ION Novel Solvent System for CO\textsubscript{2} Capture
DE-FE0013303

Alfred “Buz” Brown, PhD
ION Engineering

2015 NETL CO\textsubscript{2} Capture Technology Meeting
PROJECT OVERVIEW
Original Project: DE-FE0013303
ION Solvent System for CO₂ Capture

• Design, Build and Operate 0.5 MW Pilot at NPPD Gerald Gentleman Station in North Platte, Nebraska
• $20.2M Total Project Funding
  – $15.0M DOE
  – $5.2M ION and Partners

Original Project Partners:
Project Objectives

Overall Objective

Using ION’s proprietary advanced solvent demonstrate progress towards DOE’s targets:

• 90% capture
• 95% purity
• \( \leq \$40/\text{tonne} \)
Project Scope Change

- Host Site Selection
  - Nebraska Public Power District
  - National Carbon Capture Center
- Pilot Bay 2 – ION Slipstream Unit (ISTU)
- Existing NCCC Pilot Slipstream Test Unit (PSTU)

ION Testing at PSTU June-Sept 2015
Scope Changes: Key Tasks

**Original Project Scope**

**BP 1**
Oct 2013-Dec 2014
- Pilot Design
- Engineering
- Layout & Integration
- Costing

**BP 2**
Jan 2015-Mar 2016
- Procurement
- Construction & Fabrication
- Installation
- Commissioning

**BP 3**
Apr 2016-Jun 2017
- Pilot Operation
- Benchmarking
- ION Solvent Demonstration
- Data Analysis

**Revised Scope: PSTU**

**BP 1**
Oct 2013-Dec 2014
- Pilot Design
- Engineering
- Layout & Integration
- Costing

**BP 2**
Jan 2015-Mar 2016
- Solvent Procurement
- PSTU Modifications
- Pilot Operation
- Data Analysis
- Solvent Lifetime Testing
Current Project Participants & Roles

- **Funding**
  - NETL
  - The University of Alabama
- **Technology**
  - SINTEF
  - Southern Company
  - National Carbon Capture Center
- **Economic Analysis**
  - Host Site
  - Economic Analysis
- **Process Simulation, Design, Performance Analysis**
  - Utility Partner
  - Solvent Lifetime Studies
- **TRIMERIC Corporation**
  - Nebraska Public Power District
    - Always there when you need us
- **Optimized Gas Treating inc.**
  - ProTreat
    - The industry's most powerful gas treating simulation tool.
ION has developed a patented solvent technology that produces a more efficient & lower cost way to capture CO$_2$ than traditional methodologies.

- **Innovation**
  - Natural Gas Treating Existing Market
  - Aqueous Amine (MEA)
  - 1st Generation Post-Combustion Technology
  - Aqueous Amine (MEA)
  - Lateral Transfer of Existing Technology
  - 2nd Generation Advanced Solvents
    - Advanced Amines
  - More Ways To Improve Performance and Lower Cost
  - Limited Ways To Improve Performance and Lower Cost
  - Advanced Solvent
The ION Advantage

ION’s proprietary technology has shown the following improvements

**Solvent Performance**
- Increased CO₂ Solubility
- Increased Solvent Kinetics
- Increased Solvent Working Capacity
- Decreased Regeneration Energy

**Overall Impact**
- Lower CAPEX
- Lower OPEX
- Lower Parasitic Load on the power plant
BUDGET PERIOD 1 – RESULTS
## Budget Period 1 – Results

<table>
<thead>
<tr>
<th>Task #</th>
<th>Task Description</th>
<th>Key Objectives</th>
<th>Accomplishments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Project Management</td>
<td>• Coordinate and plan project activities</td>
<td>• PMP and related tasks were updated throughout project</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Maintain Budget, Schedule, Task Reviews, and Costs</td>
<td>• Weekly progress meetings held for Slipstream activities</td>
</tr>
<tr>
<td>2</td>
<td>Initial Slipstream Project Reviews</td>
<td>• Technology EH&amp;S Risk Assessment</td>
<td>• Initial EH&amp;S Assessment completed by Hellman &amp; Associates</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Initial Techno-Economic Analysis</td>
<td>• Initial TEA completed and accepted by DOE</td>
</tr>
<tr>
<td>3</td>
<td>Site Selection &amp; Permitting</td>
<td>• Finalize host site selection</td>
<td>• Host site selection process had two key decision points</td>
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<td></td>
<td></td>
<td>• Obtain necessary permits of pilot construction &amp; operation</td>
<td>• Final host site determined to be PSTU at NCCC</td>
</tr>
<tr>
<td>4</td>
<td>Final Pilot System Design</td>
<td>• Final Pilot System Design</td>
<td>• Final Design Package for ION Built Slipstream Unit at NCCC completed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Cost to Build System</td>
<td>• Final Design Package for PSTU modifications at NCCC completed</td>
</tr>
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</table>
INITIAL TECHNO-ECONOMIC ANALYSIS
Initial Techno-Economic Analysis Basis

- Perform bottoms up simulation of ION solvent for economic analysis
- Modeling Platform – ProTreat®, Optimized Gas Treating
  - ION specific software package developed by OGT in collaboration with ION
  - ProTreat® software provides true rate based simulation package for chemically and physically reactive systems.
- Design Basis
  - 550 MWe net output
  - 90% CO₂ Capture
  - Per DOE Case 11/12 & QGESS Guidelines, July 2014
The ION Advantage

ION’s proprietary technology has shown the following improvements:

- 47% Decrease in Capital Cost
- 28% Decrease in Regeneration Energy
- 27% Decrease in CO₂ Capture Cost
BUDGET PERIOD 2 - PROGRESS
<table>
<thead>
<tr>
<th>Task #</th>
<th>Task Description</th>
<th>Key Objectives</th>
<th>Progress</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Project Management</td>
<td>• Coordinate and plan project activities&lt;br&gt;• Maintain Budget, Schedule, Task&lt;br&gt;Reviews, and Costs&lt;br&gt;• On-Boarding of Personnel</td>
<td>• Regular meetings with project team, NCCC, and DOE&lt;br&gt;• ION Personnel needed for PSTU Testing have been on-boarded</td>
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<tr>
<td>5</td>
<td>Host Site Preparation</td>
<td>• Modifications necessary to PSTU&lt;br&gt;• ION Solvent Delivery&lt;br&gt;• Installation of mobile lab</td>
<td>• Complete June 2015</td>
</tr>
<tr>
<td>6</td>
<td>Operational Preparation &amp; Shakedown</td>
<td>• Develop Procedures for Operations&lt;br&gt;• Develop Test Plans&lt;br&gt;• Pilot System Commissioning &amp; Shakedown Testing</td>
<td>• Complete June 2015</td>
</tr>
<tr>
<td>7</td>
<td>ION Solvent Testing</td>
<td>• Solvent Testing on PSTU at NCCC</td>
<td>• PSTU Testing Start June 22, 2015</td>
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<tr>
<td>8</td>
<td>Data Acquisition, Storage &amp; Analysis</td>
<td>• Installation of Data Acquisition Systems&lt;br&gt;• Data Acquisition &amp; Analysis&lt;br&gt;• Solvent lifetime testing with SINTEF</td>
<td>• Data analysis of PSTU data on-going throughout testing&lt;br&gt;• SINTEF project to begin Q3</td>
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<tr>
<td>9</td>
<td>Decommissioning</td>
<td>• Removal of ION related equipment</td>
<td>• N/A</td>
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<td>10</td>
<td>Final Systems Analysis</td>
<td>• Final Techno-Economic Analysis&lt;br&gt;• Final EH&amp;S Risk Assessment</td>
<td>• N/A</td>
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# Milestones for Budget Period 2

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<tr>
<th>#</th>
<th>Milestone</th>
<th>Target Completion Date</th>
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<tr>
<td>1</td>
<td>PSTU Modifications Complete</td>
<td>5/15/2015</td>
<td>6/15/2015</td>
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<td>3</td>
<td>Pre-Startup Safety Review</td>
<td>5/29/2015</td>
<td>6/16/2015</td>
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<td>4</td>
<td>Pilot System Shakedown Complete</td>
<td>6/12/2015</td>
<td>6/20/2015</td>
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<tr>
<td>5</td>
<td>ION Solvent Testing Complete</td>
<td>9/30/2015</td>
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<td>6</td>
<td>Final TEA and EH&amp;S Risk Assessment</td>
<td>2/26/2016</td>
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<tr>
<td>7</td>
<td>Solvent Performance &amp; Stability Assessment</td>
<td>2/26/2016</td>
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<tr>
<td>8</td>
<td>Decommission &amp; Dismantle</td>
<td>11/27/2015</td>
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## ION Engineering CO2 Capture Slipstream Project Schedule

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Budget Period 1</th>
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<td>Q3</td>
<td>Q4</td>
<td>Q5</td>
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<td>Final Pilot &amp; Systems Design Package</td>
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<td>Final Systems Analysis</td>
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## DOE Slipstream BP2 Cost Summary

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</thead>
<tbody>
<tr>
<td><strong>DOE Funding</strong></td>
<td>$3,548,773</td>
<td>$5,167,440</td>
<td>$8,716,213</td>
<td>$15,000,000</td>
<td>($6,283,787)</td>
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<tr>
<td><strong>Cost Share</strong></td>
<td>$1,336,755</td>
<td>$845,560</td>
<td>$2,182,315</td>
<td>$5,194,044</td>
<td>($3,011,729)</td>
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<tr>
<td><strong>Total Project</strong></td>
<td>$4,885,528</td>
<td>$6,013,000</td>
<td>$10,898,528</td>
<td>$20,194,044</td>
<td>($9,295,516)</td>
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</tbody>
</table>

**DOE Funding**
- **Budget Period 1**: $3,548,773
- **Budget Period 2**: $5,167,440
- **New Scope Budget Total**: $8,716,213
- **Original Project Budget Total**: $15,000,000
- **Difference**: ($6,283,787)

**Cost Share**
- **Budget Period 1**: $1,336,755
- **Budget Period 2**: $845,560
- **New Scope Budget Total**: $2,182,315
- **Original Project Budget Total**: $5,194,044
- **Difference**: ($3,011,729)

**Total Project**
- **Budget Period 1**: $4,885,528
- **Budget Period 2**: $6,013,000
- **New Scope Budget Total**: $10,898,528
- **Original Project Budget Total**: $20,194,044
- **Difference**: ($9,295,516)
NCCC PSTU TESTING UPDATE
PSTU Testing Preparation

- ION Solvent Delivered
- PSTU Modifications Complete
  - Mobile Lab Installation
  - Process Modifications
- Analytical Lab Technicians Onboarded and Trained
- Data Acquisition Systems Implemented and Tested
- Testing Begins: 6/22/15
  - Parametric Testing
  - 1,000 hour Steady-State
ION Solvent Testing

• Parametric Testing Parameters
  – Solvent Flow Rate
  – Heat Rate
  – Flue Gas Flow Rate

• 1,000 hr Steady State Test
  – Optimized Conditions Based on Parametric Testing
NCCC PSTU Test Plan

Parametric Tests (24 hour Holds, 3 Groups, 3 Parameters, 4-5 Set points)

A. Thermosiphon Flow Testing & Warm-Up
   Confirm Mass and Energy Balances

B. Parametric Group 1 - LG @ 3.0
   Adjust Reboiler Steam to Achieve % Capture
   1. Parameter 0 - Target CO2 Capture 80%
   Data Analysis and Set Point Verification
   2. Parameter 1 - Target CO2 Capture 80%
   3. Parameter 2 - Target CO2 Capture 90%
   4. Parameter 3 - Target CO2 Capture 93%
   System Idle and Analysis

C. Parametric Group 2 - LG @ 2.5
   1. Parameter 1 - Target CO2 Capture 80%
   2. Parameter 2 - Target CO2 Capture 90%
   3. Parameter 3 - Target CO2 Capture 93%
   System Idle and Analysis

D. Parametric Group 3 - LG @ 4.0
   1. Parameter 1 - Target CO2 Capture 80%
   2. Parameter 2 - Target CO2 Capture 90%
   3. Parameter 3 - Target CO2 Capture 93%
   System Idle and Analysis

E. Stability Study
   1. Stability Study – Target 1,000 hours
   System Idle and Analysis
NEXT STEPS
## Preliminary TCM Test Objectives & Timeline

### Project Objectives:

1. Demonstrate ION’s Advanced Solvent Technology Exceeds DOE’s Performance Goals for 2nd Generation CO$_2$ Capture Technologies: 90% Capture and < $40/tonne CO$_2$

2. Demonstrate Readiness for Large Scale Demonstration by end of 2017

### TCM 13 MW Pilot

<table>
<thead>
<tr>
<th>Activities</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Q3</td>
<td>Q4</td>
</tr>
<tr>
<td>1.) Resolution of Risks Identified by TCM: Test results from PSTU, and ION/SINTEF Collaboration, 2.) Contract Negotiations, and 3.) Final Approvals from DOE and TCM</td>
<td>Permitting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Solvent Procurement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Test Plan Development, Etc.</td>
<td></td>
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<tr>
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<td>Test Period 1</td>
<td></td>
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<tr>
<td></td>
<td>TCM Planned Outage</td>
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</tr>
<tr>
<td></td>
<td>Test Period 2</td>
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</tbody>
</table>
From the Technical Staff at ION:

Nate Brown
Grayson Heller
Tyler Silverman
Greg Staab
Rene Kupfer
Reid Brown
Chuck Panaccione
Dan Swanson
Jenn Atcheson
Dillon Manzanares
Trent Hollis
Troi Bateman
Taikisha Enwright
Eric Negrey

Jason Bara (Univ. Alabama)

Thanks to Our Partners:

Nebraska Public Power District
Always there when you need us

Optimized Gas Treatment, Inc.

ProTreat
The industry's most powerful gas treating simulation tool.

Sulzer

TRIMERIC Corporation

SINTEF

The University of Alabama

Department of Energy
United States of America
QUESTIONS