Emissions Mitigation Technology for Advanced Water-Lean Solvent Based CO_2 Capture Processes

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Background Information

RTI International, in collaboration with SINTEF, will conduct a joint research and development effort in reducing the solvent and aerosol emissions for the transformational CO_2 capture technology based on water-lean solvents systems (WLSs). The overall objective of this project is to develop a comprehensive package for mitigating solvent emissions that is specifically suitable for CO_2 capture technology using WLS. WLS systems are an emerging class of system and are likely to be the next-generation advanced systems, replacing the aqueous amine (water-rich) systems–based CO_2 capture technology. Because of its low energy requirement for solvent regeneration and other added-benefits, the water-lean solvent system substantially reduces the cost of CO_2 capture and improves the economic viability of the CO_2 capture technology over the aqueous system. Amine emission control will be the key enabling technology for this class of solvents as it progresses toward the large-scale demonstration stage and, eventually, commercialization.

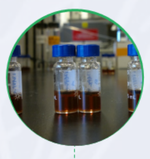
RTI's WLS development

2010 – Solvent screening
- Solvent screening to identify promising solvent formulations

2012 – Lab-scaled Performance Evaluation
- Detailed characterization on a few potential solvent candidates
- Preliminary technical and economic assessments

2014 – Bench-scaled Demonstration
- Finalize NAS formulation
- Bench-scale testing with in a process unit with major process components
- Detailed Techno-Economic & EH&S Assessments

2016 – Degradation Study
- Detailed solvent degradation and preliminary emissions studies

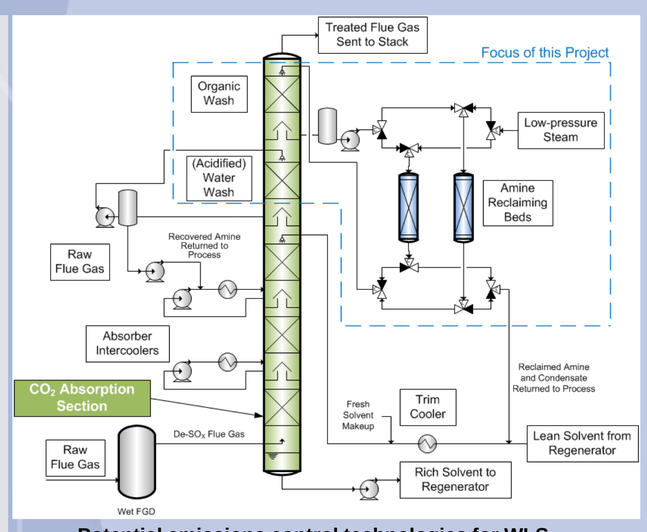


2017 – Long-term Operation
- Large bench / small pilot testing
- Demonstrate all process components for NAS process in adiabatic system

2019 – Pilot Plant Demonstration
- Complete process unit with all components size required for confident scale-up
- Emission study and control

Objective and Goals

The specific goals of this project are to:
- Characterize and understand the emission produced by water-lean solvent while capturing CO_2
- Develop a empirically derived emission model based on the solvent physical properties and on critical operating parameters from the absorber and wash section
- Evaluate suitable process arrangement for emission reduction devices
- Demonstrate the effectiveness of these emission mitigation devices on the bench-scale CO_2 capture system optimized for water-lean solvent.



Potential emissions control technologies for WLS systems to be incorporated at the CO_2 capture plant

Technical Approach

To achieve these goals and objective, we will carry out the following tasks in BP1:
(1) Determine RTI's Non-Aqueous Solvent (NAS) and a selected WLS emissions characteristics from the absorber column
(2) Develop an empirical emission model based on critical operating parameters.
(3) Screen organic solvents and amine adsorbents,
(4) Determine, implement, and evaluate the effectiveness of the ECTs at BsGAS and Tiller

In BP2, our team will:
(1) Carry out the modifications based on RTI's findings and evaluate the amine emissions using NAS-5 and a selected WLS at SINTEF's Tiller plant
(2) Refine the empirical emission model and determining the impact of the ECTs to the CO_2 capture cost

Specific Challenges
- Aerosol particle generation
- Development of aerosols and particle counts technique for WLSs
- Quantification and speciation of the emissions from WLSs
- Emission model development
- Solvent screening for organic wash section
- Process arrangement for amine extraction
- Parametric and long-term testing
- Techno-economic analysis

Potential for Impact

- Results from our ongoing NETL project have shown that a conventional absorber with a built-in water wash section does not adequately reduce the amine emissions from WLS systems. This is mainly due to the limited solubility and high degree of hydrophobicity of WLSs which hinder the effectiveness of the water wash.
- This project is highly relevant to the DOE's interest in reducing solvent aerosol emission and serves as an enabling technology for the ongoing development of these transformational water-lean CO_2 capture solvents.
- This development will make a significant contribution to the field by providing a model that predicts the amine emission using the solvent properties, key process parameters, and the recommended emission mitigation devices required for solvents specific to the developers.
- On the basic research level, the proposed project will validate the aerosol formation in a non-polar environment, identify emission pathways, and determine the particle size distribution of the water-lean aerosols generated under a realistic operation condition.
- In addition, the analytical methods developed in this project will enable a real-time emission sampling method, offline amine quantification, and emission monitoring technique that are optimized for a water-lean system.

Project Timeline

Task	Task title	Start date	End date	Months following contract award (Budget Period 1 (BP1): 3 6 9 12 15 18; Budget Period 2 (BP2): 21 24 27 30 33 36)
1.0	Project Management	10/01/18	09/30/21	
2.0	Evaluation of Amine Emission for Water-Lean System Without Emission Control	10/01/18	03/30/20	
2.1	Develop a Method to Monitor, Differentiate, and Quantify Emissions at BsGAS	10/01/18	01/31/19	
2.2	Particulate Generator Modification at BsGAS	10/01/18	01/31/19	
2.3	Establish Baseline Amine Emission for Water-Lean System Without Emission Controls	02/01/19	08/31/19	
2.4	Development of Empirical Process Model for Amine Emission from Water-Lean Based Solvent Systems	09/01/19	03/31/20	
3.0	Prototype Emissions Control System for Water-Lean Solvent	10/01/18	03/31/20	
3.1	Organic Solvent and Amine Extraction Sorbent Evaluation	10/01/18	08/31/19	
3.1.1	Wash Organic Solvent Characterization	10/01/18	08/31/19	
3.1.2	Amine Reclaiming Evaluation	10/01/18	08/31/19	
3.2	Define Emission Control Approach	06/01/19	06/30/19	
3.3	Preliminary Design for Emission Mitigation Process	07/01/19	08/15/19	
3.4	Detailed Design and Construction	08/15/19	12/31/19	
3.5	Performance Evaluation at BsGAS	01/01/20	03/31/20	
3.6	Evaluation of pH Control Concept Using CO_2 Acidification Method at Tiller	10/01/18	03/31/19	
3.7	Development of Empirical Process Model for Amine Emission from First-Stage Water Wash Using the CO_2 Acidification Concept	04/01/19	08/31/19	
4.0	Implementation at a Large Bench-Scale Unit (SINTEF)	04/01/20	06/30/21	
4.1	Update Tiller's Emissions Control Design	04/01/20	05/31/20	
4.2	Construction and Commissioning	06/01/20	09/30/20	
4.3	Performance Evaluation of Emissions Control System	10/01/20	06/30/21	
5.0	Process Simulation and Techno-Economic Assessment	04/01/20	09/30/21	
5.1	Update Empirical Emission Model	04/01/20	09/30/21	
5.2	Refine Techno-economic Evaluation	04/01/20	09/30/21	

Technology Roadmap

DOE ARPA-E Project	DOE NETL Project	DOE NETL Project (Current)	Future Development	Commercial
2010 – 2013	2014 – 2016	2015 – 2018	2018 – 2020	2020+
1 – 3 TRLs	4 TRL	5 – 6 TRLs	7 – 8 TRLs	9 TRL

Lab-Scale Development / Evaluation

Funding: ~$2,700,000
- Solvent screening to identify promising solvent formulations
- Lab-scale evaluation of NAS Process
- Preliminary technical and economic assessments

Large Bench-scale System / Relevant Environment Testing

Funding: ~$3,000,000
- Finalize NAS formulation
  - *Address evaporative losses and solvent costs*
- Develop critical process components
  - *NAS wash / recovery section*
  - *NAS regenerator*
- Bench-scale testing within a process unit with major process components
- Demonstrate ≤ 2,000 kJt/kg CO_2 using bench-scale system
- Detailed solvent degradation and preliminary emissions studies
- Detailed techno-economic and EH&S assessments
  - *Demonstrate T&EA competitiveness and environmental permitability*

Combined SINTEF (Tiller)

Funding: ~2,700,000
- Tiller Plant (~60 kWe)
  - *Demonstrate all process components for NAS process in adiabatic system*
  - *Accurately quantify solvent losses and emissions*
  - *Test campaign on coal derived flue gas*
  - *Determine materials (metals, polymers, gaskets) compatibility*
  - *Collect critical process data to support scale up, develop engineering package for TCM*

TCM Pathway Large Scale Demonstration
- TCM (~10 MWe)
  - *Complete process unit with all components at minimum size required for confident scale-up*
  - *Collect critical process information to support detailed T&E assessments, emissions monitoring, long-term testing to develop reliability, availability and maintainability (RAM) metrics*

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More Information

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