Abstract

The Värtaverket (KVV8) biomass-fired combined heat and power (CHP) plant in Stockholm, Sweden, is one of the world’s largest CHP plants. KVV8 provides 280 MW of heat and 130 MW of electricity to Stockholm, relying on forest residues and wood waste as fuel. To deploy a process at KVV8 that captures a minimum of 90% of the CO\textsubscript{2} emissions, several factors are considered, such as operational cost & efficiency; integration requirements; health, safety & environment (HSE); layout /space and construction requirements; CO\textsubscript{2} offtake approach, among others.

Subsequently, Stockholm Exergi selected a hot potassium carbonate (HPC) solvent-based CO\textsubscript{2} removal process as the preferred post-combustion CO\textsubscript{2} capture technology to be implemented and retrofitted onto KVV8. HPC-based CO\textsubscript{2} removal processes have been successfully deployed for decades in various industries, such as in gas sweetening and steam methane reformers, but has not been applied to flue gas streams at large scale.

In Q2 2021, Petrofac was awarded a Front-end engineering design (FEED) study for integrating a scaled up HPC CO\textsubscript{2} capture integrated to the CHP plant at KVV8, along with CO\textsubscript{2} compression, dehydration, liquefaction, storage and offloading. The HPC CO\textsubscript{2} capture process has been designed with a “compander” and heat recuperation configuration to maximize the efficiency of the CO\textsubscript{2} absorption and desorption from flue gas while using a safe, readily available and non-hazardous solvent that does not degrade or produce harmful emissions. Although such an innovation has not been previously deployed at such scale, the advantages it confers satisfies crucial efficiency and HSE requirements for the project that justify the attendant scale up risks.

The CO\textsubscript{2} capture and compression are designed to enable deep integration with the district heating network of the host facility by recuperating the heat available in the process. It can export more heat to the district heating network than it consumes in electrical power to run the process. Furthermore, the integration and operational requirements of the unit on the host facility are not as invasive as other competing CO\textsubscript{2} capture technologies, as the unit can be designed to operate solely on electric power while producing much of the heat required for solvent regeneration through heat recuperation (See Fig 1). As a result, the utility interface with the host plant can be simplified. Additionally, a pressurized absorber and reduced equipment cost result in a compact arrangement for the CO\textsubscript{2} capture unit, a critical requirement considering the location of the Värtaverket facility.
The waterside location of the plant also provides the opportunity for transporting the captured CO\textsubscript{2} by ships to the storage site. The temporary onsite storage of CO\textsubscript{2} is sized to avoid logistical disruptions to the operation of the capture plant while also considering the impact of CO\textsubscript{2} dispersion caused by accidental or emergency release. CO\textsubscript{2} is stored and transported in liquefied form, typically under either, 15 barg at -30 °C and 7 barg at -50 °C. The CO\textsubscript{2} offtake facilities can be designed to handle both conditions flexibly, but shipping costs and storage site requirements will ultimately decide the condition that CO\textsubscript{2} is being transported.

In completing the FEED study, Petrofac encountered and addressed several challenges related to equipment scale-up, heat integration and plant layout, and are able to demonstrate that such HPC CO\textsubscript{2} capture unit can be deployed at scale and retrofitted without significant disruption to the host plant operations and mechanical integrity, while also satisfying crucial project requirements regarding energy efficiency, heat integration with the host plant and HSE.

Keywords: CO\textsubscript{2} Capture; hot potassium carbonate, large-scale, BECCS