2020-IP11

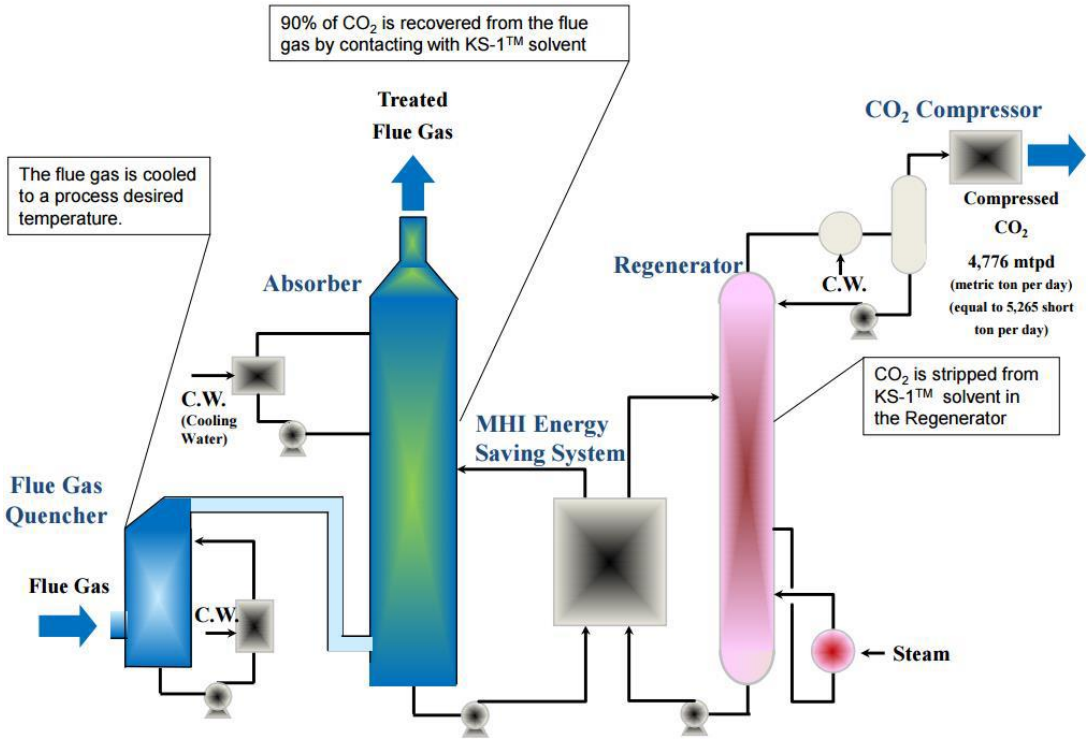
Final Scientific/Technical Report

W.A. Parish Post-Combustion CO_2 Capture and Sequestration Demonstration Project

The final report to the USDOE's Office of Fossil Energy relating to its financial support to the **Petra Nova Project** was published on 31 March 2020 (www.osti.gov/biblio/1608572-parish-post-combustion-co2-capture-sequestration-demonstration-project-final-technical-report). Some of the key points made in the report are discussed below.

The Project

1. Petra Nova is a commercial-scale post-combustion capture project developed by a joint venture between NRG Energy, Inc. (NRG) and JX Nippon Oil Exploration (EOR) Limited (JX). Of the USD 1 billion initial investment, the USDOE provided a grant of USD195 million from Round 3 of the Clean Coal Power Initiative (CCPI).
2. As it does with all recipients of its funding, the USDOE asked for a full, frank and expansive description of the project's history, with a detailed description of the operational challenges experienced by this first-of-a-kind (FOAK) project. This ensures the information is available to benefit all future developers and commercial adopters of CO_2 capture.
3. The project was designed to separate and capture CO_2 from the flue gas slipstream of an existing coal-fired unit at NRG's W.A. Parish Electric Generating Station located southwest of Houston, Texas. The captured CO_2 is dried, compressed and transported via an 81-mile (130-km) pipeline to the West Ranch oilfield in Jackson County, Texas, where it is injected to boost oil production.



Simplified Process Flow Diagram of the CO_2 Capture Facility (Generic)

4. At least 90% of the CO_2 from a 240 MW flue gas slipstream off the power station's Unit 8 is treated and captured using the Kansai Mitsubishi Carbon Dioxide Recovery advanced amine-based CO_2 absorption technology (KM-CDR Process®), which was jointly developed by Mitsubishi Heavy Industries Ltd. (MHI) and the Kansai Electric Power Co. Inc. (KEPCO).
5. Following a FEED study and subsequent construction, commercial operation was achieved on 29 December 2016, marking the beginning of a 3-year demonstration period that ran from 1 January 2017 through 31 December 2019. Notably, the project was completed on time and within budget.
6. Key aims during the 3-year demonstration period were to:
    a. Demonstrate the project's advanced technologies and
    b. Monitor the injected CO_2 at West Ranch to demonstrate technologies and protocols for monitoring, verification, and accounting (MVA).
7. Petra Nova represents the largest commercial-scale deployment of post-combustion CO_2 capture technology at a coal power plant to date.

Results and achievements

8. Petra Nova met all of the objectives that had been agreed with the USDOE. For a FOAK project, this was a notable achievement. Specific objectives were to:

    a. Demonstrate successful operation of an advanced amine post-combustion process to achieve 90% CO_2 capture efficiency from the 240 MWe slipstream.

    When operating at 100%, the carbon capture facility captured the targeted 4,700 tonnes of CO_2 per day. Over the 3-year demonstration period, the capture rate averaged 92.4%.

    b. Demonstrate technological advances to the selected amine process aimed at lowering energy requirements of the carbon capture process.

    While minimising energy requirements was important to reduce operating costs, the key goal was always to meet the CO_2 capture targets. The scale-up to a commercial system was a monumental step and provided valuable energy information, far beyond what a smaller project could deliver. In lieu of taking power and steam from the host coal unit to serve the CO_2 capture process, Petra Nova constructed a stand-alone cogeneration facility.

    c. Investigate advanced solvents, including piperazine. Demonstrate the concept of integrating a cogeneration system into the carbon capture process to provide the energy requirements to operate the system in the form of steam and power.

    To demonstrate a piperazine-based solvent developed by the University of Texas at Austin, the scope was limited to the solvent portion of the CO_2 capture plant, i.e. from absorber column to the outlet line of the regenerator/stripper column. However, modelling predicted the low-pressure CO_2 temperatures from piperazine would pose a problem for the downstream CO_2 compressor. As this could void guarantees and warranties, and damage equipment, the exercise was discontinued.

    As Petra Nova uses approximately 35 MW for its power needs, a cogeneration facility was installed. The cogeneration facility was sized to meet the steam needs of the

carbon capture process, not the electricity requirements, with the remainder of the power sold into the local energy market. Adding the cogeneration facility demonstrated that carbon capture could be achieved without being parasitic to the host coal unit, thereby not having a negative impact on local electricity prices. As the facility was powered by natural gas, the cleaner burning facility also improved the carbon footprint of the overall process. However, the downside of a standalone source of power and steam was the additional outage risk: with no back-up supply from the host coal unit, the cogeneration facility led to 88 days of incremental outage time for the capture facility over the 3-year demonstration period.

d. Capture and permanently sequester up to 2.9 million tonnes of CO_2 over a 2-year demonstration period.

The target of 2.9 million tonnes was based on an 85% capacity factor at the daily-targeted CO_2 capture rate. Petra Nova demonstrated that the facility can operate and maintain the targeted CO_2 capture rate of 4,700 tonnes per day during all ambient conditions but underestimated the assortment of system challenges to achieve an annual capacity factor of 85%. However, over the 3-year demonstration period, the capture facility captured 3.54 million tonnes of CO_2.

Factors that impacted the ability to maintain 100% capture levels included:

- Facility forced outages (including the capture facility, the host coal unit and the cogeneration facility);
- A partial or full shut-in of the CO_2 pipeline;
- West Ranch's ability to received captured CO_2;
- Weather (a key contributor was from Hurricane Harvey in 2017);
- Planned maintenance of the capture facility, host coal unit, cogeneration facility and the West Ranch facilities; and
- Partial day outages resulting from operational issues (including equipment de-rates, concentration of CO_2 in the flue gas and ramping of the host coal unit).

Notably, the capture facility saw 104 days of outage over the 3-year demonstration period, equivalent to a 91% availability. This represents a very high availability for a FOAK system, with mature environmental control systems typically returning availability rates of 95%. For example the cogeneration facility, which is a commercial technology, returned a 94% availability over the same three years.

e. Demonstrate technologies and protocols for the CO_2 monitoring, verification, and accounting (MVA) necessary to establish the permanence of the sequestered CO_2 and provide a full accounting for all captured CO_2.

The University of Texas at Austin's Bureau of Economic Geology (BEG) was commissioned to manage and report on the MVA activity. BEG designed and conducted a monitoring programme to document storage of CO_2. The monitoring program was based on the same principles of several evolving monitoring programs and proved sufficient for this application. Employing a range of processes, BEG

established an appropriate baseline prior to the injection of CO_2 and continued to monitor throughout the 3-year demonstration period to identify any changes.

f. Establish the impact of CO_2 capture and sequestration operations on the cost of electricity (COE), and provide recommendations necessary for the demonstration technology to achieve a COE reduction.

Petra Nova is not integrated with the host coal unit for power and steam requirements. As operations of the host unit are independent of the capture facility, Petra Nova had no impact on the COE to consumers. With excess power from the cogeneration facility sold to the grid, supply of power is essentially increased, which theoretically reduced the COE. However, valuable information from the project increased understanding of the energy requirements and will be of value to future CO_2 capture projects.

Further remarks

9. The full report to USDOE contains a detailed review of the three phases of project activities:
    a. Phase 1: Project definition/Front End Engineering Design (FEED)
    b. Phase 2: Detailed Engineering, Procurement & Construction
    c. Phase 3: Demonstration and Monitoring
10. A full discussion of the MVA Programme, its processes and procedures, are also included.

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