

PENANGKAPAN CO₂ DI LOJI SIMEN

Brevik CCS

Fasilitas penangkapan CO₂ terbesar dalam industri simen dunia telah mulai beroperasi di Brevik, Norway pada Jun 2025. Perkembangan ini menandakan pencapaian penting dalam pelaksanaan teknologi penangkapan karbon industri. CO₂ yang ditangkap akan melalui penyahhidratan dan pencairan. Kemudian, CO₂ ini dimuatkan ke kapal-kapal pengangkut CO₂ sebagai sebahagian daripada rangkaian pengangkutan Langskip. Kapal-kapal ini menghantar CO₂ ke terminal baharu di Øygarden untuk penyimpanan sementara sebelum dipindahkan ke penyimpanan geologi kekal di bawah Laut Utara.



Sepintas lalu

FASILITI:

Brevik CCS

SEKTOR:

Simen

LOKASI:

Brevik, Telemark, Norway

OPERATOR:

Heidelberg Materials

MULA BEROPERASI: 2025

Konkrit ialah produk pembuatan terbesar di dunia dari segi jumlah tan. Pada tahun 2024, kira-kira 30 bilion tan konkrit telah dihasilkan. Daripada jumlah tersebut, sekitar 4 bilion tan ialah simen. Sektor simen merupakan antara sektor yang mencabar untuk dinyahkarbonkan dan menyumbang sehingga 8% daripada pelepasan gas rumah hijau (GRH) global.

Kira-kira dua pertiga daripada pelepasan GRH tersebut berpunca daripada CO₂ kalsinasi yang tidak dapat dielakkan. Pelepasan ini terhasil daripada pemanasan batu kapur dalam relau bagi menghasilkan klinker simen Portland, komponen utama simen Portland tradisional. Sebahagian besar daripada selebihnya berpunca daripada pembakaran bahan api untuk memanaskan relau simen. Global Cement and Concrete Association menyatakan bahawa CCS amat penting bagi proses penyahkarbonan industri simen.¹ Industri simen sedang mengusahakan pelbagai langkah untuk mengurangkan pelepasan CO₂ dengan kemajuan yang konsisten. Namun, bagi penyahkarbonan mendalam, CCS amat diperlukan.

Terletak di kawasan fjord di selatan Norway, fasilitas simen Brevik telah menghasilkan simen selama lebih satu abad. Hari ini, fasilitas ini mampu menghasilkan sekitar 1 juta tan simen setahun untuk pasaran Eropah.

Projek Brevik telah menerima pembiayaan daripada kerajaan Norway dan Heidelberg Materials, dengan sokongan tambahan daripada program serta rakan kerjasama lain di Eropah. Loji penangkapan karbon Brevik menggunakan

teknologi “Big Catch” daripada SLB Capturi. Proses ini menggunakan teknologi “Advanced Carbon Capture”™ dengan pelarut proprietari berasaskan amina. Teknologi ini menggunakan integrasi haba dengan memanfaatkan haba buangan daripada pemampat CO₂ hiliran. Haba buangan ini menyediakan sebahagian besar tenaga yang diperlukan bagi sistem penangkapan CO₂. Sememangnya, kapasiti penangkapan CO₂ ditentukan berdasarkan ketersediaan haba buangan.

Di hiliran unit penangkapan, CO₂ kemudian dimampatkan kepada tekanan kira-kira 15 atmosfera sebelum menjalani proses pencairan pada suhu sekitar -26°C. CO₂ cecair tersebut kemudiannya disimpan sementara dalam satu set tangki penyimpanan di dermaga.

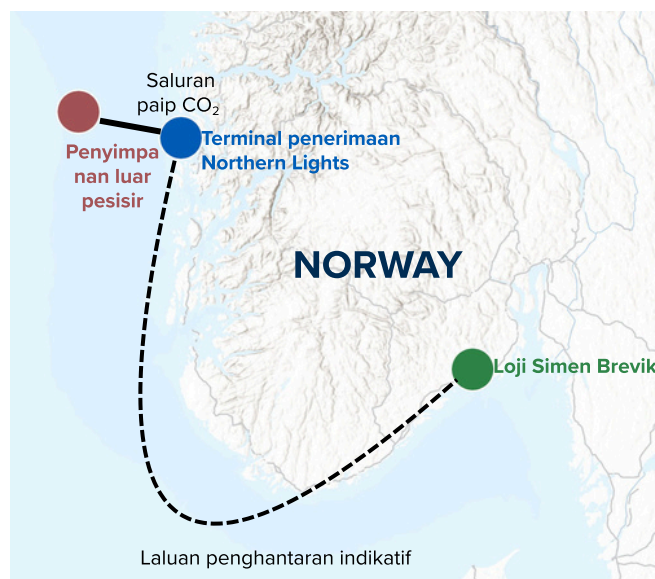
Dari sini, CO₂ tersebut dimuatkan ke atas Northern Pioneer atau Northern Pathfinder, iaitu kapal pengangkut CO₂ yang direka khas dan dibina di Dalian, untuk dihantar ke terminal CO₂ Northern Lights di Øygarden, daerah Vestland di barat Norway. Dari terminal tersebut, CO₂ seterusnya dipam melalui saluran paip ke penyimpanan dasar laut pada kedalaman 2.6 km di bawah dasar Laut Utara.

Heidelberg Materials memasarkan simen hampir sifar karbon dari loji Brevik di bawah jenama evoZero®, dengan produk premium berpotensi mewujudkan peluang margin yang lebih tinggi². Pengeluaran tahun pertama simen evoZero® telah pun habis ditempah lebih awal, menunjukkan terdapat permintaan yang kukuh terhadap produk simen rendah karbon.

Fakta Utama CCS Brevik

Kapasiti & Pengangkutan	Penyimpanan	Metrik Komersial & Kewangan	Kepentingan Strategik
Kapasiti Penangkapan: 400,000 tan CO₂ setahun (tpa) Teknologi Penangkapan: Aplikasi modular “Big Catch” oleh SLB Capturi bagi teknologi “Advanced Carbon Capture”. Pengangkutan: Kapal khas pengangkut CO₂ Northern Pioneer dan Northern Pathfinder. Setiap kapal mampu menampung 7,500 m³ CO₂ cecair Panjang Saluran Paip: ~100 km	Lokasi Penyimpanan CO₂: Johansen Formation (Aurora complex), Laut Utara Jenis Penyimpanan: Akuifer air masin dalam Kedalaman Suntikan: ~2.6 km di bawah dasar laut	Perbelanjaan Modal³: ~€421 juta Anggaran Kos Pengurangan Pelepasan⁴: NOK 1150 (~€100) bagi setiap tan CO₂ Sumber Pembiayaan: Geran pembiayaan, pengelakan harga karbon tempatan, premium hijau daripada jualan simen rendah karbon, serta pembiayaan syarikat.	Pengubahsuaian semula fasiliti yang sedang beroperasi menunjukkan bahawa CCS merupakan laluan yang jelas untuk menyahkarbonkan industri sedia ada. Menunjukkan pelaksanaan pertama penangkapan CO₂ berskala komersial di loji pembuatan simen dan sistem pengangkutan CO₂ cecair berasaskan laut yang khusus sebagai sebahagian daripada rantaian CCS. Salah satu projek penangkapan CO₂ teras bagi rangkaian pengangkutan dan penyimpanan Northern Lights.

Ringkasan: Northern Lights



CO₂ yang ditangkap di Brevik menjalani pencecairan sebelum diangkut menggunakan kapal ke terminal penerimaan CO₂ Northern Lights di Øygarden di barat Norway.

CO₂ cecair dipam ke tekanan tinggi dan dialirkan melalui saluran paip dasar laut sepanjang 100 km ke telaga penyimpanan di bawah dasar Laut Utara.

Northern Lights ialah projek infrastruktur bersama bagi pengangkutan dan penyimpanan CO₂, dan tidak lama lagi akan menerima CO₂ daripada fasiliti penangkapan lain di Norway serta daripada peringkat antarabangsa.

Fasa 1 Northern Lights mempunyai kapasiti penyimpanan sebanyak 1.5 juta tan setahun (Mtpa) dan kini telah beroperasi. Fasa 2 akan meningkatkan kapasiti penyimpanannya kepada 5 juta tan setahun dan kini dalam pembinaan.

¹ <https://gccassociation.org/wp-content/uploads/2024/11/GCCA-Cement-Industry-Progress-Report-202425.pdf>

² https://www.heidelbergmaterials.com/sites/default/files/2025-03/Heidelberg_Materials_Investor%20Presentation_FY_2024.pdf

³ <https://energywatch.com/EnergyNews/Cleantech/article13445570.ece>

⁴ <https://ccsnorway.com/longship-potential-for-cost-reductions-in-the-ccs-chain/>



CEMENT PLANT CO₂ CAPTURE

Brevik CCS

The world's largest cement CO₂ capture facility began operation at Brevik, Norway in June 2025, marking a major milestone in industrial carbon capture. Once captured, the CO₂ is dehydrated, liquefied and then loaded onto CO₂ ships, part of the Langskip transport network. These vessels deliver the CO₂ to a new terminal at Øygarden, where it is held before onward transfer to permanent geological storage under the North Sea.



At a glance

FACILITY:

Brevik CCS

SECTOR:

Cement

LOCATION:

Brevik, Telemark, Norway

OPERATOR:

Heidelberg Materials

COMMISSIONED:

2025

Concrete is, by tonnage, the largest manufactured product industry. In 2024, around 30 billion tonnes of concrete were produced. Included in this were around 4 billion tonnes of cement. The cement sector is a challenging sector to decarbonise, producing up to 8% of global greenhouse gas (GHG) emissions.

Around two-thirds of those GHGs come from unavoidable calcination CO₂, which is a consequence of heating limestone in a kiln that creates Portland cement clinker, the main component of traditional Portland cement. Much of the rest is from fuel combustion to heat cement kilns. The Global Cement and Concrete Association has stated that CCS is critical for cement's decarbonisation¹. The cement industry is working on multiple levers to reduce CO₂ with consistent progress, yet for deep decarbonization CCS is indispensable.

Located on the fjords of southern Norway, the Brevik cement facility has been producing cement for over a century. Today, it can produce around 1 million tonnes per year of cement for the European market.

The Brevik project has benefited from funding by the Norwegian government and Heidelberg Materials, with some support from other European programs and partners. The Brevik capture plant employs "Big Catch"

technology from SLB Capturi. This implements the "Advanced Carbon Capture"™ process, using a proprietary amine-based solvent. The technology incorporates heat integration, using waste heat from the downstream CO₂ compressor as well as from the cement process to provide much of the energy needed for the capture system. Indeed, waste heat availability was chosen as the basis for the capture capacity specified.

Downstream of the capture unit, the CO₂ is compressed to a pressure of ~15 atmospheres and liquefied by cooling to -26°C. The liquid CO₂ is temporarily held in a set of dockside storage tanks.

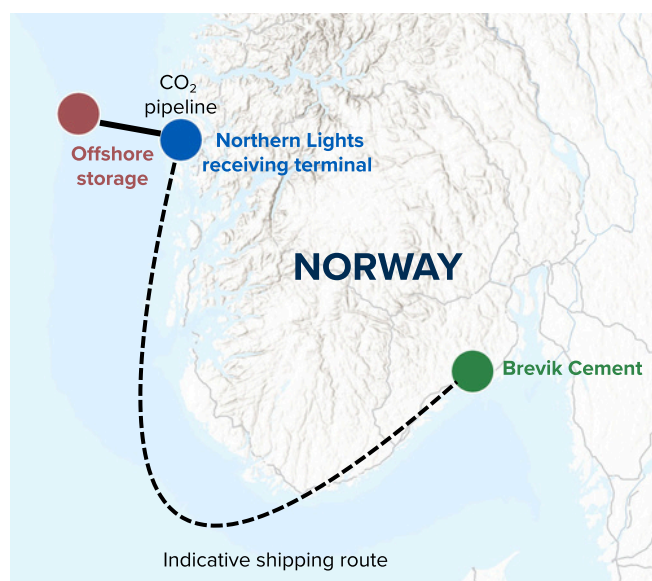
From here, it is loaded onto the Northern Pioneer or Northern Pathfinder, purpose-designed CO₂ carriers built in Dalian, China, for shipping to the Northern Lights CO₂ terminal in Øygarden in Vestland county in western Norway. From there, it is pumped via pipeline to subsea storage 2.6km under the North Sea seabed.

Heidelberg Materials is selling near-zero carbon cement from the Brevik plant under the evoZero® brand, where premium products could attract a margin opportunity². Their first year's production of evoZero® has already been pre-sold, demonstrating there is strong demand for low-carbon cement products.

Brevik CCS Key Facts

Capacity & Transport	Storage	Commercial & Financial Metrics	Strategic Significance
Capture Capacity: 400,000 tpa CO₂ Capture Technology: SLB Capturi “Big Catch” modular application of “Advanced Carbon Capture” technology Transport: Dedicated liquid CO₂ transport ships <i>Northern Pioneer</i> and <i>Northern Pathfinder</i>. Each ship can hold 7,500 m³ of liquefied CO₂. Pipeline Length: ~100 km	CO₂ Stored: Johansen Formation (Aurora complex), North Sea Storage Type: Saline aquifer Injection Depth: ~2.6 km below seabed	Capital Expenditure³: ~€421 million Estimated Abatement Cost⁴: NOK 1150 (~€100) per tonne CO₂ Funding Sources: Grant funding, avoidance of local carbon pricing, green premium for low-carbon cement sales, company financing.	Retrofit of an operating facility shows CCS as a clear pathway to decarbonise existing industry. Demonstrates first commercial-scale CO₂ capture on a cement manufacturing plant and dedicated sea-based liquid CO₂ transport with CCS. Foundation CO₂ capture partner for the Northern Lights transport and storage network.

Summary: Northern Lights



CO₂ captured at Brevik is liquefied and transported by ship to the Northern Lights CO₂ receiving terminal at Øygarden in Western Norway.

Liquid CO₂ is pumped to high pressures and flows via a 100 km long subsea pipeline to the storage well beneath the North Sea.

Northern Lights is a shared CO₂ transport and storage infrastructure project and will soon be receiving CO₂ from other capture facilities in Norway and internationally.

Phase 1 of Northern Lights has a storage capacity of 1.5 Mtpa and is operational. Phase 2 will expand its capacity to 5 Mtpa and is under construction.

¹ <https://gccassociation.org/wp-content/uploads/2024/11/GCCA-Cement-Industry-Progress-Report-202425.pdf>

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