## "Engineering-Scale Pilot for the Demonstration of ION's Transformational Solvent on NGCC Flue Gas"

#### "Project Enterprise"

DE-FE0031950 August 17, 2022

Andrew Awtry, Ph.D.

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

> U.S. Department of Energy National Energy Technology Laboratory Carbon Management Project Review Meeting August 15 through August 19, 2022

# **DE-FE0031950: Project Enterprise**



- Overall Project Objective:
  - To field test an engineering scale 10 tonnes per day (tpd) CO<sub>2</sub> capture system on a 1 megawatt (MWe) slipstream flue gas from a commercially dispatched NGCC power plant to empirically validate the low capital and operating costs for ICE-31
- Budget:
  - DOE-NETL: \$13,000,000
  - Cost Share: \$3,906,839
- Period of Performance:
  - October 1, 2020 to July 30, 2024



Calpine's Los Medanos Energy Center (LMEC) Pittsburg, CA

## **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 CO<sub>2</sub> 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



# **Project Scope and Key Milestones**

- Preliminary design, permit, and cost the pilot plant
- Finalize engineering, fabricate modules, and develop controls
- Build and install modules; Connect Balance of Plant; Commissioning
- Field-test MEA, ICE-21 and ICE-31 with NGCC flue gas
- Data evaluation and extensive reporting

#	Milestone Title / Description	Planned Completion Date	Actual Completion Date
M2	Kickoff Meeting	12/04/2020	12/09/2020
M4	HAZOP Completed	3/10/2021	05/27/2021
M6	Modular Pilot System Fixed Cost	3/24/2021	06/18/21
M10	All Required Permit Documents Submitted	5/31/2021	4/29/2021
M12	Modular System Factory Acceptance Testing	11/3/2022	
M14	Complete Pilot System Site Acceptance Testing	2/28/2023	
M16	Baseline MEA and ICE21 Testing	06/30/2023	
M17	ICE31 Testing	6/24/2024	
M19	DOE Close-Out Meeting	9/15/2024	





# **ICE-31 SOLVENT TECHNOLOGY**

#### **ICE-31**

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# ION's CO<sub>2</sub> Capture Technology Development – ICE-31





## **RESULTS FROM NCCC**

# **ProTreat® Model Validation**

**Preliminary** 



PSTU Empirical Results (Arbitrary Units)



## Variable Capture Efficiency with Simple Stripper





## **ICE-31 Transformational Stability**







## **CURRENT PROGRESS**

# Design Basis



# **Modular Design**









# Modular Design









# **Site Plan – General Arrangement**





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# **Permitting Status: End of BP1**



- Bay Area Air Quality Management District (BAAQMD)
  - Legal review of permit applications
  - Completed & submitted BAAQMD application
  - Provided update to BAAQMD application per request from permitting organization
- California Energy Commission (CEC)
  - Drafted the CEC permit application
  - Submitted the CEC permit application

# **Safety Measures:**

- All required daily operator actions (via filters, sensors, valves, etc.) were removed from upper levels and located only on the 1<sup>st</sup> two levels
- A stair tower is utilized to access levels 1 5. A ladder will be used only for access to the 6<sup>th</sup> level where no maintainable items exist
- The ladder to the 6<sup>th</sup> level features a fall-arrest system to ensure safe usage even though one is not required as it is below the OSHA & Cal / OSHA required length for a fall-arrest system
- A hoist will be located on the system to allow for equipment/supplies to be moved to all levels as needed.





- Venting the scrubbed flue gas to a safe height, coupled with restricting access to the upper level
- Automated control system with visible/audible signals for high/low alarms; System shutdown triggered on high-high and low-low alarms
- CO<sub>2</sub> Monitors on levels 1 and 2
- Mobile VOC monitors (for solvent leaks) stored on the ground level and carried by personnel to upper levels for work
- Combination safety shower / eye-wash station on the ground level with eye-wash stations on each upper level
- Guard rails with toe-boards around every module level edge & opening per OSHA & Cal / OSHA





# **Safety Measures:**

- Appropriately labeled piping
- Appropriate signage (chemical, steam, electrical)
- Fire extinguishers on every level
- Operator Training
  - Pre-Operations Materials: Standard Operating Procedures, Theory of Operations document, SDS, Calpine's (8x) established Safety/Operations documents
  - On-site: PPE, Review of documents and Qualification Exams, Cold-Flow Testing to simulate operations



#### Current Project Findings & Next Steps Budget Period 1 – Accomplishments

- Completed Preliminary Engineering Phase of BP1
  - Final design is very similar to initial conceptual design
- HAZOP completed in coordination with host site
- Fixed Cost provided for the Modular System
- No "showstoppers" in permitting
  - California permitting is among most stringent in the US
  - ION's solvent and process mitigate hazardous emissions



#### Current Project Status Budget Period 2 – Accomplishments



- Modular System
  - Modular system final design is completed
  - Module fabricator selected
  - Equipment, steel, materials, instruments received at module assembly shop
  - Assembly of the modules is underway
  - Control System is under development;
    FAT expected in November

- Balance of Plant
  - Completed BOP final design packages
  - Procurement of all hardware for BOP systems
  - Selection of General Work Contractor and fixed price quote
  - Plant Tie-in construction package; Contractor ready to execute
- Submittals to CEC Chief Building Official (CBO)
  - 5 of 7 design packages submitted to the CBO have approval; remaining items are in process

#### Current Project Status Budget Period 2 – Next Steps



- Complete Module Assembly (~3 months)
- Mobilize GWC to prepare site to accept
  modules
- Execute the Plant Tie-in Package during the upcoming fall outage
- Complete Control Software; Factory
  Acceptance Testing
- Prepare modules for shipment
- Ship modules to site
  - Targeted for early December

- Install modular system (~3 months)
- Commission modules with KM support
  - Wash and Rinse of the System
  - Cold Flow Testing of the System
  - Hot flow testing with MEA
- Operations
  - Onboard and train operators
  - Generate EH&S operations manual
  - Finalize detailed test plan
  - Delivery of solvents to site









Sargent & Lundy



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# **Project Schedule**

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D	Task Name	Duration	Start	Finish
1	Calpine Pilot Proposal	209.8 wks	10/14/2020	10/21/2024
2	DOE Project Award Start	0 days	10/14/2020	10/14/2020
3	Final Report Due	0 days	10/21/2024	10/21/2024
4	Task 1 - Project Management and Planning	209.8 wks	10/14/2020	10/21/2024
5	1.1 - Revision and Maintenance of the PMP	169.8 wks	10/30/2020	1/31/2024
10	1.2 - Technology Maturation Plan	18 wks	10/14/2020	2/16/2021
15	1.3 - EH&S Risk Assessment	209.8 wks	10/14/2020	10/21/2024
16	Initial EH&S	14 wks	10/14/2020	1/19/2021
21	Final EH&S	99.8 wks	11/23/2022	10/21/2024
27	1.4 - Techno-Economic Assessment	209.8 wks	10/14/2020	10/21/2024
28	Preliminary TEA	10 wks	10/14/2020	12/22/2020
33	Final TEA	10 wks	8/13/2024	10/21/2024
38	1.5 - Host Site Agreement	3 wks	10/14/2020	11/3/2020
42	1.6 - Reporting, Briefings and Technical Presentations	207.8 wks	10/14/2020	10/7/2024
68	Budget Period 1 - Design	48.2 wks	10/14/2020	9/15/2021
223	Budget Period 2 - Construction	78.8 wks	9/16/2021	3/21/2023
224	DOE and Vendor Agreements	60 days	9/16/2021	12/8/2021
225	BP2 Kickoff Meeting	1 day	9/21/2021	9/21/2021
226	Task 3 - Construction of the 1 Mwe (10tpd) NGCC Pilot	72 wks	10/1/2021	2/17/2023
227	LNTP Start Date	0 days	10/1/2021	10/1/2021
228	3.1 - Host Site Preparation and BOP	66.6 wks	10/4/2021	1/11/2023
229	PO to start BOP Work	1 day	10/4/2021	10/4/2021
230	Project Management Tasks	23.8 wks	10/13/2021	3/28/2022
237	IFC Work Package	59.4 wks	10/4/2021	11/22/2022
329	BOP Procurement	61.6 wks	10/13/2021	12/16/2022
357	BOP Construction	44 wks	11/5/2021	9/8/2022
368	3.2 - Carbon Capture System Detailed Engineering (7/13/2022 update)	60.8 wks	10/1/2021	12/1/2022
369	Acceptance of the PO (LNTP) - Phase 1	0 days	10/1/2021	10/1/2021
370	Process Design Package	4 wks	10/4/2021	10/29/2021
374	Review of PDP by Client	1 wk	11/1/2021	11/5/2021
376	Revised PDP	3.2 wks	11/8/2021	11/29/2021
379	Begin Detailed Engineering - Phase 2	0 days	12/15/2021	12/15/2021
380	Detailed Engineering Packages	57.8 wks	10/25/2021	12/1/2022
470	3.3 - Fabrication of Carbon Capture System Modules	27.8 wks	5/16/2022	11/24/2022
471	Modular Assembly	27.4 wks	5/16/2022	11/22/2022

# **Project Schedule**

Task Nar	ne	Duration	Start	Finish
486	3.4 - Shipment of Modules	1 wk	11/23/2022	11/29/2022
487	Shipment to Site	1 wk	11/25/2022	12/1/2022
488	Mobile Lab	2.2 wks	11/23/2022	12/7/2022
492	3.5 - Modular Plant Installation & On-site Tie-ins	33.4 wks	6/14/2022	2/1/2023
493	GWC - Construction	27 wks	7/27/2022	2/1/2023
547	MIA Installation	20 8 w/c	6/14/2022	1/13/2023
552	2.6 - Site Acceptance Tecting (SAT)	A A wks	1/10/2022	2/17/2023
555	3.6 - Site Acceptance Testing (SAT)	4.4 WKS	1/19/2023	2/17/2023
554	Instrument Loop/IO Checks	5 days	1/19/2023	1/25/2023
555	Pressure Test and Utility Check	5 days	1/26/2023	2/1/2023
556	Water Testing with Programming Check	5 days	1/19/2023	1/25/2023
557	Performance Test	15 days	1/26/2023	2/15/2023
558	Complete SAT Documentation and System Turnover	2 days	2/16/2023	2/17/2023
559 <b>Ta</b>	ask 4 - Operational Preparation	43.6 wks	5/20/2022	3/21/2023
560	4.1 - Solvent Procurement	28.5 wks	5/20/2022	12/6/2022
561	MEA Solvent	28.5 wks	5/20/2022	12/6/2022
565	ICE-21 Solvent (2nd Gen)	28.5 wks	5/20/2022	12/6/2022
569	ICE-31 Solvent (3rd Gen)	28.5 wks	5/20/2022	12/6/2022
573	Host Site Preparation for Solvent Storage	6 wks	7/15/2022	8/26/2022
574	4.2 - Detailed Test Plan & Training	20.8 wks	9/5/2022	1/26/2023
575	Detailed Test Plan	8 wks	10/3/2022	11/25/2022
580	Operator Training	20.8 wks	9/5/2022	1/26/2023
586	Continuation Application for BP3	2 days	2/20/2023	2/21/2023
587	Approval for BP3	20 days	2/22/2023	3/21/2023
588 Bude	zet Period 3 - Operations	82.8 w/s	3/22/2023	10/21/2024
589 Bd	arin RD3	1 day	3/22/2023	3/22/2023
500 To	self Dr S	CQ A wike	2/22/2023	3/22/2023
501	E 1 MEA Pasoline	6 2 wks	3/22/2023	F/2/2024
591	5.1 - MEA Baseline	6.2 WKS	3/22/2023	5/3/2023
230	5.2 - ICE-21 Baseline (2nd Gen Solvent)	8 wks	5/4/2023	6/28/2023
603	5.3 - ICE-31 Campaign	54.2 wks	6/29/2023	7/11/2024
613 <b>T</b> a	ask 6 - De-Commissioning	13.4 wks	7/12/2024	10/14/2024
614	Demolition of the Pilot System	45 days	7/12/2024	9/12/2024
615	Return the Site to Grade	22 days	9/13/2024	10/14/2024
616 <b>T</b> a	isk 7 - Data Analysis & Final Reporting	82.8 wks	3/22/2023	10/21/2024
617	7.1 - Data Analysis	68.2 wks	3/22/2023	7/10/2024
619	7.2 - Final Reporting	26.4 wks	4/19/2024	10/21/2024