



DOE/NARUC Carbon Capture, Storage & Utilization Partnership Webinar Summary

“Petra Nova and the Future of Carbon Capture”

March 23, 2017

NARUC’s Carbon Capture, Storage & Utilization Partnership hosted a webinar exploring a recently opened innovative carbon capture project, the Petra Nova facility in Thompsons, Texas. A vice president at NRG Energy joined the partnership to discuss his management of the project.

Petra Nova, the world’s largest post-combustion carbon capture facility, began operating on December 29, 2016. NRG announced the start of project commercial operations on January 10, 2017, and Energy Secretary Rick Perry joined Texas Governor Greg Abbott and the CEOs of NRG, JX Nippon, and Hilcorp Energy for a ribbon-cutting ceremony on April 13, 2017. The project can capture and sequester 5,200 tons of CO₂ per day. Captured carbon is used to increase oil production at the West Ranch oilfield. To date, the project has injected 260,000 tons of CO₂ into the oilfield. This project was delivered on-time and on-budget.

Petra Nova encapsulates five processes: transporting the flue gas from the coal unit, processing flue gas to remove CO₂, transporting CO₂ to an oilfield, injecting the CO₂ in the oilfield to produce otherwise unrecoverable oil, and transporting and selling the oil. Revenues from the oil pay for the entire project. Petra Nova demonstrates that the host coal unit does not have to

change its pricing or operations to accommodate carbon capture. The project actually increased the capacity from the host plant by 50 MW and it has not had to change its bid price into the ERCOT market.

Petra Nova captures 1.6 million tons of CO₂ per year from 240 MW of coal-fired generation – the equivalent of taking 350,000 cars off the road.

Step one in the process is a flue duct transporting flue gas out of the coal unit in a 16-foot fiberglass duct running 2,000 feet. The distance of the pipe helps cool the gas for processing.

Second, the flue gas is conditioned in a quencher using a

direct contact cooler spraying water into the flue gas stream to cool it and using a sodium hydroxide polishing scrubber to eliminate sulfur dioxide. **Third**, the 320-foot absorber tower includes structured packing beds to create abundant surface area where CO₂ comes into contact with a solvent. **Fourth**, the rich amine is pumped to a regenerator where boilers heat up the solvent, breaking the bond between the CO₂ and the solvent. The CO₂ forms a bubble in the top of the regenerator and a pipe on the top removes the separated CO₂. Flue gas exiting the absorber is 90 percent nitrogen, 1 percent CO₂, and 8 percent oxygen.

Fifth, the project integrates a compressor into the carbon capture system delivering 1900 psi

supercritical CO₂ to the West Ranch oilfield.

Finally, an 82-mile CO₂ pipeline delivers the CO₂ to the oilfield, stepping the pressure down to 1100 to 1300 psi for direct injection into the field. The project achieves these

How does Petra Nova work? Six steps:

1. Capture flue gas from coal unit
2. Condition the flue gas
3. Introduce solvent
4. Heat the gas to separate CO₂
5. Compress CO₂ for delivery
6. Pipe CO₂ to oilfield for injection



processes with a standalone cogeneration steam and power facility to avoid parasitic load on the host coal unit. The project needs approximately 40 MW to operate, and the remaining 35 – 40 MW from the cogeneration facility are sold to the grid. The project follows Southern Company's Plant Berry with Mitsubishi, treating 25 MW of output from a coal unit. Petra Nova is a scale-up of approximately three times the vessel size but ten times the throughput.

The 82-mile pipeline runs southwest to the West Ranch oilfield in Vanderbilt, Texas. Sixty miles of the pipeline are located underneath existing 345-kV transmission lines. It crosses through two other oilfields that could benefit from CO₂ and three others near the pipeline. Petra Nova chose an oilfield that chose to work with them six years ago. Now that the CO₂-EOR project has been shown to be successful in the region, additional oilfield operators may be interested in receiving CO₂. The pipeline has additional built-in capacity to transport more CO₂ for future CO₂-EOR projects.

The oilfield takes a patterned approach of one producer surrounded by four injectors. The oilfield has a comprehensive monitoring system to measure CO₂ entering the reservoir and ensure that it remains sequestered after oil is removed. A portion of CO₂ (80 percent) does come back out with the oil, and two central processing facilities work to separate CO₂ and water from the oil and prepare both for reinjection.

A number of partners including JX Holdings, Hilcorp Energy, the Japanese government, and the U.S. government comprised the commercial structure behind Petra Nova. DOE awarded a \$190 million grant through the Clean Coal Power Initiative. The Japanese

government also participated via a \$250 million low-interest loan made through export credit agencies JBIC and NEXI. NRG and JX are joint equity owners of Petra Nova Parish Holdings LLC. Petra Nova and Hilcorp formed a joint venture called Texas Costal Ventures that owns the West Ranch oilfield. Overall, approximately \$1 billion in investment went into the entire project, including the cogeneration facility, carbon capture and storage facility, the carbon dioxide pipeline, and facilities at the oilfield.

In the Q&A portion of the webinar, Commissioners asked about the economics of the facility. Petra Nova assumed a national carbon policy would be in place that would help the project outside of the use of CO₂ in enhanced oil recovery, but without the materialization of a cap-and-trade program or a carbon tax, the project had to work on oil revenues alone. In the long term, oil prices need to be above \$50 for the project to get a return. Captured CO₂ will produce oil for at least the next

decade, during which NRG hopes oil prices will stabilize around \$75 per barrel. Other than the price of oil, the federal 45Q tax credit for carbon capture and Texas incentives for clean coal projects (property tax abatements, production tax abatements, franchise tax exemptions) were also crucial to the project's success. The amine scrubbing system is the only technology that is commercially available at this time in the current policy environment. Researchers are improving the additional technologies – membranes, adsorbents, etc. – used in carbon capture, and those projects will need to be funded for future carbon capture projects to succeed.

Commissioners asked about the applicability of projects like Petra Nova to other states. CO₂

Project partners included NRG Energy, JX Holdings, Hilcorp Energy, JBIC, NEXI, and DOE.



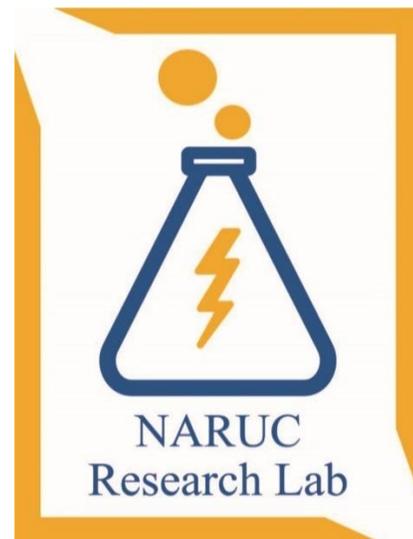
is being delivered from locations as far as Colorado to the Permian basin via thousand-mile pipelines. NRG views carbon capture as the way for coal plants to survive in a carbon-constrained era beyond the Trump administration. The Rockies and the Permian basin offer the biggest opportunities to sequester carbon dioxide. The industry could take an incremental approach to capturing carbon from plants in the Midwest and south before working to coal units on the east coast.

Regulatory Commission staff asked about monitoring requirements for sequestered CO₂. The Texas Railroad Commission has requirements for monitoring and reporting that the project complies with. As the operator of the field and the purchaser of the captured CO₂, Hilcorp has a financial interest in monitoring CO₂ and maximizing its useful life. Additionally, as part of the DOE grant, a third party needs to monitor the field for the duration of the DOE project. The University of Texas's Bureau of Economic Geology carries out this function.

A state commissioner followed with a question about the project's reception. NRG reported that a number of interested parties from the U.S., India, South Korea, Pakistan, Norway, the U.K., and other countries have visited the facility.

Petra Nova takes a few arguments against carbon capture off the table. First, carbon capture backers encounter persistent impressions that technology is not yet ready for large-scale commercial projects. The project shows that technology is available, but further research and development is needed to bring costs down. Second, projects have faced difficulty financing. In the case of Petra Nova, the project did not include a contract or hedge program for oil prices but was still able to get financing from the U.S. government and

a loan from the Japanese government under commercial terms. NRG encouraged commissioners to keep an open mind about carbon capture, given the evolution that Petra Nova went through during the six years from conception to operation. Petra Nova will be a facility to watch for states looking to encourage carbon capture projects.



This "Surge Summary" represents the synthesis of a policy conversation among state PUC commissioners & staff aimed at interstate collaboration, technical assistance, and information sharing.

Please address questions to NARUC's Research Lab staff, whose details are online at www.naruc.org/lab

We undertook this work thanks to technical assistance from the US Department of Energy under agreement DE-FE0027486.

Have a question you'd like to convene state commissions from around the country to explore? Please contact Miles Keogh, NARUC's Lab Director, at 202-898-2217 or mkeogh@naruc.org.