15th International Conference on Greenhouse Gas Control Technologies GHGT-15

15th -18th March 2021, Abu Dhabi, UAE

Full-scale FEED Study for Retrofitting the Prairie State Generating Station with an 816 MWe Capture Plant using Mitsubishi Heavy Industries Engineering Post-Combustion CO_2 Capture Technology

Kevin OBrien PhD[a]*, Yongqi Lu PhD[a], Jason Dietsch[a], Zhenxing (Jason) Zhang PhD[a], Tiffany Wu[b], Timothy Thomas[b], Keisuke Iwakura[c], Matthew Thomas[d], Alison Brown[d], Paula M. Guletsky[e], Anthony Baker[e], Rich Meyer[f], Javier Arzola[f], Don Gaston[f]

[a]Prairie Research Institute, University of Illinois at Urbana-Champaign, 615 E. Peabody Drive, MC-650, Champaign, IL 61820, USA
[b]Mitsubishi Heavy Industries America, Inc., 20 East Greenway Plaza, Suite 600 Houston, TX 77046, USA
[c]Mitsubishi Heavy Industries Engineering, Ltd., 3-3-1 Minatomirai, Nishi-ku, Yokohama, Kanagawa, Japan
[d]Kiewit Engineering Group Inc., 8900 Renner Boulevard, Lenexa, KS 66219, USA
[e]Sargent & Lundy, LLC, 55 E. Monroe Chicago, IL 60603, USA
[f]Prairie State Generating Company, 3872 County Highway 12, Marissa, IL 62257, USA

Abstract

This front-end engineering and design (FEED) study is for a carbon dioxide (CO_2) capture system for Unit #2 (816 MW) at the Prairie State Generating Company's (PSGC) Energy Campus in Marissa, IL. The capture technology used is the Advanced KM CDR Process™ from Mitsubishi Heavy Industries (MHI). The project will be the largest post-combustion capture plant in the world. In addition, it will incorporate advancements in the technology including lessons learned from past projects and a new proprietary solvent. The overall business model being developed by PSGC focuses on the generation of 45Q tax credits as a result of sequestering the captured CO_2. Because the Prairie Research Institute (PRI) within the University of Illinois at Urbana-Champaign (UIUC) leads both this capture effort and the storage effort, there is close coordination and integration between the capture and storage efforts. This integration is vital to achieving the desired business targets for the project.

Keywords: Carbon Capture; CO_2 Capture; Associated CO_2 Storage; FEED Study; Demonstration; Post Combustion; 45Q

1. Introduction

This project is a part of a US Department of Energy (DOE) initiative to design a commercial scale carbon dioxide (CO_2) capture system. The engineering design that will be developed will be used to build a facility at the Prairie State Generating Company (PSGC) site. This project is a front-end engineering and design (FEED) study and includes the process design of the CO_2 capture system (CCS) by Mitsubishi Heavy Industries (MHI) and balance of plant (BOP) integration by Kiewit Engineering Group Inc. (Kiewit) and Sargent & Lundy (S&L). The Prairie Research Institute

* Corresponding author. *E-mail address:* kcobrien@illinois.edu

(PRI) within the University of Illinois at Urbana-Champaign (UIUC) leads the project. This CO_2 capture FEED is being coordinated with a related CO_2 storage project that is also being led by PRI/UIUC.

2. Background

2.1. Description of Host Facility

The PSGC power plant is a +1,600 MW facility outside of Marissa, IL, and it is the newest coal-fired power plant in Illinois. The facility is owned by nine (9) non-profit municipal utilities and rural electric cooperatives with a mission to create a sustainable, secure energy future for the communities it serves. The high level of dedication of the host site is exemplified by the formation of the steering committee that is chaired by the CEO of PSGC. In addition to the commitments listed previously, PSGC's board of directors, with approval from all owners, has authorized $3.75 MM in cash committed as cost share to the FEED study.

PSGC is a pulverized coal (PC) plant equipped with the latest supercritical power generation technology to burn high sulphur Illinois coal from the Lively Grove mine located adjacent to the plant (see Fig. 1). The mine-mouth power plant has two units, each with a nominal capacity of 816 MW net output. Unit #1 was commissioned in June 2012, followed by Unit #2 in November 2012. The plant's youth makes it attractive for retrofitting for carbon capture, utilization, and storage (CCUS).

Each PSGC unit uses a supercritical, spiral wound coal-fired boiler manufactured by Babcock & Wilcox (B&W). The boilers deliver main steam at 3,780 psig and 1,055°F at the super-heater outlet. The steam turbine-generators were supplied by Toshiba, nominally rated at 877 MW at an exhaust pressure of 3.0 inches of mercury. Each steam turbine is a 3,600-rpm, extraction condensing, reheat type unit. The air pollution control devices include low oxides of nitrogen (NO_x) burners equipped in the boiler. The boilers are followed in sequence by a selective catalytic reduction (SCR) system for NO_x control, an activated carbon injection (ACI) system for mercury control, a dry electrostatic precipitator (ESP) for particulate control, wet flue gas desulfurization (FGD) for sulfur dioxide (SO_2) control, and a wet ESP for aerosol control. The SCR supplied by B&W and other air pollution control devices supplied by Siemens represent the most advanced air pollution control technologies to remove greater than 98% SO_2, 90% NO_x, and 99.9% particulate matters. Bottom ash and fly ash from the boilers and air quality control systems are collected and combined with FGD wastes and conveyed to an ash storage area. Wastewater produced by the power plant, such as boiler and cooling tower blowdown, is reused in the ash handling and FGD systems to achieve zero wastewater discharge. A schematic diagram of the PSGC power plant is displayed in Fig. 2.

Fig. 1. PSGC is a mine-mouth plant coal-fired plant within Southern Illinois.

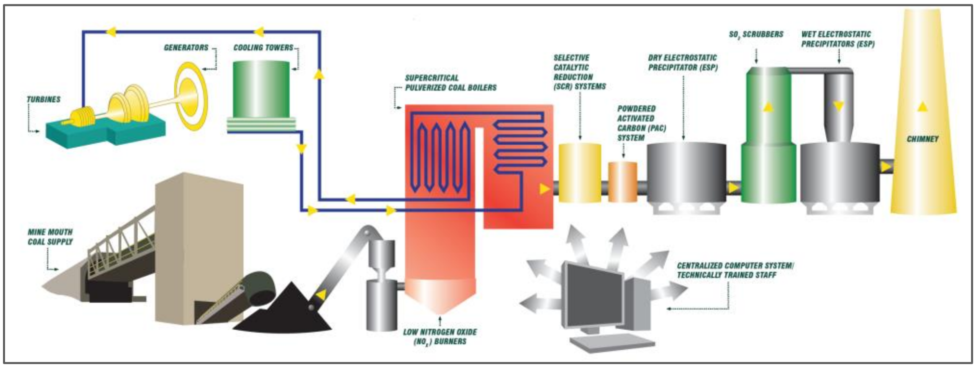


Fig. 2. PSGC schematic diagram.

PSGC power plant combines highly efficient pulverized coal technology and supercritical steam generation with advanced emission controls, resulting in a high plant efficiency and low air pollution emissions compared with subcritical plants. Due to high-energy efficiency, PSGC plant has also lowered CO_2 emissions by about 15%. Because it uses domestic coal resources and clean generation technologies to produce electricity in a more efficient and environmentally friendly manner, PSGC technology represents an important step toward creating a sustainable and secure energy future for the US. Therefore, the PSGC unit signifies an important basis representing future generation technology when considered for CO_2 capture retrofitting.

A previous DOE study outlined factors used to identify plants that would be "viable" for retrofitting with carbon capture systems [1]. Application of these factors make PSGC very attractive for installation of a carbon capture facility:

- *Plant has sufficiently large name-plate capacity*. PSGC's full name plate capacity is in excess of 1,600 MW. Retrofitting one unit (816 MW) provides sufficient economies of scale.
- *Sufficient space available for capture facilities*. The power plant is located on a 1,200-acre site, surrounded by agricultural landscape.
- *Long remaining lifetime makes retrofit cost effective*. PSGC is a relatively new plant (commissioned 2012) with the latest abatement equipment (i.e. SCR, FGD, ESP, etc.), thus retrofitting with CO_2 capture units is cost effective.
- *Accessible to Storage Sources*. PSGC is one of the major CO_2 sources in the latest CarbonSAFE Phase III proposal whose goal is to evaluate the feasibility of commercial-scale (+50 million metric tons) geological storage of industrially sourced CO_2.

PSGC power plant has demonstrated reliable operational performance since it was commercially commissioned in 2012. In recent years, the power plant has maintained a high and stable utilization rate, with the annual load factor ranging between about 75% and 85% (Fig. 3) [2]. PSGC has maintained a low annual equivalent forced outage rate (e.g., at 9.9% in 2017) and achieved a high monthly equivalent availability factor and net capacity factor (e.g., at 99.3% and 98.6%, respectively, in November 2017). This demonstrates that PSGC provides a reliable generating unit for CO_2 capture retrofitting.

Because PSGC is furnished with start-of-the-art emissions abatement equipment, there will be minimal additional flue gas polishing required to add CO_2 capture. The power plant also has sufficient electric utility, water, and other resources available for the CO_2 capture system. The agricultural landscape in the area provides ready access to the plot area required for capture units and BOP facilities.

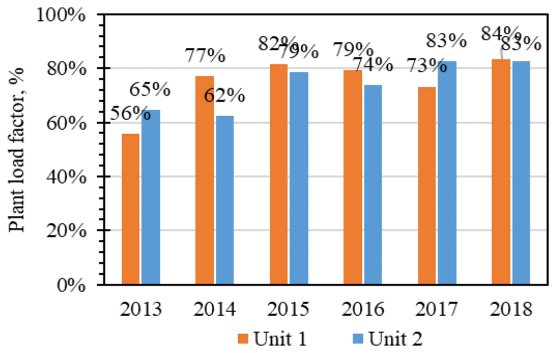


Fig. 3. Annual plant load factors of PSGC 2013-2018 showing reliable operation and high utilization.

As a mine-mouth power plant, the long-term supplier stability and coal supply cost is ensured even as the nation's coal mining industry declines, providing a consistent supply of the design coal and thereby minimizing de-rates or potential operational disruption at the power plant. All these facts suggest that PSGC plant is available for the carbon capture retrofitting project as a long-term viable source of power generation.

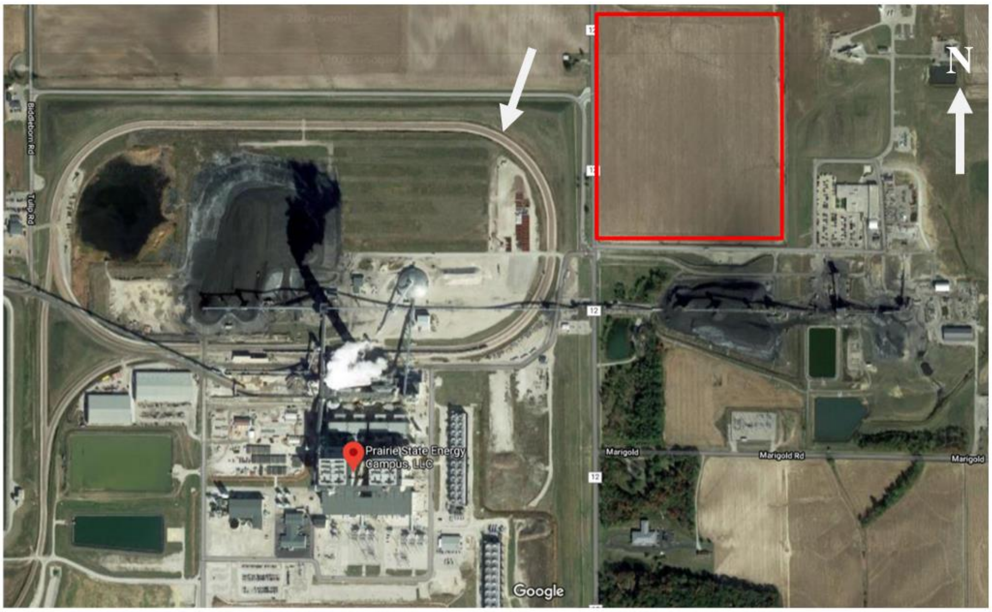
Regarding physical accessibility, PSGC has ready access through roads, rail, and river. The plant's proximity to the Mississippi River enables a modularization approach for construction. The power plant is located approximately 5 miles from Marissa, IL, and approximately 50 miles southeast of St. Louis, MO. The close proximity to St. Louis and transportation infrastructure allows for drawing from a large workforce of skilled craftsmen for the fabrication and construction of the CO_2 capture facility.

2.2. Off Take of Flue Gas and Location of Capture Plant

The location for off taking the flue gas from Unit #2 has been identified and is shown in Fig. 4. It is elevated approximately 180 feet above the ground and is readily accessible due to limited obstructions.

The final location of the capture plant is shown in Fig. 5 by the outlined red box. Factors considered included: (1) ready availability of land to accommodate plot size; (2) need for mine remediation; (3) constructability; (4) need for rail modifications; (5) amount and cost of duct work; (6) availability of natural gas; (7) cost to transmit power to location; and (8) impact on existing operations of plant. Four locations were considered: West, North, East, and inside the rail loop. The west and north locations were ruled out due to the need for extensive mine remediation at those sites. The location inside the rail loop (see arrow in Fig. 5) required the least amount of ducting, but it would require modifications to the rail loop. There were also some constructability concerns and the anticipated impact on plant operation during construction. The east location (final selection, see red box in Fig. 5) had more land availability, presented less of an impact on constructability, and was the optimal location for the capture plant even though ducting costs were greater than those for the inside the rail location.

Fig. 4. Location for Off-Take from Unit #2 denoted by circle.



Source: Google Earth

Fig. 5. Location of capture plant at PSGC facility in red. Arrow designates rail loop.

3. Capture Technology and Process

3.1. Description of CO_2 Capture Process

MHI's capture technology is a post combustion solvent-based system, similar to traditional solvent-based capture systems. The CO_2 recovery facility consists of four main sections as shown in Fig. 6: (1) flue gas pretreatment, (2) CO_2 recovery, (3) solvent regeneration, and (4) CO_2 compression and dehydration. Fig. 7 shows the process flow diagram for the CO_2 recovery and solvent regeneration steps. 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 flue gas pretreatment is minimal, consisting of cooling and polishing SO_2 removal. 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 SO_2 in the flue gas entering the amine system. A flue gas blower is installed downstream of the quencher to overcome the pressure drop across the quencher and the CO_2 absorber.

In CO_2 recovery, the cooled flue gas from the 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 amount of amine that is emitted from the top of the CO_2 absorber.

In solvent regeneration, rich solvent is first 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 into the upper section of the regenerator and flows down over the packing. As it flows down the column, the rich solvent is steam stripped and regenerated 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 further cooled to the optimum absorption temperature before being sent 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.

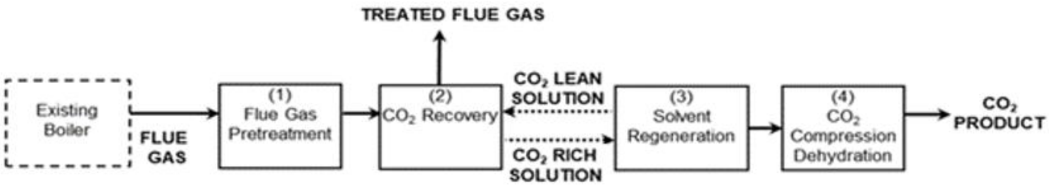


Fig. 6. Block flow diagram of the CO_2 recovery plant.

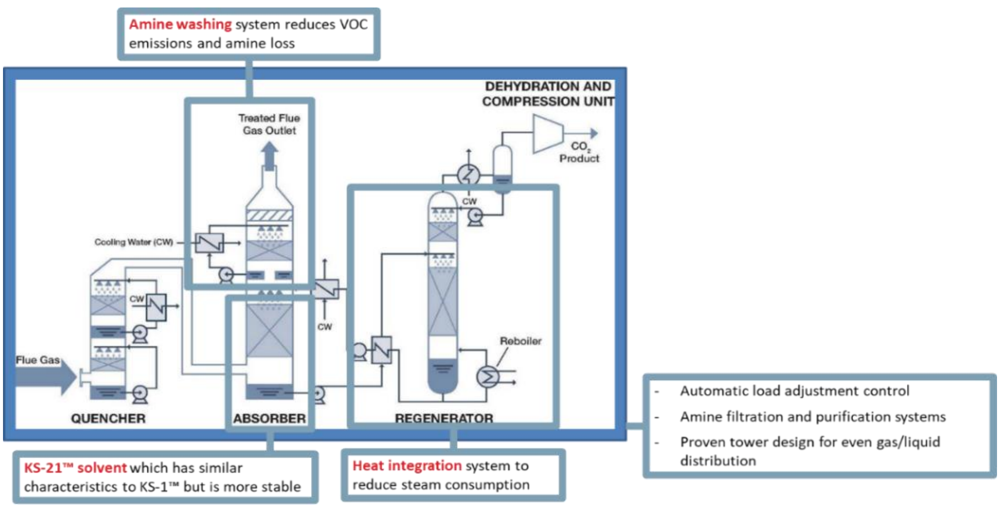


Fig. 7. Schematic of Mitsubishi solvent-based capture system.

The FEED study is being developed in preparation for the construction of a post combustion CO_2 capture system at PSGC. The capture technology that will be used is the Advanced KM CDR Process™ from MHI. The KM CDR Process™ was the technology used in previous projects.

MHI's Advanced KM CDR Process™ is an improvement on MHI's original KM CDR Process™. The original KM CDR Process™ has the following key features: (1) demonstrated performance at large scale (240 MW); (2) high-performing amine solvent KS-1™ (high absorption capacity, low steam consumption, high resistance to oxidation and thermal degradation); and (3) key process technologies such as amine emission reduction system, solvent degradation reduction, automatic load adjustment control system, and amine purification system [3].

The solvent that will be used at PSGC is MHI's next generation solvent KS-21™. KS-21™ shows favorable characteristics that will result in lower CO_2 capture cost from the original KM CDR Process™. KS-21™ is 50-60% less volatile than KS-1™. KS-21™ is more thermally stable and degrades at 30-50% the rate of KS-1™. This characteristic allows the regenerator to be operated at a higher pressure and temperature, which reduces its size and the power consumption for CO_2 compression, thereby lowering operating and capital costs. KS-21™ is more resistant to oxidative degradation and degrades at 70% of the rate of KS-1™, which reduces solvent loss associated with degradation. While the heat of absorption is about 85% that of KS-1™, the solvent circulation rate is higher, so overall steam consumption is comparable [4]. These advantages are outlined in Table 1.

Table 1. Solvent parameter comparison between KS-1™ and KS-21™.

Parameters	KS-1™	KS-21™
Volatility	100%	50-60%
Thermal Degradation Rate	100%	30-50%
Oxidation Rate	100%	70%
Heat of Absorption	100%	85%

3.2. Environmental Health and Safety Considerations (EH&S)

There is a significant amount of previous experience with the KM CDR Process™ as well as the environmental health and safety (EH&S) impacts of the amine based post-combustion CO_2 capture technology. General air and water emissions, solid waste streams, and potential environmental impacts are as follows:

Air Emissions: *(a) Treated Flue Gas* – The flue gas that has been mostly scrubbed of its CO_2 will exit the top of the absorber column. The top of the absorber column will include an amine wash section to minimize the volume of amines emitted with the flue gas. Using MHI's proprietary amine wash technology, previous projects operated well below the volatile organic carbon (VOC) permit requirements. Appropriate measures will be taken to ensure the same compliance of VOC permit emission limits at the PSGC facility. The height of the absorber stack will also be designed to ensure emitted amines do not produce any health or safety issues. *(b) CO_2* – Under normal situations, there should be no CO_2 discharged to the surrounding area. However, the CO_2 compression area should be well-ventilated in the event of a significant CO_2 release. CO_2 analyzers may also be worn by personnel to provide an added measure of safety.

Water Emissions: *(a) Flue Gas Condensate* – The flue gas entering the CO_2 capture facility area must be cooled down in the quencher. This results in flue gas condensate, which can possibly be sent to PSGC's recycle basin for reuse in the FGD and bottom ash handling systems. *(b) Reclaimed Waste* – Over time, the KS-21 ™ solvent will react with contaminants in the flue gas and accumulate heat stable salts, which degrade the performance of the system. A reclaimer will be installed to periodically remove these impurities from the solution. These impurities typically have a higher boiling point than KS-21™ and can be removed by distillation. Water and amine vaporize from the reclaimer as steam is introduced, leaving behind the degradation products. Although only small volumes are generated, reclaimer waste may contain hazardous trace metals requiring special disposal or treatment off-site.

Solid Waste: *Flue gas* from coal-fired power plants typically have high particulate matter concentrations that could build up in the solvent recirculation system. MHI implements a continuous filtration process to filter out solid impurities. This process results in a dried cake waste, which contains solid filtered impurities, filter aid, and residual moisture. The cake appears as a crumbly powder, free of airborne dust and can be easily handled.

Stormwater Runoff: *Stormwater runoff* from the BOP and CCS areas should pose no additional contamination risk relative to existing facility structures and is anticipated to flow into existing plant storm water systems. A full environmental review will determine final stormwater run-off design and the need for any special treatment (such as an oil/water separator).

Spill Containment: *KS-21™ solvent, caustic soda, reclaimed waste, and filtration unit waste* will need to be stored on-site. Spill containment structures will be provided for all chemical and waste storage areas and skids. The structures be chemically compatible with the material that is being contained.

3.3. Routes to Reduce the Cost of Capture

In addition to the capital and operating cost benefits that will be realized by using KS-21™, MHI has also reviewed the design of the KM CDR Process™ to identify other areas where capital costs can be reduced. Based on actual operating experience, MHI and Kiewit have found that they have the potential to reduce total engineering, procurement, and construction (EPC) costs by nearly 30% for the CO_2 capture system. This reduction can be accomplished by decreasing the size of the flue gas quencher and CO_2 absorber, modularizing the towers, reducing design margin of certain equipment, and modularizing the CO_2 capture system where feasible.[4]

4. Project Organization

The project organization is shown in Fig. 8. PRI/UIUC is the lead organization for the project. PSGC requested that PRI/UIUC be the awardee due to their experience with DOE, experience in commercialization, and knowledge of the framework and pathway for the State of Illinois to deploy a large-scale CO_2 capture facility. PRI/UIUC is strong in large project management skills and is equipped for US DOE reporting at the financial and technical level and has very strong relationships with power plants in the state of Illinois. This organizational stricter also provides for ease in coordination between the capture and storage efforts as PRI/UIUC is also leading the storage related project.

The partners will leverage a breadth of experience in capture technology research and development, commercialization, and large project management. The team will utilize lessons learned from previous projects by: (1) reviewing the design developed for previous projects as the starting point to inform development of PSGC capture unit design information; (2) developing a modular design for the capture unit; (3) using same team members that were engaged in previous projects; and (4) prioritizing 3D model coordination. This is beneficial to the process as it allows the project team to build off the lessons that were learned during the design and construction of the previous units. These lessons will be fully documented in order to assist in other future large-scale CO_2 capture retrofit projects on coal-fired power plants.

PSGC provides strategic guidance to the project through the steering committee. The chair of the committee is the CEO of PSGC. Members include representatives from PSGC, representatives from the organizations involved in the project, and external stakeholders. The steering committee is the forum for conflict resolution, review and approval of publications, and discussions related to project impediments. The steering committee has been regularly meeting on a quarterly basis to discuss overall progress on strategic items. Specific items are addressed at weekly teleconferences to discuss progress of the project, along with smaller group meetings to handle detailed technical items.

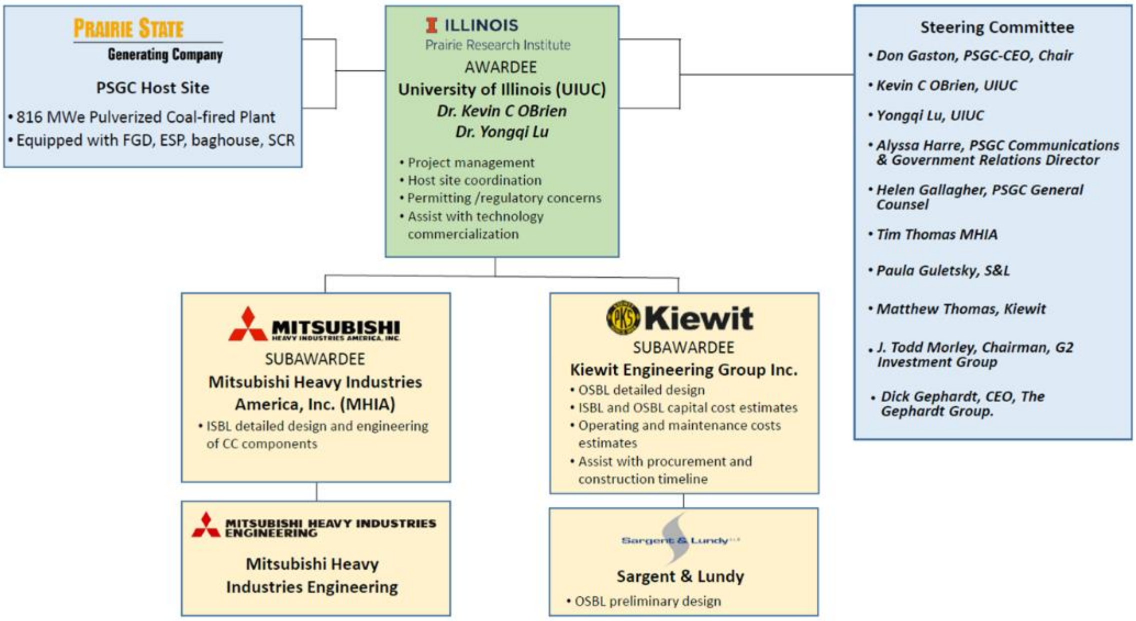


Fig. 8. Project organizational structure.

5. Critical Studies

Several focused critical studies are being conducted in parallel with the development of the project. These studies examined specific factors that would impact the design of the capture plant.

5.1. Steam and Electric Sourcing for Capture Plant

It is important to determine the source for the steam and electricity required by the capture plant. As in the past, one of the concerns was to not de-rate the plant. Options explored included (1) buying steam or electricity from the host site; (2) installation of new auxiliary boiler(s); or (3) new combined heat and electricity generation. It was determined that for this location auxiliary boilers were the best solution. Natural gas supply lines are in place and will be used to fire the auxiliary boilers. One of the critical efforts during the design stage was to optimize the location and configuration of the auxiliary boilers within the footprint of the inside battery limit. Note: CO_2 from the auxiliary boilers is captured as part of the project as well.

5.2. Water Supply for the Capture Plant

Various water sourcing options were evaluated to meet the water demands for the capture plant. Even though Illinois does not have the same water resource issues as other regions of the world, it is still important to consider the implications (both technical and regulatory) to meet the increased water needs due to capture. Power plants in this region of Illinois typically source their water from surface water instead of groundwater. Fig. 9 outlines the water supply regions in Illinois. The Kaskaskia (shown in green) is the source for PSGC's water supply.

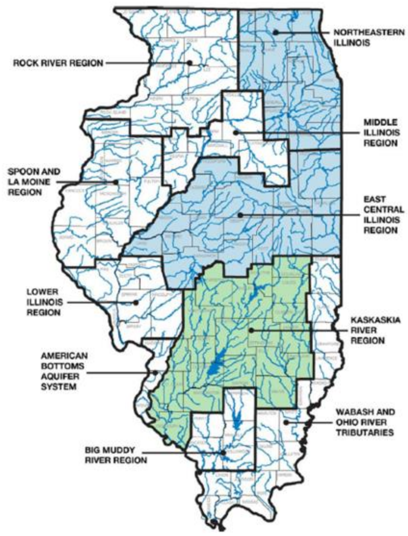


Fig. 9. Water supply regions in Illinois. The Kaskaskia watershed (green) supplies water for the PSGC plant.

There are existing hydrologic models, developed by PRI/UIUC, that are being used to assess the impact of the extra water usage on the Kaskaskia watershed. Under normal or wet years, the increased water demand for PSGC can readily be accommodated. In order to examine "worst case conditions", 25- and 50-year drought conditions were used to assess the predicted impact on the capture plant and develop strategies to mitigate these risks. Permitting needs were also assessed to determine the impact of increased water needs on existing permits held by PSGC.

5.3. Transportation Studies

Transportation studies are important because one of the key features of the construction of the capture facility will be modularization. Off-site fabrication and transport to the site is an important factor to help reduce overall costs of construction. Fortunately, the PGSC location is readily accessible by navigable water resources. Despite this convenience, there will still need to be modifications to public infrastructure when transporting the fabricated modules by land to the PSGC site. For example, one of the studies has identified what modifications would be required to various power lines that will be encountered when transporting by ground from nearby ports.

5.4. Other Studies

There are a series of other studies that are being conducted that address considerations such as wastewater treatment (mercury one of the major concerns), cooling system, compressor system overpressure relief, contracting and procurement strategy, and constructability. A hazard and operability (HAZOP) study will also be performed. The HAZOP review includes an in-depth examination of each piece of the new system to identify and evaluate any process or equipment risks. Recommendations for changes to the system design or operation will be made based on the HAZOP findings.

5.5. Regulatory and Permitting

Discussions are underway with relevant permitting agencies to indicate costs and timeline for permits required for the capture plant. Permits required include emissions (air and water), construction, and waste disposal (solid and hazardous).

6. Integrating Capture and Storage

A recent DOE initiative, called CarbonSAFE, is focused on matching CO_2 "sources" with CO_2 "sinks". The initiative determined that the PSGC facility is a key CO_2 source that is situated near several potential CO_2 storage locations. The combination of these features makes the PSGC facility an attractive location for a full-scale CO_2 capture and storage project.

The storage project is also led by PRI/UIUC, hence coordination amongst the two projects is greatly facilitated. An example of this coordination was defining the required CO_2 quality and pressure from the capture unit based on the local geological formations where the CO_2 will be stored. The designed CO_2 specifications are different from standard published pipeline specifications.

7. Business Model

The business model for the project includes considerations as to whether PSGC or a third party (most likely) will own and manage the capture, transport, and permanent storage of the CO_2. At this time one of the main financial drivers is the 45Q tax credits that can be obtained from the storage of the CO_2. Capital and operating costs will be estimated as part of the FEED Study, and the project team will make its best efforts to make this project economically viable. Other revenue generating opportunities are being explored that would utilize the captured CO_2 for options other than enhanced oil recovery.

8. Summary

The overall goal for this project is to complete a FEED Study for a CO_2 capture system that will capture 95% of the CO_2 from PSGC's Unit #2 using the Advanced KM CDR Process™ from MHI. This process represents state-of-the-art capture technology and will incorporate a next generation solvent. The FEED study will also identify the appropriate permitting agencies and timelines in order to execute future build and operation of the facility. Lessons learned during the FEED study will be documented to assist in future large-scale post combustion CO_2 capture retrofit projects for coal-fired power plants. This capture focused study is being coordinated with the related storage study. This integration is critical to assure that the full project can be financed. 45Q tax credits are the major driver from the finance side. While enhanced oil recovery is not being considered, other methods to utilize a portion of the CO_2 are being explored.

Acknowledgements

The authors wish to acknowledge the financial support from National Energy Technology Laboratory (NETL) of the US Department of Energy (Contract No. DE-FE0031841). We also appreciate coordination and discussions with Steven Whittaker, PhD, Principal Investigator for the separate but related CO_2 storage project.

Disclaimer

This paper includes an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned

References

[1] Database and Model of Coal-fired Power Plants in the United States for Examination of the Costs of Retrofitting with CO_2 Capture Technology, DOE/NETL-402/030809, April 2009.

[2] US Energy Information Agency, Power Plant Operations Report, Form EIA-923. 2003-2018.

[3] Miyamoto O, Maas C, Tsujiuchi T, Inui M, Hirata T, Tanaka H, Yonekawa T, Kamijo T. KM CDR Process™ Project Update and the New Novel Solvent Development. Energy Procedia 114; 2017. p. 5616-5623

[4] Tanaka H, Tsujiuchi T, Kamijo T, Kishimoto S, Lin Y, Kawasaki S, Nakagami Y, Nojo T. Advanced KM CDR Process using New Solvent. GHGT-14, 14th International Conference on Greenhouse Gas Control Technologies, 2018.