Stantec

SaskPower

Canadian Consulting Engineering Awards

Boundary Dam Integrated Carbon Capture Storage Project

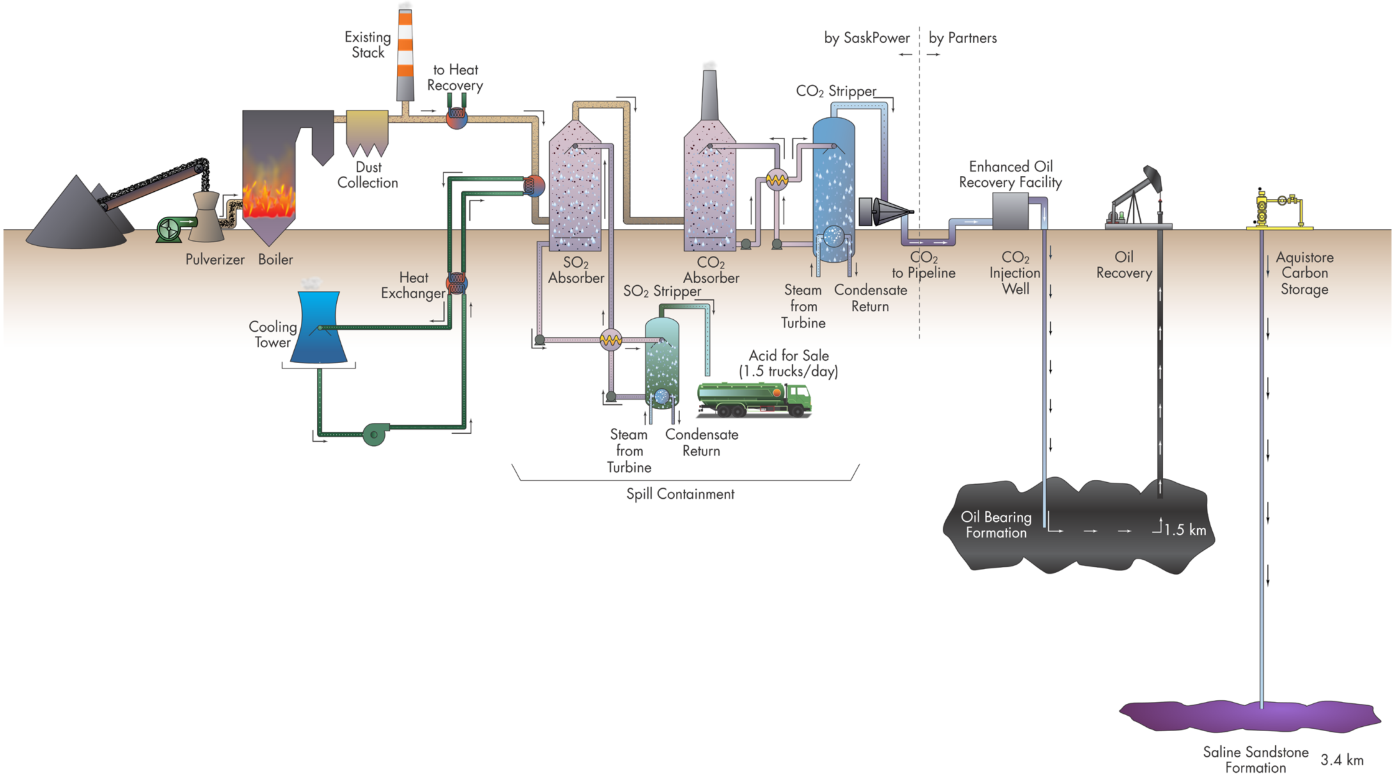
Category: Natural Resources, Mining, Industry, Energy

April 21, 2016

Executive Summary

SaskPower's ambitious plan was to build the world's first and largest integrated carbon capture and storage project on a 30 year life extended coal-fired power plant. Stantec 's work included the study of existing and emerging post-combustion carbon capture technologies, projected environmental standards, anticipated benchmarks, and regulatory variables and then support project delivery. The system was designed to capture up to one million metric tonnes of carbon dioxide annually; equal to emissions from 250,000 cars.

Carbon Capture Process



Innovation

Innovation was paramount; SaskPower's vision was a calculated effort to plan, design, and make live the world's first commercial scale integrated carbon capture and storage (ICCS) project on a coal-fired power plant. Driven by pending environmental CO_2 constraints and its aging generation assets, Boundary Dam Unit #3 (BD3) was selected for ICCS as a brownfield retrofit, including life extension.

Without reference projects, the path to commercial operation required many 'firsts' for the team. Some innovative aspects to overcome unique challenges were:

- the Capture Island was located over 1000 ft from BD3 given its large footprint, requiring the design and construction of a utility bridge and extensive ductwork (15' x 15') for the flue gas flow of 1.69 mmlb/hr, or 643,000 acfm.
- a unique, large extraction/bypass was incorporated in the crossover between the IP and LP turbines to provide 313,000 lb/hr process steam from turbine extraction without unbalancing the unit.
- a detailed 3D CAD model derived by laser scanning the existing plant was generated and maintained to provide an accurate reference for the engineering team.
- process heat and mass balance programs such as GateCycleTM and ProMaxTM were employed to optimize the interactions between the Power and Capture Islands.
- North America's first utility Flue Gas Cooler (FGC) is incorporated upstream of the Capture Island to recover low-grade heat from the flue gas and return it to the Power Island to preheat condensate; supported by a techno-economic evaluation, the arrangement increases the overall plant efficiency during capture by 2 percent.
- unique solutions for the control narratives and logic for the integrated process subsystems were required including:
  - the flue gas diverter gate system where the flue gas was either directed to the Capture Island or the atmosphere,
  - the condensate return system where process condensate from Capture Island was returned to the deaerator,
  - the steam extraction system where process steam off the low pressure turbine was delivered to the Capture Island, and
  - control logic based on feedback received after a time delay of several minutes rather than the conventional few seconds – as the feedback received from the Capture Island has significant implications on the control logic used in the entire boiler draft system.

Complexity

Project engineering complexity can be grouped into two categories: 1) the pioneering aspect of trying to achieve that which has never been done before, and 2) the sheer magnitude of plant and system modifications needed to bring the project into reality. Some pioneering examples were:

- selecting a carbon capture technology from a field of types and vendors unproven at utility scale.
- optimizing the capture technology with the Power Island to minimize the impact and increase overall efficiency.
- understanding, arranging and constructing the systems that would have to be incorporated into the existing brownfield site.

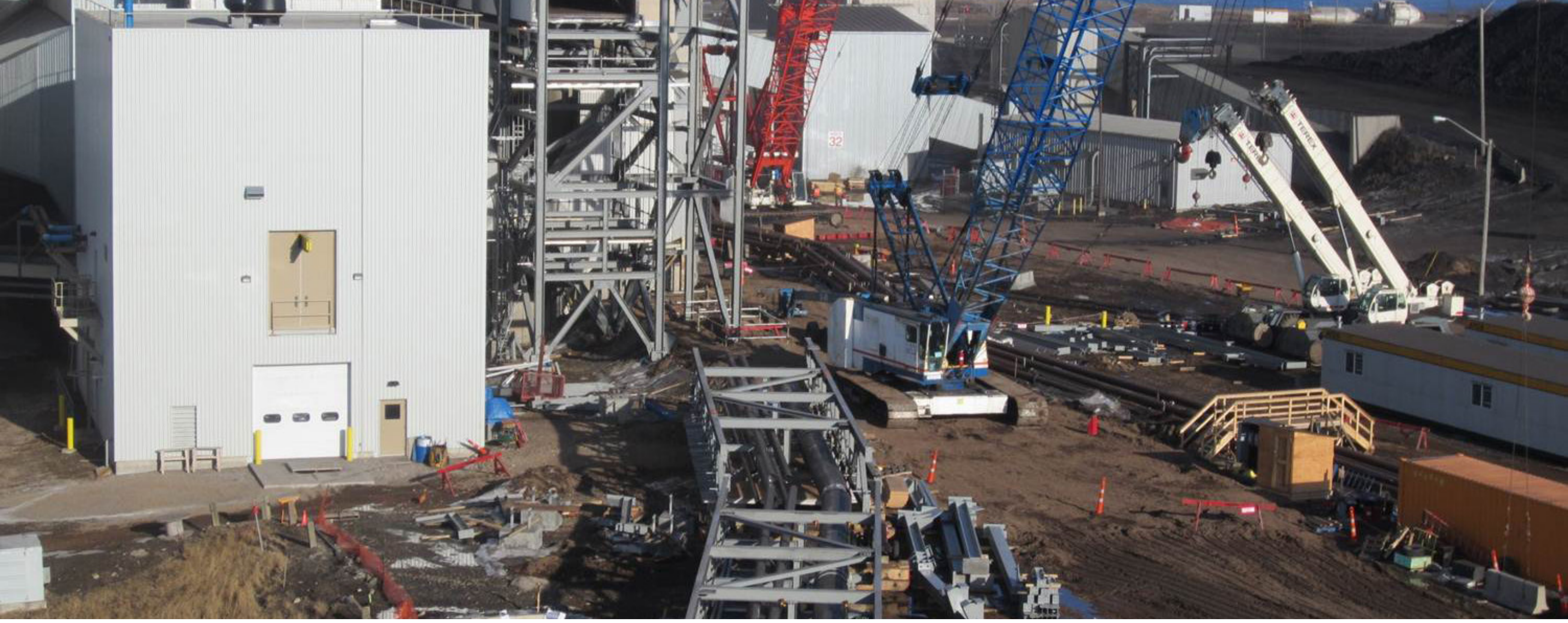
Some examples of magnitude were:

- main steam temperature was increased by 50°F to improve plant thermal efficiency. To achieve this, many issues were successfully dealt with ranging from large pipe wall thickness (~3.6") to avoid major material changes, complicated stress analysis, complex hanger designs, and cold pulls at the turbine connection.
- existing vertical feedwater heaters were replaced by horizontal heaters to overcome the existing level control problems and a single valve load control scheme was developed to eliminate the existing operational upsets and subsequent trips during transition from low load to high load.
- the high energy piping drain system capacity was increased to ensure safety and protect the turbine from potential water damage, and air assisted check valves were placed in the turbine extraction steam line to prevent a turbine over speed condition in the event of a sudden trip of the carbon capture facility.

Social and/or Economic Benefits

While the pioneering aspect of this project is inspiring, we are driven by the impact our work will foster as it relates to this project, both at home and abroad. This project will assist in advancing ICCS technologies and help the global power industry reduce their greenhouse gas (GHG) emissions. It also translates into social and economic benefits such as:

- allowed continued operation of what would likely have become a retired generating unit, maintaining 16 direct and numerous indirect jobs in the community of Estevan, SK.
- required 4.5 million direct construction man-hours during the 41 month construction period, resulting in many secondary spin-off jobs and investment in the local communities.
- recognized globally as a premier project and showcase for ICCS (Power Magazine's 2015 Plant of the year, The Edison Electric Institute 2015 Edison Award) resulting in tourism as well as benefits to local academic instructions offering ICCS courses and labs (University of Regina).
- removed CO_2 emissions from entering the atmosphere, resulting in cleaner power being generated by and for Saskatchewan rate payers.
- generated revenue from the supercritical CO_2 captured for enhanced oil recovery (EOR), a key aspect of the project's economics. In proving ICCS' ability to generate and supply CO_2 in this manner, it paves the way for future installations to do the same.



Environmental Benefits

- Initiated air dispersion modelling to predict the atmospheric behavior and ground level concentration of potential harmful amine degradation products emissions used in the capture process, which helps determine impacts to the surrounding environment and public health, and proper mitigating solutions if required.
- Developed the amine-bearing waste water disposal strategies for the capture process, which presents a unique environmental challenge for engineers due to lack of knowledge on the quality and quantity of waste water actually generated from the process.
- Developed the CO_2 pipeline filling-up procedures for compressed CO_2 product from the capture process, which eliminated the operating cost due to a commercial CO_2 delivery supply tank truck.
- Redesigned the cooling systems on unit three from an open loop system to a closed loop system preventing the possible contamination of cooling water returning to the Boundary Dam Reservoir.

Meeting Client's Needs

SaskPower was seeing significant electrical load growth (6.5% in 2008), the looming retirement of existing coal fired generating units, and facing emerging greenhouse gas and air contaminants emission regulations when it started preliminary engineering into the possibility of carbon capture. Turning these threats into extensive studies of green and brownfield opportunities, BD3 was selected to be repowered and retrofitted with a post-combustion CO_2 capture system. This allowed SaskPower to meet some of their expected load growth while also reducing their overall fleet CO_2 emissions intensity. To support these objectives, Stantec's Owner's Engineer role was to:

- refurbish BD3 boiler, replaced the turbine / generator, and replaced the associated mechanical, electrical, and instrumentation & controls for the balance of plant.
- identify which BD3 components and systems required replacement or upgrade.
- reuse as much of BD3 as possible, while maintaining its reliability and safe operation
- increase generation and overall plant efficiency wherever possible.
- support major technical EPC contracts; Flue Gas Cooler, CO_2 Capture, CO_2 Compression Balance of Plant, Heat Rejection, and CO_2 pipeline.
- integrate SO_2 and CO_2 capture processes.
- enable electrical generation to operate independently of the CO_2 capture facility.
- reduce the SO_2 emissions from the coal process by up to 99 per cent and the CO_2 emissions by up to 90%.
- demonstrate the economic, technical and environmental feasibility for coal-fired power generation with ICCS.