Inside the World's Largest Carbon-Capture Test Facility

Norwegian site lets companies qualify their carbon-cleaning tech for commercial use

By Lucas Laursen
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In a laboratory on Norway's fjord-laced coast, Jane Feste bubbles some carbon dioxide gas through a liquid for a crowd of visitors. "I will take an amine—that's a base—and that will absorb...the CO_2. So [that's] what's happening out in the plant, just shown for the eye here," the laboratory technician explains. She's referring to Technology Centre Mongstad (http://www.tcmda.com/en/) (TCM), the US $1 billion, 350-megawatt power plant and test facility that the Norwegian government and several energy firms built. The assembled journalists cannot seem to decide if they should applaud the spectacle or if they're witnessing a modern case of the emperor's new clothes.

Photo: Lucas Laursen

The Two Towers: Technology Centre Mongstad in Norway is testing two types of carbon capture.

Under rules announced last week by the U.S. Environmental Protection Agency, future coal-fired power plants in the United States can emit no more than 500 kilograms of CO_2 per megawatt-hour. That's a level experts say can be achieved only by carbon capture and sequestration (/tag/carbon%20capture%20and%20sequestration). Yet until last year, the biggest carbon-capture facilities, all pilot projects, had little more than 1 percent of the capacity required for commercial operations. Although it was launched behind schedule and over budget in May 2012, TCM is about 10 times as big as the largest pilots, and it is the best glimpse we have of the future of fossil-fuel electricity generation. The facility is intermediate in size, between pilot plant and commercial scale, offering companies a way to test how their equipment and processes will hold up in a commercial setting. "What we'd like to do is test here a little bit more high-risk, high-reward technologies," explains TCM technology manager Olav Falk-Pedersen, who has been involved in the first year's testing of postcombustion carbon capture.

The facility, which is adjacent to the town of Mongstad, hosts two types of carbon-capture technologies, with a gravel-filled lot available for a third. The test sites draw carbon emissions from two adjacent power plants: an oil refinery with a catalytic cracker and a natural-gas-burning combined heat and power plant. Those two sources allow TCM to simulate different kinds of real-world emissions, including those from coal power plants.

With carbon-emitting energy sources slated to remain an important part of the global energy mix for decades, and carbon-emissions reductions starting to find their way into government policies, the rewards for those making carbon capture cost-effective could be very high.

But capturing carbon sacrifices a lot of energy—up to 25 percent of that produced in a coal plant, says research engineer Howard Herzog (http://sequestration.mit.edu/people/hjherzog/), director of the Carbon Capture and Sequestration Technologies Program at MIT. It also uses more heat, water (http://spectrum.ieee.org/energy/environment/the-water-cost-of-carbon-capture), and raw chemicals. The rewards will go to those companies that find the cheapest way to approach the thermodynamic limits of carbon capture, which Herzog says is closer to an 8 percent energy loss for a coal-fired power plant.

So far, the two methods being tested at Mongstad show that one day there may be several carbon-capture solutions, each tailored to a different environment. In a 60-meter-tall concrete tower, a liquid amine solution drips down metal baffles, absorbing CO_2 from flue gas via the amine method (http://www.tcmda.com/en/Technology/Amine-technology/) that Feste demonstrated to the visiting journalists. The amine solution can then be stripped of its carbon dioxide and recycled. This method is currently being tried out by Aker, an oil-services company. Next door, a boxier tower bristling with pipes and yellow safety railings tests the rarer chilled-ammonia method (http://www.tcmda.com/en/Technology/Chilled-ammonia-technology/), which energy company Alstom is developing. The two systems have similar energy needs but require distinct balances of steam, electricity, and cooling water. Ammonia captures carbon at a lower temperature than amine does.

While the tests of the two technologies have been proceeding simultaneously, Falk-Pedersen says they are not really competing with each other. Instead, builders of future facilities will decide which method to use based on local availability and prices for heat, electricity, water, and solvents such as amine or ammonia. Sun-soaked Dubai, for example, may prefer a different method to hydropowered Norway.

“I’m very interested to see what data come out of those tests and what’s their plan for future tests,” says Herzog, who maintains a global database of carbon-capture and sequestration projects (http://sequestration.mit.edu/tools/projects/index_capture.html). That data will help industry watchers decide which proprietary amine mixes and capture processes have best survived the transition from computer simulation to real-world system. Builders will also need to choose among the companies that make carbon-capture equipment, such as Alstom and Aker.

To scale up pilot technology from a typical 10 000 metric tons of CO_2 per year to the capabilities of TCM, which can capture up to 100 000 metric tons of CO_2 per year, some of the reengineering will be straightforward. It will involve building larger pipes to carry more power-plant exhaust to the test flues and ensuring consistent flow inside the larger test flues. Other, more subtle changes will involve fine-tuning the mix of additives in the amine to minimize corrosion and degradation of the equipment.

But there’s no point in making those changes without measuring their results. At one stop on the tour of the valve- and gauge-filled facility, Falk-Pedersen notes that no commercial facility would pay to install so many instruments in the pipes carrying gas and liquid through the complex. Here, there are 4000, feeding data in real time to TCM and its partners.

Norway’s new government announced last week that it would not escalate the Mongstad site to commercial-scale operation. The decision came just after an audit (http://www.riksrevisjonen.no/en/Formedia/PressReleases/Pages/CCS.aspx) accused Statoil of poor financial management of the project. However, the government will boost TCM’s R&D budget, and it still plans to build a commercial-scale CCS facility somewhere in the country. So far, the country has been willing to go it alone on scaling up carbon-capture technology—many other countries have canceled demonstration projects amid the recession and austerity drives. TCM’s managing director, Frank Ellingsen, says, “It’s obvious today that [carbon-capture] technology is not a very viable industry” without government support.

However, the largest energy firms are betting that carbon capture and sequestration will someday be a viable business—almost a dozen approached TCM about securing a spot in the next round of equipment testing. They’re just letting governments take the lead on the investment.

By the time coal-power generators start making those investments for real, TCM might be pumping its captured carbon into the subsea salt deposits just beyond the ships docked at the edge of Mongstad’s refinery. But for now, it’s all catch and release.

About the Author

From Madrid, Spain, Lucas Laursen (http://lucaslaursen.com/) has been covering odd things for *IEEE Spectrum*,

such as an effort to turn snails into fuel cells (http://spectrum.ieee.org/green-tech/fuel-cells/snails-in-a-race-for-biological-energy-harvesting) and how to tell when a hen is plotting murder (http://spectrum.ieee.org/biomedical/diagnostics/computer-system-counters-hen-horrors). Norway seems to have sobered him.

To Probe Further

Two useful databases of carbon capture and sequestration projects are available on the Web—the Global CCS Institute's (http://www.globalccsinstitute.com/projects/browse) and Howard Herzog's (http://sequestration.mit.edu/tools/projects/index_capture.html).

Editor's note: Technology Centre Mongstad provided some transportation and meals for the author.