Full-Scale FEED Study for Retrofitting the Prairie State Generating Station with an 816-MWe Capture Plant Using Mitsubishi Heavy Industries America, Inc. Technology

primary project goals

The University of Illinois and its partners will perform a front-end engineering design (FEED) study for the retrofit of the Prairie State Generation Company's (PSGC) coal-fired power station with post-combustion carbon capture. The University of Illinois and the team will produce a FEED study that uses Mitsubishi Heavy Industries' (MHI) Advanced Kansai Mitsubishi Carbon Dioxide Recovery (KM CDR) Process™ carbon dioxide (CO_2) capture technology to retrofit one of PSGC's two generating units (approximately 816 megawatt-electric [MWe]) in Marissa, Illinois, to become the largest post-combustion capture plant in the world.

technical goals

- The purpose of the FEED study is to complete preliminary engineering and design work to support developing a detailed cost estimate for the cost of retrofitting CO_2 capture at PSGC.
- The team will perform multiple feasibility and design studies based on project-specific details in preparation for developing engineering deliverables. These studies will help define the scope of the retrofit project, based on project-specific decisions, technology-specific performance, site-specific requirements, and client-specific needs.
- Once the scope has been defined, detailed design will commence for the CO_2 capture system and its integration with the existing facility. Various design and engineering deliverables will be developed that will help define commodity quantities, equipment specifications, and labor effort required to execute the project.

technical content

The overall project goal is a full FEED study on a carbon capture system for Unit #2 (816 MWe) at the PSGC Energy Campus in Marissa, Illinois, based upon on the KM CDR Process CO_2 capture technology from MHI. This capture technology represents the current state-of-the-art and employs an improved solvent from that used at the 240-MWe Petra Nova capture plant in Thompsons, Texas. The capture technology will be scaled-up to 816 MWe.

Work on this FEED study will produce detailed engineering designs, costing, and timelines for the construction. It will also designate permitting agencies and timelines in order to execute the follow-on build and operate project. Lessons learned during the FEED study will be documented to assist in future large-scale capture retrofit projects at coal-fired power plants.

technology maturity:
Front-End Engineering Design (FEED)

project focus:
Advanced KM CDR Process™ Retrofit

participant:
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FE0031841

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start date:
10.01.2019

percent complete:
N/A

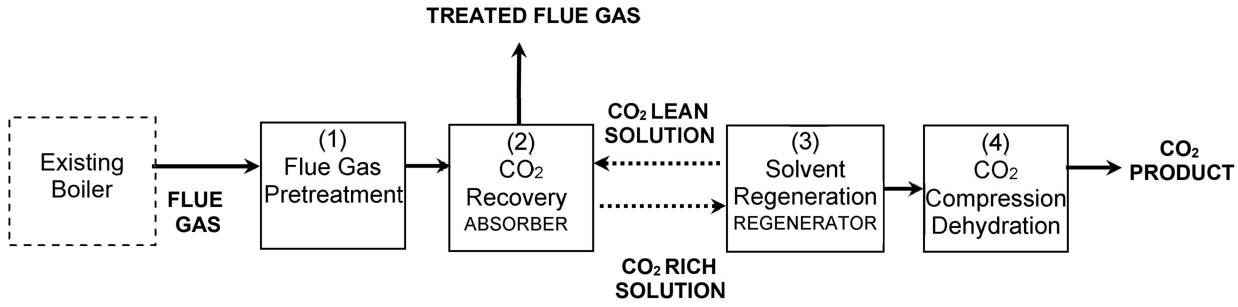

Figure 1: Block flow diagram of the CO_2 recovery plant.

The KM CDR Process is an improvement upon MHI's original KM CDR Process and is an amine-based CO_2 capture process that uses a newly developed solvent known as KS-21. The CO_2 capture system will recover 95% of the CO_2 from the flue gas and compress and treat the CO_2 to adequate pipeline conditions.

The CO_2 recovery facility consists of four main sections, as shown in Figure 1: (1) flue gas pretreatment, (2) CO_2 recovery, (3) solvent regeneration, and (4) CO_2 compression and dehydration. In flue gas pretreatment, the flue gas temperature is cooled in the flue gas quencher by direct contact with circulation water. The circulation water is injected with caustic soda to reduce the amount of sulfur dioxide (SO_2) in the flue gas entering the amine system. A flue gas blower is installed downstream of the flue gas quencher to overcome the pressure drop across the flue gas quencher and the CO_2 absorber.

Figure 2 shows the process flow diagram for the CO_2 recovery and solvent regeneration steps. In CO_2 recovery, the cooled flue gas from the flue gas quencher is introduced at the bottom of the CO_2 absorber. The flue gas moves upward through the packing while the CO_2-lean solvent is supplied at the top of the absorption section where it flows down onto the packing. The flue gas contacts with the solvent on the surface of the packing, where 95% of the CO_2 in the flue gas is absorbed by the solvent. The CO_2-rich solvent from the bottom of the CO_2 absorber is sent to the regenerator. The CO_2-lean flue gas exits the absorption section of the CO_2 absorber and enters the flue gas washing section of the CO_2 absorber. The flue gas contacts with circulating water to reduce the carryover amine that is emitted from the top of the CO_2 absorber.

In solvent regeneration, cool rich solvent is heated by the hot lean solvent extracted from the bottom of the regenerator in a heat exchanger. The pre-heated rich solvent is then introduced at the top of the regenerator column and flows down over the packing, where it contacts with stripping steam. As it flows down the column, the rich solvent releases captured CO_2 and is regenerated back into lean solvent. The steam in the regenerator is produced by the reboiler, where low-pressure steam is used to heat the lean solvent. The lean solvent is then cooled to the optimum absorption temperature before being recycled back to the CO_2 absorber.

The overhead vapor leaving the regenerator is cooled, and the condensed liquid from this unit is then returned to the system. In CO_2 compression and dehydration, CO_2 is compressed through a multi-stage gas compressor. Treatment such as oxygen (O_2) removal or dehydration may be necessary to meet pipeline and storage guidelines.

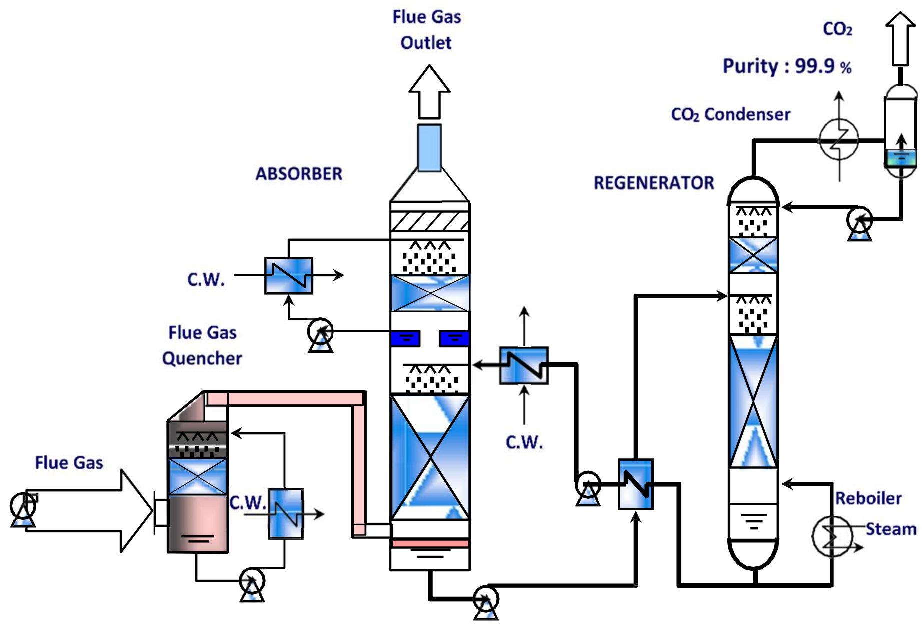

Figure 2: Carbon capture basic process flow diagram.

technology advantages

- Uses an improved, newly developed proprietary solvent known as KS-21. This solvent's properties translate into reduced capital costs.
  - Has less volatility, which reduced the height of the water wash section of the CO_2 absorber, lowering capital cost.
  - Has improved thermal stability, allowing the regenerator to be operated at a higher pressure and temperature, thereby reducing the equipment size and the power consumption for CO_2 compression, resulting in lowering operating and capital costs.
  - More resistance to oxidative degeneration, which reduces solvent loss.
  - Has lower heat of absorption, which allows higher circulation rate and therefore slightly less steam consumption.
- Will recover 95% of the CO_2 from the flue gas and compress and treat the CO_2 to adequate pipeline conditions.
- The capture system will be scaled-up using multiple trains so that it can standardized, modularized, and overall project cost can be reduced.

R&D challenges

- To deploy the post-combustion amine technology on coal-fired gas while adequately managing accumulation of impurities in the exhaust without excessive cost.
- Ensuring reliable operation over a long period at large-scale (19,000 to 25,000 short tons per day).

status

This project has commenced.

available reports/technical papers/presentations

None.