PIONEERING LESSONS FOR THE WORLD

The CCS story at BD3 is one of an evolution towards improved operation. As of the spring of 2019, the facility has captured over 2.6 million tonnes of CO_2. As well, it recently had a successful operating run at 99% reliability for a period of four months.

The facility began operation in the fall of 2014 and in the early days, the focus was addressing design deficiencies and construction quality issues, resulting in learnings - with the best of those lessons stemming from unforeseen events surfacing in operation and addressing these construction and design deficiencies. Hands-on experience has provided a wealth of knowledge in what works as well as what doesn't work.

The learnings that the Knowledge Centre has, to share from the four years of retooling operation at BD3, will save future CCS plants time, money and significantly reduce risks - by preventing and/or eliminating unnecessary detours, delays, and miscalculations from the onset. The focus now for BD3 is on achieving stable operation that will allow staff to focus on improving efficiency and cost effectiveness of the operation.

HIGHLIGHTS OF BD3
FIRST GENERATION CCS PLANT

- World's 1st CCS on a post combustion coal-fired power plant
- Surpassed 2.6M tonnes CO_2 captured
- Achieved 99 % availability for four consecutive months
- Proven industrial scale application
- Accelerated learning and innovation
- 4 years of steady improvement in operations
- Identification of areas, such as amine absorbent, that requires further work
- Informed the success of the second-generation study, Shand CCS Feasibility Study that articulates that the next CCS plant could be 67% cheaper.

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BOUNDARY DAM 3 CCS FACILITY
PIONEERING LESSONS FOR THE WORLD

Motivated to see sizable impacts on CO_2 reductions to support global climate change goals, the International CCS Knowledge Centre was established - as a non-profit by BHP and SaskPower - to share the learnings garnered from SaskPower's Boundary Dam 3 CCS Facility (BD3). The mission of the CCS Knowledge Centre is to advance the deployment of large-scale CCS so that it can be effectively and efficiently utilized around the globe.

BD3, the world's first coal-fired power station with a carbon capture and storage (CCS) facility is located in Saskatchewan, Canada. Building on lessons learned toward optimization, BD3 is recognized for its continued ground breaking effort for large-scale capture. BD3 is also renowned for its full-chain approach. It has a coal plant, capture facility, transportation infrastructure (pipelines), enhanced oil recovery (EOR), and pure storage capabilities.

BD3'S FULL-CHAIN CCS OPERATION CONSISTS OF:

THE CARBON CAPTURE FACILITY captures carbon dioxide (CO_2) instead of being released into the atmosphere. This reduces carbon emissions from the coal-fired power plant, while producing a reliable, clean source of energy.

ENHANCED OIL RECOVERY, more commonly referred to as EOR, utilizes CO_2 to maximize the removal of oil from reservoirs. Captured CO_2 is transported by pipeline 50 kilometres to nearby oilfields in Saskatchewan. The commercial sale of CO_2 helps to offset the cost of the capture process.

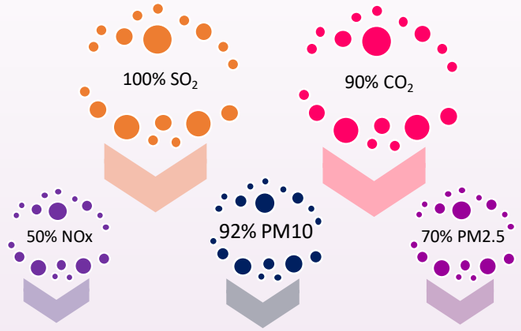
AQUISTORE Storage Project provides a 'buffer' storage option for the captured CO_2 that is not intended for EOR. Located 2 kilometres from BD3, CO_2 is delivered to the Aquistore site via pipeline where it is injected 3.4 kilometres deep in a layer of brine-filled sandstone. Using advanced, measurement and monitoring procedures, the project is demonstrating that storing CO_2 deep underground is safe and permanent.

Full-chain operations is an ideal model for CCS because the EOR creates revenue and royalties from the sale of CO_2, and if the off-taker of CO_2 has no demand, the CO_2 can be permanently stored.

WHAT THE FACILITY CAPTURES

In addition to CO_2, the process also captures other air pollutants from the flue gas, such as: sulfur dioxide (SO_2) - which causes acid rain; particulate matter (PM) - other air pollution; nitrogen; and, other elements.

Since the flue gas must be cleaned up to access the CO_2 more readily, the capture process also results in the removal of 100% SO_2, 50% of the NOx, 92% PM10, and 70% PM2.5. In addition to CO_2 capture, the by-products of the process are manufactured into other usable products. SO_2 is captured, converted to sulphuric acid, and sold for industrial use. Also, fly ash is sold for use in ready-mix concrete, pre-cast structures, and concrete products, resulting in lower GHG emissions from the cement industry.



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PM10 and PM2.5 are general terms for very small solid and liquid particles in the air that are less than 10 or 2.5 micrometres diameter.

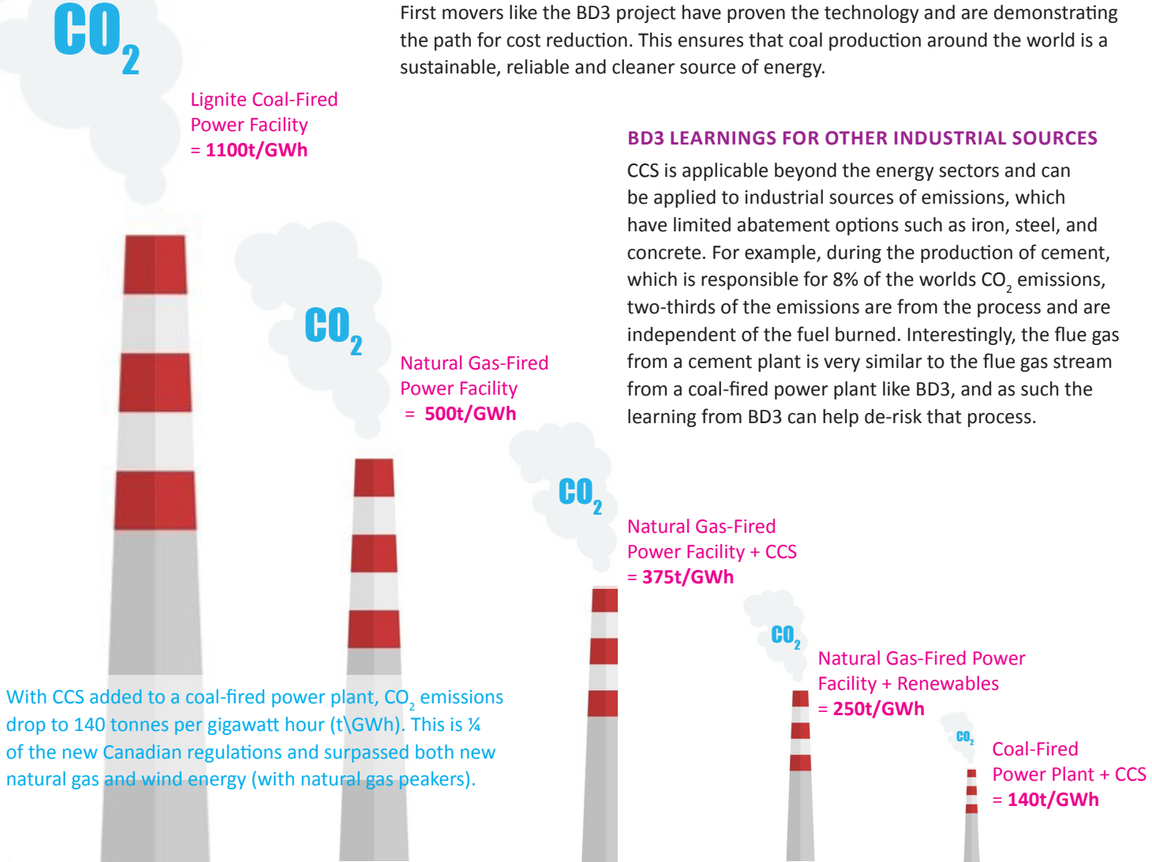
HOW DOES THE CAPTURE PROCESS WORK?

How CO_2 is captured at BD3 involves chemistry. Simply put, the flue gas goes into a big vessel called an absorber which is filled with layers of structured metal packing that is continuous to the sides of the unit (like a metal sponge). This increases the contact between liquid and gas. Next, a chemical solvent (called an amine) is showered into the vessel that targets the CO_2 gas. The amine reacts with the CO_2, absorbing the gas into the liquid before accumulating in the bottom of the vessel. The amine is then sent to a stripper, which is a chamber that heats the liquid to release CO_2 back into a gas. The amine which is now free of CO_2 is recycled back into the absorber to repeat the process and capture more CO_2. The CO_2 gas is compressed into a supercritical state and transported by pipeline to be permanently stored or used for EOR.

BD3 LEARNINGS FOR CLEAN COAL

Many developing countries have a growing middle class and demand energy security. It is important for regions to maintain value in existing generating assets, a diverse fuel mix or securing a low cost sourced fuel, such as coal, all while they also strive to lower GHG emissions.

First movers like the BD3 project have proven the technology and are demonstrating the path for cost reduction. This ensures that coal production around the world is a sustainable, reliable and cleaner source of energy.



With CCS added to a coal-fired power plant, CO_2 emissions drop to 140 tonnes per gigawatt hour (t\GWh). This is ¼ of the new Canadian regulations and surpassed both new natural gas and wind energy (with natural gas peakers).

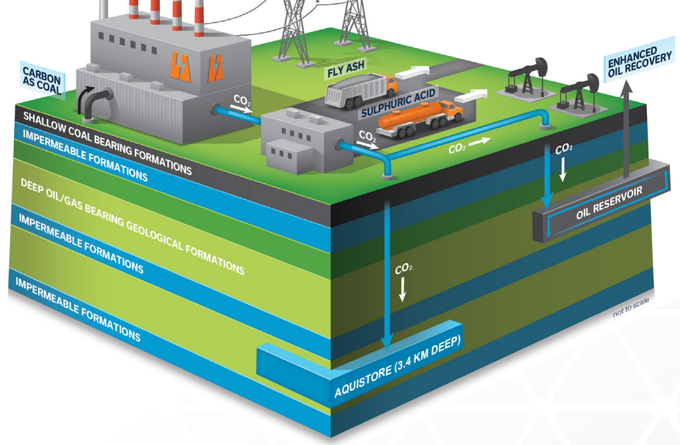
BD3 LEARNINGS FOR OTHER INDUSTRIAL SOURCES

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, and concrete. For example, during the production of cement, which is responsible for 8% of the worlds CO_2 emissions, 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.

BD3 CCS AT A GLANCE

CO_2 is captured off the power facility and transported by pipeline to nearby oil fields in southern Saskatchewan where it is used for enhanced oil recovery. CO_2 not used for enhanced oil recovery is being stored in the Aquistore Project.

In addition to CO_2, the project allowed for the manufacturing other products from the byproducts captured. Sulphur dioxide (SO_2) will be captured, converted to sulphuric acid and sold for industrial use. Fly ash, a by-product of coal combustion, will be sold for use in ready-mix concrete, pre-cast structures and concrete products.



WHY CARBON CAPTURE & STORAGE (CCS)?

Carbon emissions are a major contributor to climate change. Deploying large-scale CCS in a broad way is the only way to ensure a significant impact on emission reduction and preventing a rise in global temperatures. 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%.