IEAGHG 8th Post Combustion Capture Conference

16th to 18th September 2025 Marseille, France

Final Results of ION's CO_2 Capture System at Engineering Scale with Flue Gas from Commercially Dispatched CCGT; Proving the Conditions for Constant Negative Emissions

N.A. Fine, R. Kupfer, K.K. Jew, K.L. Gray, G. Kelly, A.R. Awtry, R.A. D'Ardenne, B.D. Dinsdale, M.A. Lynch, S. Martin, J.P. Tomey, D.H. Shierstone, J.S. Atcheson, E.E.B. Meuleman*

ION Clean Energy, 2995 Center Green Ct, Boulder, CO 80305, U.S.A.

Abstract

ION Clean Energy (ION) operated its pilot plant at Calpine's Los Medanos Energy Center (LMEC), CA, USA, to study CO_2 capture from a commercially dispatched CCGT plant. This capture system is designed to capture 10 tonnes per day CO_2 on a 1-megawatt electric (MWe) slipstream flue gas from the LMEC combined cycle gas turbine (CCGT) power plant. The test campaign focused on ultra-low emissions (to 100 ppm in the outlet) through high CO_2 capture rates and near-zero add-on emissions, low energy consumption, and negligible solvent degradation over more than 6,000 operating hours. This was accomplished through a comprehensive parametric study, followed by performance testing via long-term steady-state operations, both with constant emissions monitoring with two state-of-the-art Proton Transfer Time-of-Flight Mass Spectroscopy (PTR-ToF-MS) in tandem with extensive isokinetic testing.

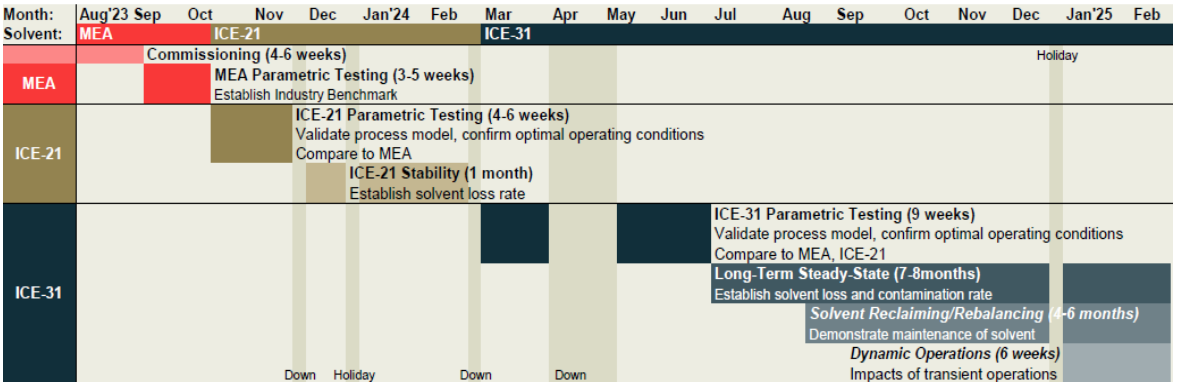

Figure 1: ENTP Gantt Chart

ION operated the capture system with MEA for approximately one month to provide a baseline comparison for ION's proprietary ICE-31™ solvent. Operation with ICE-31™ commenced with baseline testing followed by targeted parametric work packages such as varying flue gas flow, liquid to gas ratio (L/G), and cold-rich bypass ratios. Compared to the baseline MEA test, ION's ICE-31™ solvent reduced Stripper Reboiler Duties (SRD's) by 38% under similar operating parameters. The significant improvement in performance with ICE-31™ solvent was due to three main benefits:

1. Very high CO_2 carrying capacity, which reduced the heat needed to overcome heat exchanger inefficiencies
2. No foaming tendency, which allowed better heat recovery in the stripper when using a cold-rich bypass
3. Excellent solvent kinetics, which allowed ION's solvent to approach equilibrium at the bottom of the absorber

ICE-31™ also proved exceptional stability over an operating period of approximately 6,000 hours, which was visually observed and confirmed quantitatively through GC-MS, LC-MS, ICP, and NMR analyses. ION was able to consistently close the solvent mass balance within 2% of 100% closure and the system mass balance (all inlet and outlet streams) within 2% of 100% closure.

ION achieved greater than 99% CO_2 capture over a sustained period of operation using its solvent at a commercially relevant reboiler duty, whereas the pilot was only designed to capture 95.7% CO_2. The high capture efficiency resulted in emissions of CO_2 below 100 ppm, demonstrating successful deep decarbonization showing potential for negative emissions. Furthermore, the Enterprise pilot was purpose-designed to start up faster than previously built pilots to accommodate the flexibility inherent in modern CCGT flue gas operations. Through optimized solvent inventory, heat exchanger design, and control systems, the plant transitioned between setpoints and stabilized within one hour. Further testing on dynamic operations in a modern carbon capture pilot plant was carried out and is currently being evaluated to be presented in September at the conference.

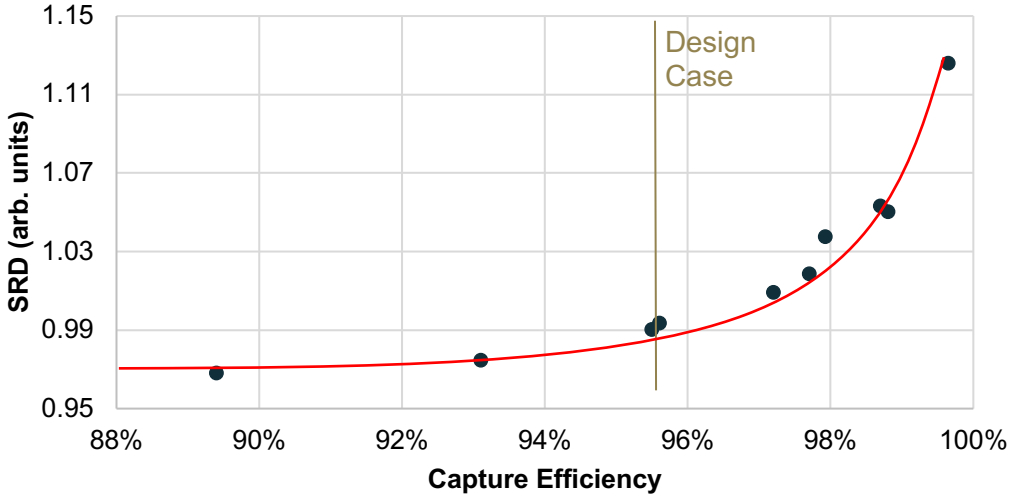

Figure 2: Capture Efficiency skew at ENTP. The design case is located at 95.7% capture efficiency

Emissions of ammonia, formaldehyde, and solvent components were below the limit of detection for the Gasmet FTIR instrumentation. ION installed two different PTR-TOF-MS analysers which provide increased sensitivity and a lower detection limit which confirmed the low-ppb emissions of the ION ICE-31™ solvent components.

ION executed a 44-week long-term steady-states test to demonstrate the long-term viability of ICE-31™ as a carbon

capture solvent. The results from the CO_2 capture pilot at LMEC, CA, USA lend strong confidence towards ION's objective to deploy its transformational carbon capture solvent with revolutionary stability on a commercial scale.

Acknowledgments:
This material is based upon work supported by the United States Department of Energy under Award Number DE-FE0031950. ION kindly acknowledges the valuable support by the team of Calpine, Los Medanos Energy Center, the ION Operations team, and the team at the University of Oslo.

Keywords: Post-combustion capture, Amine, Chemical stability