The Carbon Hunters

An IIT startup has an unusual business model – it extracts carbon dioxide from power plant waste gases and uses it to make valuable chemicals, writes **Hari Pulakkat**

Why Carbon Capture and Storage is Important

Despite the rise of renewable energy, coal and natural gas will continue to be important for four or five decades from now

India will continue to depend on coal and gas for base load, as nuclear energy is unlikely to provide a large share

Capturing and storing the carbon dioxide emitted by power plants is thus necessary to fight rapid climate change

Carbon capture is expensive, and so electricity from a clean thermal plant will cost more than current prices

Growing Investor Interest

2009 ₹60,000: Indian angel investors

2011 $1.1 million: Angel investment from India and Europe

2012 $6 million: UK Department of Energy and Climate Change

2014 $3 million: US Department of Energy for demonstration in a US plant

2015 $5.7 million: Private equity funding from the UK

Carbon dioxide may be a dangerous waste for the planet, but for Tuticorin Alkali Chemicals it is a vital input for making soda ash. The company is dependent on a nearby SPIC fertilizer plant for this gas, but a change in technology is set to reduce the amount of carbon dioxide that it can buy in the future. Its attempts to produce carbon dioxide using a lime kiln had to be abandoned due to high costs, poor quality of lime and other reasons. Tuticorin Alkali Chemicals needed a fresh source of carbon dioxide quickly to take care of the growing demand for soda ash.

Carbon Clean Solutions was looking for a problem like this. A six-year-old startup from IIT Kharagpur, Carbon Clean Solutions was set up by two undergraduate students in 2009 to extract carbon dioxide from flue gases in power plants and use it to make valuable chemicals. It was a tough problem in economic and technology terms, but the company claims to have a method that could do the job cheaply. Tuticorin Alkali had boilers in a small thermal plant that produced flue gases. Carbon Clean Solutions set up its equipment to capture carbon dioxide, while also capturing the soot and other pollutants from coal. The thermal plant now runs cleanly. Tuticorin Alkali Chemicals gets enough supply of carbon dioxide.

Thermal plants are a major source of carbon dioxide emissions in the world. Some scientists believe that capturing and sequestering thermal plant emissions is essential to control global warming, as humanity has no choice but to use fossil fuels for a few decades or more. The captured carbon dioxide is usually buried deep underground, but it can be used to make useful products as well. According to the firm Markets and Markets, the global market for carbon capture and sequestration is expected to be $8.05 billion by 2021. The technology for carbon capture is still in early stages, and the potential market in the long run can be very big, as coal plants emit billions of tonnes of carbon dioxide every year. So there is a rush around the world to develop solutions to capture and sequester carbon dioxide, or to develop valuable products if possible. "We are innovating the carbon dioxide capture so that its price is no more a constraint for conversion to products," says Aniruddha Sharma, CEO of Carbon Clean Solutions.

Dirty Business

India now generates 186 gigawatt of coal-based power, and these plants emit 600-700 million tonnes of carbon dioxide every year. Indian thermal power plants are considered inefficient, and they emit far more carbon dioxide emitted by the most efficient plants in the world. India plans to increase this capacity substantially by 2022, which would in turn double its emissions as well in a business as usual scenario. Even with very efficient plants, Indian thermal plants will emit far more carbon dioxide than the country can afford to allow, if the world has to control rapid climate change.

Although coal-fired thermal plants are declining in developed countries, they will continue to be important in developing countries for a while. So companies and public-funded labs have been trying to develop methods to capture and sequester carbon dioxide cheaply. The early carbon capture plants have all sequestered the gas in formations underground. This itself is a challenging task, as the costs are high, but now companies are trying to use the capture carbon dioxide to make valuable products.

The world's first carbon capture and storage plant came up at Saskatchewan, Canada, in 2014. Since then, 14 more such plants have come up around the world and another seven are being constructed. Together, these 22 plants have the capacity to capture around 40 million tonnes per year, according to the Global CCS Institute, an international member-driven organisation. One coal plant produces around 3-4 million tonnes of carbon dioxide per year. An average car emits 6-7 tonnes of carbon dioxide a year. Sequestering one million tonnes of carbon dioxide a year is like taking off 1.5 lakh cars off the road.

Some scientists believe that sequestering thermal plant emissions is key to controlling global warming, as humanity has no choice but use fossil fuels for a few decades or more

In 2015, India had 171 gigawatt of coal-based power generation, and these plants emit 600-700 million tonnes of carbon dioxide every year. But Indian thermal power plants are considered rather inefficient

However, the world's coal-fired plants together emit 15-16 billion tonnes of carbon dioxide a year. So it is an enormous task to capture and sequester carbon dioxide in significant amounts. It doesn't come cheap either. The Saskatchewan plant cost $1.3 billion. Two-thirds of the cost of a plant comes from capture, which had hovered around $100 for a tonne of carbon dioxide for some time. This cost has been falling, and Carbon Clean Solutions claim to have a proprietary process that costs $30 a tonne.

Few investors would have listened seven years ago, when IIT Kharagpur classmates Aniruddha Sharma and Prateek Bumb talked about making a business out of carbon dioxide capture. This was not what Indian startups did, either seven years ago or now. The students entered a business plan competition at IIT Bombay and won the third prize. Then they won an award at the Pan-IIT conference. A mentor – yet unnamed – approached them and gave some seed money. Since IIT Kharagpur did not have the labs to do this kind of research, Bumb and Sharma started building things from scratch, outside the purview of IIT. Then they approached the Institute of Chemical Technology (ICT) in Mumbai, where they set up a small pilot plant.

Carbon capture is a very difficult process, because the gas is already in a low energy state. So you have to supply energy to make it react with something, which drives up the cost. People used two kinds of compounds to absorb carbon dioxide: amines and salts. Sharma and Bumb developed a proprietary solvent that could dissolve carbon dioxide using a proprietary catalyst, and tested it at ICT. It turned out to be good, and could remove 90% of the carbon dioxide from flue gases. "They had a low cost process," says PD Vaidya, associate professor at ICT. "We found that it was better than other solvents." Carbon Clean filed for a patent.

Investor Interest

The company then went abroad for testing and expanding its business. They got more angel investment from India and Europe, and $6 million from the UK Department of Energy and Climate Change for technology demonstration. The US government gave them money too, for demonstration in a pilot plant. Last year they raised $5.7 from private equity firms. Its technology was tested at the Netherlands Organisation for Applied Scientific Research, called TNO in Europe.

TNO had special expertise in carbon capture technologies, and its scientists were impressed with the new process. "They made a breakthrough in energy consumption," says Earl Goetheer, principal scientist at TNO. Pilot plants came up in the UK and US. The first commercial customer was in India. Getting Tuticorin Alkali Chemicals was a big breakthrough for the company, as Carbon Clean Solutions had been propounding the utilisation of carbon right from the beginning.

Sharma believes that a variety of chemicals can be made economically using captured carbon dioxide as an input. Sodium carbonate, or soda ash as it is known, is a large and growing market. Carbon dioxide can be an input for making plastics, cement, urea, or even fuel. Some of these sequester carbon for some time, and some others for a long time. Plastics, for example, offer no sequestration if burned later. Cement on the other hand can sequester carbon for a long time. In fact, the cement industry is one of the largest producers of carbon dioxide, and so a carbon capture and utilisation plant can work very well along with a cement plant.

There are experts who believe that carbon capture and utilisation is not enough, as it can utilize not more than 10% of the carbon dioxide emitted by power plants. It may not even work in large plants. "There is a business case for small plants," says Goetheer, "but I will not hold my breath for large-scale utilization." The only option then is to store the gas underground, hoping that it will not escape. It may not be impractical, as the cost of capture starts coming down. If the technology works cheaply and safely, we may not need to worry too much about India's increasing emissions from coal.

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