Capturing Carbon for a Better Climate

The energy sector in Europe is coming under increasing pressure from both the European Union and the international community to reduce its emissions and improve efficiency as global warming progresses. Together with key partners, Siemens is exploring the potential of carbon capture technology, which is expected to be a significant step toward environmentally friendly energy production in both existing and future fossil fuel power plants.

By Rhea Wessel

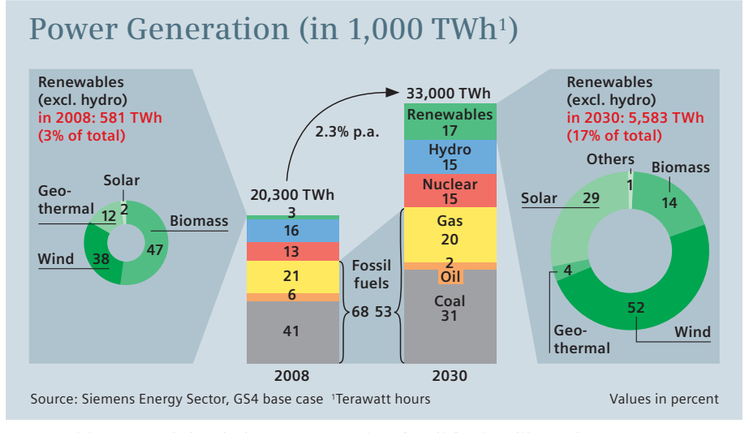
Photo: Christian Höhn

New postcombustion carbon capture technologies will help limit emissions from fossil fuel power plants.

With new environmental regulations from the European Union coming into effect, particularly those that will require all new fossil fuel power plants to be ready to capture CO_2, energy providers around Europe are beginning to test carbon capture technology that helps limit the emissions of power plants.
Companies such as German utility E.ON and Norwegian utility Statkraft are considering different varieties of technology. At a power plant near Frankfurt, E.ON and Siemens are implementing a pilot project to test postcombustion capture technology from Siemens that is used for coal-fired plants. Statkraft is conducting a study of how carbon capture technology works on gas-fired combined-cycle power plants.
Both projects will move forward the development of carbon capture technology that enables climate-friendly energy production. The European Union is expected to support large-scale demonstrations of postcombustion carbon capture technology, and the technology will be available commercially before the end of the next decade.
Power plants are seen as one of the key targets for emission reductions since they are estimated to contribute about 26 percent of all man-made greenhouse gas emissions, the source of which could be isolated at stationary points.
Over the past decades, the efficiency of coal-fired power plants has already increased significantly. For example, plants designed and built by Siemens reach efficiency ratings of about 46 percent with highly efficient steam turbines. On average, fossil fuel plants are forecast to increase their efficiency by 10 percent by 2030.
But even if the amount of fossil fuels needed for future power generation decreases on a relative basis as a result of this improved efficiency and better availability of renewable energy sources, the absolute usage will increase by almost 60 percent by 2030, according to an International Energy Agency (IEA) forecast.
Hence, scientists are pinning hopes on three types of carbon capture and storage (CCS) technologies for environmentally friendly energy production: precombustion carbon capture (called IGCC with carbon capture for coal plants or IRCC with carbon capture for natural gas-fired plants), integrated carbon capture (or oxyfuel) and postcombustion carbon capture (from flue gases of conventional power plants, based on a carbon scrubbing process). Still, by adding carbon capture technology to reduce CO_2 emissions of plants, utility companies reduce the overall efficiency of the plant. Hence, one of the focuses of carbon capture technology studies is on increasing their efficiency.
At Staudinger Unit 5 in the E.ON Kraftwerke plant in Grosskrotzenburg, Germany, E.ON and Siemens have teamed up to test CO_2 capture technology under real-world conditions after years of testing the technology in the lab. It is the first demonstration of Siemens' proprietary technology with flue gas from coal combustion in Germany.
At Staudinger, E.ON and Siemens are setting up a facility to test the solvent used, says Dr. Jörg Kruhl, Head of Technology Policy, New Technologies at E.ON. Kruhl and his team are in charge of examining carbon capture technologies from a strategic perspective.
In the pilot plant that will be operated roughly 15 months during the project, CO_2 will be removed from a small portion of the power plant's flue gas with special cleaning agents. This will hap-

Summary

Given new environmental regulations from the European Union, energy providers around Europe are beginning to test carbon capture technology that helps limit the CO_2 emissions of power plants. Siemens is offering IGCC technology for precombustion capture and developing a proprietary process for postcombustion capture in close collaboration with utilities. The German utility E.ON and the Norwegian utility Statkraft are considering several different varieties of technology. At a power plant near Frankfurt, E.ON and Siemens are implementing a pilot project to test post-combustion capture technology from Siemens that is used for coal-fired plants. The Norwegian utility Statkraft is conducting a study of how postcombustion carbon capture technology works on gas-fired combined-cycle power plants. Both projects will contribute to moving forward the development of carbon capture technology. Within a decade, the European Union will support large-scale demonstrations of postcombustion carbon capture technology, and the technology is expected to become available commercially.



Renewables are gaining in importance – but fossil fuels will continue to be the mainstay of energy production.

Photos: Christian Höhn, Graphic: Siemens

Glossary

- **Flue Gas:** Combustion exhaust gas produced at power plants.
- **Post-Combustion Carbon Capture for Power Plants:** Removes CO_2 from a power plant's flue gas using special cleaning agents before the cleaned gases are discharged to the atmosphere via the plant's stack; technology can be used in well-known fossil fuel power plant processes.
- **Precombustion Carbon Capture for Power Plants:** A method for pretreating fuel gas and extracting CO_2 before combustion; treated gas volume is only 1 percent compared to postcombustion capture, with more than twice the CO_2 concentration.

For further glossary terms see:
www.siemens.com/glossary

E.ON Kraftwerke Project Overview (Postcombustion Carbon Capture Pilot)

- Start of pilot operations: Summer 2009
- Planned end of pilot operations: End of 2010
- **Location:** Staudinger Unit 5, a hard-coal-fired power plant near Hanau, Germany, owned by German utility E.ON

Business partners: E.ON and Siemens at the Staudinger plant.

- **Technology focus:** Build pilot CO_2 capture system for coal-fired plant
- **Pilot focus:** Test cleaning agent's long-term chemical stability and efficiency of the process under real power plant conditions
- **Pilot focus:** Optimize energy consumption of the carbon capture technology
- **Goal:** Gather necessary experience and knowledge to provide large-scale demonstration plants around 2015
- **Funding:** Private funding and funding from the German Federal Ministry of Economics under the COORETEC Initiative

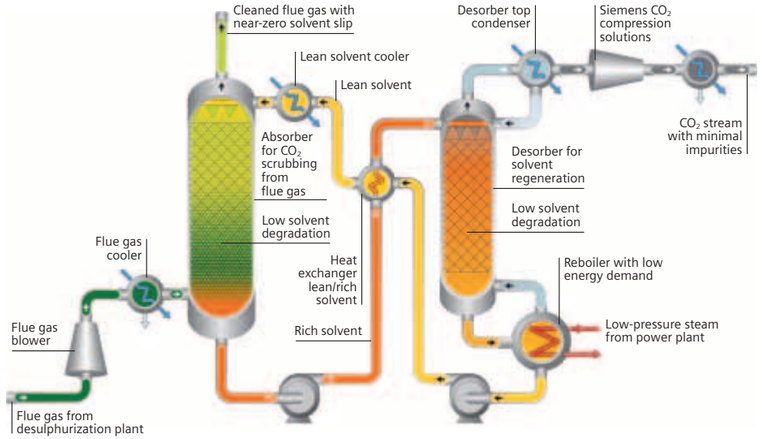
Statkraft Project Overview (Postcombustion Carbon Capture Study)

- Started in January 2009 with Norwegian utility Statkraft
- To be completed early 2011
- Based in Oslo
- **Technology focus:** Study how to adapt proprietary carbon capture technology to a gas-fired, combined-cycle power plant
- **Study focus:** Investigate the behavior of Siemens' solvent under the special flue gas conditions
- **Challenge:** Flue gas from combined-cycle power plants has a lower CO_2 concentration than that of coal-fired plants, and exhibits high oxygen content, resulting in potentially negative impacts on known solvents
- **Challenge:** These types of plants have frequent changes in load requirements, since they make up for lack of solar-produced power when the sun is not shining or lack of wind-produced power when the wind isn't blowing
- **Goal:** Optimize carbon capture process for easy backfitting of a CO_2 capture system in future combined-cycle plants
- **Funding:** Private

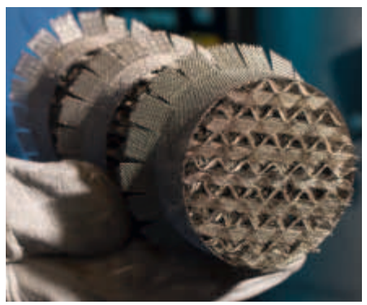
pen before the cleaned flue gases are discharged to the atmosphere via the plant's stack. Researchers hope to gain insight on the long-term chemical stability of the cleaning agent and confirm the process efficiency.
Kruhl says that E.ON has considered the advantages and disadvantages of all three carbon capture technologies by examining the technical as well as the economical aspects.
"Though we are still evaluating the matter, we have come to the conclusion that postcombustion technology has key advantages," says Kruhl.
For one, the technology is seen as an economically viable way to meet upcoming emissions standards for existing plants, since it can be retrofitted and can be used at new plants.
"We can't change the investments we have already made in coal plants. If CCS becomes a business case, we can add the technology to existing power plants," says Kruhl, adding, "We can verify the option to implement the technology later, showing politicians and the public that the investment is sustainable."
The test at Staudinger Unit 5 will be conducted in a column of the usual height of 35 meters but only 20 centimeters in diameter instead of the approximately 12 meters for first demonstration projects.
Kruhl says his company chose to test the technology from Siemens, given the company's expertise in designing and constructing power plants and its know-how in chemistry. The Siemens process uses amino acid salts to clean the flue gas. The solvent features low absorption enthalpy and near-zero vapor pressure, permitting an economic and environmentally friendly capture process. Based on the project results, Siemens will then be able to evaluate the impact on the life cycle costs on the plant including operational costs and availability and reliability which are key parameters to optimizing the technology.
The partners will focus their research on measuring the conditions, such as the degradation of the solvent and the capture rates, so that both parties can gain experience with the technology and better understand how to maximize its efficiency.
"We have to learn the full thermodynamic process to see how to improve it. Once this is done, the next step is to do it on a larger scale," says Kruhl.
The POSTCAP pilot project at Staudinger Unit 5 project is partly funded by the COORETEC Initiative of the German Federal Ministry of Economics.

Siemens CCS Study for Statkraft's Gas-Fired Plants

In another project, Siemens has teamed up with the Norwegian utility Statkraft Energi AS to conduct a study of postcombustion carbon capture technology in gas-fired, combined-cycle power plants. Since January, the partners have been studying how the technology needs to be adapted to the special conditions of this particular type of power plant. Specifically, they are examining the impact of the plant's conditions on the Siemens solvent.
For example, the flue gas in this type of plant has a lower CO_2 concentration than in coal-fired plants, but it has a higher oxygen content, which can lead to higher solvent degradation. Researchers will also study how to optimize the efficiency of the process for plants with varying loads, i.e. plants that produce more electricity at certain times – for instance when the sun is not shining or the wind is not blowing – and less at others.
The study with Siemens is particularly interesting for Statkraft, given its market ambition to be the European leader in environmentally friendly energy, including being an active contributor to sustainable development within the European energy market.
Another reason Statkraft is participating: It is preparing itself to meet the EU's upcoming requirements that new plants be capture ready by being able to be retrofitted with the technology within the next few years.
"A major part of the study will be to create a design for a gas-fired power plant and to identify all areas which could involve a low amount of preinvestment to avoid larger investments later if capture is required," says Simen Elvestad, Statkraft's project manager, adding, "We want to investigate how a carbon capture and storage plant could be operated in conjunction with a gas-fired power plant on a flexible basis. We will study how to ramp up and ramp down the capture process."
A third reason Statkraft ordered the study, to be finished in early 2011, is to learn about market price dynamics. As one of Europe's leaders in renewable energy, the company is in constant dialogue with partners and politicians about the energy market.
"We want to better understand the price implications of capture technologies on the power market to be a knowledgeable partner for a dialogue," says Elvestad.
The study, which has a budget of 1.7 million euro, is being conducted in three phases. In Phase 1, which is currently underway, Siemens is designing and adapting the process for this application. In Phase 2, the capture-ready plant that could be retrofitted with postcombustion capture technology will be developed. As they select the plant's elements, the partners are looking for possible efficiency improvements and identifying where to reserve extra space for adding the capture technology at a later time. In Phase 3, the scientists will investigate the impact of the carbon capture plant on the dynamic behavior of the gas-fired power plant.
"We would like to shut down the plant when market conditions are not favorable. This becomes more complicated when a carbon capture facility is present. We want to know what kind of operating regimes would be necessary," says Elvestad.
When the study is complete, Statkraft will be able to use what it has learned in future designs and for its specifications for market tenders. For Siemens, the goal is to optimize the process to enable easy backfitting of the carbon capture system for future combined-cycle power plants.



Siemens' postcombustion capture process has lower environmental impact and is more energy-efficient than other capture processes.



Structured packings are inside the absorber and desorber columns to provide high-contact surface for gas and liquid.

Photos: Christian Höhn, Graphic: Siemens

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Further Information

www.siemens.com/energy/ccs