Large Scale CCS ready for 2nd Generation

A team of engineers at the International CCS Knowledge Centre have uncovered a game-changer for large scale CCS – catapulting it to second generation. Bringing together over 20 years of combined CCS experience from SaskPower's Boundary Dam 3 CCS Facility (BD3), the team is spearheading a feasibility study to retrofit the Shand Power Station with impressive outcomes.

"We are excited about it because many of the common hurdles for large scale CCS are being addressed and results show that next generation CCS technology will be significantly cheaper, more efficient, and integrate well with renewable energy," says Mike Monea, President and CEO of the Knowledge Centre.

Maximizing efficiency and responding to integration from wind or solar, all whilst capturing the most CO_2 possible by using an affordable technology is key for CCS to be considered a major climate change mitigation option. The International Energy Agency says that CCS must be able to mitigate 94 (gigatons (GT)) of carbon before 2050 to limit the global temperature rise to 2°C.

The Knowledge Centre's feasibility study examines a business case for a post-combustion capture retrofit on SaskPower's Shand Power Station – located near the famed BD3 in Estevan, Saskatchewan, Canada. The Shand facility however is a 300-MW, single unit, coal-fired power plant – double the capacity of BD3.

A feasibility study is being conducted on retrofitting SaskPowers's Shand Power Station for post combustion carbon capture

Evolution to Success

With operations commencing in 2014, BD3 was the world's first carbon capture facility fully-integrated with a coal-fired power plant and a pioneer for large-scale capture. It is also renowned for its full-chain CCS including capture, transport to enhanced oil recovery (EOR), as well as to onsite geological storage to a depth of 3400M at the Aquistore site.

Motivated to see sizeable impact on CO_2 reductions to support global climate change goals, the Knowledge Centre was established - as a non-profit by BHP and SaskPower - to share the learnings garnered from BD3 to accelerate world-wide development of CCS.

The leaps in technology from first generation to second, contemplated in the Knowledge Centre's study, build on the achievements and lessons learned at BD3. Like all first-out-of-the-gate innovation, it has had its challenges. Yet the CCS story at BD3 is one of an evolution to success. In the spring, the facility celebrated a milestone of two-million tonnes of CO_2 captured. As well, it recently had a successful operating run at 99% reliability for a period of six months.

"In the early days, the focus was really on learning - with the best of those lessons stemming from unforeseen events in operation. We know what works - just as vital, we know what doesn't work. We know how to prevent detours, delays, and miscalculations because we've backtracked, and retooled to fix and adapt," says Corwyn Bruce, Head of Technical Services for the Knowledge Centre. The focus now for BD3 is on optimizing the facility.

Thermal Energy Source Optimized

Optimization is fundamental when looking to second generation. The Shand Feasibility Study – produced to be consistent with the American Association of Costing Engineers

(AACE) Class 3 / 4 Estimates – sees positive impacts on both economics and design.

One of the key challenges in post-combustion capture is to minimize the extra energy required by the host facility (parasitic load) to regenerate the solvent and release CO2. The source of this thermal energy is critical to how efficient and flexible the plant will operate.

Most studies to date -that look at derate mitigation options - have focused on the full load performance of a plant with thermal energy coming from the coal plant's steam turbine versus the combined performance of coal and gas plants in a combined heat and power arrangement. However, these studies haven't considered the realities and limits that are then imposed on the gas turbine cycle. In the Shand Feasibility Study, the Knowledge Centre details the contrast between the new gas-fired steam source and steam extraction from the coal plant.

In the scenario of when a coal-fired capture plant is integrated with a gas plant, it becomes more difficult to dispatch the two generation sources independently. In the examination of steam extraction from a coal plant, the feasibility study replaced portions of the steam path to optimize the steam extraction pressure without imposing throttling losses or adding additional equipment.

"This provides the opportunity to apply upgraded blade technology and recover accumulated degradation in turbine components, describes Mr. Bruce.

"It also provides the best environment for the plant to operate with maximum flexibility to ebb and flow with the variables that impact power plants on a daily basis." If the steam is coming from the coal plant, the quantity of steam available will follow the amount of CO2 to capture, as the load on the coal plant changes.

The study shows that extracting steam from the existing coal plant has the lowest impact and provides the most flexible and economic option.

Work on SaskPower's Boundary Dam 3 CCS Facility (BD3) is now focussed on optimising the facility and knowledge gained will be used to inform the Shand feasibility study

Cooling Technology Ensures Water Conservation

An additional benefit is water conservation. This design tackles barriers of: 1) water availability generally being a limiting factor for most thermal plants; and 2) that the integration of CCS increases the amount of cooling required. In the feasibility study, the design works with the existing water allotment of the site augmented by water condensed from the flue gas and a portion of dry cooling such that the facility can be economically cooled without requiring additional cooling water.

Increased Flexibility to Integrate with Renewables

In rendering cost effective and efficient large-scale CCS plants, there are many variables and operating constraints that all force a need for flexibility, such as: the value of electricity, markets for CO2, taxes, regulations, etc. One such example of retooling addressed in the feasibility study is the ability to adapt to a plant's operating variability. In the first-generation design and operation of BD3, it is optimized to capture carbon when the unit is running at full load.

However, units often run at decreased loads. With the increased need to incorporate more energy options, such as renewables, it is important that coal plants be able to decrease their load as required - to allow for these alternate sources of electricity production into the grid.

As such, it is important that a capture facility must be able to continue to capture CO_2 even when the unit that it is serving is running below full capacity. The Shand Feasibility Study takes advantage of the plant's ability to vary its output, and to increase the capture rate at lower loads beyond 90%, while supporting the integration of additional renewable energy from wind and solar.

The need for flexibility is key. In this study at Shand, the aim is to maximize the efficiency of the thermal plant as well as ensure that the design is nimble enough to not disrupt existing operation - creating a reliable, clean coal energy system that allows CCS to integrate well with renewable energy sources.

Scale Matters

The Knowledge Centre has examined the feasibility of CCS on potential capture facilities of numerous sizes.

In the Shand Feasibility Study, the scale increases from BD3's 150 megawatts (MW) to Shand's 300 MWs. With Shand producing approximately 1,100 kg of C02 per MW hour, the application of CCS on the plant would see the capture of as much as two million tonnes of CO_2 per year.

Increasing the size of the facility, increases the impact on emissions while decreasing the cost per tonne of CO_2 captured.

Significant Savings for 2nd Gen.

As with any second-generation technology, efficiencies are generated through what was learned, then design and approach are adapted – both of which positively impact the economics of a project. Early projections on how much would be saved to build the next large-scale CCS facility were anticipated at 30%.

However, findings from the Knowledge Centre's feasibility study indicate the potential for significantly deeper cost reductions with a greater amount of CO_2 being mitigated.

This is good news, especially for the climate – as the CCS field has often been hindered by the perception of a hefty price tag. Several global energy research organizations including the International Energy Agency, and the UN International Panel on Climate Change (IPCC) recognize that much of the world cannot meet their emission reduction targets without large-scale CCS. Research affirms that without CCS, the median increase in mitigation cost is 138%.

The cost of CCS will continue to decline as more plants are built.

Global & Industrial Application

To advance global climate change goals, an intentional and tactical approach is needed for commercial scale CCS. Many developing countries have a growing middle class and demand energy security. Implementation of CCS could meaningfully aid in decarbonizing electrical grids and even other industrial emissions.

"Globally, we have had numerous enquiries from people interested in maintaining value in existing generating assets, a diverse fuel mix or securing a low cost fuel, such as coal, all while lowering GHG emissions in response to various policy signals and pressures specific to each region," says Beth Hardy, the Knowledge Centre's Vice President of Strategy and Stakeholder Relations.

CCS is applicable beyond the energy sectors and can be applied to industrial sources of emissions which have limited abatement options such as iron, steel, concrete, and agriculture. For example, during the production of cement which is 8% of the worlds CO_2, two-thirds of the emissions are from the process and are independent of the fuel burned. Interestingly, the flue gas from a cement plant is very similar to the flue gas stream from a coal fired power plant like BD3, and as such the learning from BD3 can help de-risk that process.

The Knowledge Centre will apply the principles of the Shand Feasibility Study to other feasibility studies as well as front-end engineering design studies throughout the world in a variety of industrial applications, including cement, waste-to-energy, as well as coal power.

Our job is to improve the delivery and performance of large-scale CCS so that it can be effectively utilized around the globe," says Mr. Monea. "We've got the expertise, the hands-on experience, and we want to share it with the world."

Public release of the Shand Feasibility Study is anticipated in the autumn of 2018. For more information, see the International CCS Knowledge Centre's detailed abstracts for eight papers accepted to GHGT-14 conference, upcoming in Melbourne Australia, October 21-26, 2018.

More information

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