#### "Validation of Transformational CO<sub>2</sub> Capture Solvent Technology with Revolutionary Stability" (Apollo) – Relevant learnings of previous campaigns

DE-FE0031727 – 2020 NETL Carbon Utilization Virtual Project Review Meeting

Principal Investigator: Technical Lead: Project Manager: Erik Meuleman, Ph.D. – CTO Nathan Fine, Ph.D. Tyler Silverman

October 21-22, 2020

# **DE-FE0031727: Apollo Project**



- Overall Project Objective:
  - Scaling up a novel amine-based solvent technology with revolutionary stability and excellent CO<sub>2</sub> capture performance from a small-scale (~0.03 MWe) to a ~0.5 MWe scale using real flue gas
- Budget:
  - DOE-NETL: \$2,999,998
  - ION and partners: \$750,000
- Period of Performance:
  - June 1<sup>st</sup>, 2019 to May 31<sup>st</sup>, 2021



Pilot Slipstream Test Unit (0.5 MWe) National Carbon Capture Center (NCCC) Wilsonville, AL (Courtesy of NCCC)

#### ION's CO<sub>2</sub> Capture Technology Development / ICE-21 Accelerated development path leveraging existing research facilities





Grand Forks, ND, USA

Boulder, CO, USA

Sutherland, NE, USA

Wilsonville, AL, USA

#### Learnings from ION's Prior Test Campaigns / ICE-21 NCCC 2015 and TCM 2016-2017



- NCCC (Coal)
  - Very successful campaign
  - Good ProTreat<sup>®</sup> validation
  - Good emission data
  - Excellent corrosion data





- TCM (NGCC and RFCC (surrogate coal))
  - Very successful campaign
  - 500,000,000 data points
  - Excellent ProTreat® validation
  - Oxidative degradation benchmarked
  - SO<sub>x</sub> and NO<sub>x</sub> uptake benchmarked
  - Excellent emission data
  - MLA operated in industrial environment
  - Confirmation of corrosion data

#### Learnings from NCCC campaign in 2015 / ICE-21 Out of the ordinary learnings



- Near 100% capture throughout 6 weeks campaign
- Carrying capacity depends on many process operation conditions and evolve as solvent evolves
- Double intercooler configuration not effective for ICE-21 solvent
- Sump tank volume creates process lags
- Return of overhead water wash facilitates water and solvent balance



#### Learnings from TCM campaign in 2016-2017 / ICE-21 Out of the ordinary learnings



- Hockey stick plot developed (60-100% capture rate skew)
  - Optimal performance at 80-90% capture but, showed a minimal energy penalty to achieve up to 99% capture
- Different oxidation rate for RFCC (~ coal) gas and NGCC gas
- Different NO<sub>x</sub> and SO<sub>x</sub> uptake for RFCC and NGCC flue gases
- Experiential benefit from Oil & Gas refinery trained operators/engineers (Equinor, Shell, Total)

- Water balance could be achieved quickly in steady state
- MLA was powerful tool to accelerate campaign and achieve more setpoints



### **ICE-31**



- Low energy consumption (lower than ICE-21)
- Fast kinetics (similar to ICE-21)
- Working capacity (higher than ICE-21)
- Low heat capacity (similar to ICE-21)
- Low corrosion (similar to ICE-21)
- Revolutionary stability (better than ICE-21)



# **Technical Objectives in PSTU at NCCC with ICE-31**

- ION CLEAN ENERGY
- Parametric testing to determine operating window and validate ProTreat<sup>®</sup> model
- Demonstrate revolutionary stability of ICE-31
- Dynamic operations to determine maximum ramp-rates, minimize energy consumption and minimize emissions
- Upsets to determine process and solvent stability:
  - Increased O<sub>2</sub> concentration
  - Increased stripper temperature
  - Unplanned FGD outage (high SO<sub>x</sub> events)
  - Unplanned DCC outage (high T events)



# Lab-based Results: CO<sub>2</sub> Capture Test-rig (Ø=8") Operation



#### Lab-based Results: Oxidative stability much better MEA Bulk at 80°C; 10% CO<sub>2</sub> / 19% O<sub>2</sub>; Analyses: GC, GC-MS, TIC, KF



CLEAN ENERG

# **Other Project Progress / Results**



- β-version of ProTreat<sup>®</sup> developed based on lab-data for ICE-31
- Solvent has been procured
- MLA library developed
- Test plan developed and agreed between ION and NCCC addressing all objectives
- Cold-rich bypass modification currently being installed at PSTU



# **COVID-19 Related Project Delays**



- PSTU Testing was slated to begin in Q2 2020; COVID related delays impacted site access and travel for NCCC
- ION and NCCC are in constant communication to determine revised schedule for PSTU modifications and test campaign – Current campaign start date: 1/4/2021

### Alabama Covid Map and Case Count





Day with data reporting anomaly.

Includes confirmed and probable cases where available. 14-day change trends use 7-day averages.

# Colorado Covid Map and Case Count

By The New York Times Updated October 14, 2020, 12:16 P.M. E.T.



Day with data reporting anomaly. Includes confirmed and probable cases where available. 14-day change trends use 7-day averages.

# **Outlook for 2021**



- Execute ION's campaign test plan at NCCC's PSTU with ICE-31
- Analysis and data evaluation
- Process model validation
- Techno-Economic Analysis (TEA)

- Project Enterprise (FE-DE-0031950) Pilot at Calpine NGCC Power Plant in California
  - Design, build and test ICE-31 parametric, dynamic and long-term steady state testing including solvent reclamation systems

#### **ION Team:**



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