



Heat Rejection Design for Zero Liquid Discharge Shand Coal Fired Power Station Integrated with CO₂ Capture and Storage

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Abstract

The most common concern when integrating CO₂ capture and storage (CCS) to a coal fired power plant is the energy penalty due to the steam extraction for solvent regeneration. However, another challenging issue is the additional of water and cooling requirements especially when the plant has limited water and is operating under a zero liquid discharge. Zero Liquid Discharge Technology (ZLD) not only provides a solution to the environment challenge of eliminating wastewater but also reduces the volume of water a power plant needs to draw from other sources. This paper presents the design of a heat rejection system for the Shand power station that maintain the ZLD operation while adding SO₂ and CO₂ capture processes.

Shand power station is a 300 MW single unit pulverized coal fired power plant with CO₂ emission over 2 million tonnes per year. This lignite fired unit is located 3 miles east of the Boundary Dam Unit 3 CCS project. The international CCS Knowledge Centre is undertaking a feasibility study of Saskpower to explore the business case for a life extension with the addition of CO₂ capture. The existing power plant draws water from four sources which are Rafferty dam, Estevan Aquifer make up, Wetlands make up and yard drainage pond. The water is pumped to

Raw water pond before sending to Soft water pond to be clarified and softened. Then finally, it is blowdown and evaporated in the wet cooling tower. The blowdown water from the cooling tower is sent to a water treatment plant which producing demineralized water. The residual from the water treatment plant is sent to Decant pond and used in Lifac, a SO₂ removal process, to maintain the plant as ZLD.

The integrating of CCS to Shand power station not only results in additional water released from the process but also the increases water consumption and cooling duty. Therefore, management of water usage becomes vital for this project. Based on the design of CCS unit, the water released from the capture plant are mainly from quencher (quench water) approximately 97.5 tonne/hr and some from wet stage CO₂ compressor. The CCS unit increases the cooling duty to the plant by 339 MW_{th}. The additional cooling loads shown in Figure 1 include flue gas cooling water cooler, wash water cooler at the top of absorber, reflux condenser, lean solution cooler, CO₂ compression cooler, the dehydration unit cooler, rotational motor coolers and lube oil coolers.

Several options have been considered in this study including wet cooling, dry cooling and a hybrid cooling system which consisting of wet and dry cooling. Each option was evaluated under the assumption of 19.5°C of dry bulb and 14.2°C wet bulb temperatures. The heat rejection systems were designed and optimized to provide the cooling load of 339 MW_{th} by using Aspen HYSYS. Aspen EDR was used for equipment design and cost analysis.

From the results, it was found that the hybrid system is the most suitable for heat rejection of Shand integrated CCS. Dry cooling alone cannot provide sufficiently low temperature of cooling water year-round because it is limited by dry bulb temperature. Wet cooling system alone is limited by the amount of water resources available for the process. The diagram of water consumption and the heat rejection system is shown in Figure 2. Due to the offloading from the condenser by steam extraction for the amine regeneration, 98 MW_{th} cooling duty for the flue gas cooling water cooler will be added to the existing cooling system. The rest of 241 MW_{th} cooling duty will be put into the hybrid system which including a wet surface air cooler (WSAC) and an air cooled exchanger. The optimized cooling water temperature is 25°C with temperature different of 20°C. 75% of the cooling load will be treated by air cooled heat exchanger and the remaining duty will be treated by wet surface air cooler.

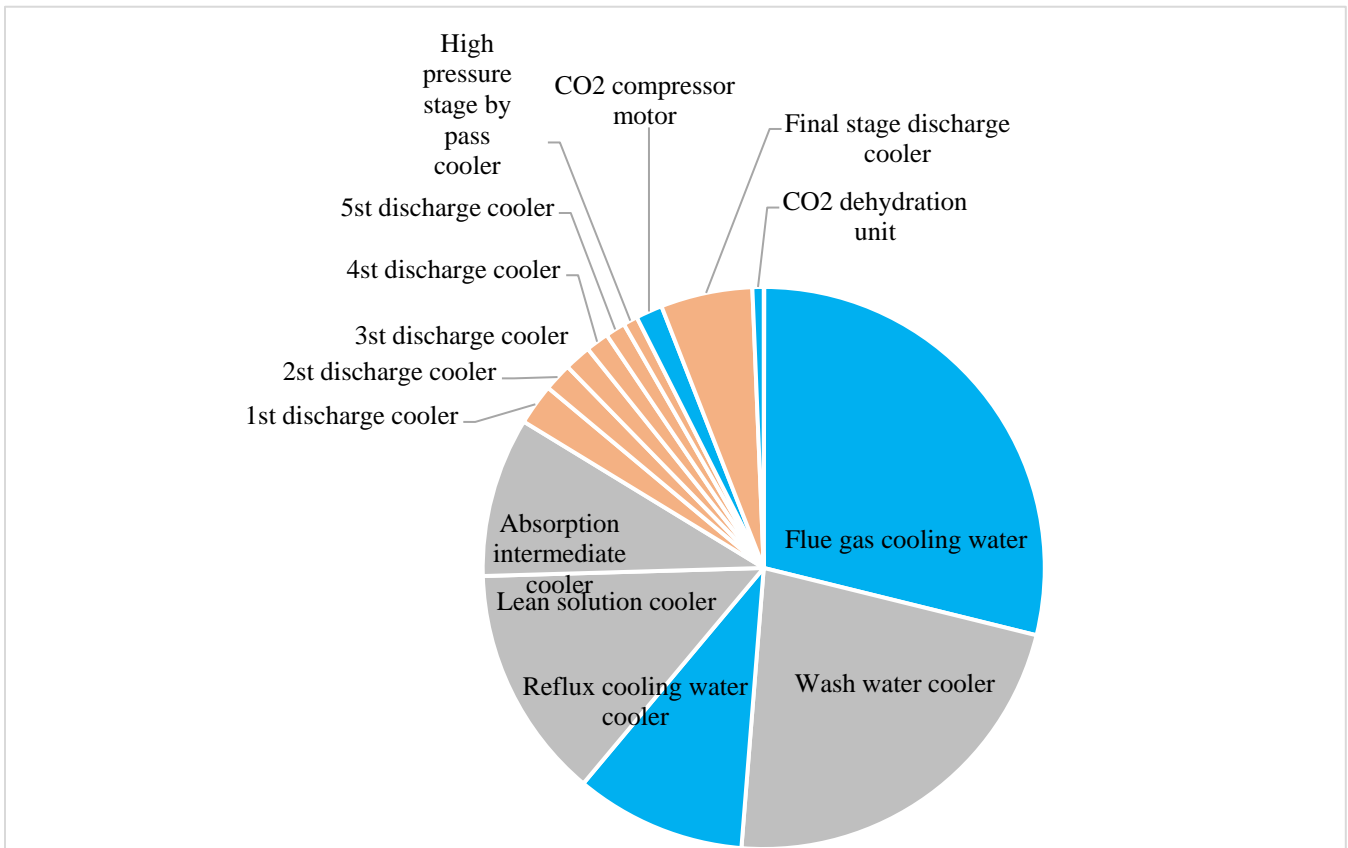


Figure 1 Additional cooling duty from CCS

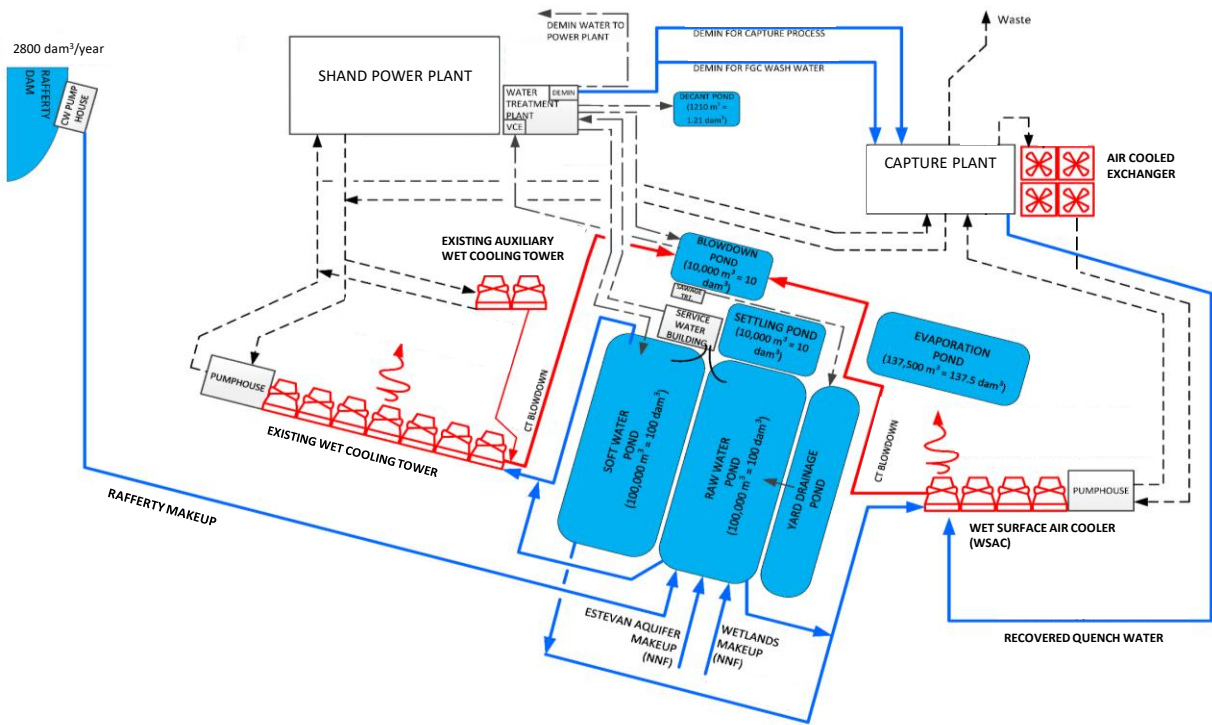


Figure 2 Schematic diagram for the designed hybrid cooling system at Shand power station