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ScienceDirect

Energy Procedia 00 (2013) 000–000

Energy Procedia

www.elsevier.com/locate/procedia

GHGT-12

Start-Up of World's First Commercial Post-Combustion Coal Fired CCS Project: Contribution of Shell Cansolv to SaskPower Boundary Dam ICCS Project

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Abstract

The world's first commercial scale post-combustion coal fired carbon capture and storage project was started in September of this year at the SaskPower Boundary Dam Power Station in Estevan, Saskatchewan. Above and beyond being the process licensor, technology provider and amine supplier for both the flue gas desulphurization and CO_2 capture processes, Shell Cansolv has provided a multitude of products and services to SaskPower for this first-of-a-kind achievement. Shell Cansolv's contribution spanned from the supply of modular amine filtration and amine purification units to overall process performance optimization, going through operator training, support of plant commissioning and start-up and review of standard operating procedures. This project will be a milestone for the fossil fuel power industry worldwide, as it will prove the viability of large scale CO_2 capture and demonstrate that carbon capture can be brought successfully to commercial scale.

Keywords: Carbon Capture and Storage, CCS, SaskPower, Cansolv;

Nomenclature

CCS	Carbon Capture and Storage
CO_2	Carbon Dioxide
EOR	Enhanced Oil Recovery
ICCS	Integrated Carbon Capture and Storage
ppmv	Parts per million, volumetric basis
SO_2	Sulfur Dioxide

1. Introduction

Saskatchewan relies heavily on coal for electrical power and is affected by federal emission regulations. With one of the fastest-growing economies in Canada, Saskatchewan is a strong supporter to the development of Carbon Capture and Storage (CCS) because the Province's circumstances mean the technology can provide significant economic and environmental benefits. This article will focus on Shell Cansolv's contribution to this project along with a brief description of major challenges and lessons learned.

Fig. 1: The Boundary Dam Integrated Carbon Capture and Storage Project – Capture Plant and Compression Plant

2. Project description

Unit 3 of the Boundary Dam Power Station was an aging asset in the SaskPower fleet and was subject to the new federal regulations on the reduction of carbon dioxide (CO_2) emissions from coal-fired power plants. According to the current projections, the upgrades to the unit will extend its useful power production life by 30 years.

At full capacity, the SaskPower Integrated Carbon Capture and Storage (ICCS) Demonstration Project captures over one million metric tons of CO_2 per year, reflecting a 90% CO_2 capture rate for the 139 MW coal-fired unit. The resulting captured CO_2 emissions are compressed and transported through pipelines to Cenovus Energy who uses the CO_2 for Enhanced Oil Recovery (EOR) activities in the Weyburn oil field. Weyburn is recognized as the largest geological CO_2 storage project in the world. Meanwhile, all the sulfur dioxide (SO_2) present in the flue gas is recovered and used for production of sulphuric acid which is subsequently sold as a valuable by-product.

The SaskPower Boundary Dam ICCS Project is a major step towards the global deployment of the Shell Cansolv post-combustion CO_2 capture technology. The technology uses regenerable amines to capture both SO_2 and CO_2, which means that no direct waste by-products are generated.

The Cansolv process line-up for the SaskPower BD3 ICCS Project, presented in figure 2, includes a particular design enhancement: The selective heat integration with Shell Cansolv's innovative combined SO_2/CO_2 capture system helps to reduce energy requirements associated with carbon capture. With this approach, the Capture Plant steam requirement is significantly reduced [1].

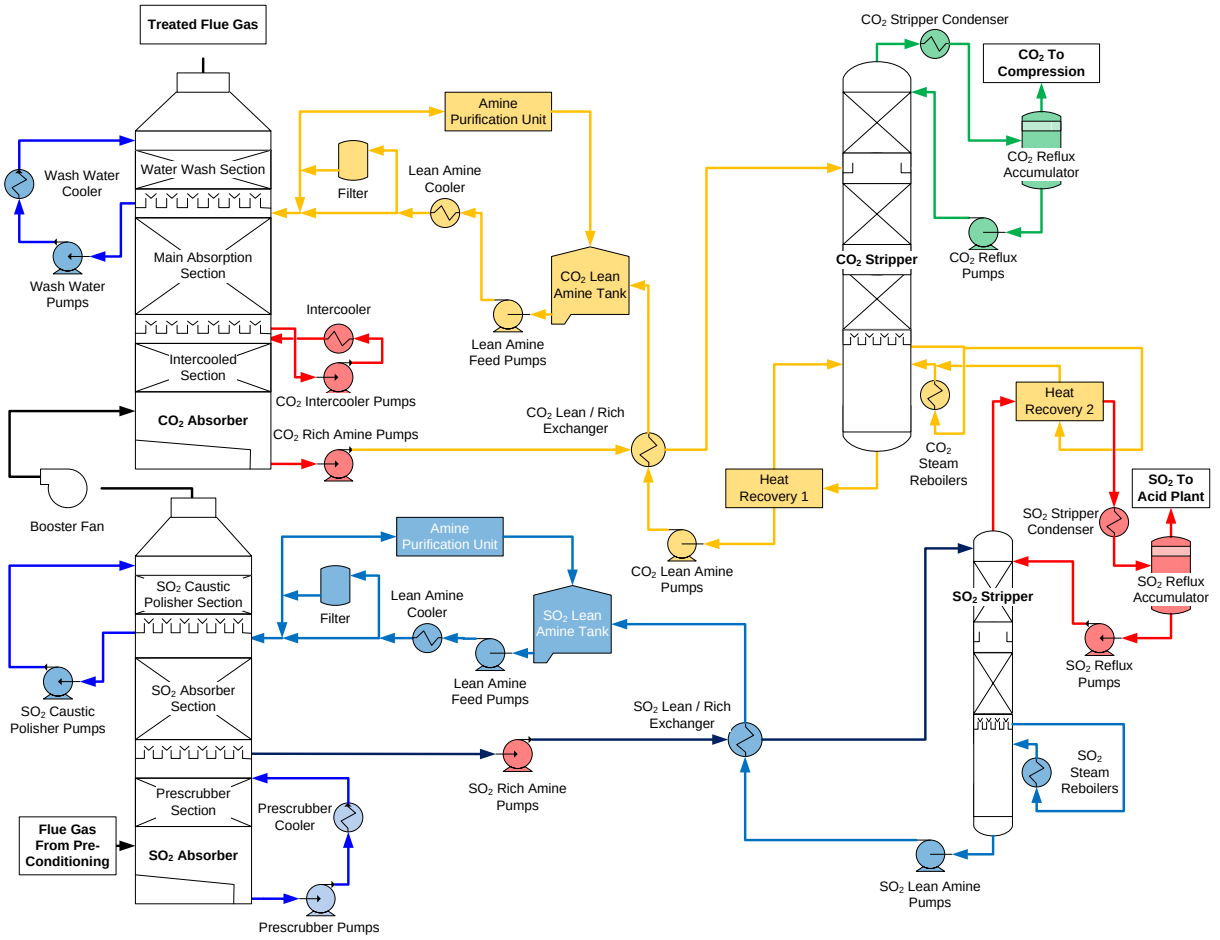

Fig. 2: Cansolv Process Line-Up for the SaskPower BD3 CCS Project

"As the first large scale project of its kind in the world, this is a huge step forward in validating that our technology is enabling an economical benefit while providing a profitable EOR development", states Luc Camiré, Interim President and General Manager at Shell Cansolv. *"The use of Shell Cansolv's technology will enable SaskPower to meet the growing demand for sustainable and affordable low carbon intense electricity."*

3. Shell Cansolv

Shell Cansolv, a subsidiary of Shell Global Solutions, is a world leader in the design and development of regenerable amine-based gas scrubbing technologies. Shell Cansolv offers solutions for the control of atmospheric pollution through high efficiency post combustion removal of SO_2 and CO_2 in a wide range of industrial applications. Coal fired power plants represent the largest single point emitters of anthropogenic CO_2. Depending on the origin of the coal, SO_2 emissions can be as high as 5,000 parts per million (ppmv). Shell Cansolv has developed a technology that targets the combined capture of SO_2 and CO_2 from such applications, exploiting opportunities for integration and further reducing energy requirements. This breakthrough technology sets a new paradigm for amine-based scrubbing technologies operating in oxidative environments.

4. Shell Cansolv Contribution

The contribution of Shell Cansolv to SaskPower Boundary Dam ICCS Project is quite diverse. Above and beyond being the process licensor, technology provider and amine supplier for both the flue gas desulphurization and CO_2 capture processes, Shell Cansolv has provided a multitude of products and services to SaskPower. For example, Shell Cansolv has:

- Supplied modular amine filtration and amine purification units;
- Reviewed detailed engineering documents and vendor drawings;
- Developed and reviewed training material and provided training to the operators;
- Helped environmental permitting efforts by conducting thorough biodegradability, toxicity and ecotoxicity tests;
- Managed evaluations to identify the best available waste water treatment technologies;
- Advised and supported organization, preparation and execution of commissioning and start-up;
- Helped prepare and register safety data sheets used for operation and maintenance;
- Reviewed standard operating procedures;
- Offered specialized support of experts from the wider Shell organization;
- Supported successful start-up through specific project assurance activities;
- Provided council to optimize overall process performance before and after Warranty Test Run.

Shell Cansolv has also established a Joint Development Agreement with SaskPower to tackle with specific long term development and optimization activities.

5. Major Challenges & Lessons Learned

As shown on figure 2, chimney trays are separating the prescrubber section, SO_2 absorption section and caustic polisher section of the SO_2 Absorber. To prevent cross contamination between these sections, the chimney tray design was enhanced to ensure no liquid could leak or weep from one section to another under all conditions. This requirement was especially important for the SO_2 Rich Amine Chimney Tray since amine leaking into the prescrubber would eventually lead to amine traces in the prescrubber purge stream which is ultimately released to the ash ponds. To avoid changing the water release permit for the ash ponds, it was very important for SaskPower to have less than 1 ppmw of amine in the prescrubber purge. Shell Cansolv understood that achieving this condition was challenging and insisted that chimney tray leak testing be a central part of the Water Commissioning activities. Where the enhanced design proved to be effective, the initial fabrication quality did not meet the requirements. After multiple test and repair sessions, conducted in a very confined area, the weld quality finally met specifications and no leaks were detected under both static and water circulation mode.

The delivery of the CO_2 capture absorbent inventory was also quite challenging. To simplify storage and transportation logistics while reducing delivery cost, the absorbent was shipped as 99%wt amine to be diluted with demineralised water once on site. 1,575,000 lbs of 99%wt amine was shipped to site via 35 tanker trucks. The amine manufacture spanned over 6 months of production while the delivery took 3 weeks. However, the Lean Amine Tank on site was not yet ready to receive the total absorbent inventory. For this reason, 12 temporary tanks were installed on site to store the amine until water commissioning activities could be completed and once amine could be transferred to the Lean Amine Tank. Despite these difficulties, the amine was delivered on time, on specifications and was finally loaded in the CO_2 Capture Plant successfully.

Another challenge was encountered during the detailed engineering phase when SaskPower revised the design hydrochloric and hydrofluoric acid concentrations present in the Flue Gas. This change resulted in metallurgy upgrades in the prescrubber section and hot zones of the SO_2 capture system and required modification of the tiles used to line the concrete prescrubber section and SO_2 absorption section of the SO_2 Absorber. Nevertheless, these changes were implemented in time and did not delay the plant construction.

6. Operational Data

This article was written in mid August 2014, just a few weeks before first Flue Gas Contact. For this reason, preliminary Operational Data cannot be presented in this article. However, operating highlights will be presented at the Conference.

References

[1] Karl Stephenne, Ajay Singh, Devin Shaw. The Cansolv SO2 and CO2 capture technology deployed in the Coal-fired power plants. 37th International Conference on Clean Coal and Fuel System, 3rd- 7th June 2012, Clearwater, Florida, USA.