Frightened, furious neighbors undermine CO2-trapping power project

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BRANDENBURG, Germany -- Vattenfall wants someone to take its CO2. Please.

The first electric utility in the world to launch a coal-fired power plant designed from the ground up to capture its carbon dioxide emissions, Vattenfall has found that building the complicated €70 million pilot plant may have been the easy part. Finding a home for its captured gas? Now that's hard.

For more than a year, the plant has been doing its job, capturing 90 percent of its CO2, the heat-trapping gas that drives global warming. Nestled in strip-mining country in eastern Germany, the plant could provide the prototype for the next generation of relatively affordable "clean" coal plants. But until Vattenfall finds a place to stash its CO2, those dreams will be as intangible as the CO2 it collects and vents every few days back into the atmosphere.

Vatenfall AB, which is owned by the Swedish government, has been frustrated by boisterous local opposition to its plans to pump CO2 more than a kilometer underground into porous rock formations. Unnerved by the popular uprising, politicians have stalled on passing needed regulations. And the delays have allowed the utility's competitors in the natural gas industry to buy up rare storage formations in Vattenfall's backyard.

The protests began last year. Residents are concerned that CO2, which causes suffocation at high concentrations, will leak from rock formations, despite assurances from geologists that escape is practically impossible. And there are other worries -- about stored CO2 turning groundwater acidic and forcing real estate prices to plunge.

And in coal-rich Brandenburg, some locals fear CO2 storage would encourage expanded surface mining, destroying more towns in a region environmentally devastated by communism and economically crippled by capitalism. They have launched demonstrations in churches and created Internet sites splayed with foreboding images of gas masks and bombs, fuses burning, buried in the soil.

"No one believes the companies," said Michael Kess, a leader of CO2 Endlager Stoppen, a local opposition group. "The only thing Vattenfall wants is to make a profit. In hearings, we heard only nice things about [storage]. Every problem could be solved by Vattenfall. We don't believe them."

The unrest and delays confronting Vattenfall are not unique to the Brandenburg region. Similar protests strangled a project in Germany's west, and a Dutch town is feuding with its government and Royal Dutch Shell PLC over CO2 storage. European industry and governments, which have almost never seen protests over similar natural gas storage, now realize they are far ahead of society and are scrambling to allay the fears of a confused and angry public.

"It was amazing how angry and scared people were" about CO2 storage, said Filip Neele, a Dutch government geologist. Many believe CO2 is toxic at any level or that it will be buried in shallow rock near their homes' foundations, he said. "It's very difficult," he said, "to take away that kind of fear."

Placating a skeptical public is only one of many quandaries facing bureaucrats and businesses in Europe, which has been one of the earliest and loudest proponents of using carbon capture and storage (CCS) to contain CO2

emissions from coal. While the United States, a research leader, has made enormous recent leaps toward implementing projects in the past year, nowhere has seen CCS become as tangible, and problematic, as in Europe.

For more than a decade, several European countries have taxed carbon emissions, prompting the first CO2 storage projects, located mostly offshore.

Since 2005, the European Union has had a price on carbon, and the bloc has committed €1 billion to six large CCS projects, including a successor to Vattenfall's plant. Billions more euros will soon begin flowing to CCS projects from revenue raised by auctioning CO2 emission permits. In effect, the gas-poor region is making a big bet that it can burn its coal and still lead the world in combating climate change.

For that gamble to prove out, CCS has no choice but to work.

Putting CO2 'back into its bottle'

CCS is based on a simple idea.

The technology relies on one of several known chemical processes -- like methods used for decades to scrub excess CO2 from submarines -- to capture coal's emissions. Then compressed CO2 is pumped deep underground, allowing it to catch in the type of rock formations that have long been used to squirrel away natural gas or helium.

Since suitable storage sites are limited, and there is only so much coal to burn, CCS would be a stopgap against worsening climate change, a bridge to renewable energy, coal companies say.

In effect, attempting CCS amounts to a reversal of fossil fuel exploitation. But unlike flamable coal, CO2 is recalcitrant, tightly bonded and a poor feedstock for industry. It takes tremendous energy to make CO2 useful, except for plant life. And humans emit far too much of the gas for even the most aggressive algae to absorb it all through photosynthesis.

"There's no way around it. We need to put energy in to put CO2 gas back into its bottle, so to speak," said Christoph Heubeck, a petrogeologist at the Free University of Berlin who is skeptical that large amounts of CO2 storage exist.

The relatively little energy needed to pump CO2 underground has become CCS's primary selling point.

Despite the large costs involved in CO2 capture, the overall model has offered a lifeline to vertically integrated utility companies -- like Vattenfall -- whose futures, along with their coal supplies, seemed dim in the face of carbon limits.

Early research on CO2 capture technologies -- there are three competing candidates, including the system pioneered by Vattenfall -- has gone well, posing more of an economic and engineering challenge than a scientific issue. And surveys of German geology have found sites suitable for storage.

But questions remain: What happens to underground saltwater displaced by CO2? How much pressure can be added to porous rocks? How does CO2 flow underground?

There are larger questions, too: Does funding CCS perpetuate an outdated model of power generation? Can Europe create a CO2 infrastructure similar in size to that of today's oil pipelines? How much gas can these rock reservoirs truly hold? And will the public -- even if properly "educated" -- accept even tiny amounts of additional risk to halt climate change?

For the past several years, scientists and businesses in Germany and its neighbor, the Netherlands, have discovered that even incremental attempts to solve these questions come hand in hand with frustration, fear and public confusion.

No one knows this better than Vattenfall.

More carbon, more problems

Vattenfall arrived in Brandenburg more than a decade ago, lured by the German government, which wanted more competition on the market.

Previously, Vattenfall had been the model Swedish utility, its portfolio comprised of low-carbon hydroelectric and nuclear power. But Sweden's government wanted to make money, so it bought a suite of coal-fired plants and strip mines in Germany's post-communist east.

In retrospect, it is not surprising that the Swedes -- who have had a carbon tax since 1991 -- became annoyed that their government was buying into brown coal, which they view as dirty, said Katharina Bloemer, Vattenfall's spokeswoman. Facing angry citizens, the company searched for answers that could preserve its coal investment and placate voters. And, in 2001, it found oxyfuel.

Oxyfuel is the most unproven of the three technologies competing to take the lead in CO2 capture. It relies on using pure oxygen, separated from the air, to burn finely pulverized coal. The result is a waste gas that captures up to 99 percent of the plant's CO2 at high purities.

The idea is limited by the cost of removing nitrogen from the air, but despite this hurdle, Vattenfall has focused its research on oxyfuel, believing its simplicity will allow it to be quickly scaled up, said Göran Lindgren, head of Vattenfall's CCS research.

"The challenge, of course, is to scale any capture technology as soon as possible to scale with a reliability that is commercially attractive," Lindgren said. "Getting to that ... is one of the critical advantages of oxyfuel."

But scaling up is also expensive. In the absolute best case, it will cost €55 to capture a ton of CO2 at the larger oxyfuel plant Vattenfall wants to build by 2015. The cost is prohibitively expensive, though better than estimates from the consulting firm McKinsey & Co.

"We're talking about being able to achieve €20 per ton," Vattenfall's Lindgren said.

Vattenfall built its pilot plant in Schwarze Pumpe in the shadow of the firm's 1,200-megawatt coal-fired power plant. (Each day the commercial coal plant burns 36,000 tons of coal, a weight equal to 2,600 school buses.) Partnering with engineering firms like Alstom and Linde, Vattenfall paid for the plant with almost no subsidies.

While construction began, Vattenfall also identified where it wanted to store its CO2 in the long-term.

There was a rock formation capable of holding decades of emissions located under Schweinrich, a small town northwest of Berlin, smack in the middle of one of the most seismically tame regions in Germany. Teaming with geologists, Vattenfall pored over the site's structure and published its results in 2007.

Some 1,500 meters under the town sit several layers of sandstone, a highly porous rock flush with brackish water that millions of years ago was a sandy beach on a since forgotten sea. Overlaying the sandstone is a thick bowed layer of clay, dense and nearly impermeable. Called a cap rock, it provided an ideal structure for containing CO2. The gas, lighter than water and acting like a liquid thanks to high pressure, would rise flush beneath the clay. There it would sit, trapped.

But Schweinrich wasn't to be.

Vattenfall's candor backfired. The Russian natural gas giant, Gazprom, saw the Schweinrich site and, knowing the similar mechanisms needed to trap CO2 and natural gas, purchased permits for the formation in 2007. Planning to build a direct gas pipeline to Germany through the Baltic Sea, Gazprom needed somewhere to store its future reserves. Schweinrich suited them perfectly.

"They acted because they were developing within an existing business," Lindgren said with bemusement. "They had the opportunity. We had a more problematic situation," lacking any certainty CCS would move forward.

Vattenfall's first speed bump -- more were to come -- has made other companies wary of collaborating on possible storage sites, chilling the public research process, said Henk Pagnier, a Dutch geologist and prominent CO2 storage researcher.

"You develop a site in a public project," Pagnier said. "It was completely geologically modeled, and then somebody says, 'Thank you. Thank you for the work.'"

Dwindling options

Despite the Gazprom setback, Vattenfall pushed ahead with its pilot plant at Schwarze Pumpe, finishing it to fanfare in September 2008.

Testing got under way, as engineers studied how much flue gas to recycle or how hot to burn coal dust. But lacking a storage law, Vattenfall began talking with the only project that could pump its CO2 underground, a research site outside Berlin known as CO2 Sink.

It seemed a natural fit. CO2 Sink has been pumping small amounts of the gas into an underground formation redolent with sensors that were meant to provide the most rigorous look so far at tracking CO2 behavior. The project is expensive, and its leaders want to test industrial CO2 that carries few impurities -- exactly the kind of gas Vattenfall is venting.

But two years on, the two sides are still just talking. The cash-poor CO2 Sink researchers want Vattenfall to pay them for taking the gas. It is a source of exasperation for Vattenfall spokeswoman Bloemer.

"They keep changing the provisions," Bloemer said.

As negotiations faltered with CO2 Sink, Vattenfall encountered a far greater challenge to its gas disposal: Protests to storage bloomed in the Germany's northwest and then spread to Brandenburg. Vattenfall was

targeting geological storage in two formations similar to Schweinrich beneath the towns of Beeskow and Neutrebbin, and residents of Brandenburg were not pleased.

Driven largely by northwest protests, CO2 storage became a national issue last summer during Germany's national elections. Enabled by the Internet and high-profile farmer protests, the movement spread quickly. Politicians balked and delayed passing a CO2 storage law required by the European Union. The law, which legalizes storage and settles many liability and monitoring issues, remains dormant. And when it is revived, it will likely allow regions to ban CO2 storage.

For now, Brandenburg's government supports Vattenfall, one of the area's largest employers. Last month, Vattenfall received permission to study Neutrebbin, but its request for Beeskow has been complicated by the town's desire to explore its geothermal potential. Neither town's residents would stand to profit from storage: In Germany, mineral rights are owned by the state, not landowners.

Even if they were paid to accept the gas, some would resist, said Kess, the protest spokesman. "I won't support CCS even if I receive financial support," he said. "But if CCS comes, they have to pay a lot of money. It is our land. Not the land of the companies or government."

There is a distinct possibility that Vattenfall's storage proposals for Brandenburg will fail, Bloemer said. It remains too controversial. And should they fail, Germany has limited alternative storage options. It has few offshore reservoirs, unlike Britain, another CCS proponent that plans most of its storage for offshore fields.

But for now, Vattenfall can postpone these questions for another day. The firm has had one stroke of good luck: Just recently the Altmark, a natural gas field in Germany's interior, has begun running dry.

Depleted gas field beckons

The Altmark could hold a lifetime of emissions from one of Vattenfall's massive coal-fired power plants.

Already an industrial site, CO2 storage is less likely to engender local protest. Vattenfall wants to begun trucking CO2 to the Altmark from Schwarze Pumpe, but local politicians have again intervened, saying the request -- workable under mining directives -- must wait for the storage law.

CO2 appears likely to end up in the Altmark. The European Union sent €180 million to Vattenfall in its stimulus package for a new 250-megawatt oxyfuel plant to be built at Jänschwalde, 50 kilometers north of Schwarze Pumpe. The grant obligates Vattenfall to begin work on the demonstration plant, which will cost some €1.5 billion, this year.

Depleted gas fields like the Altmark are probably the best near-term storage bets, said Ralf Littke, a scientist at Aachen University who has literally written the book on Germany geology.

"These gas fields have been there for millions of years, so there's a good possibility that one could store CO2," Littke said. But few similar facilities exist in Germany, where most storage options would come underneath bucolic towns or jigsaw tracts of farmland.

"Germany is densely populated," Littke said. "Here in Western Germany we have more than 300 inhabitants per square kilometer. I foresee great problems."

Indeed, in Germany's current political climate, the possibility of outfitting most of the country's coal-fired power plants with carbon capture seems dim. And the government must understand there will not be another safety valve like the Altmark, said Heubeck, the Berlin petrogeologist.

"At the moment, we are very fortunate to have this huge gas field become empty," he said. "It's a coincidence that will never happen again."