CAPTURING SHAND'S POTENTIAL

CCS retrofit would make plant an eco-powerhouse, study shows

As Mark Twain — whose death was rumoured well before the actual event — might have said, the imminent demise of fossil fuel-powered electrical plants has been greatly exaggerated.

New environmental regulations may now surround the coal-fired generation of electricity, but as the Saskatchewan experience has shown, carbon capture and storage (CCS) has not only extended coal's usefulness, but also the life of power plants.

The province's electrical utility, SaskPower, began the movement toward retrofitting power plants many years ago, culminating in the reinvigoration of Boundary Dam 3 CCS Facility (BD3) four years ago. Now, a new study prepared by the International CCS Knowledge Centre shows that the Shand Power Plant has potential to be next, although with higher levels of capture and much lower capital costs.

SaskPower decided not to retrofit Boundary Dam's fourth and fifth units; but Shand, with a potential lifespan of another two decades or more, is a different story.

"We don't see a fossil-free future for a considerable period of time," said Corwyn Bruce, Head of Technical Services for the Knowledge Centre.

"In North America, these plants are 30 and 40 year old . . . (but) I don't think they're at the end of life. These coal-fired power plants are getting to be like refineries, where they have an infinite life if you replace a small number of key components.

"A lot of coal-fired thermal plants have emissions that need to be mitigated," he said. "And CCS is the only way to do that."

Dustin Duncan, Minister Responsible for

SaskPower, said the Shand study is positive news for CCS not just in Saskatchewan, but globally.

"We know around the globe, conventional, unabated coal-fired generation is going to be continued to be used well into the future," Duncan said in an interview.

"SaskPower is waiting for a more detailed report from the International CCS Knowledge Centre which will provide additional information for the analysis that needs to take place on whether or not to retrofit Shand or any of the other coal fleet's units with CCS," added Duncan.

"Certainly, from a very high level, it's positive news that looks like the capital costs will be significantly lower than on Boundary Dam 3."

Not long after the BD3 plant's retrofit came online, SaskPower and the mining giant BHP formed a partnership to support CCS investigation. BHP agreed to provide $20 million over five years, with the goal of leveraging what had been learned at BD3 to push forward CCS as a greenhouse gas (GHG) reduction tool. The outcome was the creation of the Knowledge Centre.

"We provide advocacy and outreach for CCS, as well as technical expertise to those who are pursuing CCS in their facilities at locations around the world," said Bruce. "As per our articles of incorporation we're a not-for-profit, non-partisan company with an independent board which includes representation form SaskPower, BHP as well as independent board members from the global community working on climate change."

Looking for the next CCS potential in Saskatchewan was an obvious next step, and the Shand Power Station was the obvious choice for a study. So, the Knowledge Centre with support from SaskPower dove in. They joined forces with Mitsubishi Heavy Industries-MHI, who focused on the economic benefits of scaling up a power unit from the knowledge of construction on BD3.

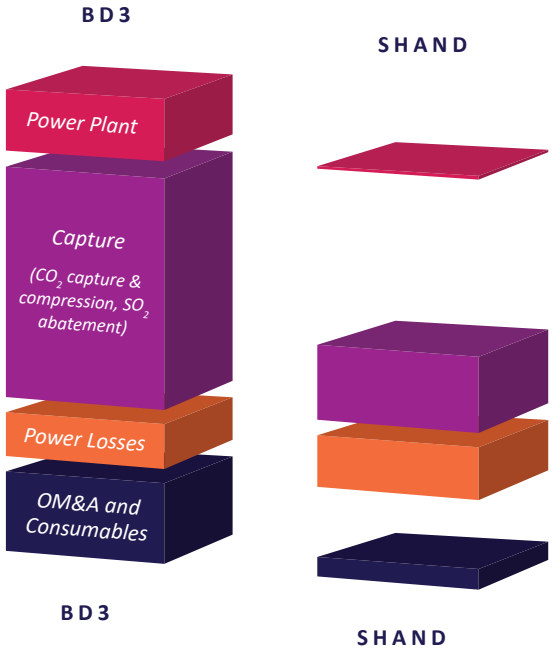
The study showed that not only could Shand's carbon dioxide (CO2) output be reduced by more than 90 per cent, the capital cost of its retrofit could be significantly reduced from the outlay on BD3. And why?

"The first thing is that scale matters," said Bruce. "When you build a mine or industrial facility or power facility, the reason these things get bigger over time is that it's cheaper to build it as big as you can.

"BD3 is a 150 megawatt unit and Shand is 300 megawatts. That is a major driver of cost improvements.

Cost Comparison

BD3 CCS Facility & Proposed CCS Facility on Shand Power Station



The *Shand CCS Feasibility Study* shows there is a 67% reduction to capture plant capital costs.

"The next big driver of cost improvements is the lessons learned at BD3. When it was put together there were a number of unknowns on how it would work and how reliable it would be. We put a lot of flexible and multiple features that would address these 'unknowns'. Now we know which of these are required and which are not."

BD3 was designed to run at full output whether or not the CCS system was in service, he explained, which required significant modifications to the power plant.

"That was a good idea and it made sense in 2010 when there were no regulations and we, and the regulator, weren't sure what a regulation may even look like. Now that we know the regulations, and have experience with operating the facility, a lot of that functionality isn't required.

"We looked at Shand, and we determined what we could do in the power plant is minimize the changes to maximize efficiency."

Briefly, here's how CCS works. The flue gas that would go up the stack is cooled and sprayed with amine liquid, which absorbs the CO2 gas. When heat is taken from the steam turbine and applied to the amine, pure CO2 bubbles out of the liquid and is removed. The amine liquid, now CO2-free, is recycled to capture more CO2 from the flue gas; and the pure CO2 is compressed, dried and put in a pipeline.

"The basic process is literally that simple," said Bruce.

The Shand study is based on 90 per cent carbon capture, the same as BD3, but "we believe that 90 per cent capture is an artificial limit," he added. "We asked ourselves things like, what about 95 per cent capture?"

The engineers found that 97 per cent of CO2 could be captured when the power plant was running at 62 per cent capacity. That lower capacity can occur when renewables, particularly wind, kick in to pick up some of the generating power. As Shand reduces its coal-fired output, the CCS system continues to run at a high rate, still removing carbon from the stack. Even at the base case of 90 per cent, CCS is much cleaner than using natural gas, Bruce pointed out.

For the Knowledge Centre's wider purposes, the study has been "great" for outreach, Bruce added.

"Through the publication of this study, we've shown some great cost savings that helps us get in touch with others pioneering CCS on industrial sources such as waste energy plants, cement and steel plants," he said. "This flue gas process has pretty good applicability to those facilities as well. We're collaborating with people around the world on future CCS projects."

There are further CCS benefits as well — for example, selling fly ash off the back of the coal-fired power plant.

"Fly ash is actually used in the concrete business as a replacement or a supplement

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>
> **CORWYN BRUCE, TECHNICAL SERVICES, INTERNATIONAL CCS KNOWLEDGE CENTRE**

instead of using as much concrete, which is a high emission product," he said.

"We actually looked at that for the Shand system, what would net emissions be (if we included fly ash)? And we determined emissions would be, just below zero or what industry calls 'negative emissions."

"We paused for a second, went back and made sure we were right. If you include the GHG reduction potential for cement, it basically has no net emissions of CO2."

THE BUSINESS CASE FOR SASKPOWER

The study is a first step toward SaskPower determining whether installing CCS at Shand is an economic option.

Cost is an important factor, Duncan noted; but when SaskPower needs to make a decision on Shand or any of the other units, there will be others that must be considered.

Technology risks associated with the next generation of CCS, the market conditions for alternatives such as natural gas and even the potential CO2 sales will come into the decision.

"Boundary Dam 3 currently produces CO2 that is used in enhanced oil recovery, so that's part of the business model for CCS," Duncan said. "We'll need to make a determination on what the demand will be for CO2, because that is part of the analysis that will take place when it comes to whether or not to proceed with CCS on Shand or any of the other units."

The study was prepared on Shand because it is the newest unit in SaskPower's fleet, and because of its larger 300 MW capacity, he added.

"It just made sense to look at the bigger units that we have from an efficiency perspective," Duncan said.

There are two other reasons. One is that the Shand site design originally included two 300 MW units, but one was built.

"The Shand site has space in the event that we need to build CCS. That was one of the challenges with BD3," Duncan said. "The Boundary Dam power station footprint is very congested to begin with. That did have an impact on the capital costs. Shand essentially has a large enough footprint that that won't be a problem."

Perhaps most importantly, under the new federal regulations, a coal-fired power unit must be shut down by its retirement date or 2030, whichever comes first. Under the former regulations, it was whichever date came second.

"All our other units have a retirement date prior to 2030, except for Shand," Duncan said. "Shand has a retirement date of 2042, so under the former regulations we would have been able to run Shand out to 2042. Under the new regulations, we have to shut it down if it doesn't have CCS before 2030.

"What that means for SaskPower and all the ratepayers and the owners of Saskatchewan, without CCS under these regulations we will potentially have a stranded asset. We will basically be forgoing the last 12 years of the Shand unit that we are paying for and have already paid for. In terms of ensuring that we are optimizing the lifecycle of the Shand unit, the only way to do it would be CCS under these regulations. That adds a little more urgency as to why we would look at Shand."

The new report will provide more specific cost estimates that will help make a comparison with proceeding with Shand over other options. Duncan said SaskPower will have to make a decision by 2024, in order to accomplish a CCS retrofit by 2029, the year before a potential 2030 shutdown. SaskPower is still considering next steps for the rest of the coal-fired fleet.

"It's not that much time. One of the challenges SaskPower will have and the government will have, is that the alternative for us for baseload is really natural gas. Five years from now, what's the price of gas? Nobody really knows.

"We'll have a firmer idea not only on costs of capital and operations through the work the Knowledge Centre is doing … but by the next decade we'll have a better outlook on renewable energy, gas costs and hopefully some of the learnings of the other CCS projects around the world."

The study shows that compared to the BD3, a CCS system at Shand could see capital cost reductions of 67 per cent per tonne of carbon dioxide (CO2) captured as well as 92 per cent in potential savings to power plant integration capital cost.

Based on the model, the levelized cost of captured CO2 is calculated at $45US/tonne.

The Shand CCS system would be designed without the requirement of additional water, mitigating a key constraint for thermal plant operation retrofits and expansions.

At this site, up to 140,000 tonnes per year of fly ash would be saleable to the concrete market (subject to demand), which could offset emissions in concrete production. This equates to a potential net reduction of 125,000 tonnes of CO2 each year resulting in a facility with net-negative CO2 emissions.

The Shand CCS project design capacity is nominally 2 million tonnes of CO2 captured per year – twice the initial design capacity of BD3.