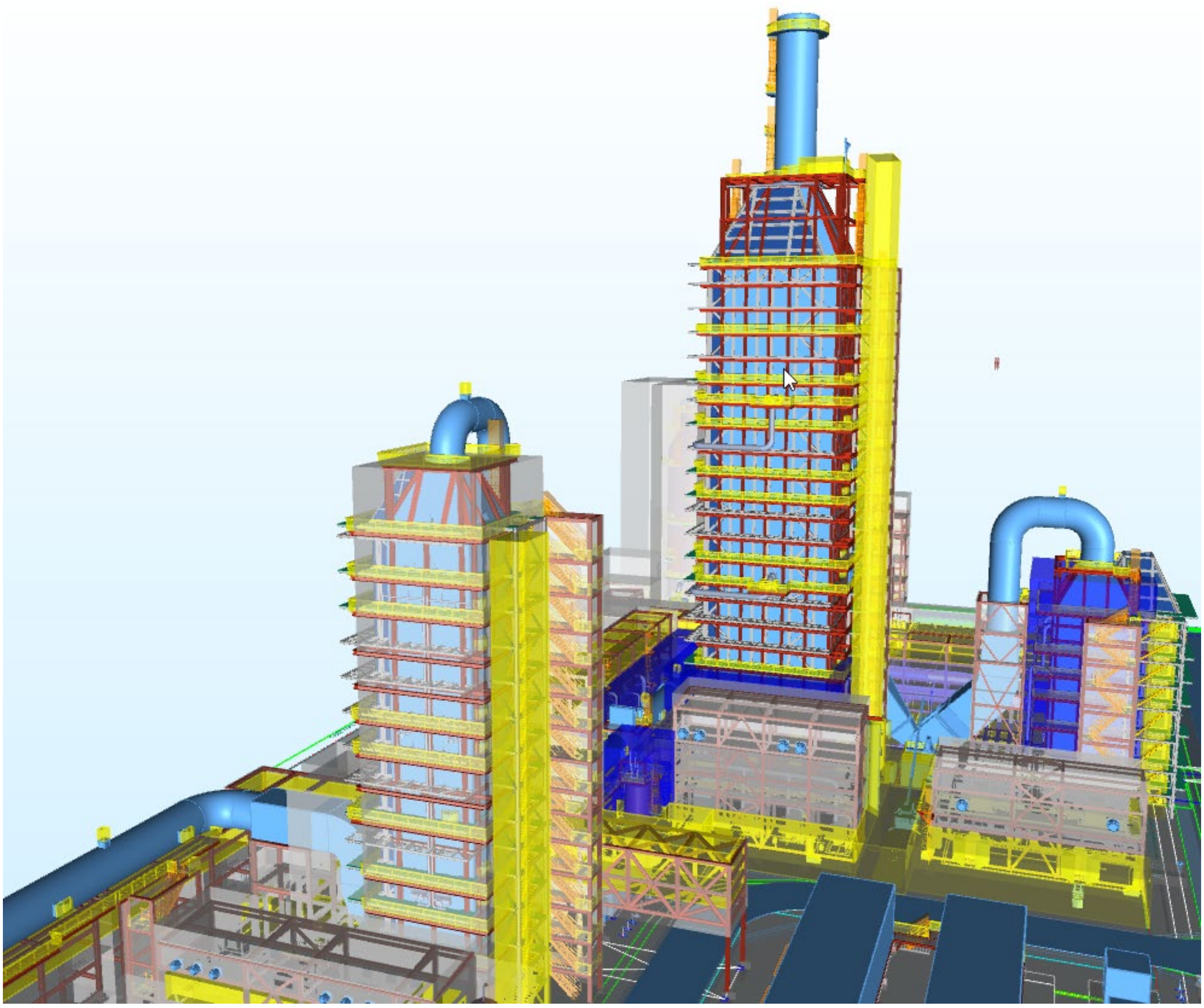

Edmonton CCS plant design and layout

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Executive Summary

This report consolidates the key lessons learned from the pre-development phase of the Edmonton CCS (Carbon Capture and Storage) Project (2022–2025), one of the world's first full-scale applications of CCS for the cement industry. The project is a flagship initiative for Heidelberg Materials, designed to capture up to 1 million tonnes of CO_2 annually through proven amine capture technology integrated with alternative fuels and a combined heat and power (CHP) unit. Beyond its technical ambition, the project serves as a critical learning platform for advancing CCS deployment in hard-to-abate sectors.

The lessons captured span multiple dimensions of project execution:

- **Organizational Structure & Teaming:** Early direct hiring of a core project team fostered strong alignment and commitment but underscored the importance of dedicated project management roles and clearly defined reporting processes.
- **Project Management & Standards:** The absence of standardized CCS-specific procedures created rework, emphasizing the value of reusable project management libraries and adherence to proven guidelines.
- **Communications & Stakeholder Engagement:** Strategic external communications raised the project's profile nationally and internationally, while internal co-location of teams accelerated cohesion. Clear ownership of government relations and a single accountable point of contact proved essential to securing funding and permits.
- **Technical Studies & Piloting:** Parallel pilot campaigns validated technical concepts and generated crucial data for performance guarantees, while also highlighting reliability challenges. Maintaining a living "basis of design" document emerged as a key best practice for clarity and alignment across phases.
- **Engineering & Contracting:** The dual-FEED (Front End Engineering Design) approach delivered high confidence in cost and design realism, while early alignment across engineering, legal, and procurement teams proved vital for efficient contracting. Interface complexity, such as flue-gas ducting, demonstrated the importance of scoping major elements early.
- **Commercial & Policy Levers:** Business case optimization relied on a combination of value engineering, partnerships, and strong policy alignment, underscoring the interconnected nature of technical and commercial success.

In summary, the Edmonton CCS Project illustrates that while CCS deployment is complex, it is achievable through proactive planning, strong organizational foundations, and sustained collaboration with partners, regulators, and communities. The insights captured here form a replicable framework for future CCS initiatives and strengthen the business case for scaling carbon capture more broadly in the cement sector and beyond.

Edmonton CCS Project Overview

The Edmonton CCS project accelerates Heidelberg Materials' (HM) goal of achieving net-zero emissions by 2050, establishing one of the world's first full-scale CCS applications at a cement facility. Integrated with the Edmonton cement plant, the project employs proven amine capture technology, alternative fuels, and a combined heat and power (CHP) unit to capture 1 million tonnes of CO_2 annually. This approach eliminates plant-gate emissions and reduces net Scope 1 and 2 emissions to zero. Two competing EPC (Engineer Procure Construct) consortia have validated the design. Captured CO_2 will be transported to Enbridge's nearby Open Access Wabamun Carbon Hub, currently under development, for deep saline storage, offering safe, verified, permanent sequestration at world-leading costs.

Heidelberg Materials' Edmonton cement plant is a dry-process, natural gas–fired facility with a 4-stage preheater/pre-calciner. Built in the late 1970s (650 kt/yr) and expanded in 1997 to 1.2 Mt/yr, the site owned by Heidelberg Materials will host both the cement and CCS plants.

The pre-feasibility, feasibility, pre-FEED, and FEED phases have been completed, and a value-engineering optimization phase is currently underway. The FEED phase included stack testing and piloting of two technologies, which validated the designs and informed the EPC commercial bids received. Major permits are secured, and the team will move forward with preferred vendors to maximize project value.

Business case optimization is ongoing across three key levers ahead of the Final Investment Decision (FID):

1. **Value Engineering**: Refining design, procurement, and contracting strategies to capture efficiencies in construction and delivery.
2. **Partnerships & Offtake**: Mitigating risk through strategic partnerships that complement HM's capabilities, while improving Environmental Attribute Certificate (EAC) offtake terms.
3. **Policy Support**: Aligning with federal and provincial programs to secure tailored support, strengthen the business case, and advance a domestic net-zero materials supply chain.

Project timeline

2019: Pre-Feasibility and technology selection study completed

2021: Feasibility study completed

2022: Pre-FEED optimization completed: CHP added to business case, FEED budget approved

2023: Enbridge selected, main equipment tendered; MHI (Mitsubishi Heavy Industries) pilot launched

2024: FEED mobilized; SIF (Strategic Innovation Fund) funding secured, Shell pilot plant started

2025: FEED completed; final EPC offers negotiated, value engineering phase initiated to address gaps and improve business case

Team Organization

Direct hiring of the core team proved highly effective, offering strong alignment in commitment and skill fit compared to third-party staffing. Attracting top talent does require a strong public profile, and the current team is well-positioned for success. Several members bring firsthand experience from previous CCS projects, contributing valuable expertise to both planning and execution.

The project highlighted the importance of clearly defined internal reporting processes. Establishing reporting requirements early will enhance coordination and efficiency in future initiatives. While the absence of a dedicated Project Manager under the Project Director required area leads to report directly, this experience informed the development of Heidelberg Materials' CCS organization chart guideline, which should be adopted going forward.

Communications

External: Financial support of the Carbon Capture Canada conference in Sept 2023 was an effective vehicle to announce the project to the country and provided a substantial level of visibility in Western Canada. The use of 3rd party communications experts was effective in helping to obtain this recognition.

Internal: Co-locating in the owner's engineer offices (WSP) strengthened team cohesion and team building; wherever possible, remote teams should be consolidated into a single office in person to optimize collaboration and cohesion.

Stakeholders & government relations

Stakeholders: CCS projects demand an elevated focus on government engagement and clear ownership for stakeholder management. Country-specific government relations capability was well-developed and supported within the company.

Government funding: Funding processes are complex and benefit from a single accountable owner; distributing the work across many individuals created confusion and inefficiency in Edmonton. Government counterparts were supportive; a single point of contact and a steady cadence of communication worked well. Heidelberg Materials' Sustainability Marketing assets developed by the team helped articulate a compelling funding narrative and should be shared across projects.

Permits: The permitting strategy demonstrated strong leadership by anchoring the project to a third party vetted preliminary life cycle emissions assessment, identifying permitting requirements early across jurisdictions, and proactively collaborating with regulators to establish a clear path that avoided critical delays. Transparency was prioritized through early community engagement, helping surface design-phase concerns. The team led knowledge-sharing efforts by aligning emissions modeling with AEPA (Alberta Environment and Protected Areas) standards for post-combustion amine CCS evaluations.

Looking ahead, there are valuable opportunities to build on this foundation: enhancing stakeholder engagement through dedicated budgeting and resourcing for rezoning and third-party land agreements; developing a CCS permitting primer to streamline future reviews; aligning branding elements and content with key project milestones and regional priorities; and highlighting the sustainability aspects of our brand through the evoZero(R) product lines and increased community presence.

Procedures & standards

The Heidelberg Materials project management guidelines aligned closely with actual execution and should be adopted early in the process. It is recommended for other projects to become familiar with it in the early stages of the project.

The lack of established project procedures in some cases created avoidable rework for the project team. This is a common problem with companies developing unique “first of a kind” large projects and examples of specific project procedures are needed. It is recommended that Heidelberg Materials build a reusable library of CCS project procedures to streamline future efforts and improve the effectiveness of additional CCS project deployment.

Third-party engineering & specialists

Heavy workloads assigned to certain contractors hindered cost control, as large teams advanced work before Heidelberg Materials could redirect effort. Introducing statement-of-work gating improved scope discipline and spend control.

Engaging specialist companies adds value to the project through unique expertise and efficiency. While their services come at a higher cost and require more management effort from the project team, the time savings and specialized capabilities ultimately make this a cost-effective approach.

Study phases

Feasibility Study & Pre-FEED: As the business case evolved, the initial feasibility study naturally diverged from the final concept. While a single summary document of the technical concept was not developed during this phase, the experience highlighted the value of maintaining a living “basis of design” document throughout the project. Such a document would enhance clarity and streamline communication. To ensure its effectiveness, this task should be appropriately resourced—an opportunity identified during the Edmonton CCS project, where staffing levels limited capacity for this effort.

Pilot: The co-located pilot plants provided valuable hands-on learning for Heidelberg Materials operations team, accelerating troubleshooting and strengthening operational readiness. The testing campaigns successfully met all key objectives: validating the flue-gas pretreatment strategy, generating critical data for performance guarantees (including amine consumption and degradation), and offering reliability insights such as heat-exchanger fouling and corrosion behavior.

While the pilots encountered challenges—including ABSA (Alberta Boiler Safety Association) registration processes, transport-related damage to vibration-sensitive mag-drive pumps, and limited cement plant utilities that required standalone cooling and wastewater systems—these experiences offered important lessons that will inform future design and execution. Reliability was impacted by non-industrial-rated instruments and control systems, monitoring limitations, compact equipment that complicated maintenance, and site constraints related to water, power, and space.

To enhance future pilot and full-scale system reliability, recommended actions include shipping sensitive equipment separately to prevent damage and upgrading critical components to industrial/commercial standards.

FEED: The dual-FEED approach successfully met project expectations by enabling a robust comparison of technical solutions and fostering competitive bidding. The convergence of EPC price levels across both bids reinforced confidence in cost realism. While the workload was intensive and response times occasionally impacted review quality, the process significantly accelerated team learning, enhanced design quality, and provided valuable insights through direct comparison—ultimately delivering a stronger outcome than a single FEED approach would have.

To further strengthen future programs, expanding discipline leadership—such as dedicated leads for process and key mechanical areas (piping, rotating equipment, and static equipment)—is recommended. On procurement, the FEED-based competitive process attracted highly responsive, well-priced proposals and encouraged constructive vendor engagement, with many suppliers going above and beyond to meet project requirements.

To ensure consistency and completeness, it is important to conduct rigorous line-by-line reviews against clear standards.

Commercial & contracting

The contracting process offered valuable insights into cross-functional collaboration. While the late delivery of contract conditions added schedule pressure and extended negotiations into the winter holiday period, it highlighted the importance of early alignment across legal, procurement, and engineering teams—especially when operating at this scale which is uncommon. For future projects, establishing shared ways of working, clear timelines, and aligned deliverables from the outset will help streamline execution and strengthen team coordination.

The flue-gas ducting between the cement plant and CCS facility presented greater complexity and cost than initially anticipated, in part due to its late-stage scoping. This experience underscores the importance of exploring all major interfaces early in the project lifecycle. Proactively assessing interface requirements—rather than relying on simplified assumptions—can help avoid surprises, improve cost accuracy, and support smoother execution.

Conclusions & recommendations

The Edmonton CCS Project has demonstrated that deploying large-scale carbon capture in the cement sector is both technically feasible and commercially viable when supported by strong organizational structures, proactive stakeholder engagement, and disciplined project management. The experiences from 2022–2025 provide a robust foundation of knowledge that can be applied not only within Heidelberg Materials but also across the broader CCS community.

Key Conclusions

- Early organizational alignment and direct hiring of core talent enhanced commitment and efficiency, though future projects would benefit from dedicated project management roles and standardized reporting structures.
- Piloting and dual-FEED studies validated technical concepts, accelerated learning, and confirmed the competitiveness of commercial bids, highlighting the value of structured, comparative approaches.
- Stakeholder and government engagement proved critical, with success tied to having a single point of accountability, proactive transparency, and consistent messaging supported by sustainability materials.
- Commercial processes underscored the need for cross-functional coordination; late-stage scoping of key interfaces reinforced the importance of exploring all major technical and contractual dependencies early.
- Policy support, including funding mechanisms and regulatory clarity, was essential in strengthening the business case and must remain a cornerstone of future CCS deployment.

Recommendations

1. **Establish Standardized CCS Project Frameworks:** Develop a reusable library of procedures, standards, and reporting templates tailored to CCS projects to minimize rework and accelerate early-phase execution.
2. **Resource Dedicated Project Management:** Ensure a clear organizational chart with defined responsibilities, including project management and discipline leads, to streamline oversight and reporting.
3. **Maintain a Living "Basis of Design" Document:** Resource this effort adequately from the outset to ensure continuity, clarity, and alignment across evolving study phases.

4. **Strengthen Stakeholder & Government Engagement:** Invest in specialized government relations teams, maintain a single point of contact, and build dedicated budgets for community engagement and rezoning activities.
5. **Scope Major Interfaces Early:** Conduct thorough assessments of critical project interfaces, such as flue-gas handling and utility integration, during feasibility phases to reduce late-stage surprises.
6. **Embed Commercial Alignment Upfront:** Initiate early collaboration between engineering, procurement, and legal teams to define contract conditions and negotiation strategies well before EPC engagement.
7. **Continue Leveraging Policy & Partnerships:** Proactively align with evolving federal and provincial support programs and strengthen offtake partnerships to de-risk projects and enable long-term market competitiveness.

By adopting these recommendations, future CCS initiatives can benefit from Edmonton's pioneering experience, reducing risks, accelerating timelines, and increasing the likelihood of replicable success. The project's legacy is not only in its ambition to achieve net-zero cement production but also in the practical blueprint it provides for scaling CCS across industries worldwide.