Design of a Post-Combustion CO₂ Capture Process for a Gas-Fired Plant

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CSLF Mid-Year Meeting

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Agenda

1. Introduction
2. Project Overview and Concept Study Details
3. Summary - How information developed can assist as we look at future projects
Stantec at a Glance

- Established in 1954
- Publicly traded on two stock exchanges
  - TSX: STN (1994)
  - NYSE: STN (2005)
- Canadian based with over 60 years of secure & stable growth
- More than 250 offices
- ~15,000 employees
- Gross Revenue: ~$3B
Stantec Power

- Conventional Power Generation
  - Coal
  - Natural Gas

- Renewable Generation
  - Wind
  - Solar
  - Geothermal
  - Biomass
  - Landfill Gas
  - Hydro

- Transmission & Distribution
- Substations
- Industrial and Chemical Processes
Air Quality Control System Experience

- SCR’s
- FGD’s
  - Dry
  - Wet
- Low Nox Burner Conversion
- SNCR’s
- Carbon Capture
CO$_2$ Capture - Stantec

Stantec has a long history working in CO$_2$ capture and clean coal technologies

- Evaluation of Retrofit Emission Control Options (Canadian Clean Power Coalition) 2002
- Emission Control Technology Survey (Confidential Client) 2004
- Power Plant CO$_2$ Capture using Ceramic Membrane Technology (NRCan) 2004
- Evaluation of Retrofit of Shand 1 Power Plant for CO$_2$ Capture (SaskPower) 2006
- Owners Engineer for Boundary Dam Integrated Carbon Capture and Sequestration (ICCS) Facility (SaskPower) 2011-2014
And a lot more…
Project Description

Carbon Capture at StatOil’s Mongstad Facility near Bergen, Norway

Large industrial gas-fired combined heat and power (CHP) plant - 280MW electricity, 350MW heat

Five (5) of the world’s leading capture technologies were evaluated for application using a rigid format:

- An Engineering Feasibility Study
- A Technology Qualification Program (TQP)
- An Engineering Concept (Pre-FEED) Study

Evaluation was conducted over a period of ~21 months concluding in July 2013

Today’s focus: Engineering Concept Study (pre-FEED)
Project Team

**Powerspan - Portsmouth, NH**
- Developer of CO$_2$ capture (ECO$_2$®) technology
- Has been operating laboratory and pilot plants on actual and simulated flue gas streams since 2005, including its most recent pilot plant near Beijing, China.

**Stantec - Scarborough, ME**
- A world leader in engineering large carbon capture projects, e.g., as Owner’s Engineer at SaskPower’s Boundary Dam plant and Shand Power Station Test Center, and as design engineer on numerous applications
Project Team

Powerspan
- Technology Supplier
- Portsmouth, NH, USA
- Overall Project Management
- Process Engineering

Skanska/Aibel Team
- Construction Planning/Estimating
- Boston, MA, U.S.A.
- Bergen, Norway
- Asker, Norway

Stantec
- Engineering Design/Estimating
- Scarborough, ME, U.S.A.
- Detailed Engineering
- Acoustic Evaluation
- WWTP Technical Evaluation

Subcontractor
- BK Reliability – RAM Analysis

Technical Consultants
- Fronek Power Systems - PDMS
- RTP Environmental – HSE Study
- NEM – HRU Design
- Alden Research – CFD Analysis
Engineering Scope

Concept Study scope:
• Flue gas handling (blower, extraction control, transport, heat recovery and cooling)
• Design and supply of the CO₂ removal system, solvent handling, and reclaim
• CO₂ desorption, drying, and compression (~900psi)
• HP steam let-down and steam condensate return/treatment
• Waste water treatment and waste handling
• Power distribution system
• Solvent storage
• Cooling water system
Technical Approach

**Establishing confidence:**

- Focused on critical equipment - advanced designs for confidence in performance, sizing, and pricing
- 3D modeling – modeled all piping 8” and larger to ensure MTOs and craft labor were highly accurate
- Ensured realistic design – conducted detailed RAM analysis, noise evaluation, and CFD analysis
- Involved constructor contractor throughout process
- Considered safety throughout - reviews conducted and recommendations incorporated in design
- Operations - Equipment arranged on site with maintenance alleys and lifting beams, evacuation routes, etc.
Health & Safety

**Process, Environmental and Operational Hazard Reviews Conducted**

- HAZOP, ENVID and WEHRA reviews conducted
- Concept level acoustical analysis performed for near and far field
- CO\textsubscript{2} operational and relief venting analysis performed
- Completed safety risk analysis and supplied input to site safety plan
Overview - 3D Model
3D Model – Piping Layout/ MTOs
Process Equipment Highlights

Booster Fans

- 4 fans @ 5,250kw each with Variable Speed Control
- Noise attenuation included

Heat Recovery Units

- Worked closely with EU vendor for design and pre-assembly plan (8 modules)
- Flue gas latent heat used for steam and hot water generation
Process Equipment Highlights

**Absorber Vessel**

- Vent and exit cap optimized for dispersion after modeling
- Worked closely with EU vendor for fabrication plan (shipping in preassembled sections)
- CFD modeling completed to ensure acceptable distribution at inlet to the mass transfer sections and flow for isokinetic sampling
Process Equipment Highlights

**Cross Heat Exchangers**
- 3 x 50% heat exchanger trains to facilitate maintenance during operations
- Maintenance access and lifting beams to pull units included

**Regenerator Unit**
- Proposal from EU vendor
- Each column to be hydro tested and shipped as single units
**Process Equipment Highlights**

**Reboilers and Preheaters**
- 3 x 50% arrangement for process turndown and maintenance

**CO$_2$ Drying and Compression**
- Layout based on single unit multistage compressor
- CO$_2$ dryers included
Detailed Engineering
Construction Planning

Active Participation of Constructor during design work

- Constructability considered throughout the design.
- Prefabrication, preassembly, and use of skid mounted systems used extensively to lower congestion during construction, and reduce safety issues and field erection.
- Labor requirements researched by Skanska and Aibel, both familiar with Norwegian labor practices and the experienced working at the site.
- Completed a constructability review with client, owner’s engineer, and constructor.
Construction Review
Absorber Island - 90 Days
Construction Review
Absorber Island - 270 Days
Construction Review
Regenerator Island - 90 Days
Construction Review
Regenerator Island - 270 Days
Construction Review
Regenerator Island - 450 Days
Construction Review
Regenerator Island - 630 Days
Cost

**Basis for Estimating Cost**

- Major equipment list (MEL) with over 300 items
- Developed Construction MTOs using 3D model, detailed design drawings & hand sketches, etc.
  - >14,000 feet of large bore and 40,000 feet of small bore piping
  - ~25,000 cubic yards of concrete
  - ~3,500 Tons of structural steel
  - >500,000 Linear feet of cable
- Provided confidence factors for every line item in both the MEL and MTOs.
Summary

Extrapolating Data

• Information and data generated for the CCM project and others like it, provide tools to develop early capital cost estimates for similar sized systems.

• Work products like MEL, MTOs, etc., can be scaled and adjusted for plant-specific estimates and planning.

• Data can be scaled using comparison of flue gas flows, CO$_2$ intensity, and labor factors.

• Extrapolated data provides opportunity to generate early capital cost estimates for both coal and gas plants.
Questions?

• **Contact Information**

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