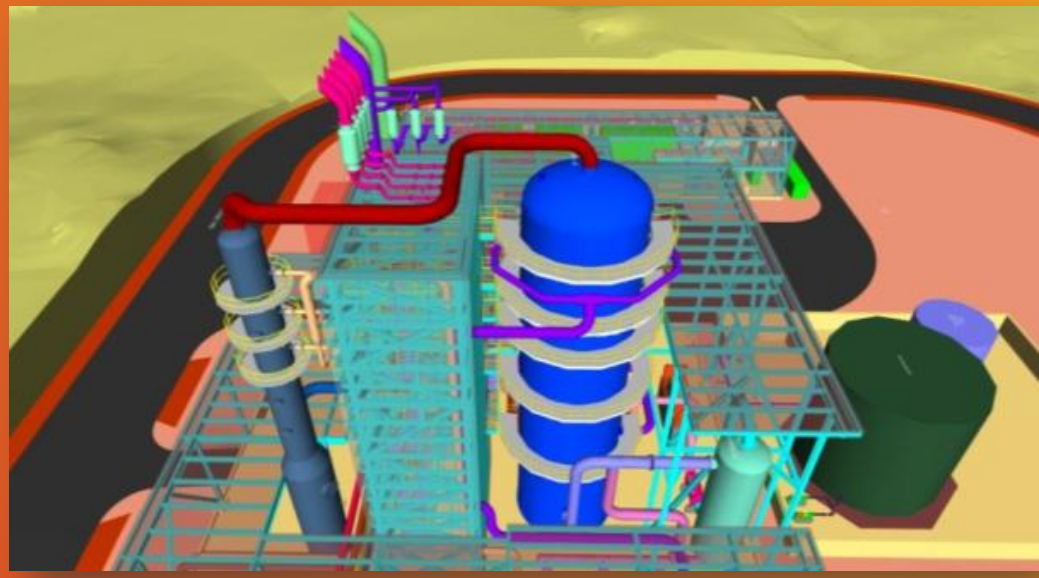
# Design of a Post-Combustion $CO_2$ Capture Process for a Gas-Fired Plant

**Dave Bernier, Senior Principal - Stantec**

**CSLF Mid-Year Meeting**

**June 16, 2015**



# Agenda

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

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# 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**

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# Air Quality Control System Experience

- SCR’s
- FGD’s
  - Dry
  - Wet
- Low Nox Burner Conversion
- SNCR’s
- Carbon Capture

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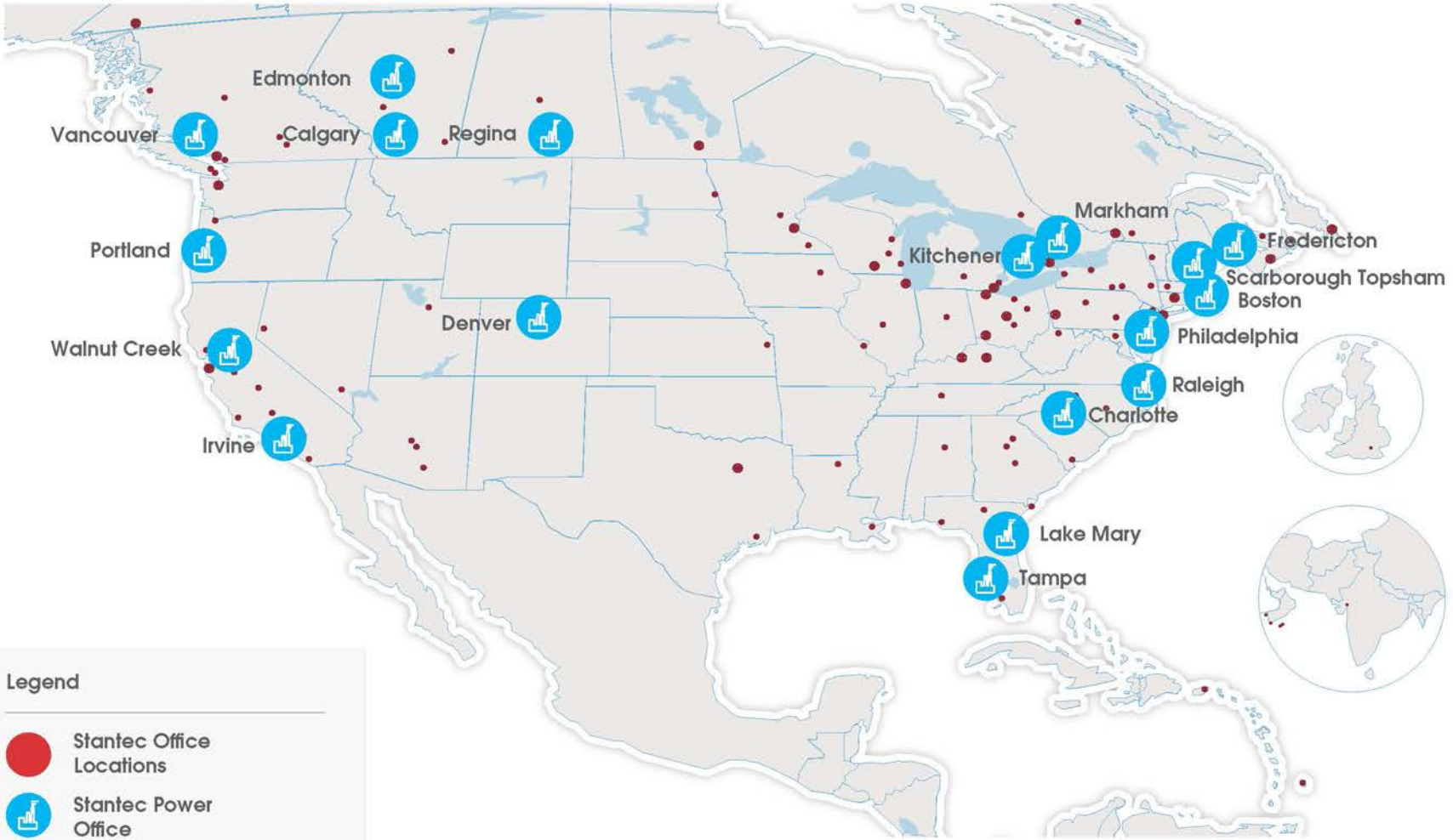
# Stantec Power Offices



# $CO_2$ 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

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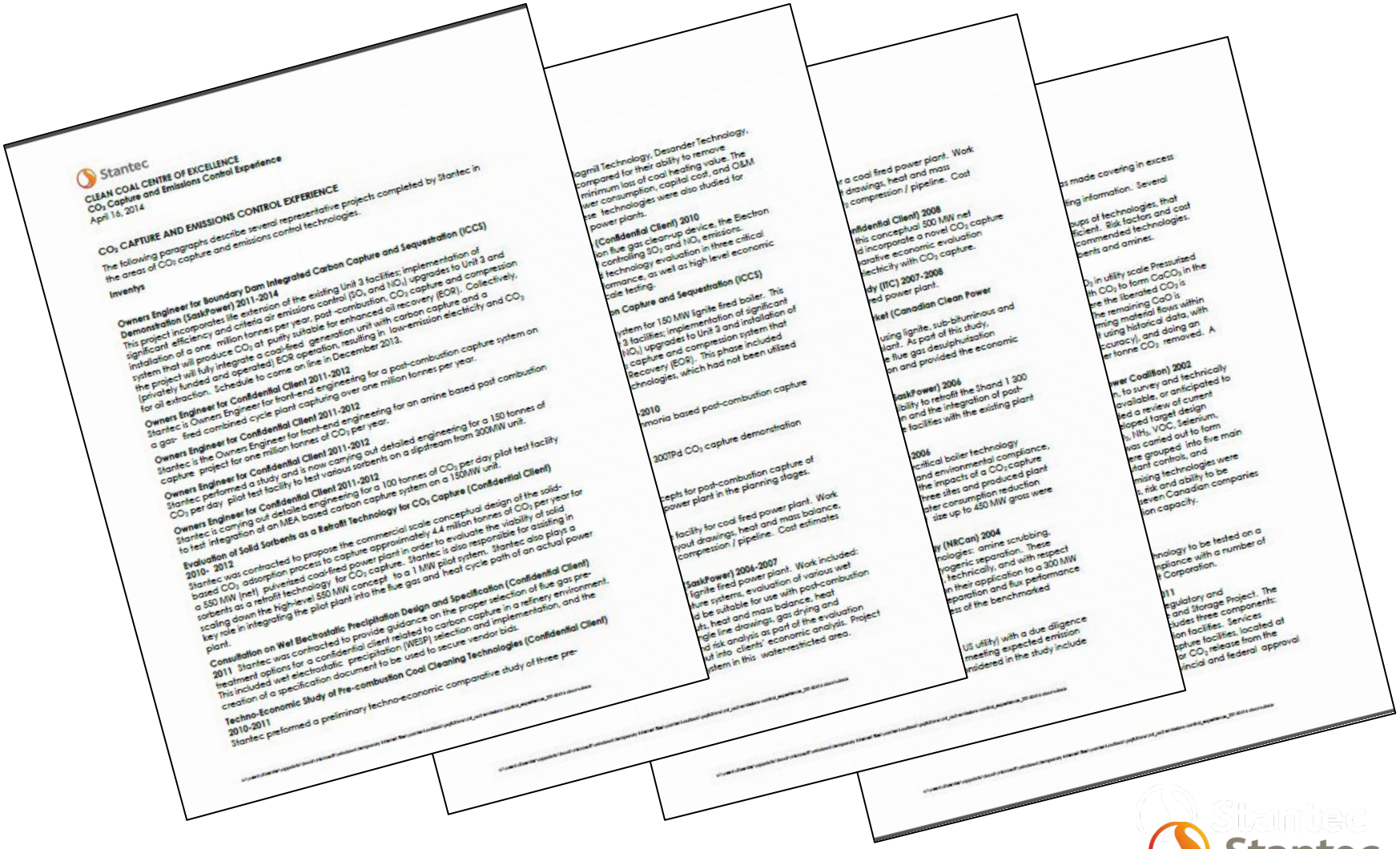
# And a lot more...



# 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)

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# 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

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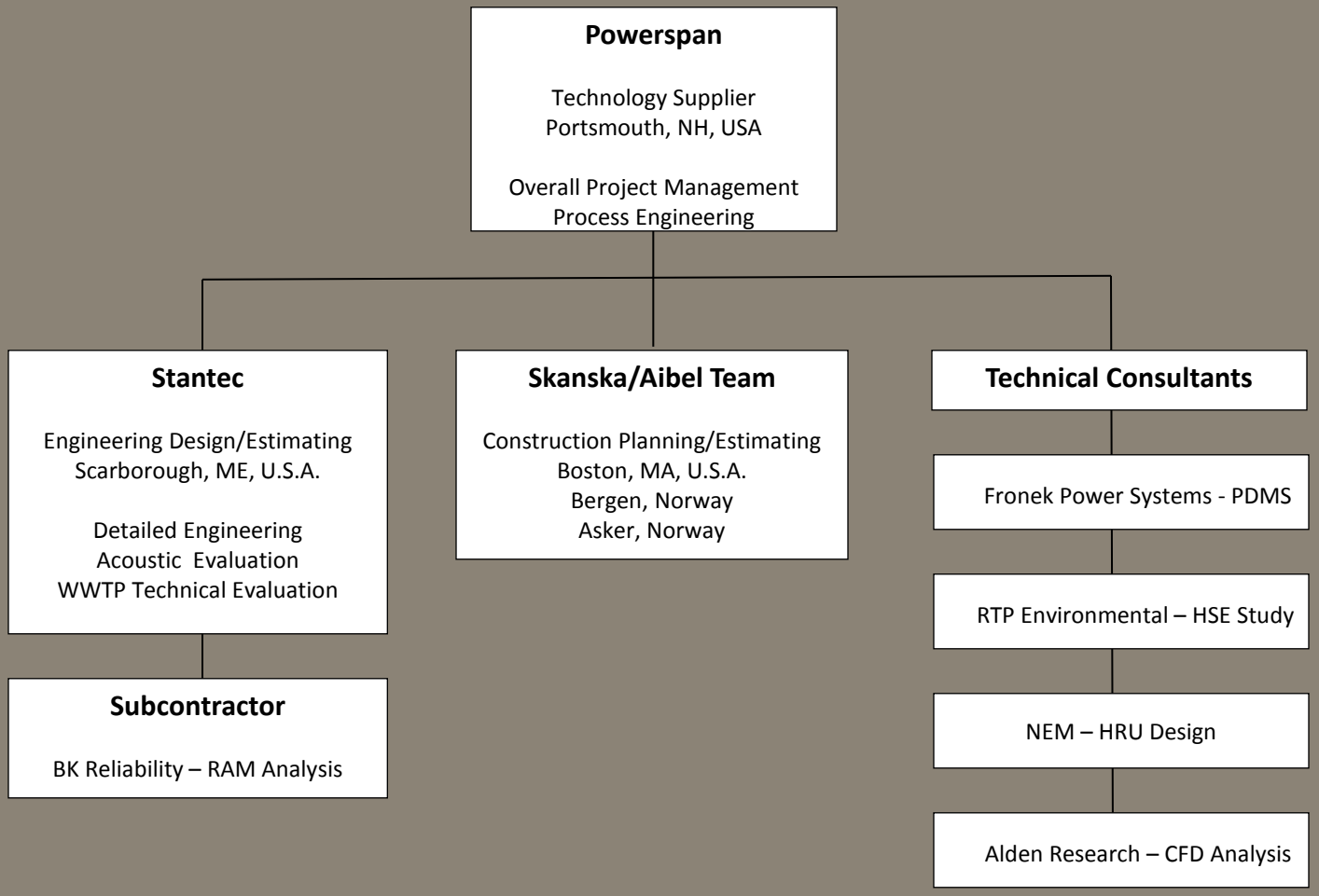
# Project Team

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# Engineering Scope

**Concept Study scope:**

- Flue gas handling (blower, extraction control, transport, heat recovery and cooling)
- Design and supply of the $CO_2$ removal system, solvent handling, and reclaim
- $CO_2$ 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

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# 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.

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# 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
- $CO_2$ operational and relief venting analysis performed
- Completed safety risk analysis and supplied input to site safety plan

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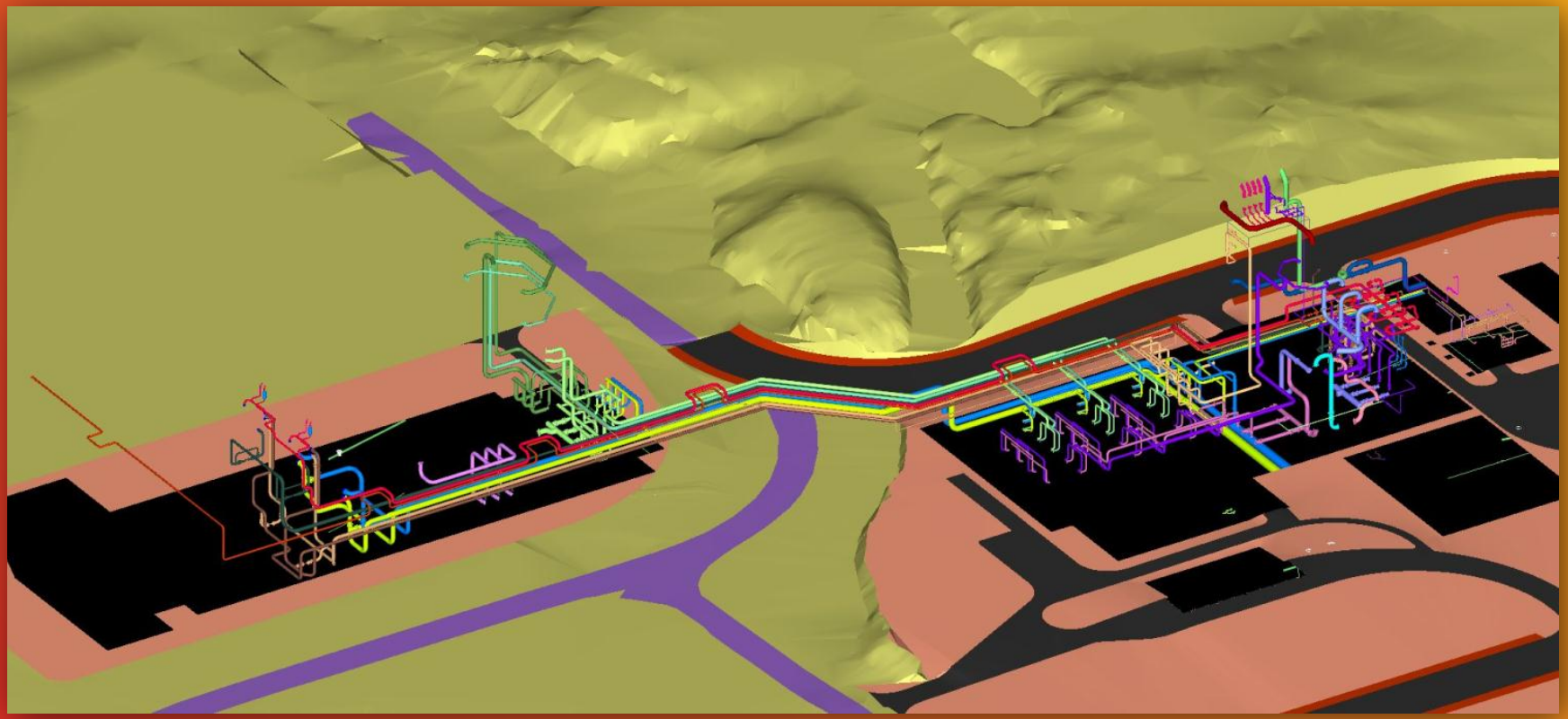
# Overview – 3D Model

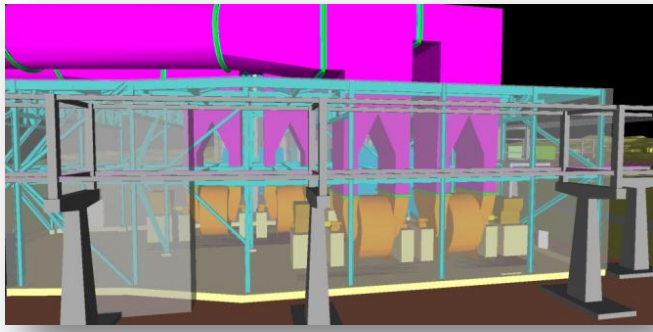
# 3D Model – Piping Layout/MTOs



# Process Equipment Highlights

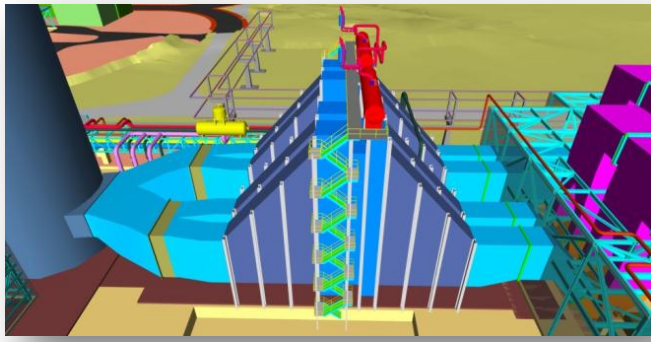
## Booster Fans

- 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



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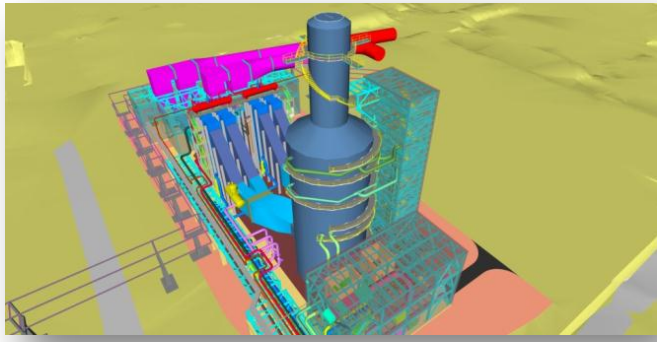
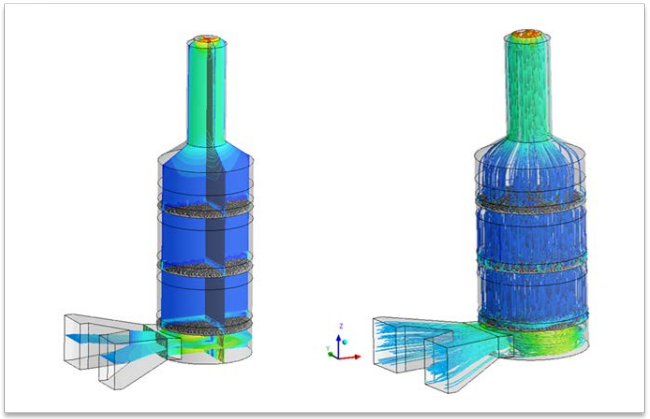
# Process Equipment Highlights

## 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





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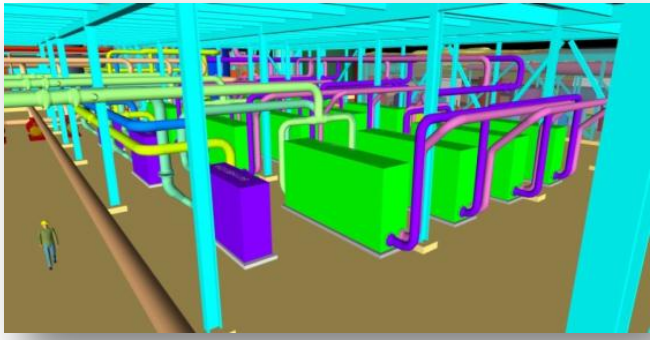
# Process Equipment Highlights

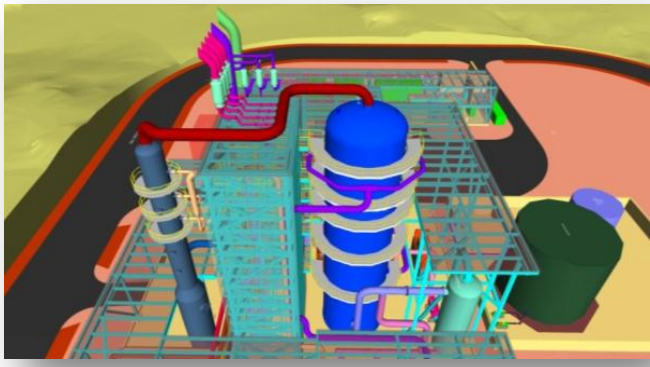
## Cross Heat Exchangers

- 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



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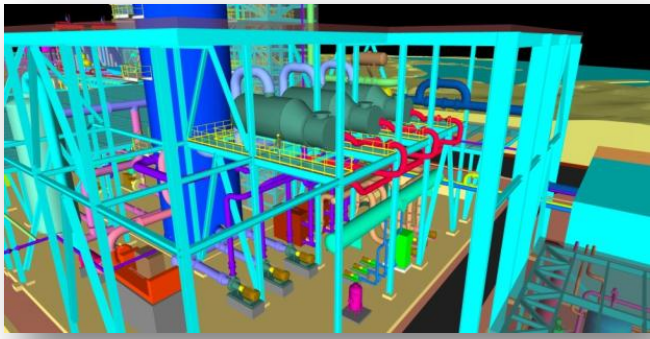
# Process Equipment Highlights

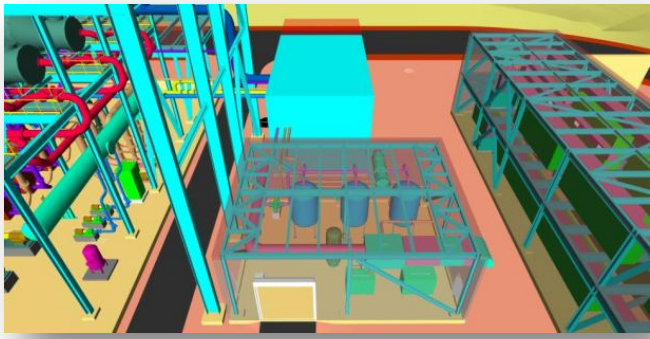
## Reboilers and Preheaters

- 3 x 50% arrangement for process turndown and maintenance



## $CO_2$ Drying and Compression

- Layout based on single unit multi stage compressor
- $CO_2$ dryers included



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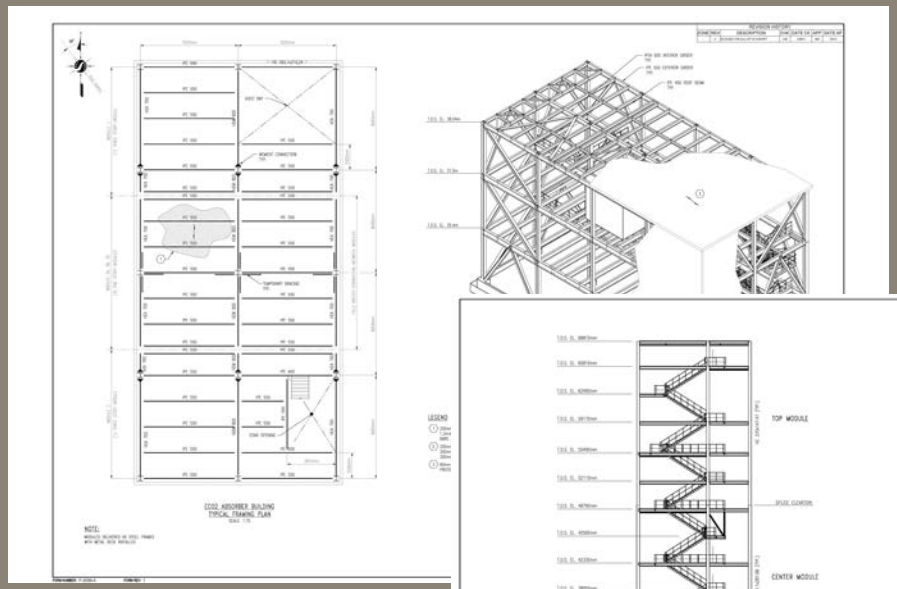
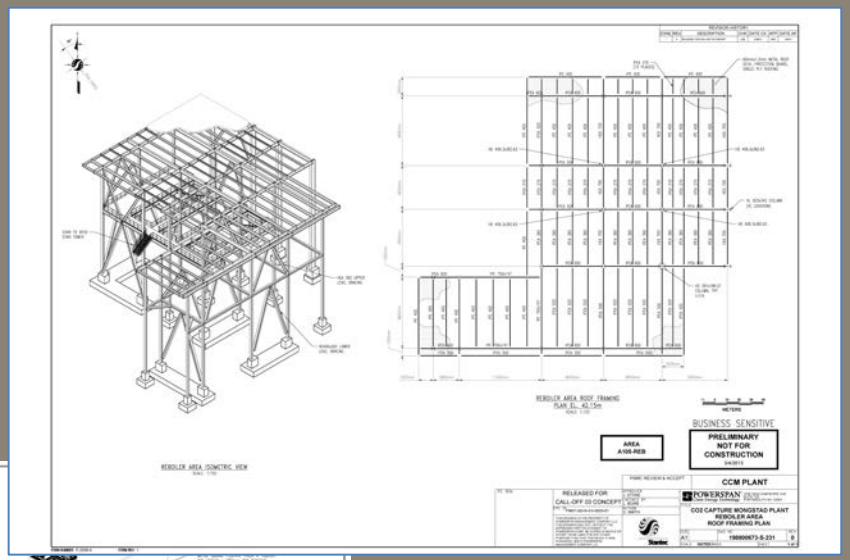
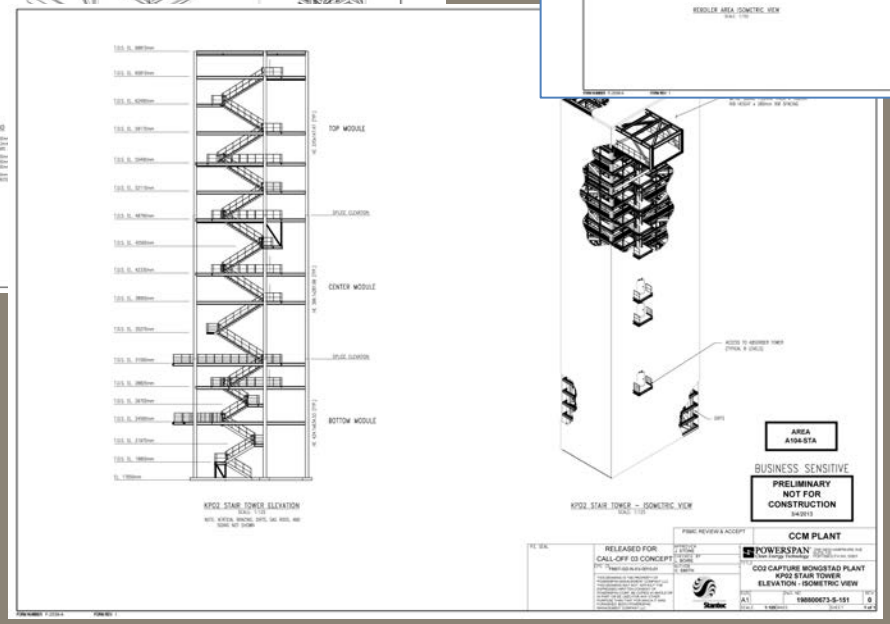
# Detailed Engineering



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# 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

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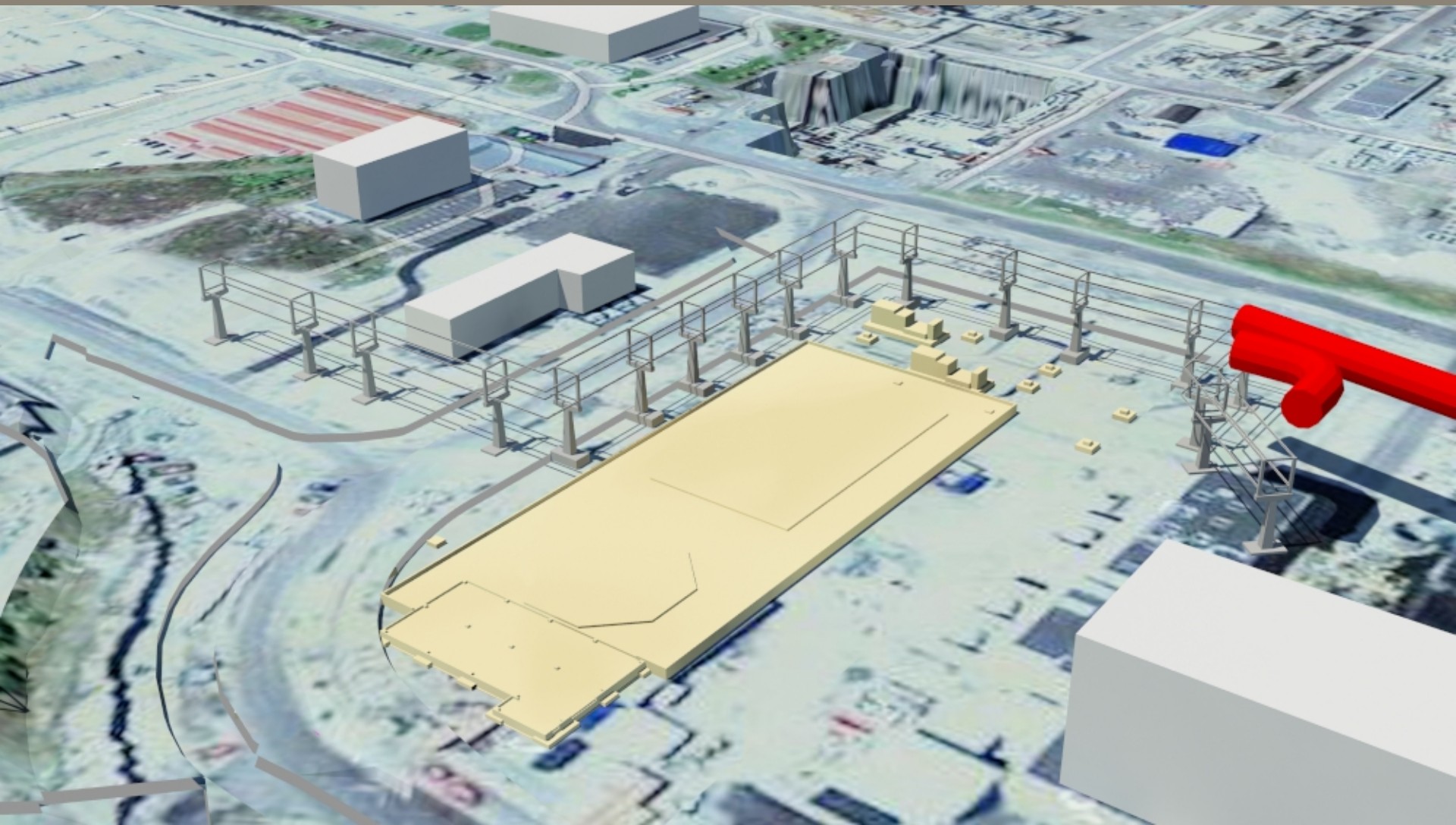
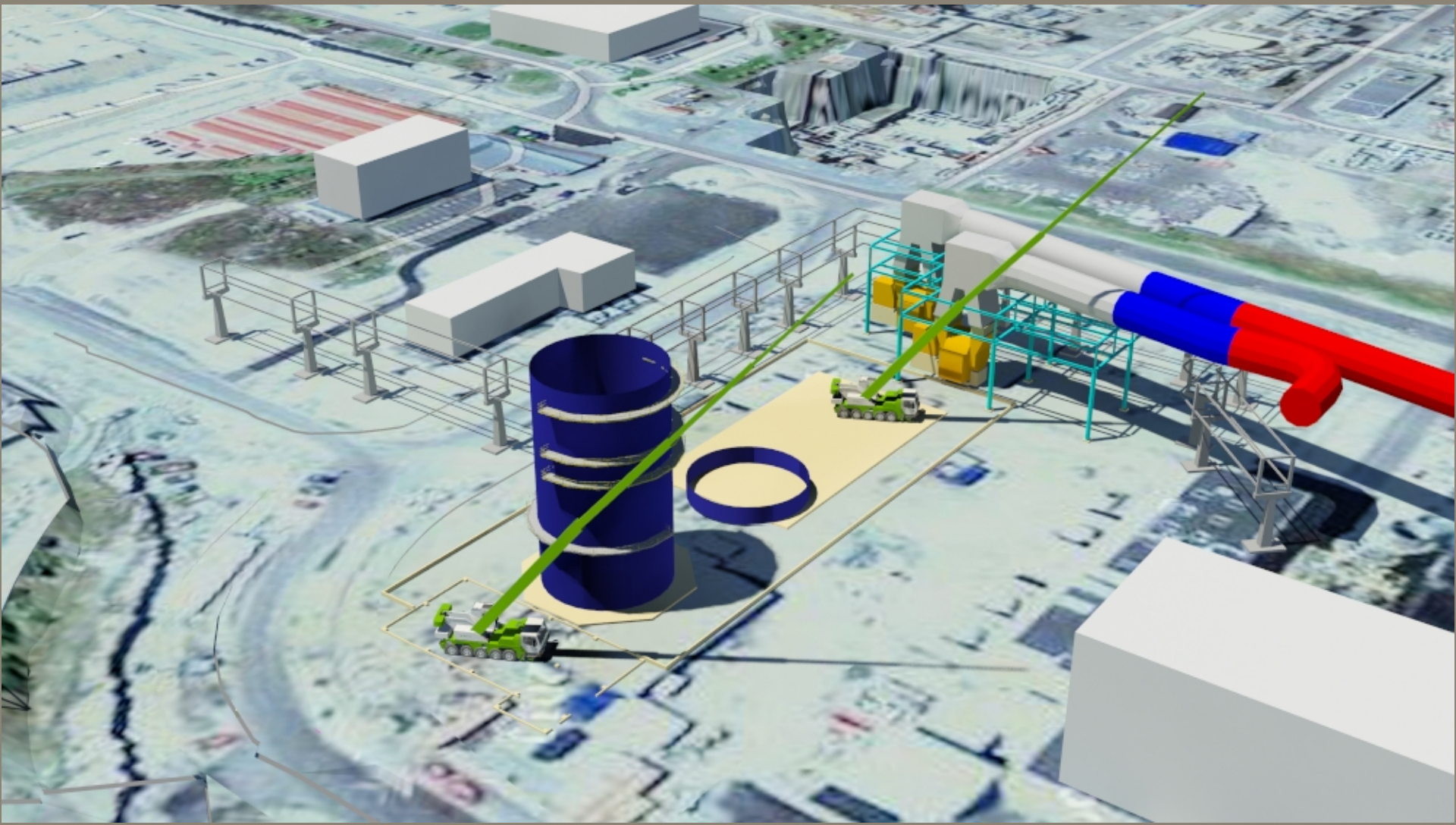
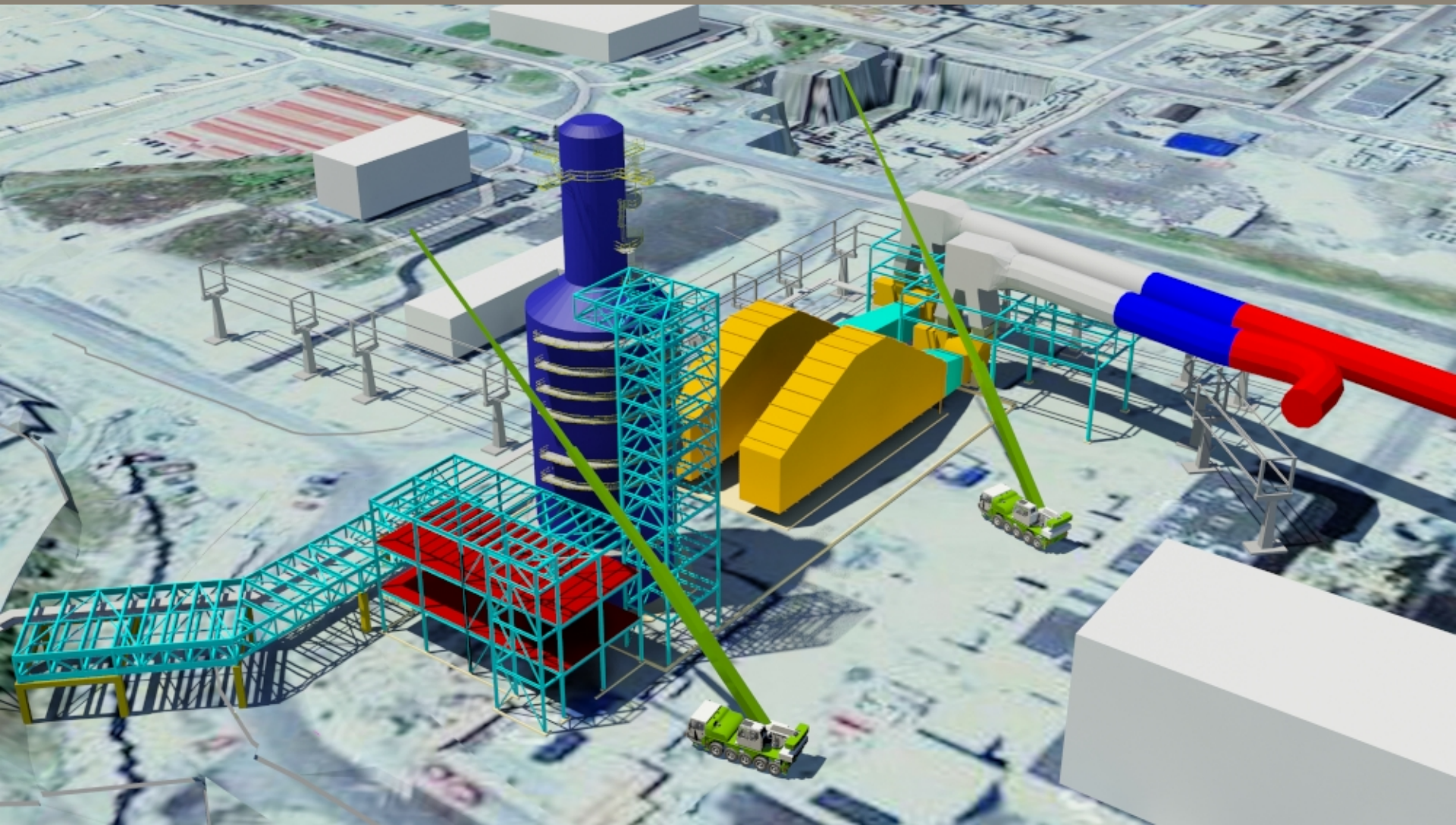
# Construction Review
# Absorber Island - 90 Days



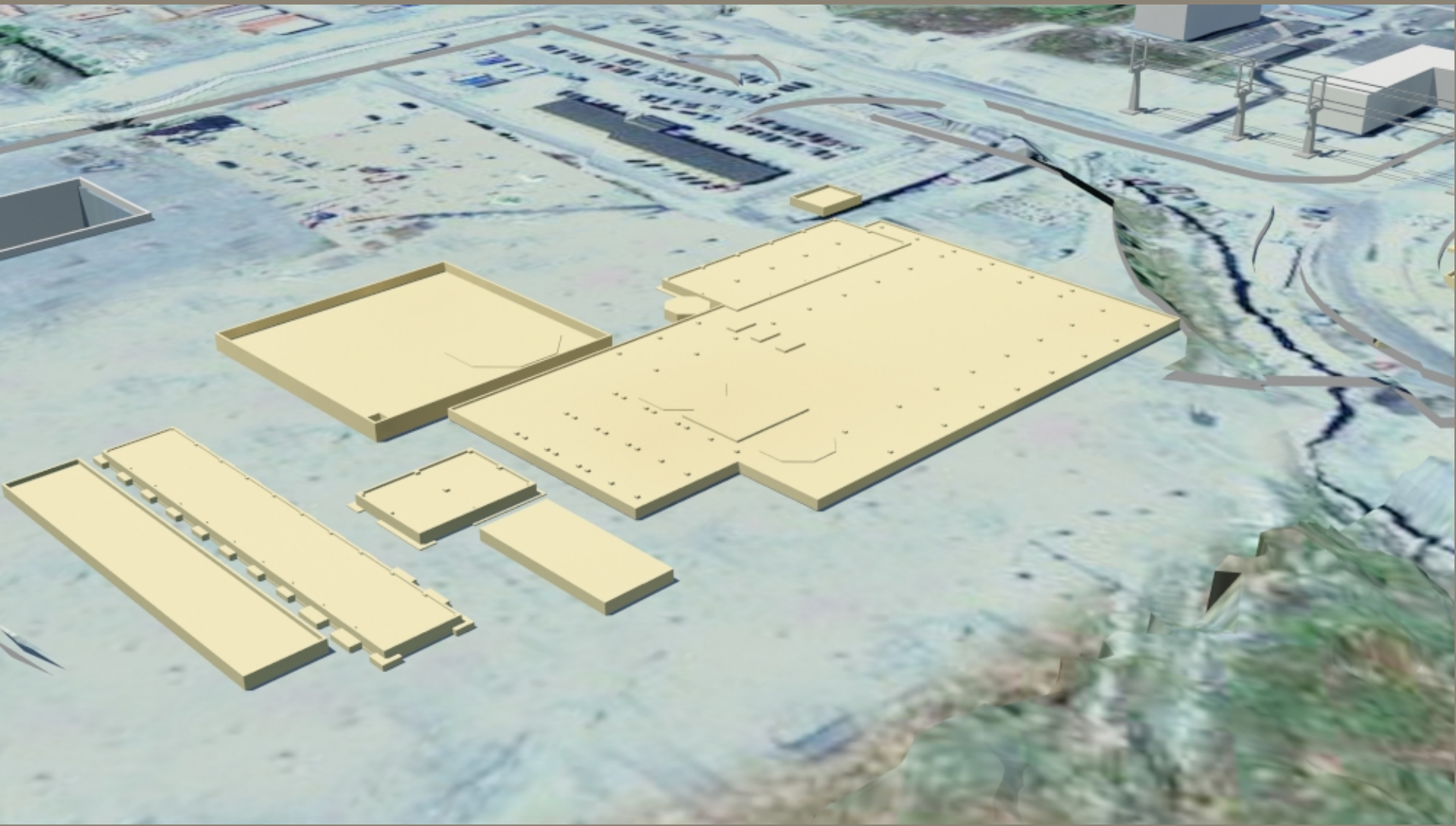
# Construction Review
# Absorber Island - 270 Days



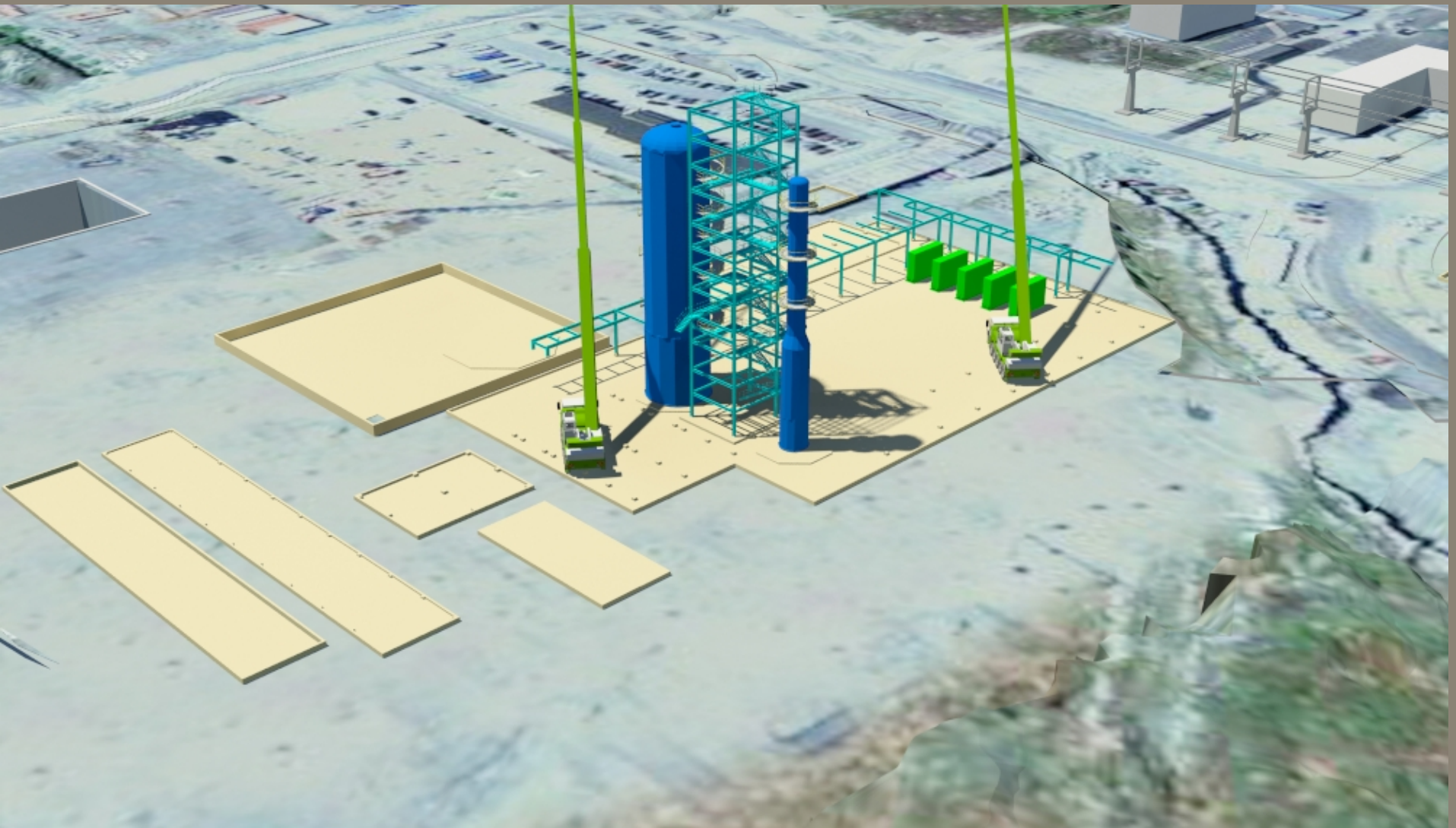
# Construction Review
# Absorber Island - 630 Days



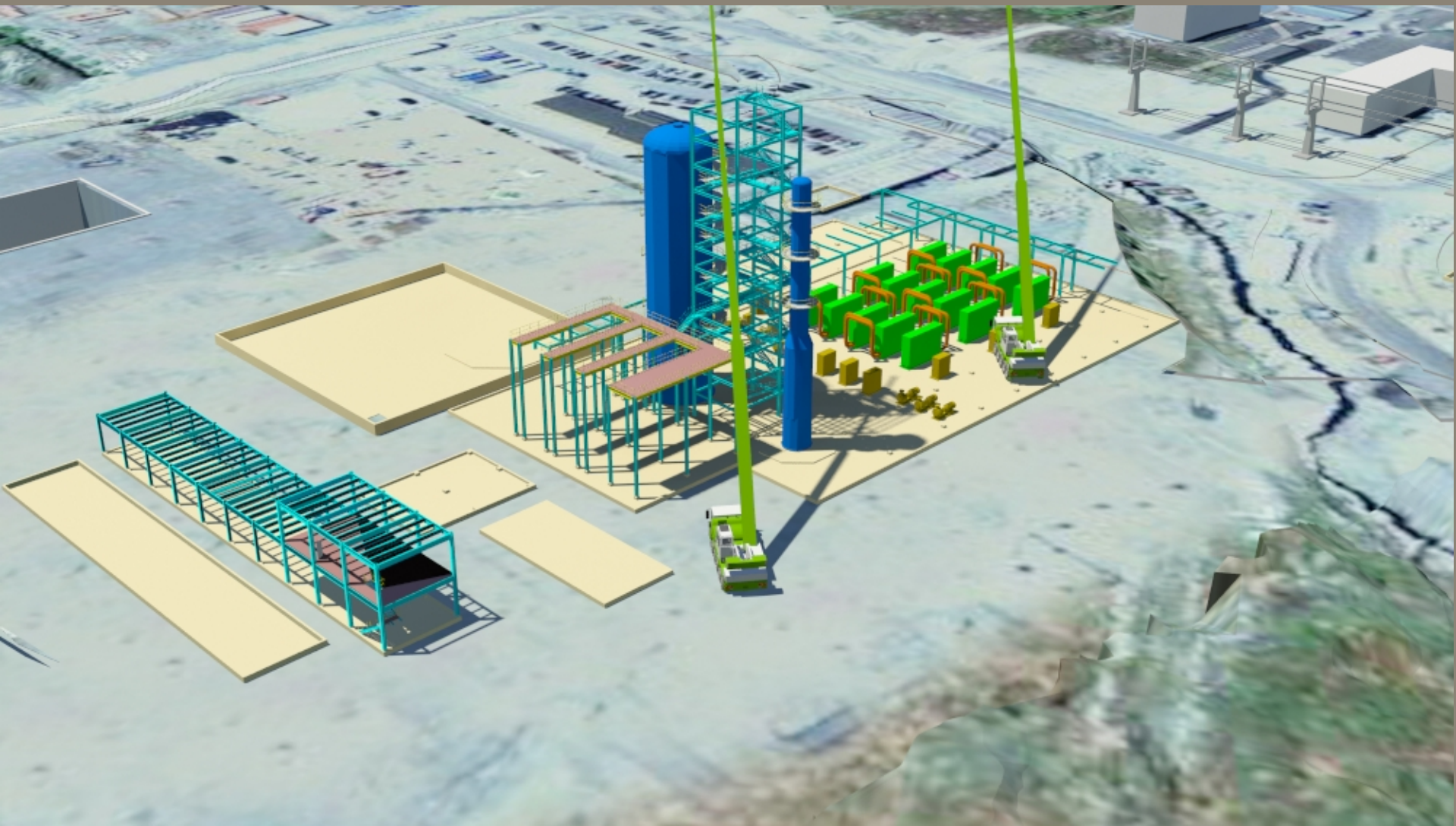
# Construction Review
# Regenerator Island - 90 Days



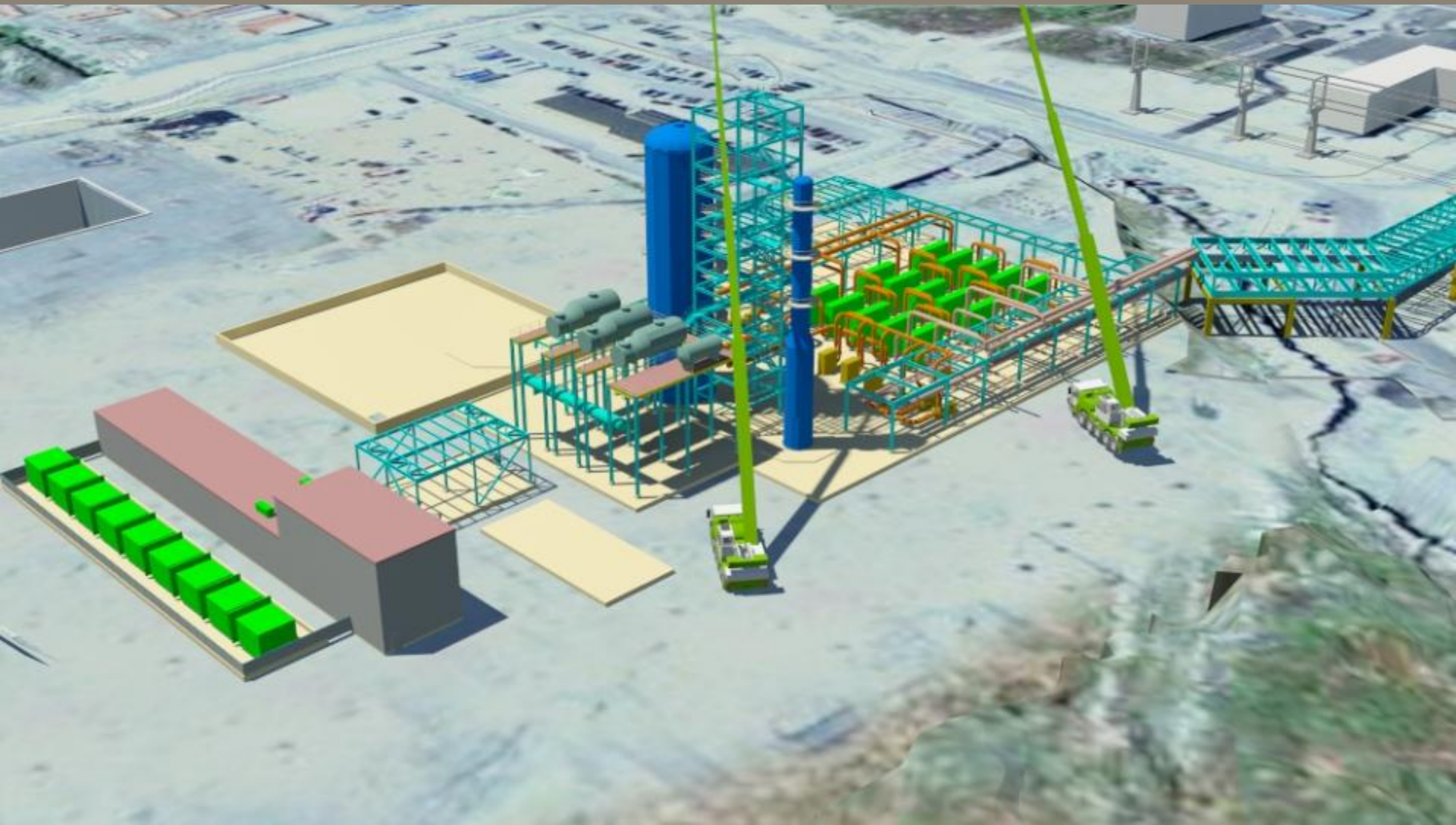
# Construction Review
# Regenerator Island - 270 Days



# 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.

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# 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

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# Questions?

- **Contact Information**

David Bernier
Senior Principal – Stantec
Auburn, NH USA
603.203.0471

Bob Drever
Senior Principal – Stantec
Regina, Saskatchewan
306.515.0425 (Cell)
306.781.6605 (Office)

Frank Alix
President – Powerspan
Portsmouth, NH USA
603.661.4827

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