CANSOLV TECHNOLOGIES INC.

SaskPower

Boundary Dam 3

Project Update & some Lessons Learned

March 2013

Agenda

1. Why CCS? SaskPower perspective
2. How Cansolv got involved
3. Design Objectives
4. Design puzzle: important considerations
5. Major equipment / Commercial summary
6. Absorber & Regenerator
7. Design Challenges / Lessons Learned

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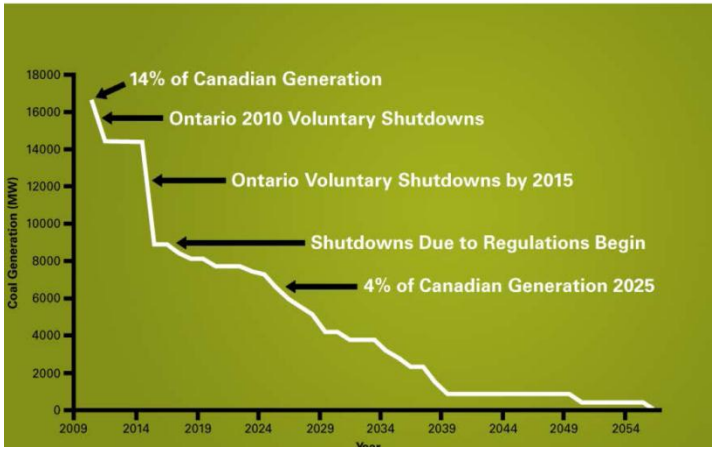
Project Summary – Owners perspective

- Why CCS for SaskPower at BD3?
  1. Coal is cheap and abundant in Saskatchewan
  2. Oil & Gas is strong – EOR presence for CO_2 off-take
  3. Regulations have arrived – predicted to worsen
  4. 240MM CAD funding support to evaluate project (get it off the ground)
  5. SaskPower want to be recognized as leaders and innovators in environment, power generation and CCS

Coal Generation in Canada on Decline



Regulations Have Arrived

September 2012, federal regulations announced limiting CO_2 emissions

- Limit of 420 tonnes CO_2/GWh (equivalent to natural gas combined cycle)
- Existing units must comply at 50 years of age or shut down

April 2011, received approval for building a capture facility

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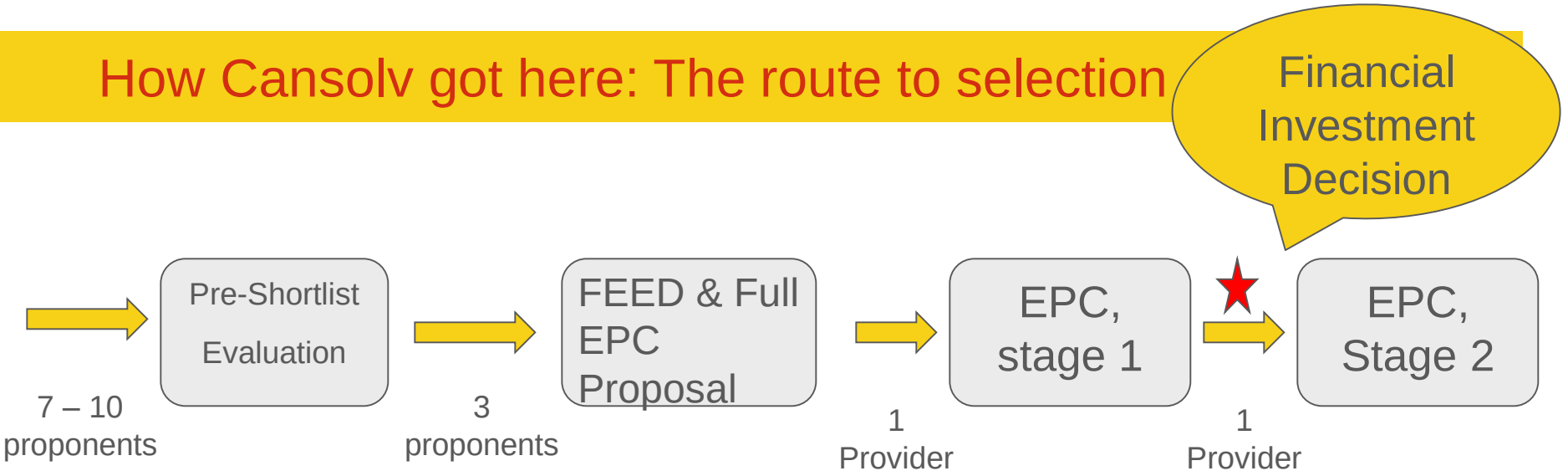
How Cansolv got here: The route to selection

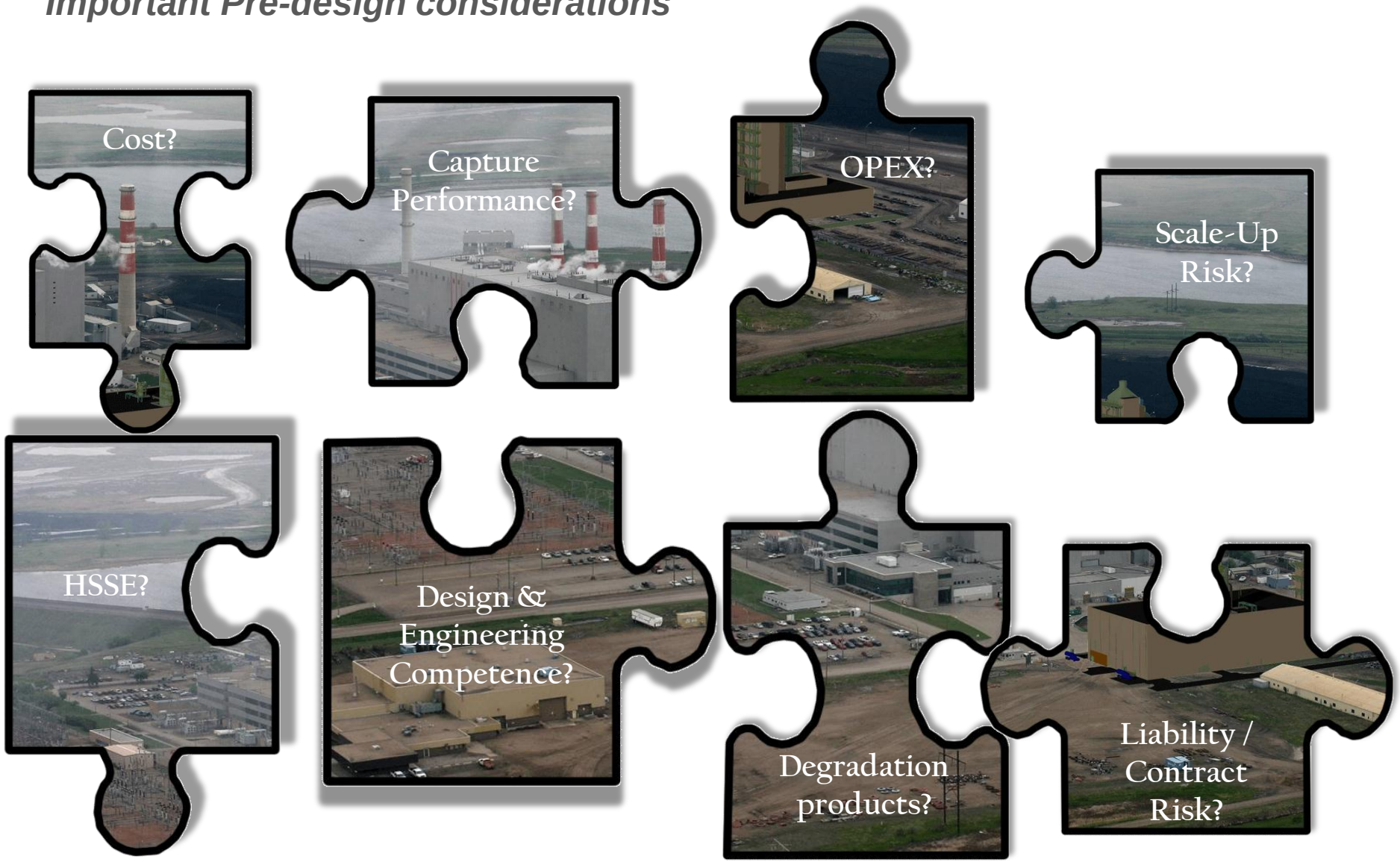


- FEED included vigorous design verification by SaskPower
  - Checked compatibility & degradation using actual BD coal
  - Scale-up analysis performed and submitted
- FEED included risk analysis & mitigation
- EPC broken into 2 stages
  1. Detailed Design and Long Lead Procurement
  2. Construction, Start-up and Warranty Test Run

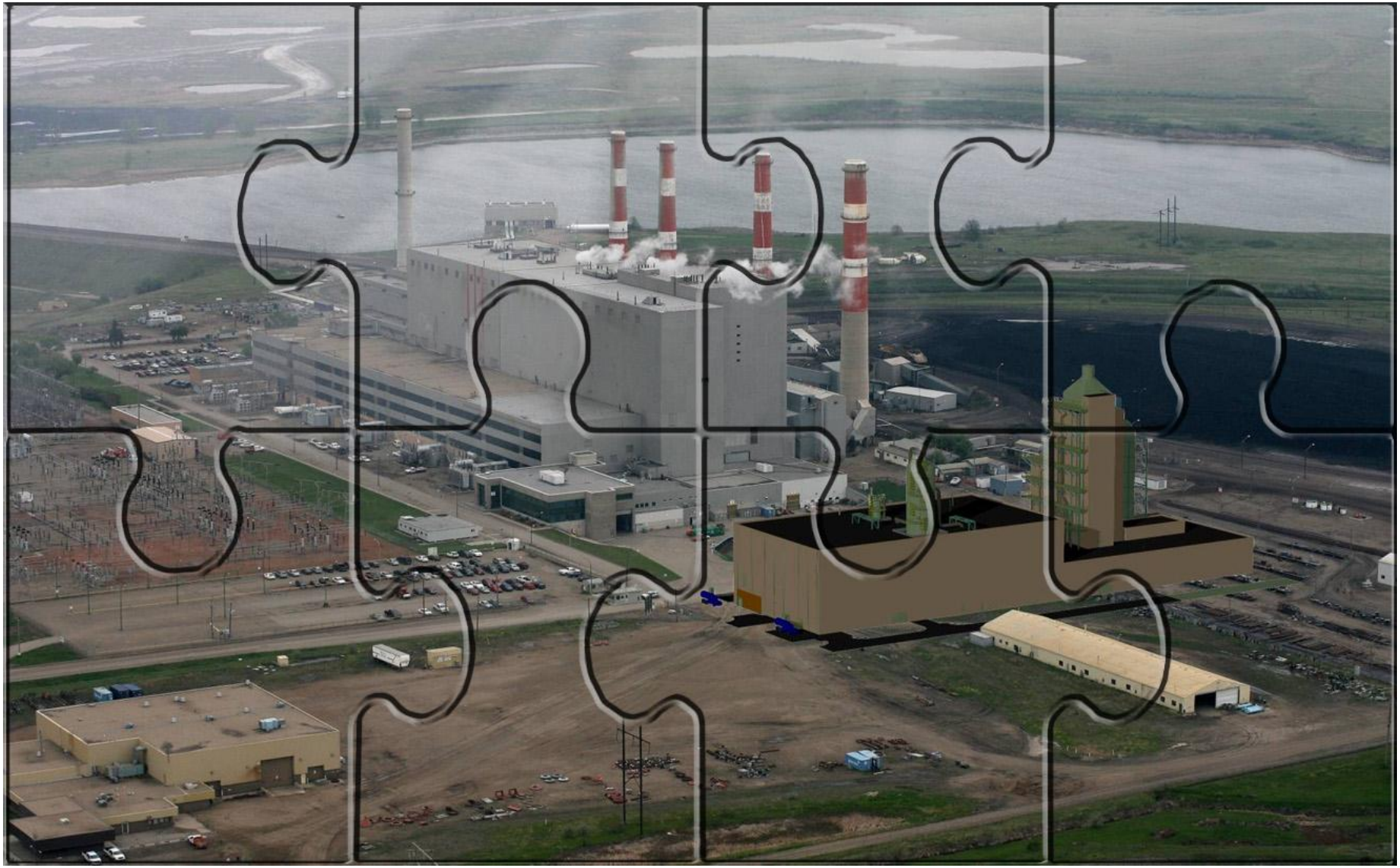
❖ FEED and full EPC Proposal deliverables were key to SaskPower understanding the full cost of technology

The Design Puzzle: fitting the pieces

Important Pre-design considerations



Piecing together a successful design…



Can lead to a successful Construction

SASKPOWER DESIGN BASIS / REQUIREMENTS

- Lignite coal fired power plant (150 MW)
  - ~12% CO_2, 1000 ppmv SO_2
  - 90% Capture required
- Near-zero liquid effluent
- No negative environmental impact (air or water emissions)
- Simple, proven design (user friendly)
- Lowest possible energy consumption
- Commercial guarantees on Capture rate, Steam, Solvent consumption

KPI's

- Overall CO_2 capture steam consumption: ~2.5 GJ/ton CO_2
  - or just less than 1 ton steam / ton CO_2
- 90% capture
- EOR grade CO_2 purity

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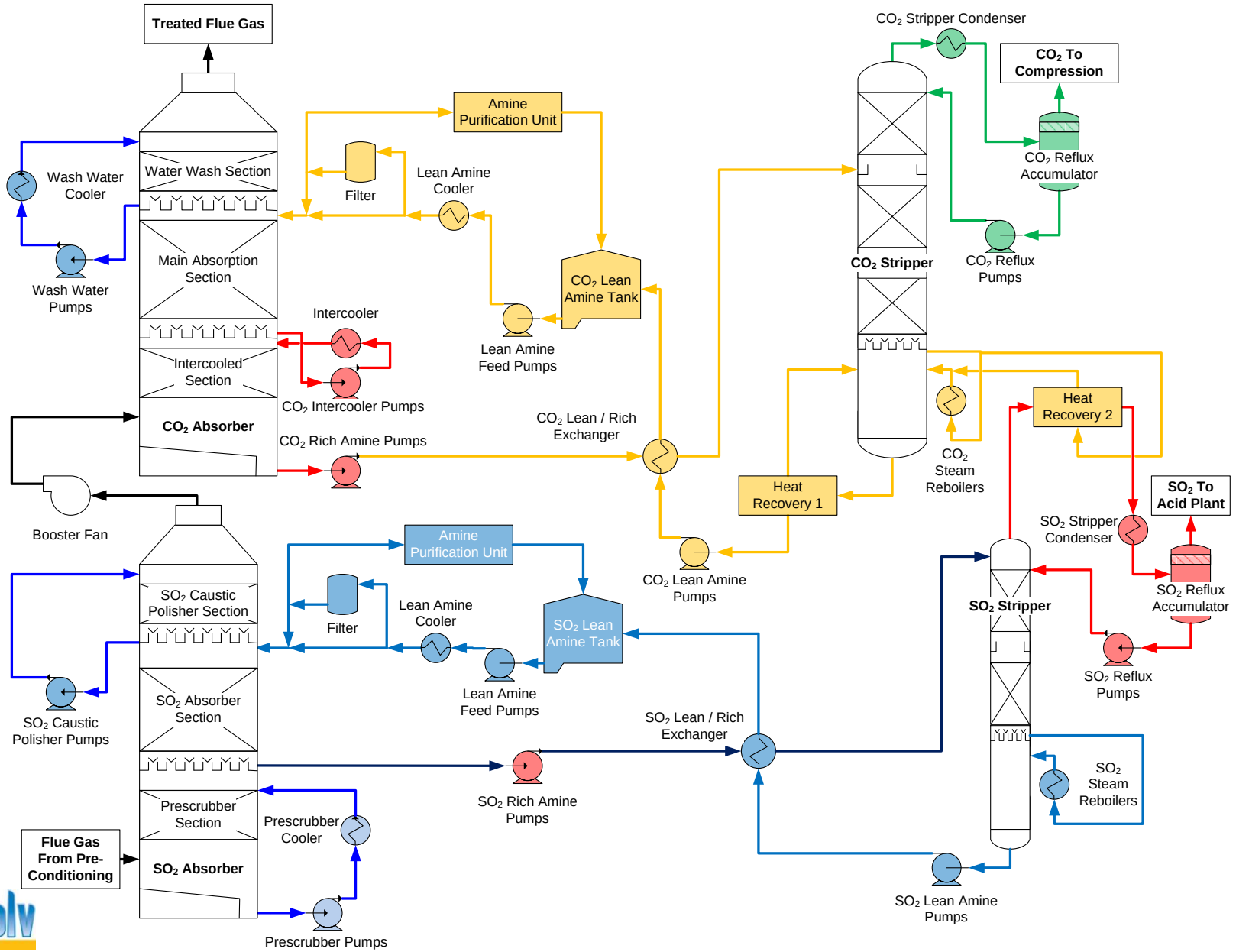
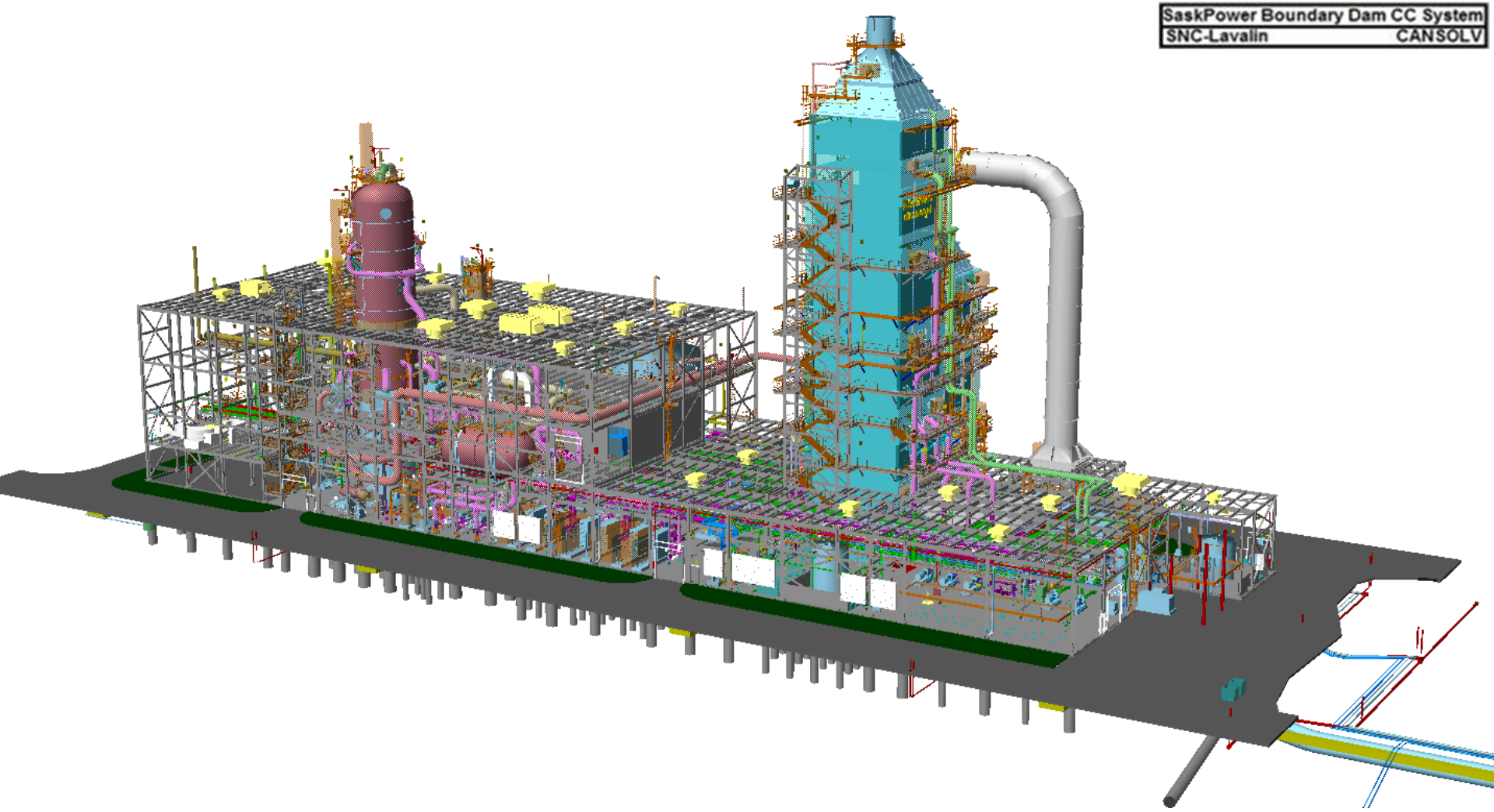
THE PLAN (PFD)

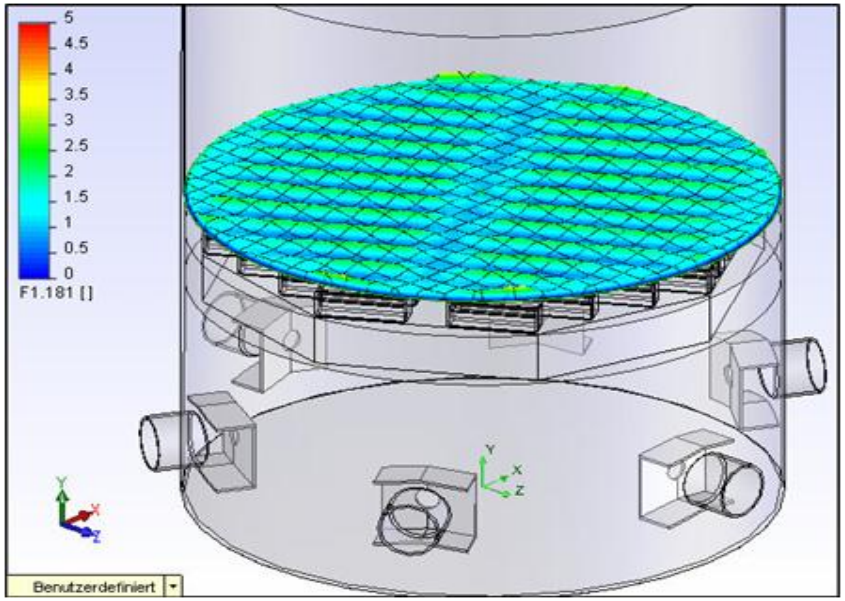

Treated Flue Gas
Water Wash Section
Wash Water Cooler
Wash Water Pumps
Main Absorption Section
Intercooler
Intercooled Section
CO2 Absorber
CO2 Intercooler Pumps
CO2 Rich Amine Pumps
Booster Fan
Amine Purification Unit
Filter
Lean Amine Cooler
Lean Amine Feed Pumps
CO2 Lean Amine Tank
CO2 Lean / Rich Exchanger
CO2 Lean Amine Pumps
CO2 Stripper Condenser
CO2 To Compression
CO2 Reflux Accumulator
CO2 Stripper
CO2 Reflux Pumps
CO2 Steam Reboilers
Heat Recovery 1
Heat Recovery 2
SO2 To Acid Plant
SO2 Stripper Condenser
SO2 Reflux Accumulator
SO2 Reflux Pumps
SO2 Stripper
SO2 Caustic Polisher Section
SO2 Caustic Polisher Pumps
SO2 Absorber Section
Prescrubber Section
Prescrubber Cooler
Prescrubber Pumps
Flue Gas From Pre-Conditioning
SO2 Absorber
Amine Purification Unit
Filter
Lean Amine Cooler
Lean Amine Feed Pumps
SO2 Lean Amine Tank
SO2 Rich Amine Pumps
SO2 Lean / Rich Exchanger
SO2 Steam Reboilers
SO2 Lean Amine Pumps

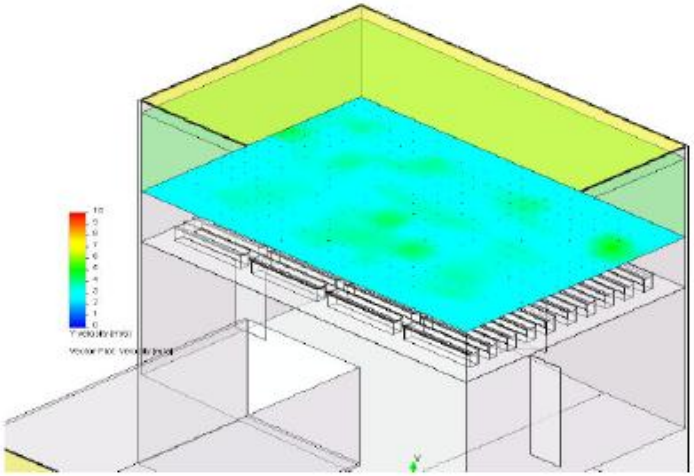
THE PLAN (P F D)

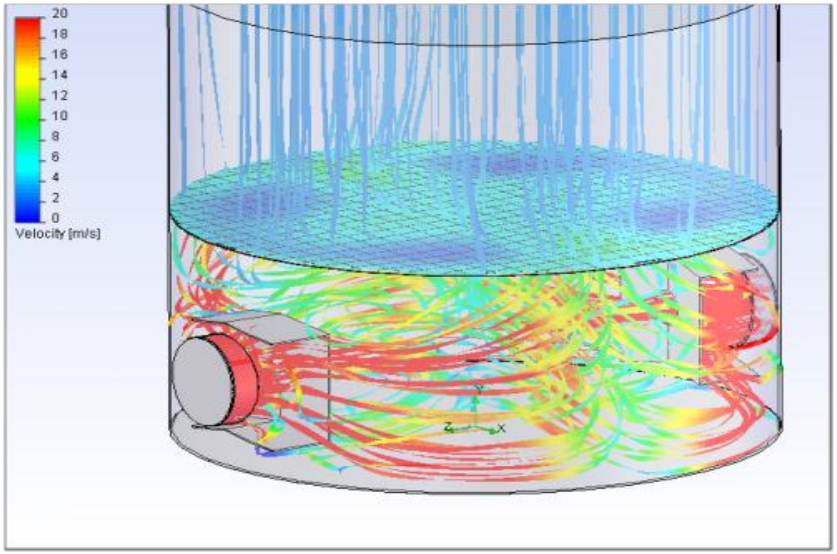


Large Tower Design: Confirmed by CFD

- Use CFD to model distribution (including for square / rectangular)
- Factory Acceptance Tests of liquid distributors
- Careful design of structural components

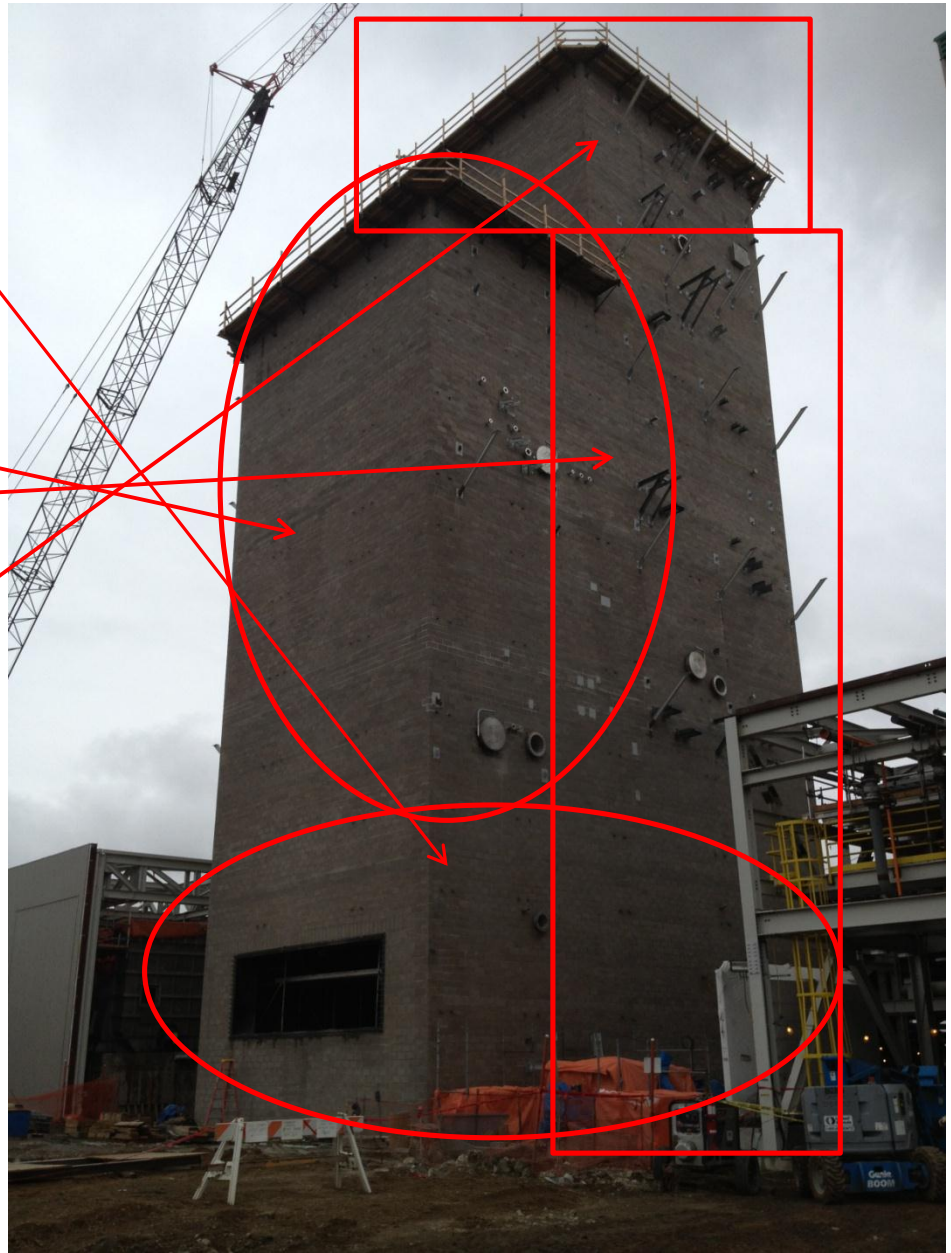






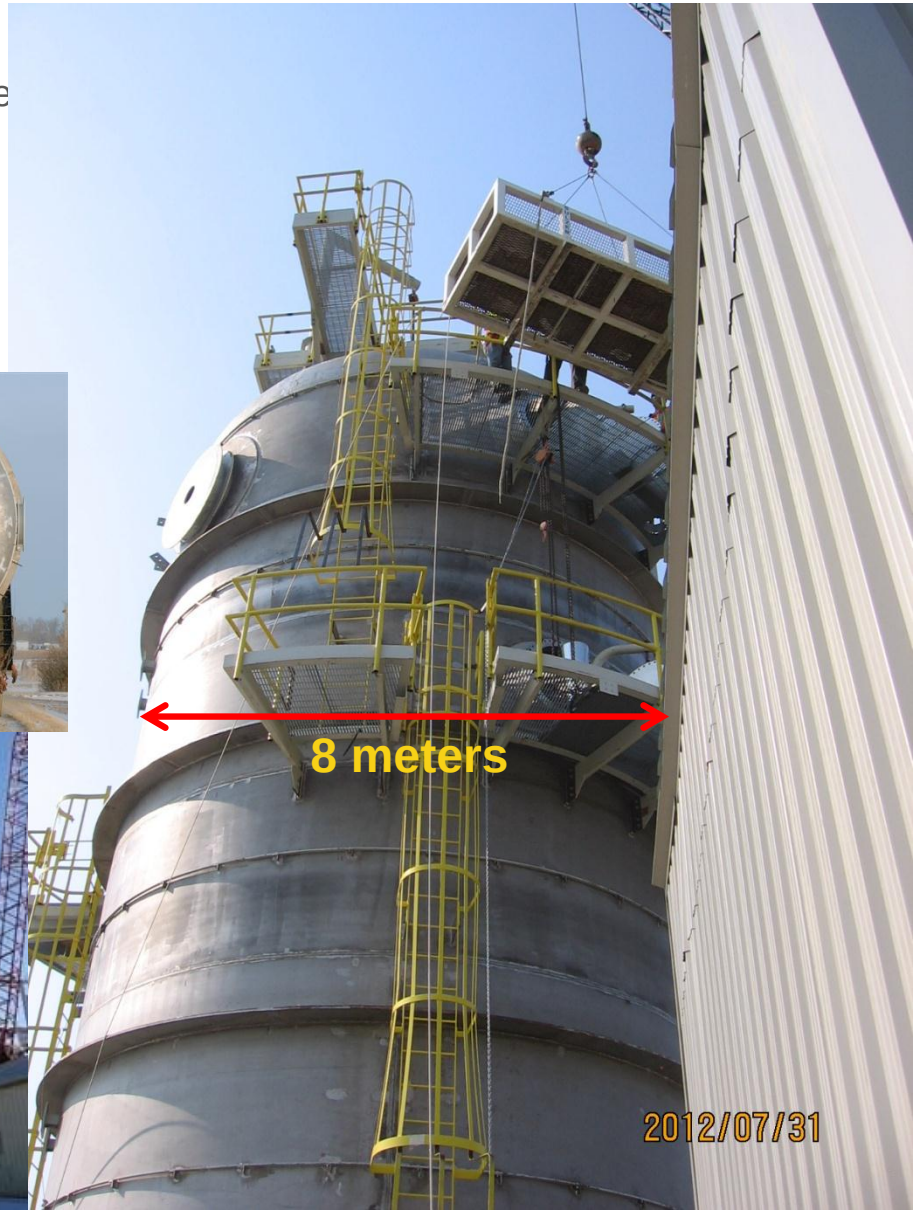
SaskPower: Absorbers

- Installation complete
- Prescrubber section (higher corrosion resistance zone) quenches gas and removes some dust, chlorides and fluorides
- SO_2 Absorber removes SO_2
- CO_2 Absorber removes CO_2
- Water wash (cooled) is last line of defense – keeps amine from exiting the system
  - Shared Common Wall (plot-space and cost savings)
  - Acid resistant lined concrete construction (Stebbins)
  - Integrated development with SNC, Stebbins and Sulzer (packing Vendor) minimized on-site time and labour and optimized overall design



SASKPOWER: CO_2 REGENERATOR

- Installation complete
- One of the largest strippers worldwide
- Main source of energy consumption for capture plant
- 5 large Compabloc reboilers
- Equipped with MVR heat recovery
- Constructed offsite



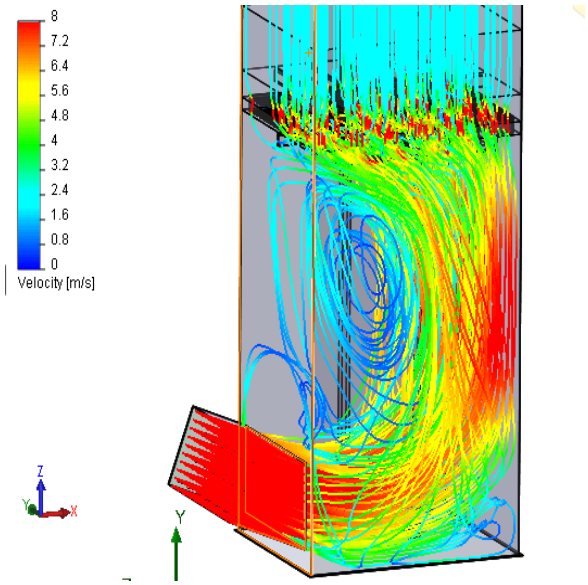
Major Equipment

CO_2 Absorber	Ceramic tile lined concrete packed tower, 11m x 11 m x 54m	Supplier: Stebbins
Prescrubber/ SO_2 Absorber	Ceramic tile and carbon brick lined concrete packed tower, 5.5m x 11m x 31m	
CO_2 Amine Tank	Ceramic tile lined concrete tank, 11 m dia x 18.5m height	
CO_2 Stripper	Packed steel tower, 304SS 8m x 43m height	Supplier: SNC-Lavalin
SO_2 Stripper	Packed steel tower, 316SS top, AL6XN lower section, 2m dia x 25m T/T	Supplier: SNC-Lavalin
Packing	All Mass transfer packing and Internals	Supplier: Sulzer
Reboilers	5 X Compabloc HX (largest available)	Alpha-Laval
Booster Fan	2240 KW	Supplier: Covent
MVRs	1120 Kw (SO_2) & 2240 KW (CO_2)	Siemens

LESSON LEARNED #1: ABSORBER GEOMETRY

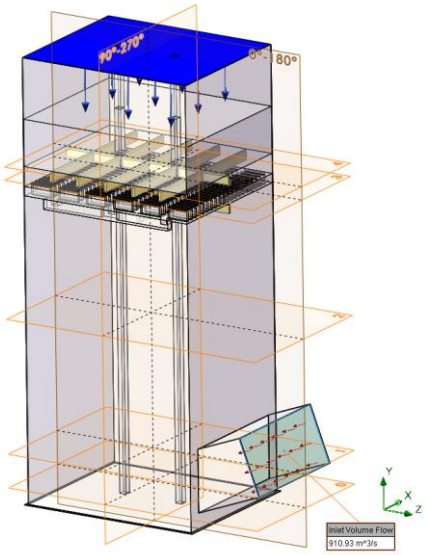
Detailed engineering reviews done to confirm compatibility and effectiveness, including:

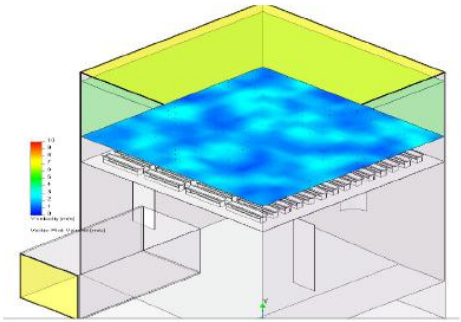
- CFD analysis
- Value Engineering
- Aspen + design modeling
- Estimate TIC Cost comparison

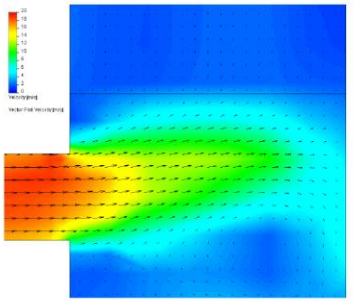


Outcome: Design Validation

- CFD analysis confirmed expected performance and mechanical design
- Rectangular/Square geometry equivalent in process and *superior* in costs



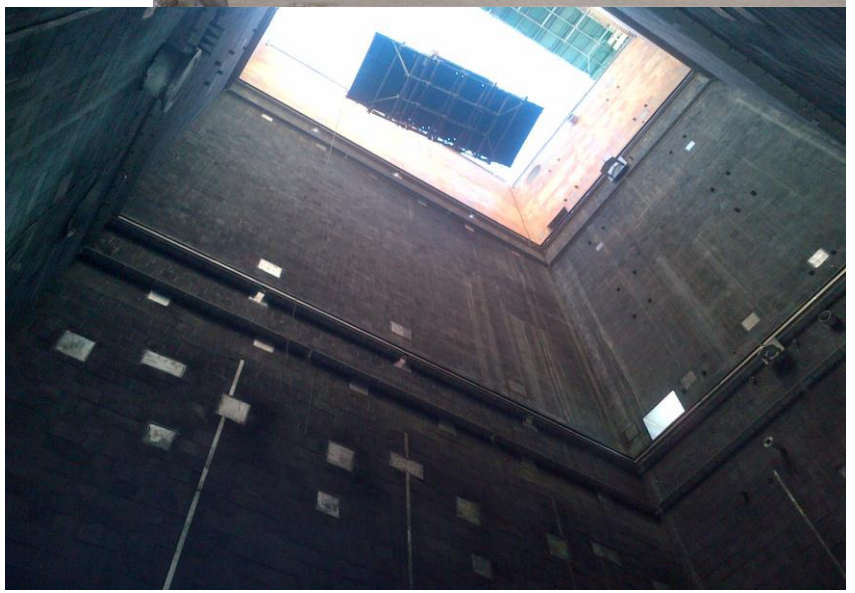




LESSON LEARNED #2: ABSORBER MOC

Detailed engineering reviews done to confirm compatibility and effectiveness, including:

- Review of past corrosion coupon analysis
- Vendor qualification
- 3rd party specialist confirmations
- Estimate TIC Cost comparison



OUTCOME: MOC SELECTED

- Analysis and studies confirmed compatibility of alternate (to steel) MOC
- Concrete structure (with acid resistant lining) equivalent in process and *superior* in costs

LESSON LEARNED #3: CHIMNEY TRAY DESIGN

- During Design, it was highlighted the chimney tray design (industry standard used in past) was unproven for BD conditions and scale
- Verification at lab-scale, an existing client and RWE revealed risk existed for amine loss into prescrubber blowdown due to design inadequacy
- Small amine losses as well as increase in water treatment philosophy might be a result

Water droplets splashing inside chimney

OUTCOME: IMPROVED DESIGN

- Chimney cover design and installation - covers (or hats) meant to prevent liquid from passing down through chimneys modified to prevent liquid from passing around the chimneys or through opening.
- Riser height is increased and chimney hat is redesigned (increased width with baffle plate) to avoid splashing of liquid back to the riser.

New designed hat

Riser Height is increase

One Slide Summary – De Risked Scale-Up

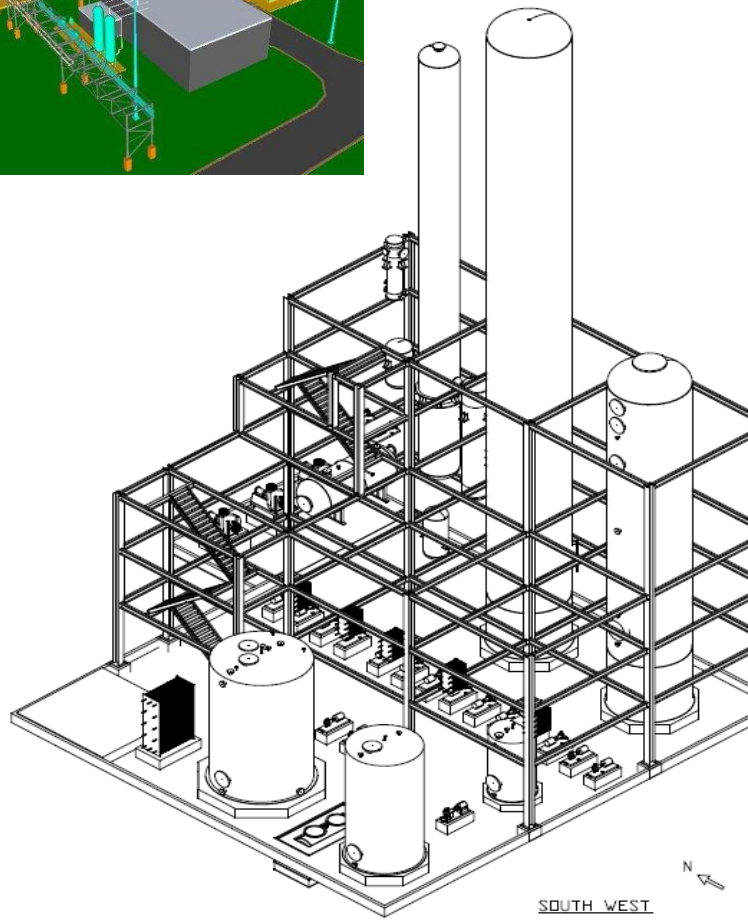
- 1,000,000+ tpy CO_2 captured
- CO_2 sold to Cenevous for EOR
- SO_2 (~60 tpd) converted to acid & sold
- Overall investment: CAD 1.24BB
- Detailed HSE performed, mitigations complete
- Construction @ 80%+
- Start-up will be December 2013
- Unique Cost savings features employed
  - Material on construction: Ceramic/carbon tile lined concrete absorbers & lean amine tank
  - Rectangular tower to save on plot space and optimize packing design/installation
  - Integrate Heat Recovery between SO_2 and CO_2 systems for ultimate energy performance
- Unique plant permitting experience (operation & environmental)
- Unique and repeatable integration experience
  - Capture plant integrated into new build power block
- Unique proven constructability: Only commercial scale project worldwide

Additonal slides

Cansolv CO_2 – what else we're doing...

Cansolv CO_2 Capture Unit at Lanxess

- Location: South Africa
- Scale: 170 tpd CO_2 capture
  —90% removal
- Natural Gas Boilers
  —Not CCGT's
- EPC in progress (Detailed Design)
- Construction complete: June 2013
- CO_2 generated for on-site use
- Strategy: Project makes client self-sufficient on steam and CO_2



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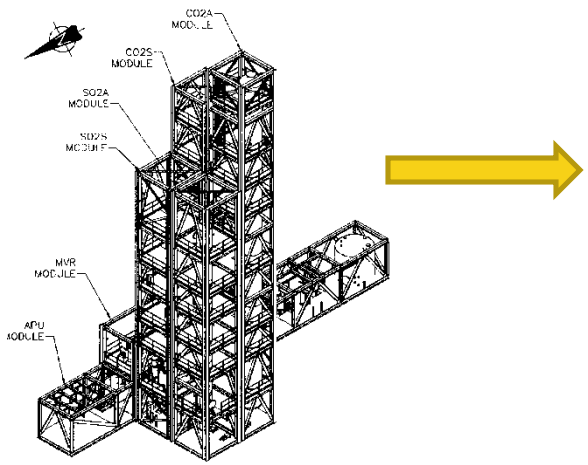
RWE SO_2 & CO_2 Capture Demonstration



Location: Coal-Fired power Plant, Wales

- 50 ton/day CO_2 capture (~3 MW)
- 12 % vol CO_2 & 1,000 ppmv SO_2
- 90% removal of CO_2
- Complete Chinese Modular Construction
- Conforms to UK regulations and CDM
- Will demonstrate capture plant ability to adapt to UK power needs
- In Operation since Q1 2013

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Shell/SSE Peterhead – CCGT CO_2 Capture

- Selected by SSE to be capture provider based on a paid competitive Pre-FEED competition (vs 2 other competitors)
- Peterhead project selected by DECC to receive funding March 2013 (“UK Competition”)
- Will be a retrofit of a ~300MW CCGT to include CCS
- Sequestration of CO_2: Goldeneye (off-shore North Sea)
- FEED starts Q2, projected start-up is 2017

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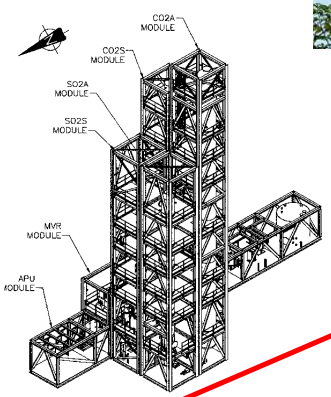
Cansolv – De-Risked Scale-Up

Scaling Up CO_2 capture

- Integrated Learnings
- Guaranteed Performance
- Design, Engineer → Deliver



2000-2005 | 2009-2010 | 2011 - 2012 | 2012-2013 | 2013-2014 | 2016-2017

Cansolv Scale-up – proven constructability

	Boundary Dam Design	Peterhead Design	Guodian Duyun Design
Flue Gas Type	Coal Retrofit	Gas Retrofit	New Pulverised Coal Fired Power Plant (PCPP)
Power Capacity	~170MWe	~400MWe	2 * 660MWe
Flue Gas Flow Rate	~650,000 Nm^3/hr	~1,940,000 Nm^3/hr	2 * ~ 2,350,000 Nm^3/hr
Absorbent Circulation Rate	~2,000 m^3/hr	~2,100 m^3/hr	2 * ~ 1,500 m^3/hr
CO_2 Capacity	~3,300te/day	~3,200te/day	N/A

	Boundary Dam Design		Peterhead Design		Guodian Duyun Design	
Equipment	**Material**	**Dimensions/Size**	**Material**	**Dimensions/Size**	**Material**	**Dimensions/Size**
Prescrubber (structure)	Lined concrete	~80m2 * ~12m	Lined concrete	~150m2 * ~35m	Lined concrete	2 * 420m2 * 30m
Absorber (Structure)	Lined concrete	~120 m2 * ~50m	Lined concrete	~400-450m2 * ~50m	Lined concrete	2 * 420m2 * 60m Total Tower Absorber ~12m
Absorber (internals)	304L SS / 316L SS	~ 21 m packing height	304L SS	~ 16 m packing height	316L SS	~ 5.5 m packing height
Stripper	316L SS	~45m2 * ~25m	316L SS	~55 m2 * ~27m	Clad CS	2 * 50m2 * 27m
CO_2 Stripper (internals)	316L SS	~ 12 m packing height	316L SS	~ 9.5 m of packing height	316L SS /254 SMO	~ 5.5 m of packing height
Booster Fan	316L SS	~ 3 MWe	Mild steel	~ 8 MWe	Mild Steel	Not available
Reboilers	316L SS	~90 MWth	316L SS	~ 100-120 MWth	316L SS	2 * ~ 100 MWth

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