“Engineering-Scale Demonstration of Transformational Solvent on NGCC Flue Gas” (Project Enterprise)

DE-FE0031950
August 13, 2021

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Principal Investigator: Andrew Awtry, Ph.D.
Project Manager: Jennifer Atcheson
Outline

• Project Overview
• Introduction to Technology
  – Results from NCCC Pilot
• Project Scope and Schedule
• Progress & Current Status
  – Design Basis
  – Balance of Plant Design
  – Module and GA Drawings
• Summary & Development Path
DE-FE0031950: Project Enterprise

- **Overall Project Objective:**
  - To field test an engineering scale 10 tonnes per day (tpd) CO₂ capture system on a 1 megawatt-electric (MWe) slipstream flue gas from a commercially dispatched natural gas combined cycle (NGCC) power plant to empirically validate the low capital and operating costs for ICE-31

- **Budget:**
  - DOE-NETL: $13,000,000
  - ION and partners: $3,906,839

- **Period of Performance:**
  - October 1, 2020 to October 31, 2023
Project Enterprise Team

U.S. Department of Energy
National Energy Technology Laboratory

ION Clean Energy
(Lead Institution)

- Project Management and Communication with all relevant stakeholders on status and results
- Supervise design and construction of CO₂ Capture and Balance of Plant Systems
- Develop and execution of test plan for 1-MWe demonstration; Analysis of data during demonstration
- Complete DOE Deliverables: TEA, EH&S Risk Assessment, Technology Maturation Plan

Koch Modular Process Systems
Subcontractor
- Process design & costing for CO₂ capture pilot
- Fabrication of modular CO₂ capture pilot system

Calpine Corporation
Host Site
- Host site of 1-MWe test facility
- Facilitate permits for pilot
- Operations support during test campaign

Sargent & Lundy (S&L)
Subcontractor
- Design of all required balance of plant systems
- Installation of BOP and modular systems
- Decommissioning of the pilot system
- Techno-economic Analysis

Hellman & Associates
Subcontractor
- EH&S Support for test campaign
- EH&S Risk Assessment
ICE-31 SOLVENT TECHNOLOGY
ICE-31

Basis of Performance (compared to ICE-21)

- Lower energy consumption
- Similar fast kinetics
- Higher working capacity
- Low heat capacity
- Low corrosion
- Revolutionary stability
ION’s CO₂ Capture Technology Development – ICE-31

Development Path

- **2016**
  - Lab Development
    - Simulated Flue Gas

- **2017 - 2018**
  - Bench-scale Pilot
    - Coal

- **2020 - 2021**
  - National Carbon Capture Center
    - 0.5 MWe
      - Coal & Natural Gas

- **2020 - 2023**
  - Project Enterprise Engineering Scale
    - 10 tpd (~1 MWe)
      - Natural Gas

- **2022 →**
  - Commercial Scale

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First 60 Days of Operation

70 Different Parametric Settings

- Flue Gas: 4.4-7.9% CO₂ Baseline: 4.4%
- Flue Gas Inlet T: 30-40 °C Baseline: 35 °C
- Capture: 80-98% Baseline: 95%
- Absorber: 12-18 m MP252Y Baseline: 18 m
- Stripper: Simple and CRB Baseline: Simple
- CO₂ Pressure: 1.75-1.9 bara Baseline: 1.9 bara

Switch To and Recalibrate Low Steam Flowmeter
Account for Heat Loss

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Stable SRD and Operations

Specific Reboiler Duty (Arbitrary Units)

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NCCC Apollo Campaign

溶剂浓度

（归一化）

No Solvent Additions
Constant System Inventory (± 2%)
PROJECT SCOPE AND SCHEDULE
Project Scope and Key Milestones

- Design, permit, and cost permit the pilot plant
- Finalize engineering, fabricate modules, and develop controls
- Install modules, connect Balance of Plant, finish commissioning
- Field-test ICE-21 and ICE-31 with NGCC flue gas
- Final data evaluation and extensive reporting

<table>
<thead>
<tr>
<th>#</th>
<th>Milestone Title / Description</th>
<th>Planned Completion Date</th>
<th>Actual Completion Date</th>
</tr>
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<tbody>
<tr>
<td>M2</td>
<td>Kickoff Meeting</td>
<td>12/04/2020</td>
<td>12/09/2020</td>
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<tr>
<td>M4</td>
<td>HAZOP Completed</td>
<td>3/10/2021</td>
<td>05/27/2021</td>
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<tr>
<td>M6</td>
<td>Modular Pilot System Cost</td>
<td>3/24/2021</td>
<td>06/18/21</td>
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<tr>
<td>M8</td>
<td>Balance of Plant Cost</td>
<td>5/18/2021</td>
<td>06/18/21</td>
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<tr>
<td>M12</td>
<td>Modular System Factory Acceptant Testing</td>
<td>2/28/2022</td>
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<tr>
<td>M14</td>
<td>Complete Pilot System Site Acceptance Testing</td>
<td>5/24/2022</td>
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<tr>
<td>M16</td>
<td>Baseline MEA and ICE21 Testing</td>
<td>09/21/2022</td>
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<tr>
<td>M17</td>
<td>ICE31 Testing</td>
<td>10/05/2023</td>
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<tr>
<td>M19</td>
<td>DOE Close-Out Meeting</td>
<td>12/31/2023</td>
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# Success Criteria

<table>
<thead>
<tr>
<th>Decision Point</th>
<th>Success Criteria</th>
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<tbody>
<tr>
<td><strong>Conclusion of BP1</strong></td>
<td>• Completion of initial TEA and EH&amp;S Risk Assessments</td>
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<td></td>
<td>• Completion of design package for modular pilot system</td>
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<td>• Fixed price quotation for modular pilot system</td>
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<td></td>
<td>• Completion of design of BOP scope to commence construction period</td>
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<td>• Approval from the host site to commence construction period</td>
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<tr>
<td><strong>Conclusion of BP2</strong></td>
<td>• Fabrication, delivery, installation and commissioning of modular pilot system</td>
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<tr>
<td></td>
<td>and all balance of plant tie-ins</td>
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<td></td>
<td>• Test plan finalized</td>
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<td></td>
<td>• Solvents required for test campaign delivered to host site</td>
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<tr>
<td><strong>Project Completion</strong></td>
<td>• Completion of engineering-scale demonstration of baselines and ICE-31</td>
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<tr>
<td></td>
<td>• Issuance of updated TEA and EH&amp;S Risk Assessments</td>
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</table>
CURRENT PROGRESS
Modular Design
Modular Design
SUMMARY AND DEVELOPMENT PATH
Current Project Findings & Next Steps

• Completed Engineering Phase of BP1
  – Final design is very similar to initial conceptual design
• HAZOP completed in coordination with host site
• Modular system design is prior Koch Modular built units
• No “showstoppers” in permitting
  – California permitting is among most stringent in the US
  – ION’s solvent and process mitigate hazardous emissions
• Continuation application submitted

*Example of Typical Koch Modular Install
Project Enterprise Next Steps

Budget Period 1
4Q2020 – 2Q2021
- Host Site Agreement
- Modular System Design
- BOP Design
- Cost Estimates for Construction
- Permitting

Budget Period 2
Starts 3Q2021
- Modular System Fabrication
- Site Preparation
- Installation
- Commissioning

Budget Period 3
2022 – 2024
- Baseline Testing MEA & ICE-21
- ICE-31 Testing
  - Parametric
  - Long-term Testing
- Final Reporting

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THANKS

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Project Schedule

Figure 1: Project Schedule (Revised July 2021)