Front-End Engineering Design Study for Retrofit Post-Combustion Carbon Capture on a Natural Gas Combined Cycle Power Plant
DE-FE0031842

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Program Manager

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National Energy Technology Laboratory
Carbon Capture Front End Engineering Design Studies and CarbonSafe
2020 Integrated Review Webinar
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Overview: CalCapture FEED Study

- **Funding Total** $8,644,807
  - DOE: $6,915,845 (80%)
  - Cost-Share: $1,728,962 (20%) from EPRI, California Resources Corporation (CRC), and Elk Hills Carbon, LLC, a Joint Venture between CRC and Oil and Gas Climate Initiative

- **Project Performance Dates**
  - October 1, 2019 – March 31, 2021

- **Project Participants**
  - NETL: Sai Gollakota
  - EPRI: Abhyojit Bhown, Adam Berger, Des Dillion
  - CRC: Kenneth Haney, Braden Carroll
  - Fluor: Satish Reddy, Timothy Simonson, John Gilmartin

- **Project Objectives**
  - Determine technical and economic feasibility of deploying Fluor’s Econamine FG+SM post-combustion carbon capture process on CRC’s 550 MWe NGCC Elk Hills Power Plant (EHPP)
  - Captured CO₂ used for enhanced oil recovery (EOR) and/or storage surrounding EHPP (outside FEED scope)

- **Commercial Drivers**
  - EOR, Federal 45Q, California Low Carbon Fuel Standard, California Cap & Trade provide significant commercial drivers
  - Pending results of this FEED study, CRC plans on construction completion and project startup by mid-decade
Carbon Storage Credits Make Carbon Capture Economically Viable

California Low Carbon Fuels Standard (LCFS)

Federal 45Q Credit

California Cap & Trade

Additional Upsides:
- Clean Power Contract
- Emissions Reduction Credits

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Technical Approach

▪ FEED Scope
  – Design basis document led by CRC
  – Completed 1Q20

▪ FEED Study
  – Engineering design and economics led by Fluor
  – Expect late 4Q20

▪ FEED Package = FEED Scope + FEED Study
  – Final deliverable 1Q21

▪ Project Success Criteria
  – A comprehensive FEED Package submitted to DOE
  – Sufficient information for CRC to make a yes/no decision for deployment at site

▪ Project Risks
  – Design changes, mitigated by project team focusing on highest priority items
Site Selection

- Elk Hills Power Plant is a 550 MW NGCC located in the middle of the Elk Hills Oil Field providing both EOR and storage options co-located with the facility
- The site has been extensively reviewed over the past decade for EOR, storage and capture
- Current and expected policy allows for economic development of carbon capture including benefits from:
  - IRS 45Q Tax Credits
  - California’s Low Carbon Fuel Standard
  - California Cap & Trade Avoidance

“Elk Hills Field one of the most suitable locations for the extraction of hydrocarbons and the sequestering of CO₂ in North America.”

Appendix F. URS Report on CO₂ Sequestration for California Energy Commission. 2010
Elk Hills Power Plant

- Commissioned 2003
- Powered by two General Electric (GE) 7FA technology combustion turbine generators (CTG’s).
- Exhaust gas from the CTG’s is directed to two supplementary-fired heat recovery steam generators (HRSG’s) for the generation of high-pressure, intermediate-pressure, and low-pressure steam that drives the steam turbine generator (STG).
- Supplementary (duct burner) firing capability is provided in each HRSG to generate additional steam for peak power production.
- Selective Catalytic Reduction (SCR) systems for the control of NOx emissions and oxidation catalysts for the control of CO and VOC emissions.
- Fuel for the CTGs and duct burners is natural gas.
- A mechanical draft cooling tower provides heat rejection for the steam cycle.
Technology Selection

- CRC selected best technology options in early 2019.
- Narrowed to amine absorption after an evaluation of technical readiness and performance metrics at scale.
- Fluor’s Econamine FG+SM selected because:
  - Over 30 commercial Econamine FG operating plants around the world validating the design of the process
  - Technology commercially proven on a gas turbine flue gas with 15 years of operating experience
  - Solvent maintenance system provides for low air emissions and waste generation
  - Energy efficient and low solvent make-up
Finalized FEED Scope – Design Basis

- 4,000 tonnes CO$_2$/day design capacity
- 1.3 MMSCF/min flue gas supply with 5% CO$_2$ at 200°F
- Delivery of pipeline grade CO$_2$ at 2,300 psi
- Completed detailed analysis of flue gas characteristics
- Aligned on off-plot tie-in parameters
- Expanded plot space to meet design requirements
- Gas fired boiler supplies steam to the carbon capture plant
- CO$_2$ emissions from the boiler are captured in the carbon capture plant
- 80% of CO$_2$ captured is from power plant, while 20% is from boiler
3-D Model of the CCS Facility

- Absorber
- Stripper
- Direct Contact Cooler
- Wet Surface Air Coolers
- Air Coolers
- Cooling Tower
- Natural gas fired boilers
- EHPP flue gas Inlet

Image from Fluor
Incorporated Fresh Water Reduction into Design

- Ambient conditions and fresh water availability made this very challenging
- Cost effectively reduced freshwater consumption by over 50%

Air Coolers
Services that do not need to be below ambient conditions + Approach

Wet Surface Air Coolers
Large Duty Process Water Services

Cooling Tower
Streams impractical to use other methods
Design Status

"Fit for Purpose" approach incorporating application design standards from:

- American Petroleum Institute (API)
- American Society of Mechanical Engineers (ASME)
- National Electrical Manufactures Association (NEMA)
- American National Standards Institute (ANSI)
- Process Industry Practices (PIP)

Incorporated into the issuance of (approximately):

- 200 Project Specifications
- 70 Data Sheets
- 150 Drawings

Completed design activities to date:

- Process modeling
- Heat and Material Balances
- Process Flow Diagrams
- Piping & Instrumentation Diagrams
- Equipment Sizing and Selection
- Process Hazard Analysis
- Plot Plan
Design Challenges

- Logistics are resulting in increased field work
  - Large flue gas flow rate → Large equipment sizing
  - Landlocked site with relatively small shipping window

- Plot space availability
  - Expansion of plot has been incorporated to accommodate wet surface air coolers
  - Relocation of existing infrastructure is required
  - Additional plot space needs may be identified in execution planning

- Freshwater sourcing
  - Freshwater mitigation has been implemented reducing required freshwater make-up
  - Aligning with CRCs Sustainability Goals
CRC’s Elk Hills Field Is Primed to Lead California into CCS
CCS with EOR Cuts Lifecycle Oil Emissions by 40% - 50%

Conventional Oil Production
emits 0.51 tons CO₂ per barrel oil

Enhanced Oil Recovery

Emits 0.54 tons CO₂ per barrel oil
Stores 0.30 metric tons of CO₂ per barrel
Net emissions are 0.24 tons CO₂ per barrel

Phase 1 (10-15 years)
Captures 15-20 million metric tons of CO₂
~250,000 vehicles/year

Additional Targets
Up to 20 million metric tons
CalCapture Delivers Multiple Benefits to the Energy Transition

- Significant immediate emissions reductions
- Clean, safe and affordable energy for California
- Prolific economic impact on local, state and national economies
- Potentially first large-scale CCS on NGCC power plant
Acknowledgment

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APPENDIX
### Gantt Chart

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<td>Milestones</td>
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<tr>
<td>Finalize Project Management Plan</td>
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<td>Feed Package Submitted</td>
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<th>Task 2.0 – FEED Scope (CRC)</th>
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<td>Milestones</td>
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<td>Project Design Basis Package</td>
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<td>Subtask 3.1 – Design and Engineering of Primary Plant Systems</td>
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<td>Subtask 3.2 – Constructability, Cost, and Supporting Systems</td>
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<tr>
<td>Milestones</td>
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<td>Design of Primary Plant Systems</td>
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<td>Engineering FEED Study</td>
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Oct 1, 2019 - March 31, 2021 (18 months)