The NORDIC WAY

A NOVEL INDUSTRIAL LAB COULD HELP ALLEVIATE DOUBTS – AND VALIDATE INVESTMENT – IN CARBON CAPTURE AND STORAGE

Written and Photographed by Jeff Lewis

OLAV FALK-PEDERSEN IS IN HIS ELEMENT. Never mind the slashing rain. Ignore the driving wind. High above Europe's second-largest oil port, on a rocky outcrop north of Bergen on Norway's west coast, the technology manager is talking carbon. Specifically, he's shouting – about how to get rid of it. "Down there I had removed all the CO_2," he says, pointing with a gloved hand 60 meters to the base of a concrete tower. The next few words are garbled in the wind. I hear "amines" and "exhaust" but am certain of neither.

This, it turns out, is what capturing carbon looks like. Bereft of its political symbolism, atop a labyrinth of pipes, heat exchangers, valves, nozzles and pressure gauges, the process of stripping the unwanted byproduct of fossil fuel production from power plant exhaust bears only a passing >>

THE MONGSTAD REFINERY NORTH OF BERGEN IN NORWAY, OWNED JOINTLY BY STATOIL ASA AND ROYAL DUTCH SHELL PLC

TECHNOLOGY MANAGER OLAV FALK-PEDERSEN GESTURES AT AN AMINE PLANT, ONE OF TWO TECHNOLOGIES DESIGNED TO STRIP CARBON DIOXIDE FROM POWER PLANT EXHAUST. LONG-TERM PLANS CALL FOR BUILDING A FULL-SCALE CARBON CAPTURE FACILITY AT THE SITE. AT RIGHT, THE TECHNOLOGY CENTER'S ASPIRATIONAL SLOGAN

resemblance to the industrial Rubik's cube that has so far stumped the technology's commercial evolution. "It's not that tricky," Falk-Pedersen says.

His appraisal seems warranted from this vantage. For here, in the shadow of the Mongstad refinery jointly owned by Statoil ASA and Royal Dutch Shell PLC, workers in hard hats and steel-toed boots are busy putting the final touches on a facility many hope will help alleviate stubborn doubts – and validate public investment – in a technology derided by Alberta's Wild Rose Party as "government waste."

IN JUNE NORWEGIAN OFFICIALS WILL MARK the opening of a NOK$6-billion (about C$1.05-billion) carbon capture test center. Falk-Pedersen, the facility's technology manager, calls it a "very expensive sandbox" designed for an explicit purpose. "We would like to be more educated buyers and users of CO_2 capture units," he says, from the shelter of a low-slung office building, "so, of course, we are learning a lot from the construction and operation of this."

The lessons, in turn, will help plug a knowledge gap at a critical juncture. Researchers from Statoil, Shell and South African chemicals manufacturer Sasol Ltd. – whom together share 25 per cent ownership of the facility – hope to get a better sense of which technologies are best-suited to snaring carbon dioxide from power plant exhaust. Gassnova SF, the government arm in charge of carbon capture and storage (CCS), hopes to use that knowledge to build a full-scale, NOK$20 billion (about C$3.5 billion) capture facility at the refinery by 2020.

"The idea is to try to make it a hub and a business opportunity, for the owners and for Norway," says Anne Strømmen Lycke, vice-president of asset management at Gassnova. The Oslo-based agency owns and has paid for 75 per cent of the carbon test center, officially called Technology Centre Mongstad, or TCM for short. "It's quite the plant, actually," Lycke says in an interview. It is also the product of government fiat. In 2006, Statoil was awarded a permit to build a natural gas-fired power plant at its Mongstad refinery. The license was contingent on building a CCS component to offset emissions released by the gas-fired turbines. "I think Norway must be one of the few countries in the world, if not the only one, who thinks that gas-fired power is a dirty fuel," Lycke says.

Technology trials are underway. Early participants in a qualification program include French giant Alstom SA and a division of oil-platform maker Aker Solutions. No carbon will be stored during tests, but long-term plans call for a commercial facility big enough to stash 100,000 tonnes of the waste gas annually below the North Sea. "There will be an export pipeline to take the clean carbon out and store it forever and a day, hopefully," Lycke says.

Such caution is well founded. Although broadly endorsed as a critical tool for slowing growth in fossil fuel-related greenhouse gas emissions – the technology secured an important designation as a so-called Clean Development Mechanism under the Kyoto Protocol at last year's climate talks in Durban, South Africa – carbon sequestration has not been spared from government austerity measures.

Two months before I visited Oslo as a guest of the Norwegian government last December, a pilot project at Europe's third-largest coal-fired power plant, in Scotland, collapsed amid disagreements between government and

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industry over who should foot the bill. Aker Clean Carbon, the same firm participating in trials at TCM, was slated to provide proponent ScottishPower with its proprietary capture technology before the deal fell apart. Its shares were subsequently written down to zero from NOK$147 million (about C$33 million). "The financial situation for CCS vendors is, of course, shaky," Lycke says. "The market for large-scale CCS plants is not quite there."

Closer to home, even Alberta has shaved $400 million from its $2-billion commitment to the technology, made by former premier Ed Stelmach during the 2008 bull-run in oil prices. In Oslo, the doubts reach to the highest levels of Parliament.

"Because of financial unrest, because of a very stressed U.S. and European economy, a lot of projects have been delayed or cancelled already," Ola Borten Moe, the Norwegian minister of petroleum and energy, told me. "It's not only a notion but a fact that we are globally moving forward more slowly than we hoped to just a few years ago."

TO GET A SENSE OF WHY NORWAY IS stubbornly pressing ahead, it helps to look west of Mongstad, 65 kilometers offshore to the Troll natural gas field. It was discovered in dribs and drabs in the late 1970s and early 1980s. Today it ranks among the biggest of Norway's offshore treasure troves.

How big? In the temporary offices occupied by the Ministry of Petroleum and Energy in downtown Oslo, Lars Erik Aamot glances up from an unfurled map that shows the continental shelf subdivided into colored exploration blocks. His finger lands on a red smudge. Troll produced just shy of 30 billion cubic meters in 2011, he says. That's roughly a third of the country's total annual gas exports to continental Europe.

Yet its prominence as a monster gas field belies an engineering feat, and a Norwegian brand of ingenuity that comes from decades spent poking holes in what can be an unforgiving offshore environment. "I think the story of the Norwegian continental shelf is technology," the director general of the oil and gas department says.

Troll stands out as a case study in innovation. Not long after it was discovered, the formation served as a testing ground for horizontal drilling in an offshore environment. Norway's Petroleum Directorate (the equivalent to Alberta's Energy Resources Conservation Board) and industry together pioneered the technology in order to tap a thin but inaccessible layer of oil discovered beneath the gas zone.

"That was a hard, hard fight to commercialize that technology," Aamot recalls. But it worked. Production started in the late 1980s and early '90s. "That was the first [horizontal well] ever offshore," Aamot says, "and it became the biggest oilfield in Norway for many, many years."

Stick with carbon capture, the thinking goes, and it could yield a similar – but by no means lucrative – payoff. In fact, at least one aspect of the capture scheme at Mongstad mirrors the rate at which new technologies find their way to commercial well sites. "It's been a long, long process," Aamot says.

INSIDE AN UNFURNISHED OFFICE AT Mongstad, Falk-Pedersen, the technology manager, is flying through a virtual tour of the carbon test center on a wall-mounted LCD screen. The entire industrial setup – including twin capture plants, a water intake system and the refinery – has been rendered in stunning detail on a 3-D simulation. The technology boss burns through the tour as though he's played this particular video game a thousand times. Now and then he pauses to quibble with the placement of a nozzle or wayward pipe. "This is actually not quite correct," he tells his team.

Small imperfections notwithstanding, the digital display figures prominently at trade shows and international conferences – most recently in Durban, and again at the World Future Energy Summit in Abu Dhabi – but >>

AN ABSORPTION TOWER STANDS 60 METERS ABOVE THE FACILITY, LEFT. AT RIGHT, THE VIEW OVERLOOKING MONGSTAD, EUROPE'S SECOND-LARGEST OIL PORT AFTER ROTTERDAM

it hardly captures the scale of TCM. Outside, the virtual world springs to life. Contractors crawl atop scaffolding, fitting the final few pieces of a chilled ammonia plant together. Pipes and valves jut out at every turn. Gauges and manual sampling points number in the thousands. "It's industrial, there's no doubt," Falk-Pedersen says at one point on a guided tour, "but it's instrumented almost like you would do in a lab or a pilot unit."

Pipe racks are laid out overhead to carry flue gas from the refinery's catalytic cracker and the natural gas-fired power plant. The exhaust is treated in one of two facilities by carbon-absorbing solvents; one uses liquid amines, the other will run trials using a chilled ammonia solution.

200% how much the cost of building the Mongstad carbon test center has increased before construction began

In each case, the flue gas can be made "dirtier" by increasing the concentration of CO_2, from 3.5 up to 14 per cent, essentially mimicking emissions at a host of industrial sites, including coal-fired power plants. The objective is to determine average capture rates, mirroring operations at a live power plant, whether it's a base-load or peaking unit.

"The trick here is to get the simulations to fit," Falk-Pedersen says. "If you look at a conventional full-scale unit, and you take the whole chain including transport, compression and storage, at least here in Norway on the coast for a gas-fired power plant, you will find that the capture rate should be between 85 to 90 per cent."

IN SOME WAYS, THE WORK IS A NATURAL progression from gas-processing CCS schemes already in operation on the continental shelf.

Roughly 12 million tonnes of carbon has been stored 800 meters beneath a portion of the Sleipner gas field offshore Norway since 1996. Statoil has also injected at least 3.8 million tonnes of the industrial byproduct deep below the Sahara Desert in Algeria at its In Salah venture with BP and Sonatrach. Another effort at the Snøhvit liquefied natural gas project in the Barents Sea transports captured CO_2 153 kilometers by pipeline and buries it 2,600 meters below a gas reservoir.

"It's a valuable blend of experience for us," says Philip Ringrose, project leader of carbon storage at Statoil. At Sleipner, for instance, the underground carbon "plume" is mapped using 4-D seismic surveys. Wellhead pressure and flow-rates are watched continuously. The flagship project is known internationally. "It continues to be of enormous interest around the world, despite the fact that it's been running for 15 years," Ringrose says. Monitoring technology continues to evolve. In Algeria, for example, the In Salah property serves as a model for long-term onshore storage, Ringrose says. Long-reach horizontal wells began injecting CO_2 in 2004. Sophisticated satellites are used to monitor subtle shifts in surface elevation, and have proven "incredibly valuable" for keeping tabs on pressure changes below 900 meters of shale and another 80 meters of sandstone.

"We're not trying to say this is a piece of cake," Ringrose says. But nor are commercial ventures entirely out of reach. Statoil's CCS projects are "more than pilots," he notes. "It can definitely be done. We've shown that we can understand the process."

KNOWLEDGE ALONE WON'T accelerate the commercial development of CCS, however. The full-scale carbon capture facility planned for Mongstad couldn't survive without public funds. "It's heavily subsidized by the Norwegian government," says Borten Moe, the energy minister

Still, he believes the money is well spent. Long-term plans call for exporting technology to countries with similar emission profiles. Some, including Mads Greaker, a research director at Statistics Norway, have suggested the government will have a difficult time selling its know-how in what remains a shaky market.

Cost inflation is a particular risk. The price tag at Mongstad ballooned by more than 200 per cent before shovels even hit the ground, Greaker noted in a 2009 report. "Our results suggest that capture technologies that are intended as end-of-pipe technologies have a small market potential unless such solutions become cheap," Greaker wrote.

The lesson is not lost on ministry officials. "It's a big danger," Borten Moe says. "Norway is not going to be able to lift this by ourselves." But it will try. As a lengthy interview draws to a close, the minister rushes to a press conference. The Petroleum Directorate is presenting a storage "atlas" of the continental shelf, which could hold an estimated 70 billion tonnes of carbon dioxide. "This is what we've been doing for 15 years," the minister says. "This is possible. It's not science fiction." AO

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