Carbon Capture Plant FEED Study for Cement Manufacturing

DE-FE003220

Technology Advancement & Commercialization Division, RTI International

2023 FECM / NETL Carbon Management Research Project Review Meeting

Aug 28 – Sep 01, 2023

DE-FE0032220 : Carbon Capture Plant FEED Study for Cement Manufacturing

- Complete FEED study for CO_2 capture from cement flue gas using RTI's non-aqueous solvent (NAS) with 95% capture efficiency
- Develop AACE Class 3 cost estimate for a commercial 1,600,000 t-CO_2/year scale CO_2 capture system integrated with a cement facility
- Project Funding:

US DOE	$3.68 MM
Cost-share	$0.92 MM
TOTAL	$4.60 MM

- Period of Performance (21 months)

April 14, 2023 – Jan 13, 2025

Project Team

RTI International

Prime Recipient responsible for project management
Technology developer for the NAS technology
Responsible for process design, TMP, TEA, LCA, EJ40 & workforce readiness plans

CEMEX

Leading cement and concrete producer
Host site operator
Provide support on permitting and process integration

KBR

EPC firm performing the FEED.
Conduct HAZOP and Constructability review
Develop AACE Class 3 cost estimates (+/- 15%)

slb

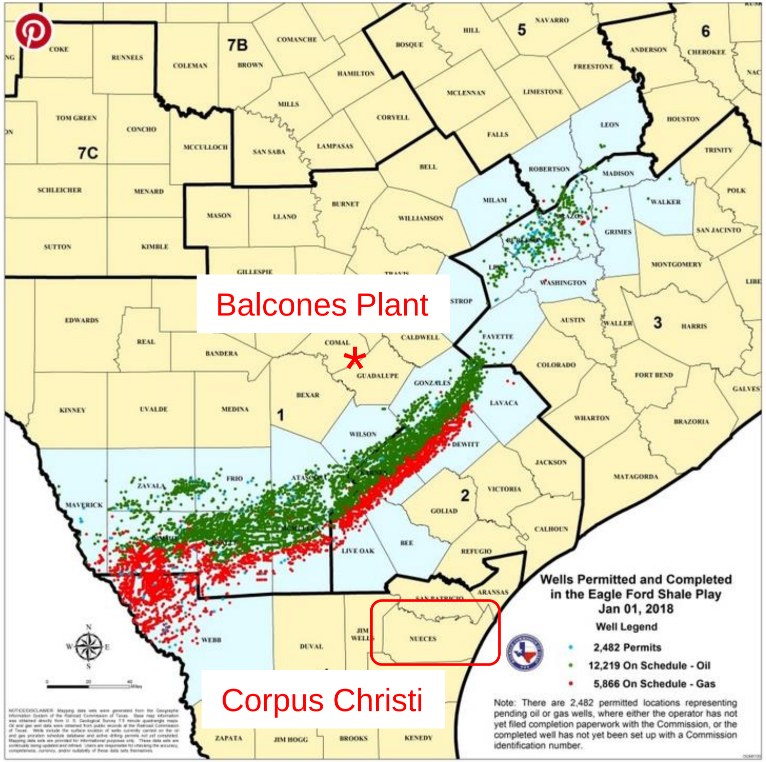
Global technology company with100+ years in energy sector
Technology licensor for the NAS technology
Serve as Owner’s Engineer

Host site – Balcones Plant

- Host site - CEMEX Balcones plant Located in New Braunfels, TX
- 2 cement kilns with total production rate of ~7000 tons of clinker per day
- CO_2 emissions of 1.5 MM tonnes per year.
- FEED study will capture 95% of emissions from cement plant + natural gas steam boiler

CEMEX

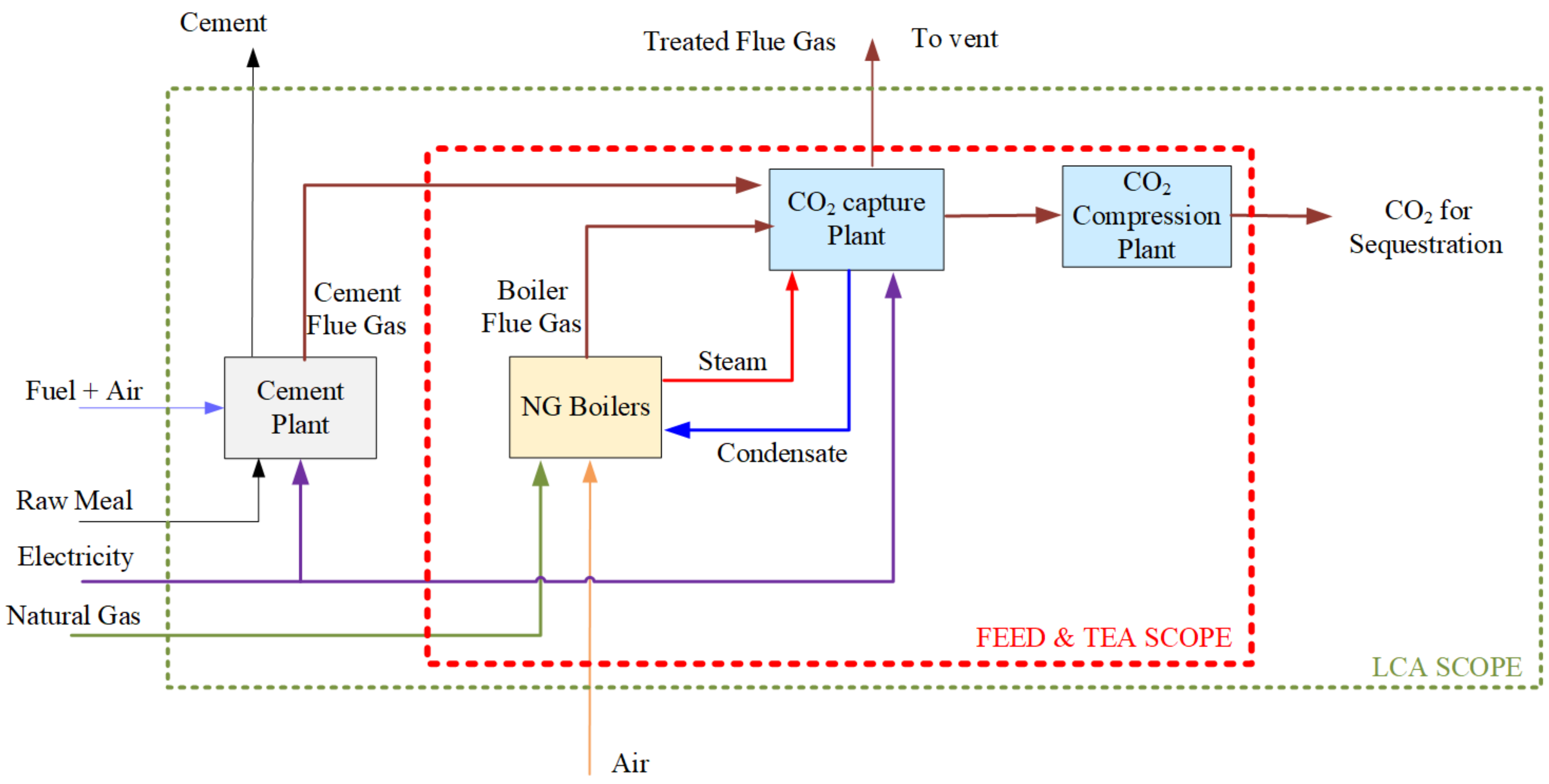
CO_2 Sequestration Options



Eagle Ford shale

Corpus Christi region

Integrated Cement Plant with CO_2 Capture



NAS Technology

NAS - formulation of hydrophobic amine, an organic diluent and water (0-10 wt.%)

Negligible heat of vaporization	▪ Lowers specific reboiler duty (SRD ~ 2.3-2.4 GJ/t-CO_2)
Low heat capacity	▪ Lowers SRD ▪ Requires intercooling of the absorber ▪ Larger lean/rich heat exchanger
Regeneration temperature < 100 °C	▪ Use of lower quality steam
Higher pressure regeneration	▪ leading to elimination of the 1^{st} stage of CO_2 compression lowering OPEX and CAPEX
Lower corrosion compared to aqueous solvents	▪ Use of lower cost materials of construction leading to lower CAPEX.
Faster CO_2 absorption kinetics	▪ Reduces column height lowering CAPEX
Commodity scale production of NAS components	▪ Ready for scale-up and commercialization

Technology Overview – NAS Technology Development Path

Lab-Scale Development & Evaluation

(2010-2013)

Solvent screening and lab-scale evaluation

0.0015 t-CO_2/day

TRL 2-3

Large Bench-Scale System (RTI facility)

(2014-2016)

Demonstration of key process features (≤ 2.3 GJ/t CO_2) at bench scale

0.11 t-CO_2/day

TRL 4

Pilot Testing at Tiller Plant Norway,

(2015-2018)

Demonstration of all process components at pilot scale

1.0 t-CO_2/day

TRL 5

Pilot Testing at SSTU, NCCC

(2018)

Degradation, emission, corrosion characterizations under real flue gas

1.1 t-CO_2/day

TRL 5

Engineering-Scale Validation, TCM, Norway

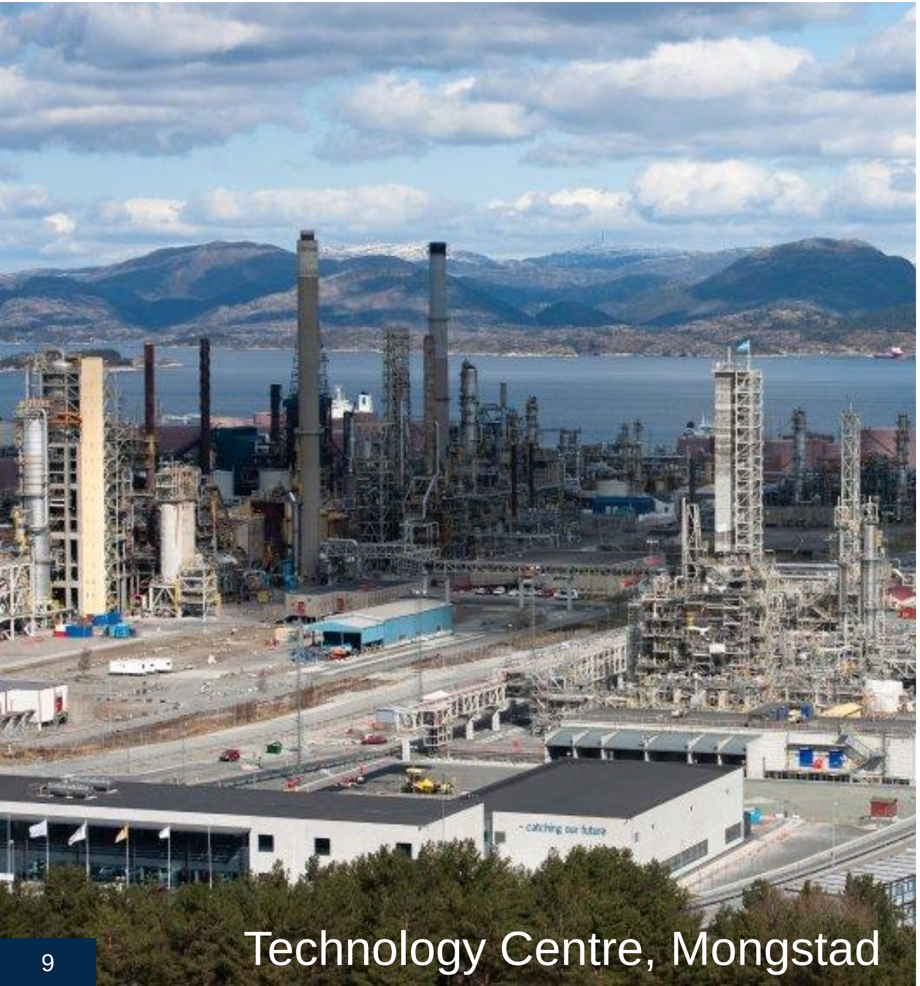
(2018-2022)

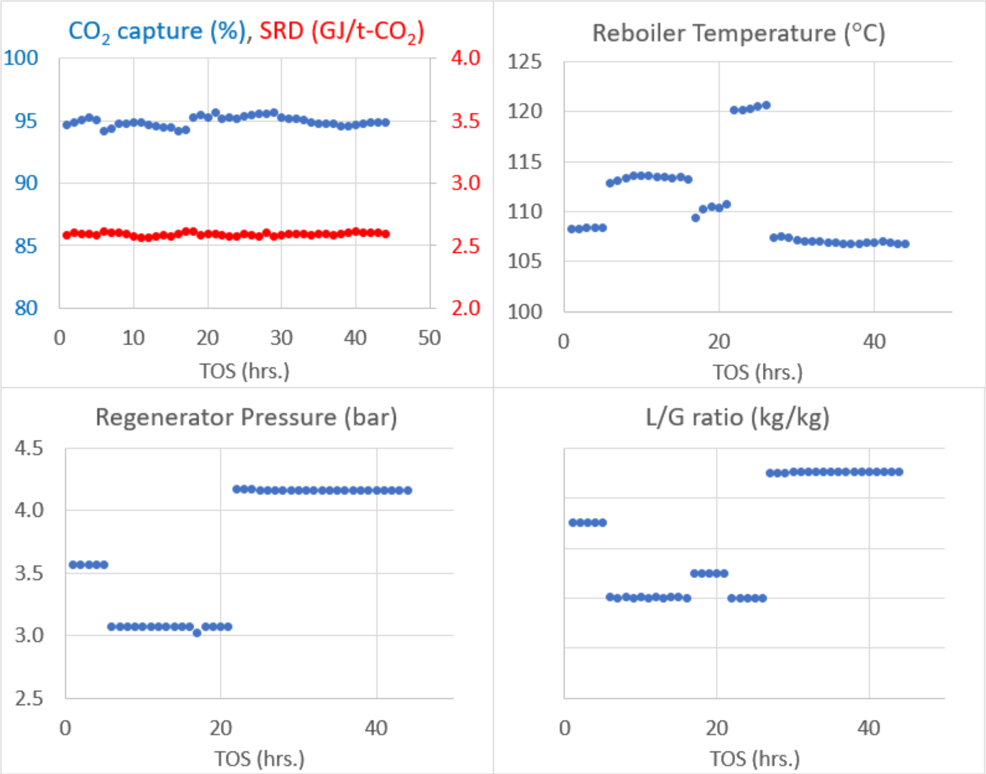
Pre-commercial demonstration at TCM, Norway (~12 MWe)

220 t-CO_2/day

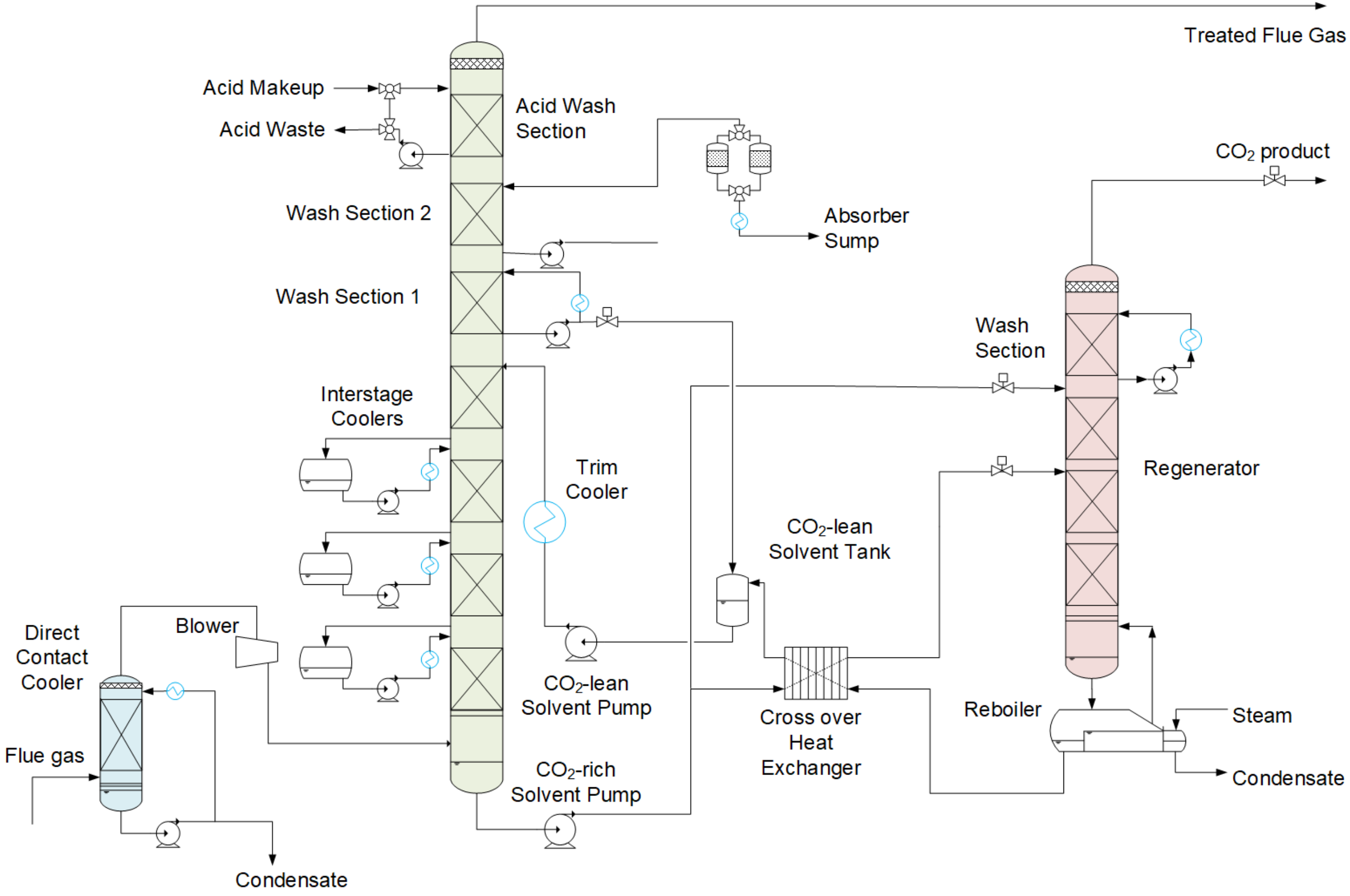
TRL 6

NAS Technology





NAS Process Flow Diagram



Project Timeline

Task	Task Description	4/14/2023	1/13/2025
1.0	Project Management	04/14/23	01/13/25
	1.1 Project Management Plan	04/14/23	01/13/25
	1.2 Technology Maturation Plan	5/1/203	01/13/25
	1.3 Workforce Readiness for Technology Development	07/01/23	01/13/25
	1.4 Environment Justice Analysis	07/01/23	01/13/25
	1.5 Economic Revitalization and Job Creation Outcomes Analysis	07/01/23	01/13/25
2.0	Project Design Basis Definition	05/01/23	07/31/23
	2.1 Host site review	05/01/23	07/31/23
	2.2 Permitting requirements review	05/01/23	07/31/23
3.0	Basic Design Package	05/01/23	08/31/23
4.0	Front-End Engineering Design Study	07/01/23	08/31/24
	4.1 Engineering Design Package	07/01/23	01/31/24
	4.2 Integration and Utilities Design	09/01/23	06/30/24
	4.3 HAZOP Review	04/01/24	05/31/24
	4.4 Schedule and Cost Estimate	05/01/24	08/30/24
	4.5 Constructability Review	01/01/24	02/29/24
5.0	Tech to Market	01/01/24	01/13/25
	5.1 Techno-Economic Analysis	01/01/24	01/13/25
	5.2 Business Case Analysis	05/01/24	01/13/25
	5.3 Life Cycle Analysis	08/01/23	01/13/25
	5.4 EH&S Risk Analysis	01/01/24	01/13/25
Total		**04/14/23**	**01/13/25**

Months after contract award

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Milestone Log	*(Table 3)*	A		B			C,D						E						G-J						
Reporting / Deliverables	*(See footnote)*				Q			Q			Q			Q			Q			Q					F
Project Meeting	*(See footnote)*	K								L									M						

Q = Quarterly report due 1 month after quarter's end; F = Final report due 3 months after project end.
K = Project kick-off meeting; B = Project briefing (annual); C = Project closeout meeting

Project Milestones

Task or Subtask	Description	Planned Completion	Actual Completion	Verification Method
1.1	Project Management Plan (PMP)	May 14, 2023	May 10, 2023	Submission of PMP
1.2	Initial Technology Maturation Plan (TMP)	Jul 14, 2023	Jul 14, 2023	Submission of initial TMP
2.0	Project Design Basis	Jul 31, 2023	Aug 29, 2023	Submission of Design Basis Definition Report
4.0	Initial Engineering Design Package	Oct 14, 2023		Submission of Initial Engineering Design Package
5.2	Initial Life Cycle Analysis (LCA)	Oct 14, 2023		Submission of initial LCA
4.5	Constructability Review	Feb 29, 2024		Summarized in Quarterly report
1.3	Initial Workforce Readiness Plan	Apr 14, 2024		Submission of Workforce Readiness Plan
4.3	HAZOP review	May 31, 2024		Summarized in Quarterly report
1.2	Final TMP	Oct 14, 2024		Submission of final TMP
1.4	Environmental Justice Analysis	Oct 14, 2024		Submission of Environmental Justice Analysis
1.5	Economic Revitalization & Job Creation Outcomes Analysis	Oct 14, 2024		Submission of Job Creation Outcome Analysis
4.0	Final Engineering Design Package	Oct 14, 2024		Submission of Final Engineering Design Package
5.1	Business Case Analysis (BCA)	Oct 14, 2024		Submission of BCA report
5.3	Final LCA	Oct 14, 2024		Submission of final LCA
5.4	Technology EH&S Analysis	Oct 14, 2024		Submission of EH&S Analysis
1.3	Updated Workforce Readiness Plan	Jan 14, 2025		Submission of Workforce Readiness Plan

Success Criteria

- A FEED study of commercial-scale NAS carbon capture process rated at 1,600,000 tonnes-CO_2/year with capture efficiency of 95%+ at CEMEX's Balcones Cement Plant will be produced with AACE Class 3 level cost estimate to estimate the cost of CO_2 capture in various matrix (e.g., \$/t-CO_2 captured, \$/t-CO_2 avoided, \$/tonnes-cement product)
- A CO_2 lifecycle analysis of the process conceived in FEED study that shows the reduced CO_2 emission per cradle-to-gate definition for a cement production plant
- A business case analysis of various commercial strategies and how the 45Q tax credit impacts the commercial viability of these strategies.

Anticipated Project Risks

Perceived Risk	Probability	Impact	Overall	Mitigation and Response Strategies
Financial Risks				
Cost share	Low	Moderate	Low	The prime recipient and subrecipients have been approved individually by their institutions to provide the required amounts.
Cost/Schedule Risks				
Cost of performing a FEED study	Low	Low	Low	KBR quote covers essentially all the engineering aspects of the FEED study. The Project Team does not expect a substantial scope addition or expansion.
Project schedule slip	Low	Low	Low	Proposed project timeline is conceived based on the task complexity, staff availability from each party, and past experience in conducting similar sized project.
Management, Planning, and Oversight Risks				
Contractual, performance, and IP	Low	Low	Low	KBR subcontract has been issued. Other subcontracts are close to execution. RTI has ownership of the background IP and no new IP is expected from FEED activities
Wastewater management	Low	Low	Low	The amount of wastewater and the handling approach will be identified during the FEED.

Anticipated Project Risks

Perceived Risk	Probability	Impact	Overall	Mitigation and Response Strategies
Technical Risks				
Limited Cooling water availability	Low	High	Low	Team will evaluate options for hybrid / dry cooling, and use of condensed water from flue gas in the direct contact cooler, after treatment.
EH&S Risks				
Emissions Control	Low	High	Low	RTI will use its advanced emissions control technology developed under another DOE project in the FEED design. This technology has been demonstrated to limit amine emissions to under 1 ppm in the treated gas.

Emissions Control Strategy

- Use of advanced emissions control technology developed in DE-FE0031660
- Operate water wash at lowest temperature possible by minimizing flue gas dew point temperature
- Higher CO_2-lean loading in solvent returned to absorber top
  - Maximizing absorber intercooling to increase rich loading
  - Increasing absorber L/G to increase lean loading
- Acid wash with amine recovery to minimize amine losses

Summary of SOPO Tasks

Task 1 - Project Management and Planning

Task 2 - Project Design Basis Definition

Task 3 - Basic Design Package (BDP)

Task 4 - Front-End Engineering Design Study

Task 5 - Tech to Market

Task 1 - Project Management and Planning

Task 1.1 – Project Management Plan

Task 1.2 – Technology Maturation Plan

Task 1.3 – Workforce Readiness for Technology Development

Task 1.4 – Environmental Justice Analysis

Task 1.5 – Economic Revitalization and Job Creation Outcomes Analysis

Task 2 - Project Design Basis Definition

- Task 2.1 - Host site review
  - Site characteristics and ambient conditions
  - Fuel feedstock and flue gas characteristics
  - Process and utilities tie-ins
  - Host site environmental requirements
- Task 2.2 - Permitting requirements review
  - Identify all permits and environmental reviews & required control technologies
  - Identify internal and corporate approvals required to initiate construction.

Task 3 – Basic Design Package

- Develop a BDP of the proposed CO_2 capture plant that will later be refined into the FEED package
  - Integration points with the cement plant
  - Process Flow Diagrams (PFD)
  - Heat and Materials Balance (HMB)
  - Sized Equipment List
  - Required Utilities
  - Identify areas for detailed evaluation
    - Cooling strategy and sourcing of makeup water for cooling towers
    - CO_2 product polishing to meet pipeline specifications

Task 4 – Front-end Engineering Design (FEED) Study

- Task 4.1 – Engineering Design Package
- Task 4.2 – Integration and Utilities Design
- Task 4.3 – HAZOP Review
- Task 4.4 – Schedule and Cost Estimation
- Task 4.5 – Constructability Review

FEED will include:

- ❖ CO_2 capture plant
- ❖ CO_2 compression
- ❖ Balance of Plant
  - all utilities
  - natural gas boiler for steam generation
  - Hybrid cooling / cooling tower
  - water treatment
  - wastewater treatment
  - evaluation of different cooling options for water management
  - CO_2 product meeting pipeline specifications

Task 5 – Tech to Market

- Task 5.1 – Technoeconomic Analysis
- Task 5.2 – Business Case Analysis
- Task 5.3 – Lifecycle Analysis
- Task 5.4 – Environmental Health & Safety Risk Analysis

Current Project Status

Task 1 - Project Management and Planning

Task 2 - Project Design Basis Definition ✓

Task 3 - Basic Design Package (BDP) ✓

Task 4 - Front-End Engineering Design Study

Task 5 - Tech to Market

Lessons Learned

- Contracting process can be time consuming and sufficient time should be allocated in the work plan.
- Importance of availability of cooling water and cooling water temperature. This has impact on both the cost and emissions control.

Plans for Future Development

In this project

- Evaluate cooling strategies to minimize water consumption
- Evaluate amine recovery from acid wash to control emissions and minimize amine losses

After this project

- Identify CO_2 sequestration sites
- Evaluate pipeline transmission and storage costs

Summary Slide

- RTI working with CEMEX, SLB and KBR to develop a FEED package for CO_2 capture from Balcones cement plant, with 1.6 MM t/year CO_2 capture at 95% capture efficiency.
- Project and Process Design Basis criteria finalized
- Evaluating different cooling strategies to address limited availability of cooling water.
- Currently working on finalizing the engineering design package.

Acknowledgement

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Project Funding

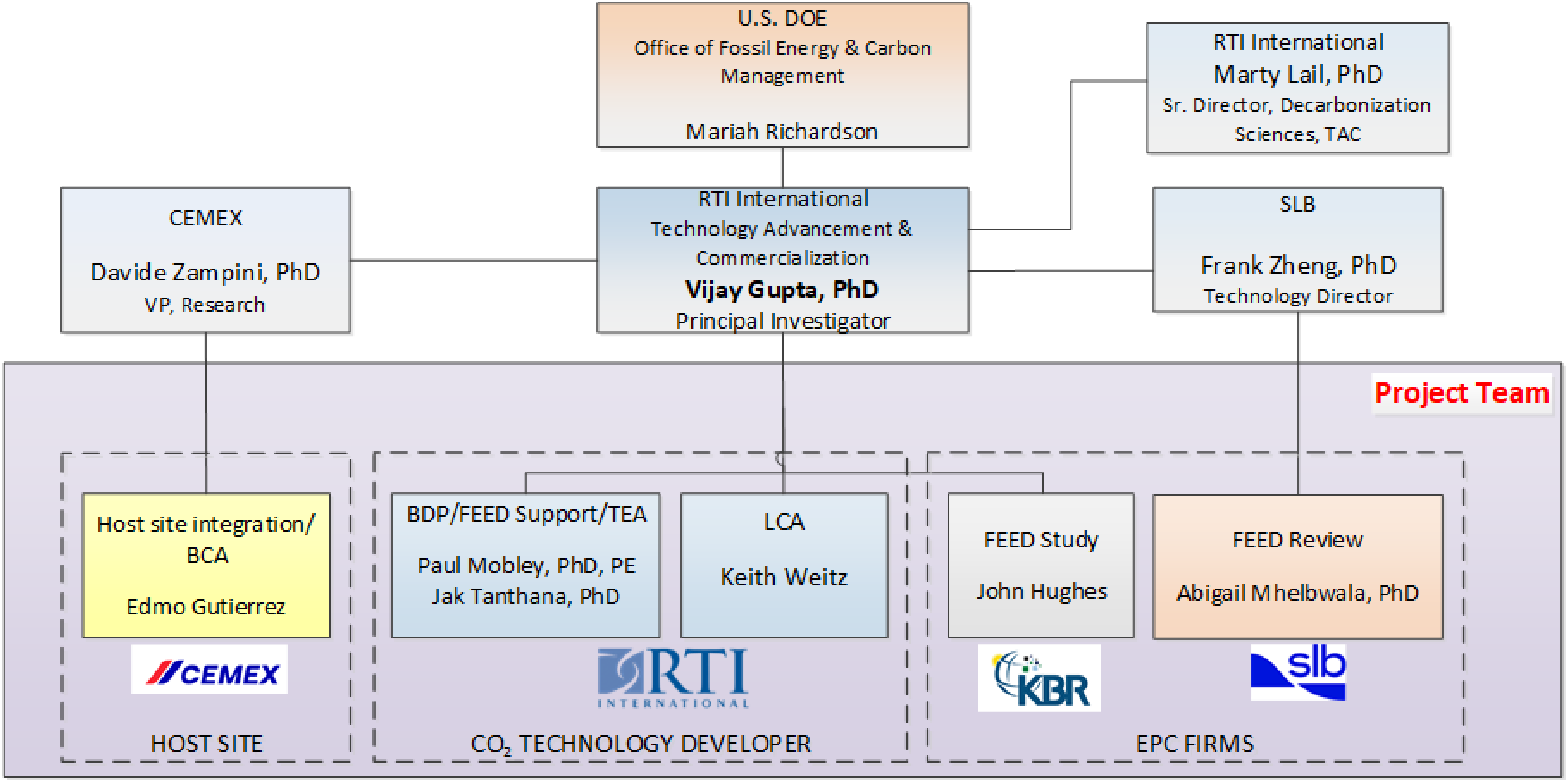
Award Number
DE-FE003220

Cost share Partners:

Appendix

- These slides will not be discussed during the presentation but are mandatory.

Project Team



GANTT Chart

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