This page shows a variety of approaches to carbon capture . . .

Ethan Novek wants to capture carbon and clean up fossil fuels

By **Thomas Page**, CNN

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Story highlights

- Novek's prize-winning method aims to strip CO2 from power station emissions
- His concept has been peer-reviewed and patented
- Novek is currently scaling-up his technology and has attracted investors

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(CNN)"You can't achieve the Paris accord values unless you have some form of carbon capture," says Ethan Novek.

The 19-year-old founder of Innovator Energy is keen to stress the urgency of the problem. The majority of energy is still sourced by burning fossil fuels, releasing CO2 into the atmosphere. Continuing to do so at current rates will make it impossible to limit global temperature rise to 1.5 degrees Celsius above pre-industrial levels.

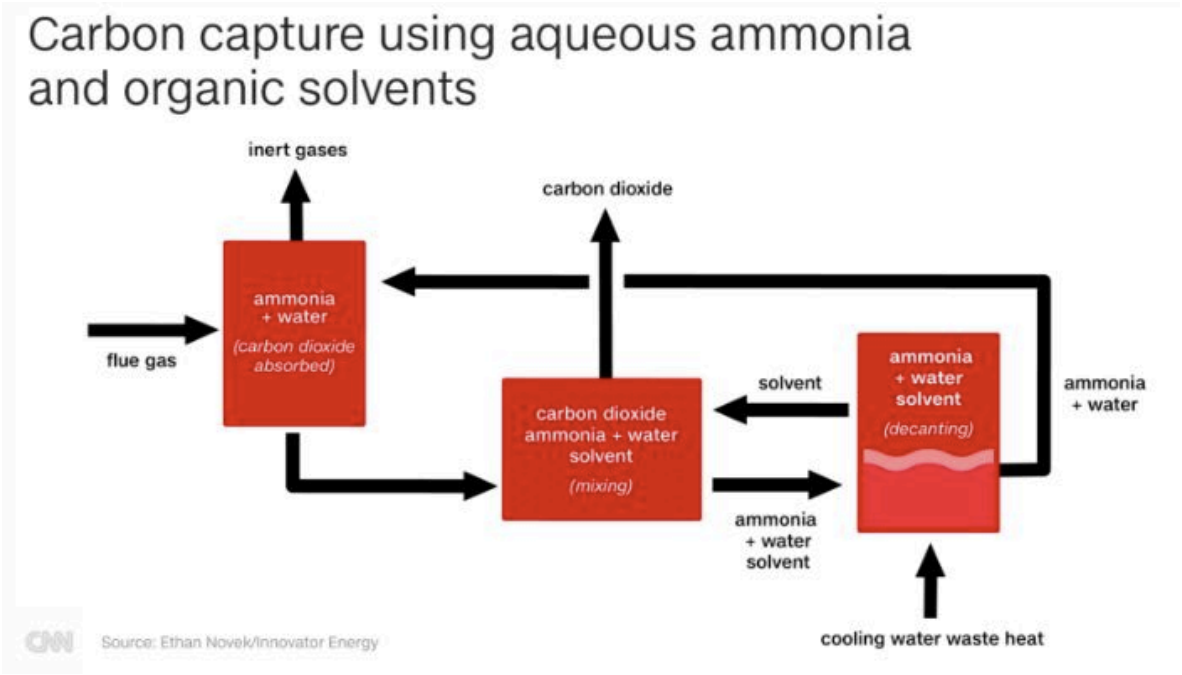
That is, unless the act of burning fossil fuels can be cleaned up -- and Novek is in the business of making that happen.

An age-old problem

Carbon capture is not a new idea. One method, oxy-combustion, was pioneered in the late 19th century, while another, using chemical absorption, was patented in the 1930s.

"These key technology elements have a very long history at a very substantial industrial scale," explains Niall Mac Dowell, senior lecturer at the Centre for Environmental Policy at Imperial College, London.

In West Texas, the oil industry has used carbon dioxide in enhanced oil recovery since the 1960s and '70s, he adds. It remains the most popular use for captured CO2. More recently, intrepid startups have sought to turn carbon dioxide in to gasoline and ethanol, a liquid alcohol.



Novek, a Connecticut native, is blunt in his assessment of current methods.

"Present technologies for capturing CO2, or separating emissions into pure CO2, are fundamentally flawed," he argues. They are prohibitively expensive, Novek says, and due to being energy-intensive, somewhat counterproductive.

He claims his solution can capture over 90% of CO2 emitted by coal or natural gas power plants while operating at $5-8 per ton of carbon dioxide -- substantially cheaper than other carbon capture technologies, he argues.

"I've discovered a very different approach that enables the technology to be entirely powered by waste heat from a power plant -- not just any waste heat, but the ultra-low temperature, worthless waste heat," he says, referring to the thermal pollution we see evaporating from cooling towers.

Novek's method pumps flue gas emissions through a mixture of water and aqueous ammonia. CO2 in the flue gas binds to the ammonia forming a salt, while inert gases are released. The salt is then separated with a

solvent and the carbon dioxide is captured. Finally, the mixture is separated using waste heat from the power plant to render the two components insoluble, allowing the ammonia and the solvent to be decanted for re-use.

"The entire process uses non-toxic, non-volatile reagents," Novek adds. "They're all commodity chemicals, so very inexpensive."

"It's fantastic that people are innovating in this space," says Mac Dowell, but offers the caveat that while low operating costs are a positive, any method "would need to be very quantitatively demonstrated that (it) also significantly reduces the capital cost of the CCS (carbon capture and storage) process."

Nonetheless, he describes the work as "a small but important contribution" in the field.

Heading to market

Novek's idea has won prizes at state and national science competitions. As a research fellow at the Elimelech Lab at Yale University, his method was peer-reviewed in 2016 and a US patent granted in April 2017. Now it's the cornerstone of Novek's company Innovator Energy.

The global demand for CO2 was estimated at 80 million metric tons in 2011, rising to a predicted 140 million metric tons in 2020 according to the Global Carbon Capture and Storage Institute. It's a tiny fraction of the 36 billion metric tons emitted in 2016, per the Global Carbon Project. Many academics, including Mac Dowell, advocate pumping captured carbon dioxide underground into saline aquifers; the best way, he says, to ensure it is "locked away from the climate forever."

However, if we're not going to lock away all captured CO2, finding

valuable uses for it is imperative. Innovator Energy, for one, has proposed converting carbon dioxide into commodity chemicals.

Scaling-up his carbon capture technology has taken the student to Norway, where he is conducting more research and testing. Novek expects to have a commercial product in two-to-three years-time, and in five anticipates greater growth of Innovator Energy's other pursuits. To the layman the chemical engineering may sound complex, but behind the work there's a simple intention:

"Increasing the standard of living typically involves increasing resource consumption. All my work surrounds the concept of decoupling the two," says Novek. "I think that's essential to making people successful in life."

Photos: Solving the carbon problem

Sleipner gas fields, North Sea – Sleipner gas platform, 155 miles off the coast of Norway. Its carbon storage facility captures and injects carbon dioxide deep under the North Sea into a sandstone reservoir. StatoilHydro, who operate the rig, has sequestered 16 million metric tons of CO2 since 1996, say the company.

Photos: Solving the carbon problem

Boundary Dam, Saskatchewan, Canada – Boundary Dam Carbon Capture and Storage Project in Estevan, Saskatchewan, captures approximately one million tons of CO2 per year according to the Global Carbon Capture and Storage Institute (GCCSI). The Canadian facility uses CO2 in enhanced oil recovery, a process where gas is injected underground to flush out residual oil from rock formations between oil wells.

Photos: Solving the carbon problem

Petra Nova Carbon Capture Project, Texas – Coal mounds NRG Energy Inc. WA Parish generating station in Thompsons, Texas. The plant, home to the Petra Nova Carbon Capture Project, injects 1.6 million metric tons of CO2 every year in its enhanced oil recovery operation -- equivalent to 90% of its CO2 emissions, say NRG. It's the largest project of its kind in terms of capture volume currently operating in the US, per the GCCSI.

Photos: Solving the carbon problem

Hellisheidi Geothermal Power Plant, Iceland – Hellisheidi Geothermal Power Plant outside Reykjavik, Iceland. Carbon dioxide emissions from the plant are dissolved in water and re-injected into basaltic bedrock and locked in mineral form. Reykjavik Energy's CarbFix2 program aims to make the site carbon neutral, and at present 60% of gases are now turned into minerals underground, with the long-term objective to make the site's operation "traceless" in terms of gas emissions.

Photos: Solving the carbon problem

Illinois Industrial Carbon Capture and Storage, Illinois – In Decatur, Illinois, the Archer-Daniels-Midland Co. plant processes corn and turns it into ethanol. The factory produces 350 million gallons of ethanol each year, and in 2017 announced it plans to inject approximately 1.1 million metric tons of CO2 per annum emitted during manufacture into a nearby saline aquifer 7,000 feet underground.

Photos: Solving the carbon problem

Quest Carbon Capture and Storage, Alberta, Canada – Quest's hydrogen production plant outside Edmonton launched its CCS initiative in November 2015, transporting captured CO2 to a separate site for geological storage. Shell, who operate the site, reported it had stored its first 2 million metric tons ahead of schedule, and also made the argument that if they built the site again, it would cost 20-30% percent less to construct and operate.