WHAT WILL SASKPOWER **DO NEXT TIME?**

PLANNING FOR FUTURE CLEAN COAL POWER PLANTS

While SaskPower continues to ensure construction deficiencies are rectified at BD3 during 2015–16 to improve overall performance and efficiency of power generation, as well as regeneration of the amine in the capture plant, aiming to achieve 115 to 120 MW of net power generation, the retrofit can clearly be deemed a success. But SaskPower cannot rest on its laurels. Time is marching on. There is now regulatory clarity in Canada requiring immediate action. The new federal Regulations require that SaskPower make decisions regarding the fate of the remainder of its coal-fired power fleet over the next decade or so. Table 3 lists the plants that are affected and SaskPower's decision window, including the potential implementation schedule [Figure 20]. It can be seen that a decision must be made by the fourth quarter of 2016 regarding the fate of BD4 and BD5!

IN PARALLEL with SaskPower's planning for its future power plant options, the Government of Saskatchewan may negotiate an "Equivalency Agreement" with the Government of Canada. A negotiated Saskatchewan-specific interpretation of the federal Regulations governing coal-fired power generation could include consideration of any or all of the following:

> The intent of the Regulations is to reduce GHG emissions from coal-fired power generation nationwide.

> In 2012, Saskatchewan had a GHG footprint of approx. 12 million tonnes per year of CO_2e emissions associated with coal-fired power generation.

> At 90% capture, the BD3 upgrade has far exceeded the regulatory requirement for its own regulated reduction in emissions, or approximately 67%.

> An argument could be made that holding each of SaskPower's coal-fired power units to the regulated performance standard is not the only or most sustainable approach to meeting the targeted reduction in emissions.

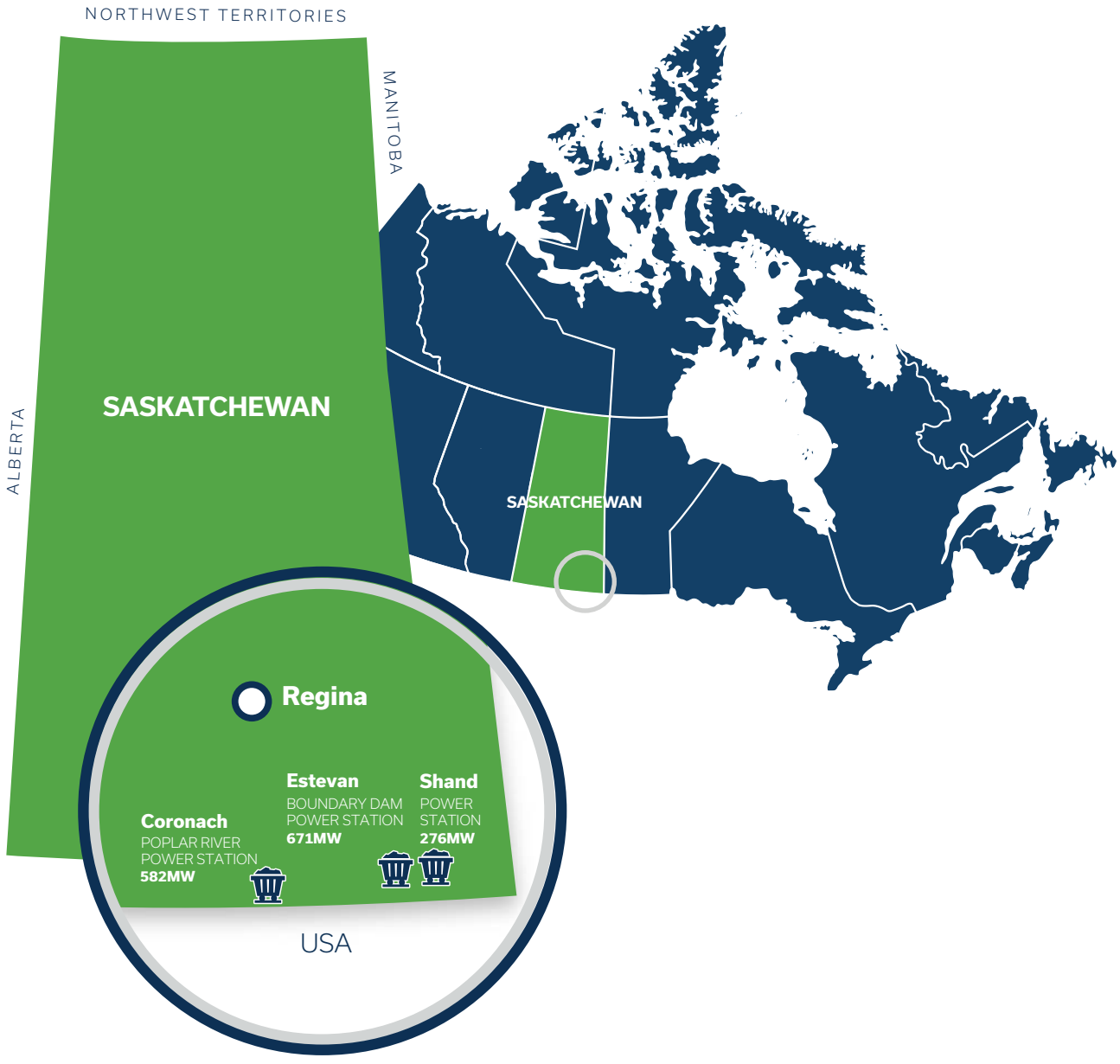
> Saskatchewan could achieve the intended reductions differently. Perhaps meeting a 90% reduction standard in GHG emissions at SaskPower's larger power stations (Poplar River Units 1 and 2, Shand), which each generate 300 MW, are newer and more amenable / economical to retrofit, well ahead of schedule and foregoing the retrofits of the remaining BD power units, could permit SaskPower to continue to operate some or all of the BD 4, 5, and 6 units without CO_2 capture for a few years beyond their CEPA-required retirement dates.

> Additionally, SaskPower voluntarily retired BD1 and BD2 early (in 2013 and 2014 respectively); each had an emissions reduction value that could be acknowledged by the Government of Canada, even though they would not qualify under CEPA's substitution rules.

TABLE 3 | SASKPOWER CLEAN COAL RETROFITTING SCHEDULE

UNIT	DATE OF CONSTRUC-TION	ACTUAL SIZE (NOMINAL SIZE)	REGULATORY SHUTDOWN DATE	INITIAL INVEST-MENT	FINAL INVEST-MENT	CCS RETROFIT IN SERVICE
BD4	1970	139 (150) MW	2019*	2016	2019*	2025†
BD5	1973	139 (150) MW	2019*	2016	2019*	2025†
BD6	1978	273 (300) MW	2028‡	2022	2024	2028†
PR1	1980	291 (300) MW	2029‡	2024	2026	2030†
PR2	1980	291 (300) MW	2029‡	2026	2026	2030†
SHAND1	1993	276 (300) MW	2043§	2037	2039	2043†

FIGURE 20 | MAPPING THE FUTURE OF CLEAN COAL POWER GENERATION AT SASKPOWER



*CCS Clean Coal retrofit plans must be filed with the Government of Canada no later than the end of 2019, or the power plant must be retired by Dec 31, 2019 or 50 years from plant commissioning (whichever is earlier). Construction and commissioning must be completed by the end of 2024.

†Fixed by federal regulation

‡CCS Clean Coal retrofit plans must be filed with the Government of Canada no later than the end of 2024, or the power plant must be retired by Dec 31, 2029 or 50 years from plant commissioning (whichever is earlier). Construction and commissioning must be completed by the end of 2029.

§CCS Clean Coal retrofit plans must be filed with the Government of Canada no later than the end of 2024, or the power plant must be retired by 50 years from plant commissioning. Construction and commissioning must be completed by the regulated retirement date.

DEVELOPING THE BUSINESS CASE FOR **THE NEXT COAL POWER PLANT RETROFIT**

When it comes to considering the specifics of what SaskPower would do the same way for the next retrofit and what would be done differently, the following checklist would be considered:

1. Capital costs make or break any project for a small power utility like SaskPower. With the intent of reducing capital costs, conduct an ***equivalent availability study*** to ascertain how much "up time" would be required on the capture plant to meet regulations.
2. Would it be necessary to capture 90% of the CO_2 in the flue gas or would 80% be acceptable?
3. What on-line timing and on-off delays would be required to operate both of the plants (power and capture)?
4. What efficiency improvements could be made in the power plant to generate the steam required for capture?
5. What would be the impact of coal quality and availability on the operation of both plants?
6. Simplify the power and capture plants. For instance:

   > Would operation of the capture plant be required every day in a climate where there are only a handful of days where temperatures exceed 30 °C? Or could one simply shut down the capture plant on those days and emit?

   > What equipment used at BD3 to mitigate operational risk and uncertainty would be considered redundant now that SaskPower has operating experience? For example, would six feed water heaters be required in the power plant when very often only four would be in service due to energy savings associated with heat transfer from the amine regeneration units in the capture plant?

7 What equipment was added to BD3 after construction in order to improve operation on the basis of safety, ease of use, maintainability, reliability, and efficiency of overall power generation?

8 What would be the critical pieces of equipment, and what would be their reliability in terms of maintenance and repair? Consequently, how many replacement units must be on site in the event of equipment breakdown?

9 Has there been a change in regulations or interpretation of regulations that might impact the level of required CO_2 capture or even the need for CO_2 capture (e.g. Equivalency Agreement)? Future regulations could be imposed upon emissions from alternative power generating facilities that could change the economics of comparisons.

10 Would it be better to over-achieve the regulated capture target or just meet the target? A smaller capture unit would require a lower parasitic load on the power plant, and somewhat lower capital costs. A larger capture unit would have the economic benefit of scale and could have an emission profile that would be significantly cleaner than NGCC.

11 Would the 300 MW units at Poplar River and Shand Power Stations, which already operate with more efficient turbines and are almost identical in design, be better, more cost effective targets for future retrofitting than the power units at Boundary Dam Power Station?

12 Modularize the plant so that large sections of it could be constructed elsewhere by more highly-skilled tradespeople than could be enticed to work at the construction site. This could likely be achieved at a much lower construction cost. Site installation would also become simpler and would likely entail a much lower risk for cost overrun(s).

13 Continue the good work on operational standards and safety procedures that began with BD3 (e.g. new confined space procedure, new PPEs, new chemical handling SOP, etc.).

14 Perform a labour market assessment for skilled trades and map out a construction schedule that would eliminate the impact of any possible shortage of skilled labour.

15 Fully develop design and engineering and let fixed-price contracts to eliminate cost overruns.

16 Reduce construction costs. This could entail packaging engineering and construction activities differently than BD3 and potentially modularization.

17 Ensure the next PCC unit would be similar enough to reduce technical, construction and operating risks based on the insights from BD3.

18 Continue to have the flexibility to generate power without capture and still meet regulatory requirements. This would likely necessitate PCC technology in the near term and most likely focus technology choices on amine-based capture as they would be the most mature and less technically and operationally risky.

19 Utilize a solid staff retention plan to avoid critical shortages in SaskPower staff that have gained invaluable experience from the BD3 ICCS project. This would include developing a SaskPower culture that would reward the behaviours and the stamina that would create a successful project outcome.

20 Ensure meaningful public engagement about the costs and benefits of clean coal broadly throughout the Province. Expect that public engagement would be more critical in a region where there would be no oil industry presence to support infrastructure to capture CO_2 that could be used for EOR. Develop a communications and engagement plan accordingly. Public acceptance would doubtless necessitate a third party business investment and technology review for each proposed clean coal project.

21 Invest in the establishment of a CO_2 end-use market amongst oil producers. This could require building a CO_2 trucking infrastructure at the BD3 capture plant to support CO_2–EOR pilots in SE Saskatchewan and to provide CO_2 at a reasonable cost to oil producers that wish to pilot CO_2–EOR at their operations.

22 Consider a change of "ownership" of the retrofitting projects. SaskPower is a power generation utility whose main job is to maintain facilities to ensure the "lights stay on". It is not an EPC company that designs and builds major facilities on a regular basis.

23 Deploy a larger SaskPower group to work on the planning phase of the project if it would be reasonably certain the project would be approved. This would shorten the time from inception to operation and would minimize the burnout experienced during the BD3 ICCS retrofit project.

ABBREVIATIONS

This is not a comprehensive list.

BD3 – Boundary Power Plant Station Unit 3

CCS – Carbon Capture, Transportation and Storage

CCPC – Canadian Clean Power Coalition

CCTF – SaskPower's Carbon Capture Test Facility (at Shand Power Station)

CEPA – The Canadian Environmental Protection Act

CIC – Crown Investments Corporation of the Government of Saskatchewan (owner of all Crown corporations such as SaskPower)

CO_2e – The climate forcing factor associated with a greenhouse gas expressed as "carbon dioxide equivalents". For example, the climate forcing factor of methane (CH4) is 21 times the factor for CO_2. Hence, one methane molecule is equivalent to 21 carbon dioxide molecules in terms of greenhouse impact on the climate.

C$ – Canadian Dollars

EC – European Commission

ECRF – SaskPower's Emissions Control Research Facility (at Poplar River Power Station)

EOR – Enhanced Oil Recovery

EU – European Union

GHG – Greenhouse Gas

GWh – Giga-Watt-Hour, the energy unit of total power generation

ICCS – Integrated Carbon Capture and Storage, which is the name of the combined BD3 power plant retrofit project and the geological storage of its captured CO_2.

IEAGHG – IEA Greenhouse Gas R&D Programme

MW – Mega-Watt, the energy unit used for power-generating capacity

PCC – Post-Combustion Capture

$PM_{2.5}$ – Fine Particulate Matter found in the air that is less than or equal to 2.5 mm (micrometres) in diameter and normally only observed by electron microscope. This material is often associated with energy combustion and the fine particulate matter is believed to cause serious health issues upon entering lungs of air-breathing animals.

PM_{10} – Coarse Particulate Matter found in the air that is less than or equal to 10 (mm) micrometres in diameter. It can be seen with the human eye in the air as soot, dust, dirt and liquid droplets. This material is often associated with energy combustion.

PTRC – Petroleum Technology Research Centre, a non-profit R&D corporation located in Regina, Saskatchewan

R&D – Research and Development

QA/QC – Quality Assurance and Quality Control

SE - Southeast

SaskPower – Saskatchewan Power Corporation

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[1] 2014 SaskPower Annual Report

[2] SaskPower's fiscal year runs from January 1 to December 31.

[3] From 2010–2014, SaskPower invested C$4.7 billion in capital assets (upgrades, new construction)

[4] Canada Gazette, Vol. 146, No. 19 — September 12, 2012 (Government of Canada)

[5] Provided by SaskPower

[6] **http://www.ir.gov.sk.ca/coal**

[7] The Encyclopedia of Saskatchewan. The Oil and Gas Industry. **http://esask.uregina.ca/entry/oil_and_gas_industry.html**

[8] Melzer, Stephen, 2012. Report for the National Enhanced Oil Recovery Initiative, Center for Climate and Energy Solutions Carbon Dioxide Enhanced Oil Recovery (CO_2 EOR): Factors Involved in Adding Carbon Capture, Utilization and Storage (CCUS) to Enhanced Oil Recovery

[9] From Leasing Mineral Rights: "Unitization of a producing field: The purpose of unitization is to produce oil or gas more efficiently and effectively by bringing together an area involving a large number of sections. Unitization is used where the industry feels that a large portion of the oil and gas can be produced with fewer wells. Upon unitization, an owner within the boundaries of the unitized field is entitled to participate in production, even though no well is located on his land. The provisions of a lease may therefore permit "pooling," in which case you receive a portion of the royalty, based on the number of acres you put in the pool. The lease may permit "unitization," which converts your royalty into a "tract factor," based on a complex formula. Even though unitization in the vast majority of cases provides a better total income for the mineral owner, an owner should not grant the right to unitize automatically; nor should he leave it up to the company's discretion. Because participation in a unit is not based on the number of acres you have in the unit but is determined by the company, based on geological factors, you should very carefully assess your position. For example, while you may hold five per cent of the area in a unit, you may be allocated only two per cent of the production."

[10] **http://www.economy.gov.sk.ca/PR-IC11**

[11] Pan Canadian was a subsidiary company of Canadian Pacific Railway until it merged with Alberta Energy Company in 2002 to form EnCana Corporation, an independent oil and gas corporation. In December 2009, Cenovus Corporation split from EnCana to operate as an independent integrated oil company, including all of the oil assets from the original firm. EnCana continues to operate the natural gas assets of the original firm and is a leading independent Canadian natural gas producer.

[12] Numac Energy Inc. was incorporated in Alberta in 1971 and was an independent oil producing company until it was purchased by Anderson Exploration Inc. in early 2010. Anderson was subsequently purchased by Devon Energy (USA) to form Devon Canada Corporation in late 2010. Numac, in partnership with Nexen Inc., operated a CO_2–EOR pilot at its Elswick Midale oil leases in 2001 using trucked CO_2 from the Air Liquide plant in Medicine Hat, Alberta. It ultimately decided not to proceed with full-scale operation of CO_2–EOR due to various technical issues it encountered during the pilot as well as poor economics due, in part, to the lack of a pipelined source of CO_2. The Elswick oil field is one of many potential CO_2–EOR targets in SE Saskatchewan.

[13] **http://www.economy.gov.sk.ca/adx/aspx/adxGetMedia.aspx?DocID=10290,10289,3384,5460,2936,Documents&MediaID=26122&Filename=SPRI+CO_2+Pilot+Injection+Test.pdf**

[14] **http://www.ucsusa.org/global_warming/science_and_impacts/impacts/early-warning-signs-of-global-1.html#.Va6YMnnbKTM**

[15] **http://unfccc.int/kyoto_protocol/items/2830.php** ; The agreement came into force in 2005 upon ratification by 55 signatory parties belonging to the UNFCCC. Those signatories include Canada but notably exclude the USA as of mid-2015.

[16] Clift, R. and J. Seville (Editors), 1993. Proceedings of the Second International Symposium on Gas Cleaning at High Temperatures. University of Surrey, UK. Springer Science and Business Media. P. 129.

[17] **https://en.wikipedia.org/wiki/Integrated_gasification_combined_cycle**

[18] **http://www.nrcan.gc.ca/energy/coal/carbon-capture-storage/4307**

[19] **http://www.nrcan.gc.ca/energy/coal/carbon-capture-storage/4333**

[20] **http://cornerstonemag.net/exploring-the-status-of-oxy-fuel-technology-globally-and-in-china/**

[21] Tanner, C. S., Baxley, P. T., Crump, J. G., & Miller, W. C. (1992, January 1). Production Performance of the Wasson Denver Unit CO_2 Flood. Society of Petroleum Engineers. doi:10.2118/24156-MS

[22] Beliveau, D. A. (1987, November 1). Midale CO_2 Flood Pilot. Petroleum Society of Canada. doi:10.2118/87–06-05

[23] The Midale and Weyburn oil fields are operated in the same geological formation, along with several surrounding oil leases/operations. Each of the two oil fields is owned by approximately 30 owners but each field was "unitized" in the 1960s to support water flooding infrastructure investment. Each unitized oil field is operated by one major oil company on behalf of the owners. Pan Canadian was an owner of part of the Midale oil field and consequently had access to the CO_2–EOR pilot program undertaken by Shell Canada.

[24] **http://www.dakotagas.com/CO_2_Capture_and_Storage/Pipeline_Information/index.html**

[25] Apache Canada began a commercial CO_2–EOR flood at Midale in 2006 using approx. 1800 tonnes per day of CO_2 supplied by DGC. At that time Apache Canada contributed data and sponsorship to the renamed IEAGHG Weyburn-Midale CO_2 Monitoring and Storage Project.

[26] Hitchon, Brian (Editor), 2012. Best Practices for Validating CO_2 Geological Storage: Observations and Guidance from the IEAGHG Weyburn Midale CO_2 Monitoring and Storage Project. Chapter 1. Updated data from Cenovus and PTRC as of 2014.

[27] Approximately one-third of the CO_2 injected in a given oil production cycle is "lost" to the reservoir. The uncertainty prior to the IEAGHG Weyburn CO_2 Monitoring Project beginning its work was, "Where does the CO_2 go?"

[28] **http://ptrc.ca/projects/weyburn-midale**

[29] **http://www.canadiancleanpowercoalition.com/**

[30] **http://www.SaskPower.com/our-power-future/our-electricity/our-electrical-system/cory-cogeneration-station/**

[31] **http://www.canadiancleanpowercoalition.com/index.php/ccpc-materials/ccpc-reports-phase/phase-i/**

[32] Wilson, M. and M. Monea (Editors), 2004. IEAGHG Weyburn CO_2 Monitoring and Storage Project Summary Report 2000–2004. From the Proceedings of the 7th International Conference on Greenhouse Gas Control Technologies, September 5–9, 2004, Vancouver, Canada. Petroleum Technology Research Centre, Regina.

[33] **http://hub.globalccsinstitute.com/sites/default/files/publications/151303/co2-stored-underground-ieaghg-weyburn-midale-co2-monitoring-storage-project.pdf**

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[35] By this time, CO_2 sequestration in deep saline aquifers associated with "acid gas reinjection" at natural gas producing operations was an accepted practice, e.g. StatOil's Sleipner field. See Tore A. Torp and John Gale, Proceedings of the 6th Conference on Greenhouse Gas Control Technologies, 2003, Volume 1, p. 311–316.

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[38] **http://www.SaskPower.com/our-power-future/our-electricity/our-electrical-system/boundary-dam-power-station/**

[39] **http://www.shell.com/global/products-services/solutions-for-businesses/globalsolutions/shell-cansolv/shell-cansolv-solutions/co2-capture.html**

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[42] There are many sources of ENGO criticism of the BD3 ICCS Project. One example from the Sierra Club of Canada is embedded in the newspaper article noted in reference 51.

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