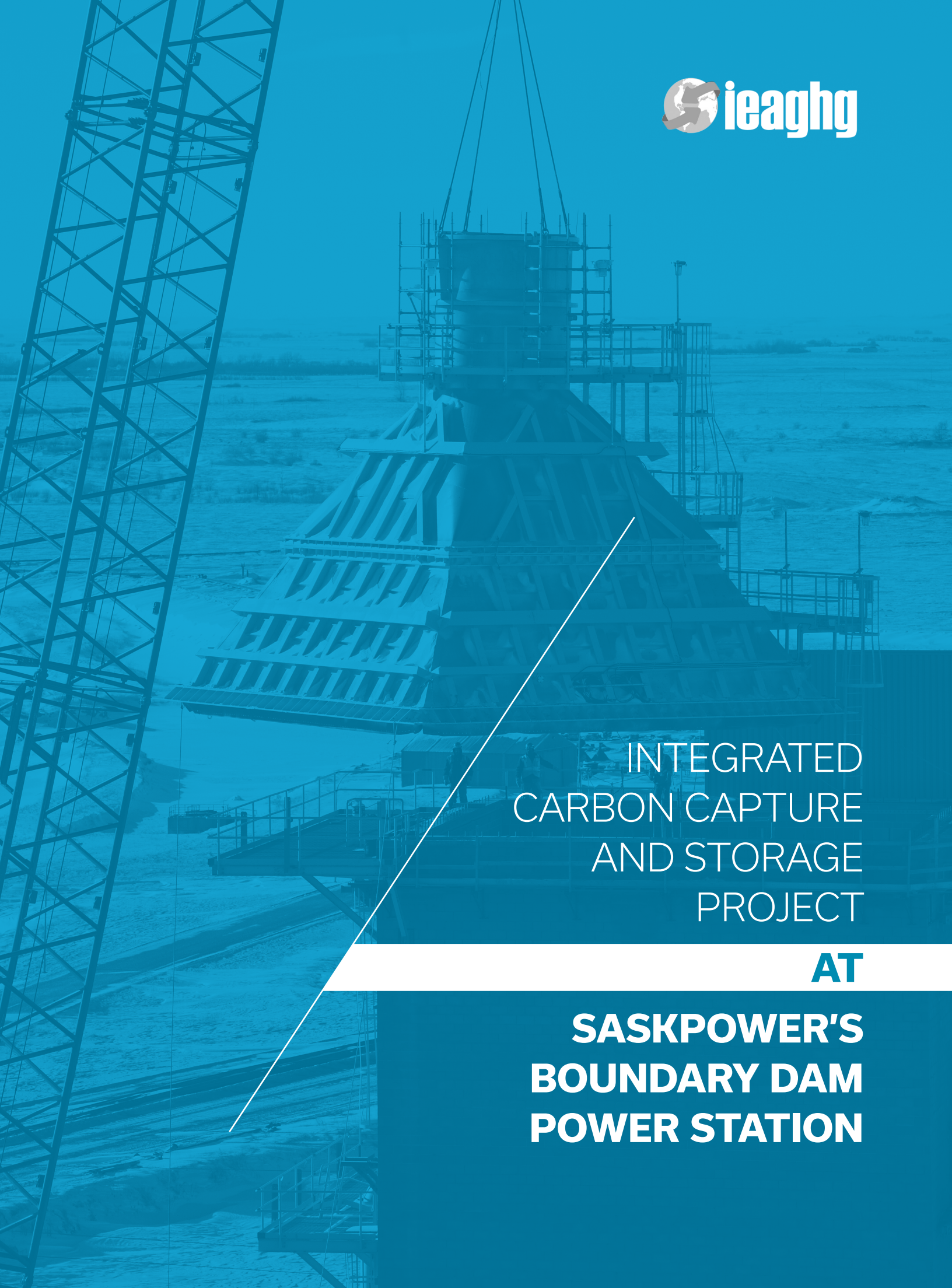

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INTEGRATED CARBON CAPTURE AND STORAGE PROJECT

AT

SASKPOWER'S BOUNDARY DAM POWER STATION

A **WORLD'S FIRST** IN CARBON CAPTURE AND STORAGE

INTERNATIONAL ENERGY AGENCY

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EXECUTIVE **SUMMARY**

On October 2, 2014, the first-ever, commercial–scale, coal-fired power plant incorporating amine solvent absorption carbon capture began operation near Estevan, Saskatchewan, Canada. This was a global landmark event. Although carbon capture technologies had been pilot tested prior to this, a commercial–scale power plant now exists that has demonstrated that a number of high-risk technology and business issues have been overcome. This report summarizes the experience and learnings of SaskPower in a way that will hopefully provide insight to other clean-coal initiatives.

FOR SASKPOWER, owner and operator of the retrofitted Boundary Dam Power Unit 3 (BD3) that now incorporates carbon capture and storage (CCS), this event was the culmination of decades of work to continue operating coal-fired power-generating stations, while at the same time mitigating the climate change impact of associated air emissions. The CO_2 captured at BD3 is geologically stored at **two** locations: in an oil reservoir approximately 1.4 kilometres deep at Cenovus' CO_2–EOR operation near Weyburn, Saskatchewan, and in a deep saline aquifer approximately 3.2 kilometres deep at the SaskPower Carbon Storage and Research Centre, located near the Boundary Dam Power Station. The latter geological storage site is the subject of the measurement, monitoring and verification (MMV) activities of the Aquistore Project that is managed by the Petroleum Technology Research Centre in Regina, Saskatchewan.

SaskPower had forged ahead with design and construction of the BD3 ICCS retrofit well in advance of GHG Regulations being enacted in Canada, which came into effect on July 1, 2015. This was a strategic and environmentally-responsible decision to ensure continued use of lignite coal reserves in Saskatchewan that could last 250–500 years. The investment in the approx. 120 MW (net) BD3 power unit's retrofit and carbon capture plant was approximately C$1.467 billion.

This report explores the journey that SaskPower made from the 1980s to mid-2015 in pursuit of clean-coal power generation. SaskPower pursued various technology options for carbon capture from oxyfuel combustion to amine solvent absorption that ultimately led to the decision to select the commercially unproven CANSOLV amine solvent carbon dioxide capture process. SaskPower then coupled that technology with Shell Cansolv's proven sulphur dioxide capture process to simplify the capture plant operation and to further reduce emissions.

Two key factors contributed to the decision to retrofit BD3 to convert it to clean coal power:

1 The ability to continue to realize value from the sunk investment in the original 1970 BD3 power unit by retrofitting it with a modern boiler and turbine, rather than building a new power plant; and

2 The value that would be realized over the next 30 years of operating the retrofitted power plant from the sale of three valuable by-products: carbon dioxide, sulphuric acid and fly ash. This would help to offset the cost of capture.

The latter two by-products provide the off-taker market with essential materials for the production of fertilizer and cement, respectively. The captured CO_2 is geologically stored, as noted above, with an associated revenue stream from sale of a portion to oil producers deploying CO_2–EOR.

Construction challenges that were faced by SaskPower are explored in the report.
These included:

- complicated contracting issues by using multiple vendors;
- management of a retrofitting project at a "brown-field" site;
- orchestration of the complexities of integrating the power plant with the capture plant;
- safety, risk and permitting management and;
- transition to operations.

One of the most important recommendations for future retrofitting construction projects of this nature is to modularize the design to make the construction simpler and more cost-effective to implement.

Given SaskPower's status as a public power utility, it was critically important to ensure full engagement by its stakeholders in government and the public. SaskPower made dozens of presentations around the province to inform the public and address questions and concerns. Its design team ensured that technology options were kept open and available to enable key decision makers to build confidence in their technology choices so they could see their way to approving both the power unit's retrofit and the capture plant construction. SaskPower continues to engage its stakeholders in effective and meaningful discussion about BD3 and consideration of future power-generating options.

A summary of challenges that SaskPower faced from inception to operation of the BD3 ICCS project is presented.

KEY CHALLENGES INCLUDED:

- Choosing a CO_2 capture technology when no commercially–proven technology existed, and managing first-time operation of unfamiliar capture processes and equipment
- Proceeding with a high, targeted CO_2 capture level (90%) and the associated design and construction in the absence of any guidance from GHG regulation that had yet to be enacted
- Managing continual changes in design, equipment, and construction plans throughout the project due to a variety of technology, procurement and corporate policy requirements
- Technology risk and managing the costs associated with the redundancy in processes and equipment that was essential to managing that risk
- Controlling construction costs at a time of very high competition for materials and labour in western Canada, primarily due to a very high level of oil and gas activity

Consideration is given in the report to the issues SaskPower will face as it contemplates the future of its coal-power generation fleet, given new Regulations that require CCS retrofitting installation during 2019–2043:

Would retrofitting existing infrastructure to generate clean coal power be comparable to power generation alternatives such as NGCC, wind and hydro?

HAVE there been any regulatory changes that might impact decisions?

WHICH existing coal-fired power plants would be the best target(s) for retrofitting?

WOULD there be an opportunity to replicate the BD3 retrofitting design at other power plants?

WOULD there be any other commercially–proven carbon capture technologies to consider?

WHAT would be the appropriate level of capture? What would be the associated plant operating strategies?

WHAT efficiency improvements could be made?

WHAT technology risk-reducing, redundant equipment could be eliminated versus BD3?

HOW could construction costs be reduced?

HOW could SaskPower help build an enhanced market for by-products?

A series of issues and questions is presented in the report that could assist parties outside Saskatchewan contemplate the applicability of the BD3 ICCS project to their unique set of jurisdictional circumstances. These involve regulations, business and market factors, technical design, and construction.

The project has proven to the world that commercial–scale carbon dioxide capture at a coal-fired power generating station is possible.

The report concludes with a discussion of SaskPower's CCS research activities—past, present and future—to develop and validate new technologies to mitigate environmental impacts associated with GHGs, SO_2, NO_X, mercury and particulates. The aim has always been to reduce capital and operating costs, improve reliability and operability, enhance knowledge and understanding, and manage technology risk. These research activities have been/continue to be:

Bench and pilot-scale testing of capture technologies to further their development and/or to build a database of scalable engineering factors essential to commercialization through:

- The SaskPower Carbon Capture Test Facility (CCTF) that was opened at the Shand Power Station in June 2015.
- The SaskPower Emissions Control Research Facility (ECRF) at the Poplar River Power Station where mercury control technologies were validated in the early 2000s. It is used to continue the testing of capture technologies and associated systems.
- Investments in proving CO_2 geological storage through the IEAGHG Weyburn-Midale CO_2 Monitoring and Storage Project (2000–2012) and Aquistore (2009–2017).

AS OF MID-2015, SaskPower is contemplating a new CCS Consortium that may include collaborative opportunities for participants, pending suitable alignment, on: technology, research, regulatory affairs and government relations, and all aspects of project management through design and construction.

The BD3 ICCS project has, to date, garnered many awards. It can be regarded a success. The project has proven to the world that commercial–scale carbon dioxide capture at a coal-fired power generating station is possible rather than an elusive future option. SaskPower has led the way. It is now up to the rest of the world to follow this remarkable pioneer to ensure that the anthropogenic carbon emissions associated with fossil-fuel power generation and use are significantly reduced worldwide.

BOUNDARY DAM CCS PROJECT

PREFACE

This report includes summaries of interviews undertaken by the author with former and current SaskPower project execution team members who were a part of creating the BD3 ICCS commercial project, as well as conclusions drawn therefrom by the author.

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