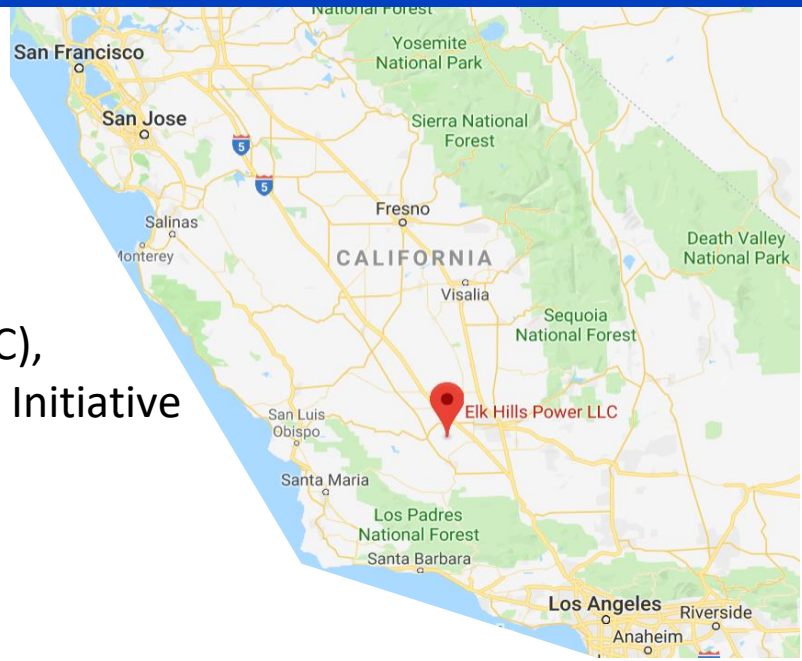
Front-End Engineering Design Study for Retrofit Post-Combustion Carbon Capture on a Natural Gas Combined Cycle Power Plant

DE-FE0031842

Abhoyjit S. Bhown, Ph.D.
Program Manager
Advanced Generation & Carbon Capture and Storage

U.S. Department of Energy
National Energy Technology Laboratory
Carbon Management and Oil and Gas Research Project Review Meeting
August 2-31, 2021

Overview: CalCapture FEED Study



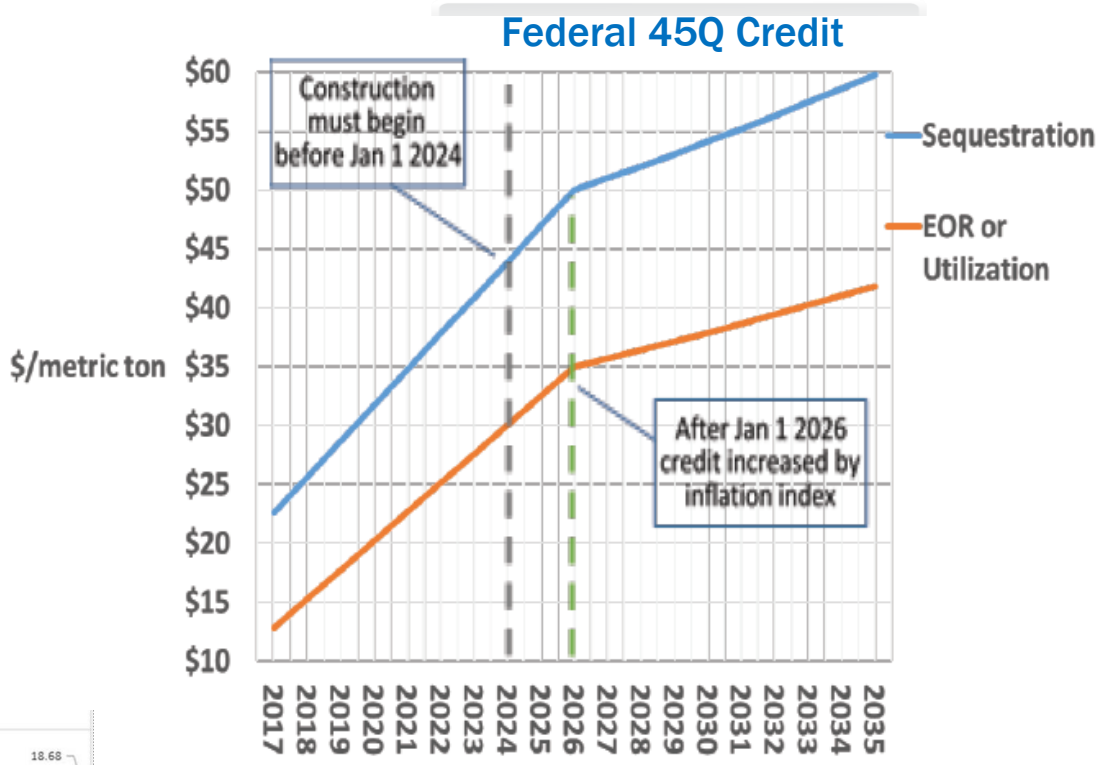
- Funding Total $8,644,807
  - DOE: $6,915,845 (80%)
  - Cost-Share: $1,728,962 (20%) from EPRI, California Resources Corporation (CRC), and Elk Hills Carbon, LLC, a Joint Venture between CRC and Oil and Gas Climate Initiative
- Project Performance Dates
  - October 1, 2019 – September 30, 2021
- Project Participants
  - NETL: Carl Laird
  - EPRI: Abhoyjit Bhown, Adam Berger, Yang Du, Desmond Dillion
  - CRC: Kenneth Haney, Christopher Kolar
  - 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 CO_2 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)

California Cap & Trade

Federal 45Q Credit



Additional Upsides:
Clean Power Contract
Emissions Reduction Credits

Images from CRC

Technical Approach

- FEED Scope
  - Design basis document led by CRC
  - Completed March 2020
- FEED Study
  - Engineering design and economics led by Fluor
  - Expect late August 2021
- FEED Package = FEED Scope + FEED Study
  - Final deliverable late September 2021
- Project Success Criteria
  - A comprehensive FEED Package submitted to DOE
  - Sufficient information for CRC to make a Financial Investment 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

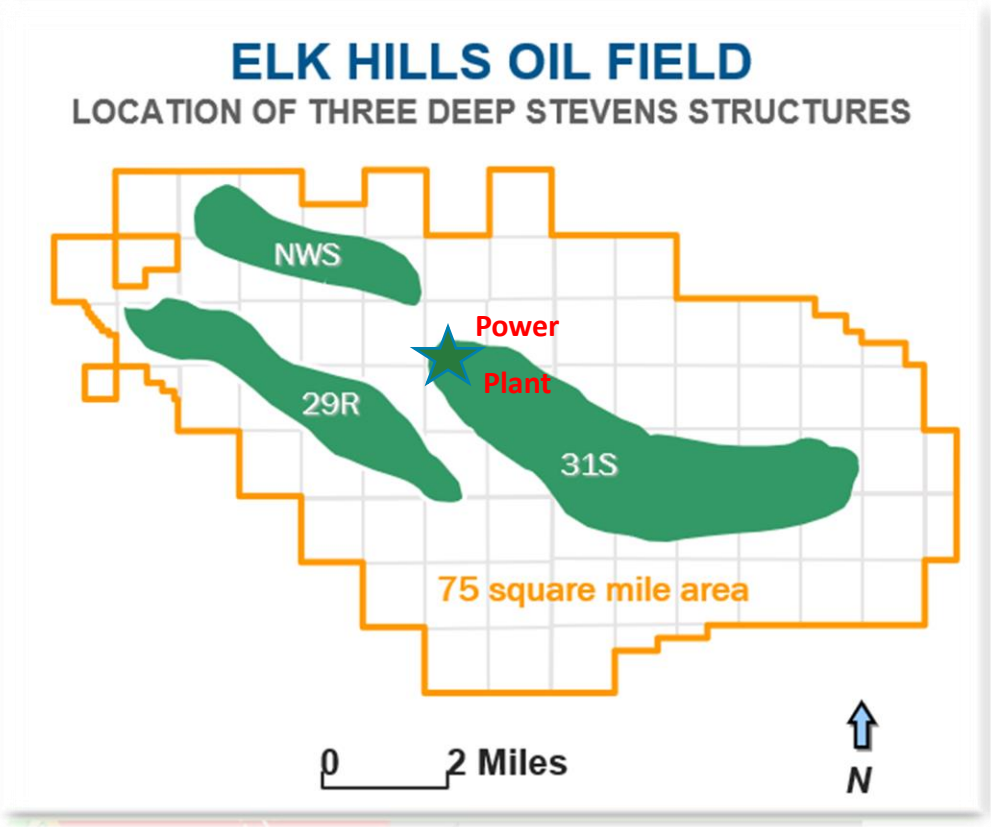


Image from CRC

"Elk Hills Field one of the most suitable locations for the extraction of hydrocarbons and the sequestering of CO_2 in North America."

Appendix F. URS Report on CO_2 Sequestration for California Energy Commission. 2010

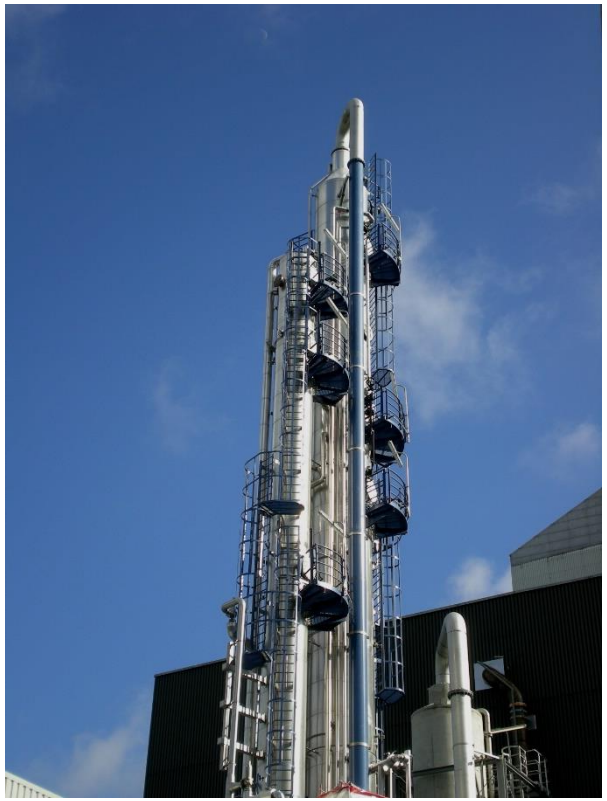
Elk Hills Power Plant

- 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 NO_x 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.

Image from CRC

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



© Fluor, Used with Permission

Demonstration Plant, Germany

FLUOR®

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

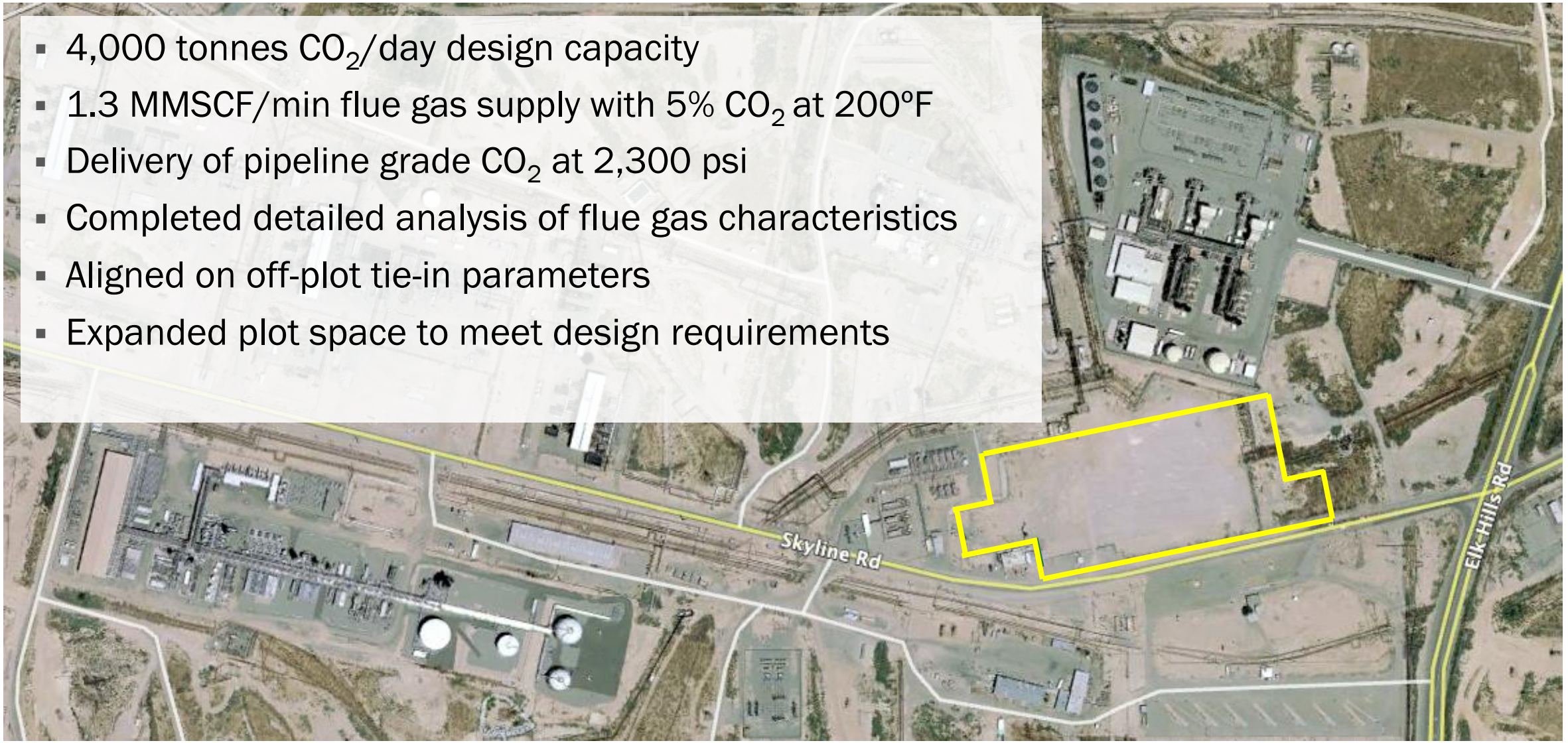
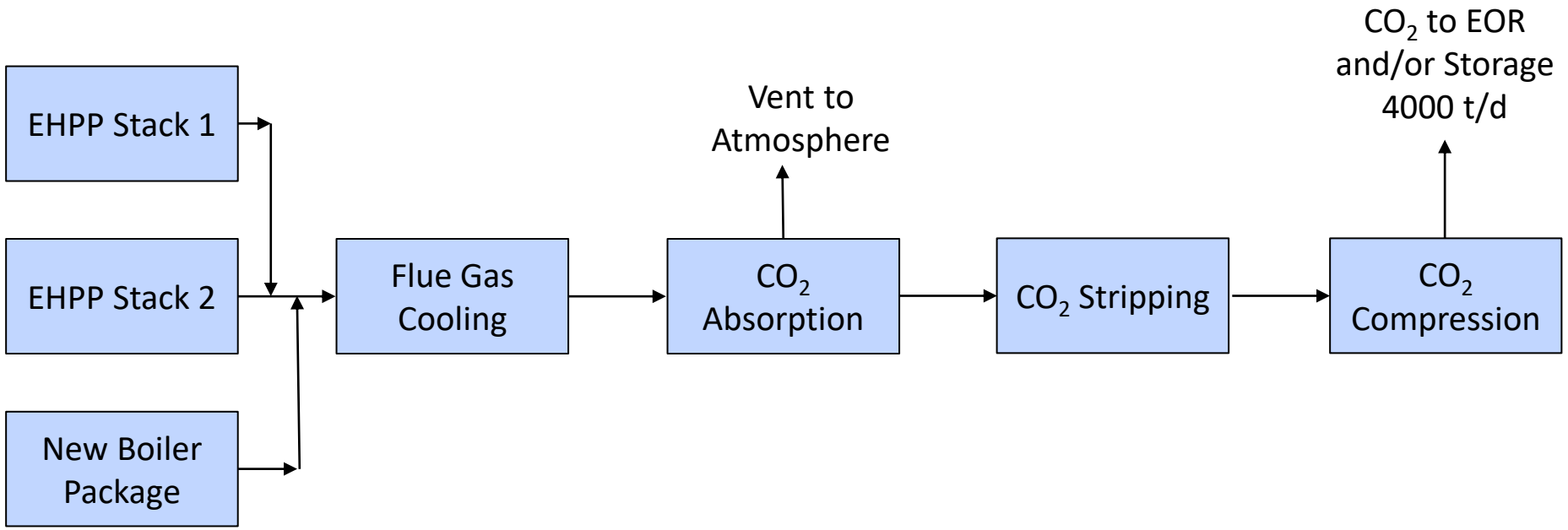


Image from CRC

Carbon Capture Plant Configuration



- 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

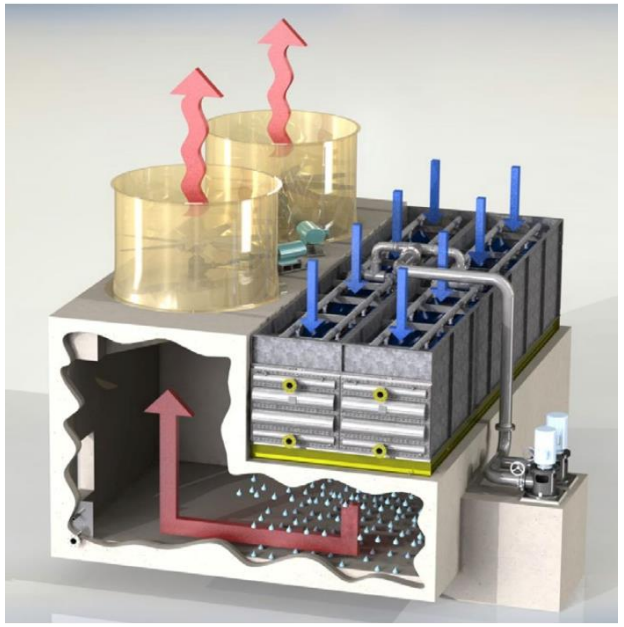
Incorporated Fresh Water Reduction into Design

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

Courtesy Alfa Laval

Air Coolers

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



Courtesy Alfa Laval

Wet Surface Air Coolers

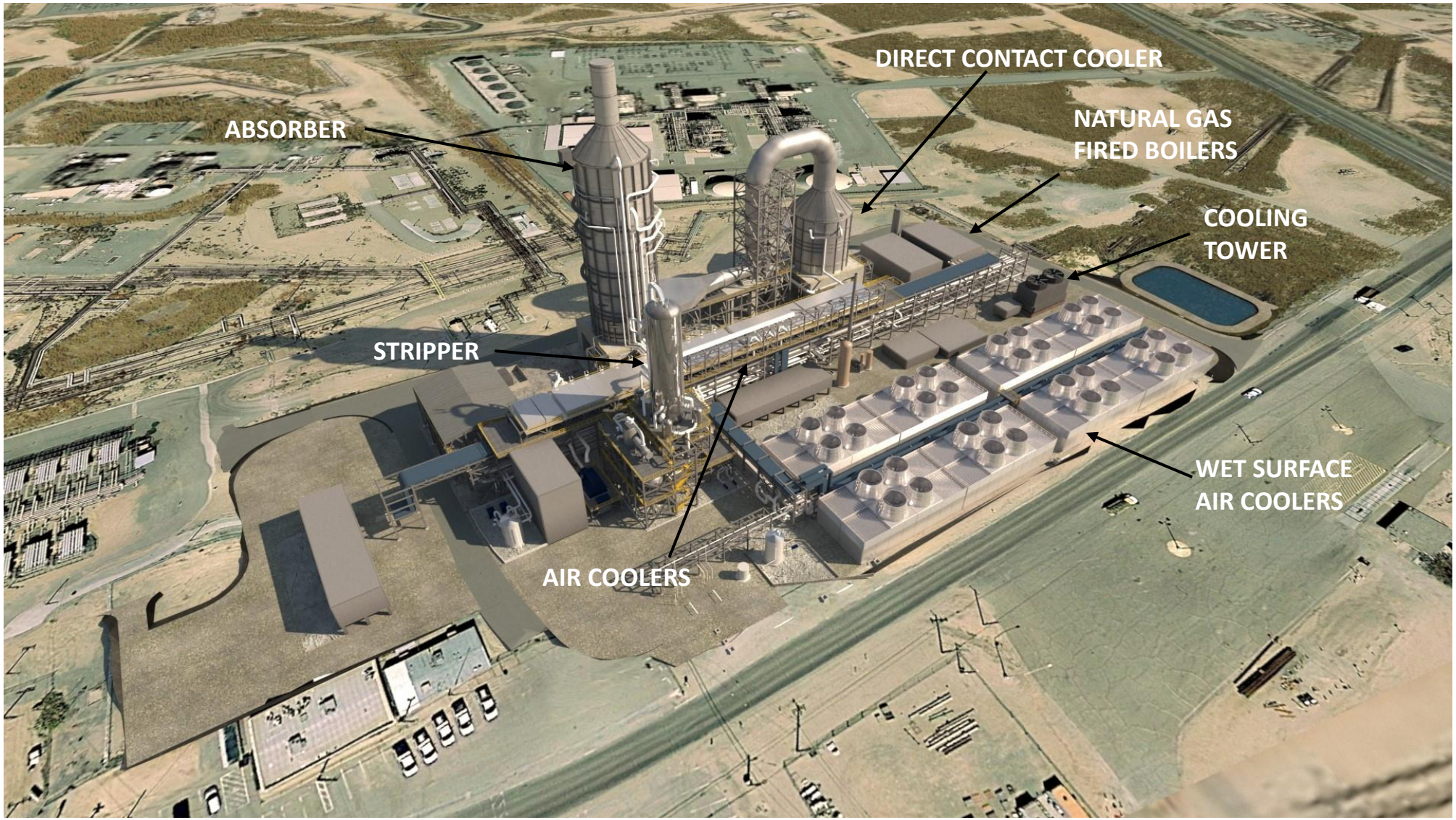
Large Duty Process Water Services

Courtesy SPX Cooling

Cooling Tower

Streams impractical to use other methods

Rendering of the CCS Facility



© Fluor, Used with Permission

Completed Design Activities

- ✓ Process modeling
- ✓ Heat and Material Balances
- ✓ Process and Utility Flow Diagrams
- ✓ Piping & Instrumentation Diagrams
- ✓ Equipment Sizing and Selection
- ✓ Process Hazard Analysis
- ✓ Cause and Effect Diagrams
- ✓ Plot Plan
- ✓ Electrical Load List
- ✓ 3D Model Development
- ✓ Capital and Operating Cost Estimates

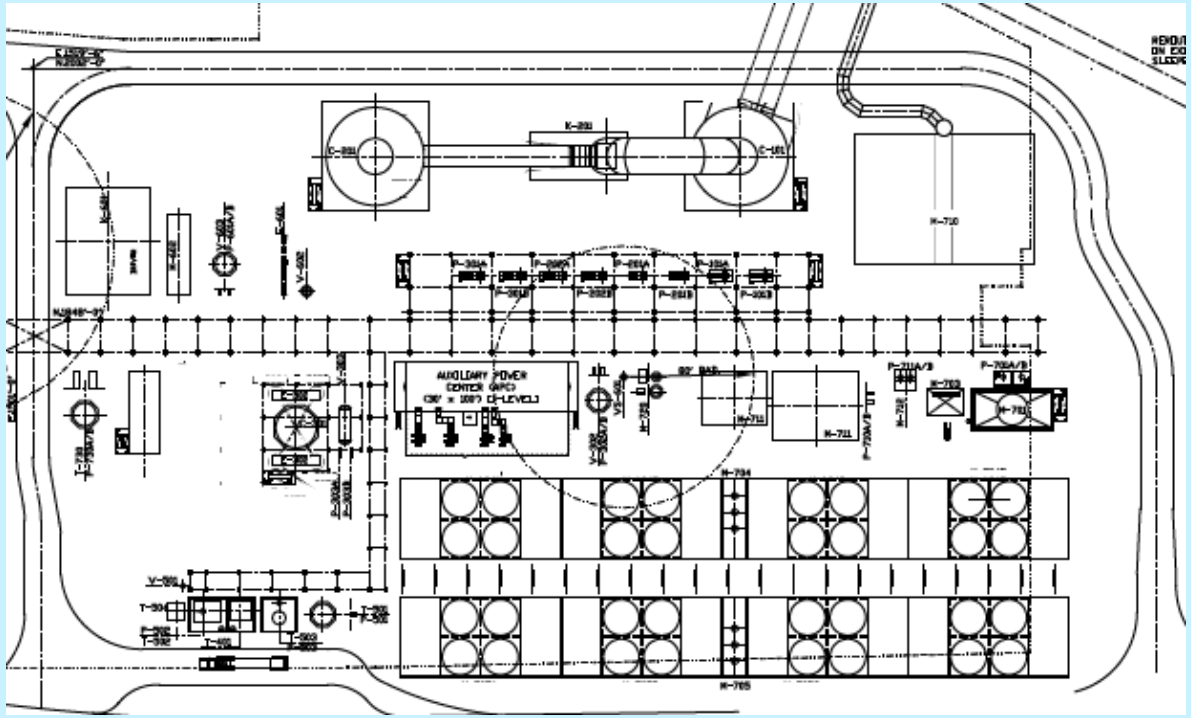
© Fluor, used with Permission

Incorporated into the issuance of (approximately):

- 200 Project Specifications
- 70 Data Sheets
- 150 Drawings

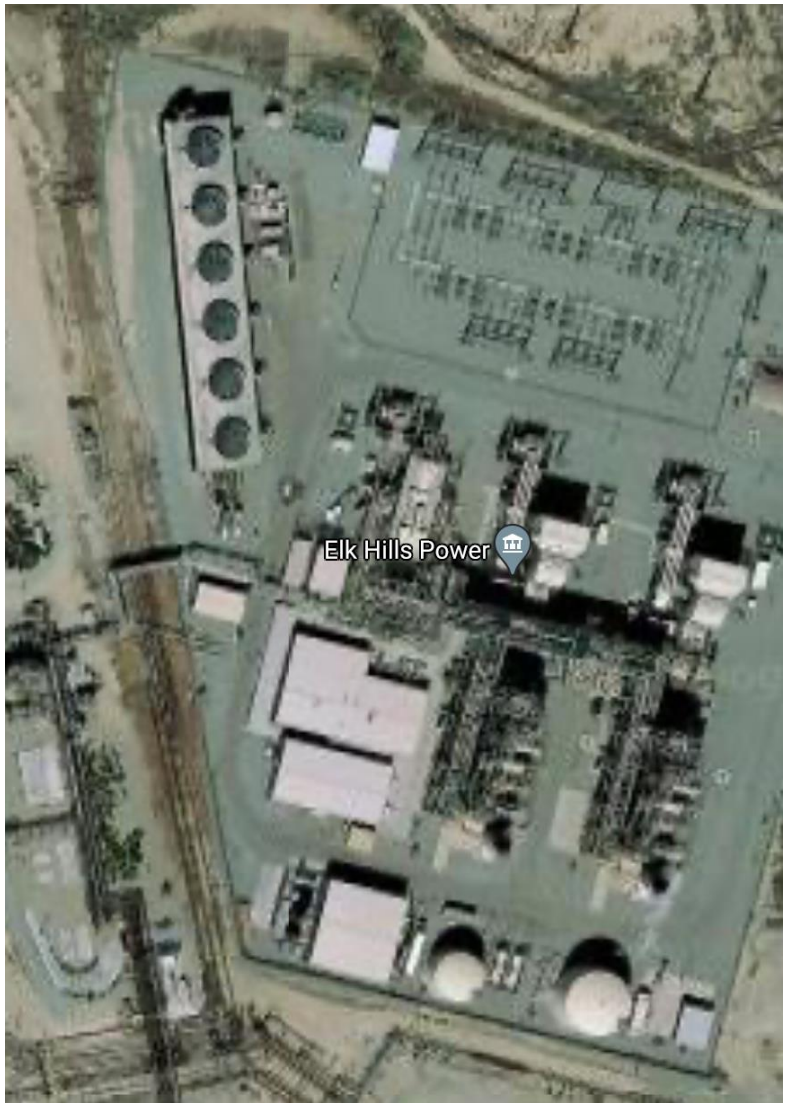
Ongoing Value Engineering Studies

- Updated DCC and Absorber Column Designs
  - Reduced column heights
- Reduce flue gas ducting costs
  - Alternate shapes and metallurgy
- Optimize Plot Layout
  - Reduce size of plate and frame exchanger support structure
  - Minimize length of higher cost alloy piping



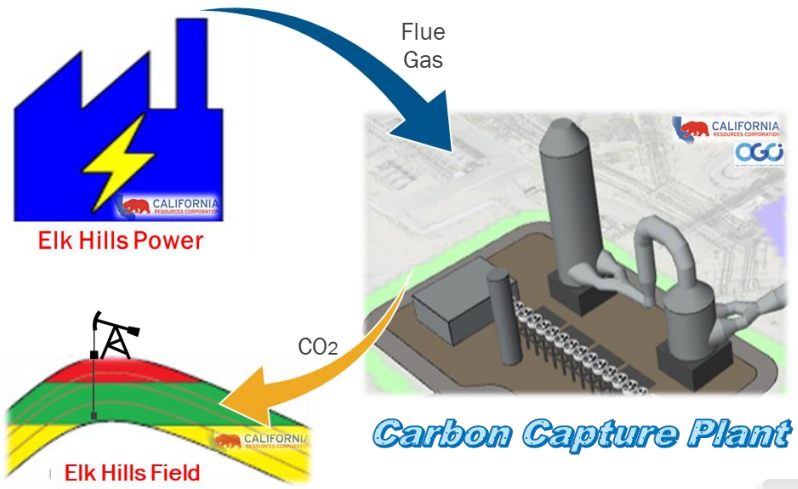
© Fluor, Used with Permission

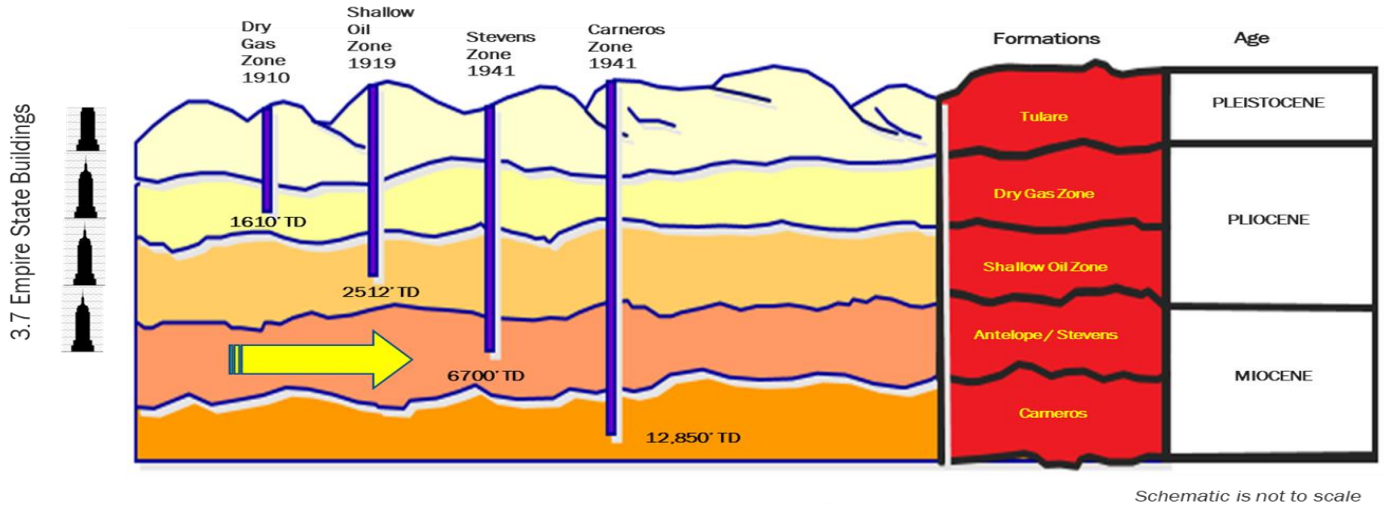
Ongoing Value Engineering Studies (*continued*)



- Integration with Host Power Plant
  - Modify existing steam turbine to allow capture plant to draw 100% of regeneration steam requirement
    - Eliminates need for new natural gas fired boiler packages dedicated to carbon capture unit
      - More CO_2 captured from power plant
      - Higher CO_2 emissions avoided
    - Frees up cooling capacity in existing cooling tower
      - Potential to eliminate some or all carbon capture unit Wet Surface Air Coolers
      - Further reduction in water consumption

Capture, EOR, and Storage





Schematic is not to scale

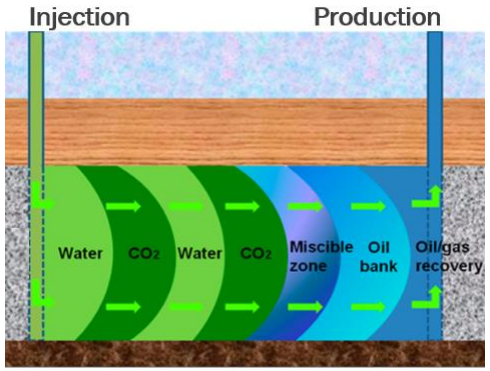
Project and Social Benefits

- ✓ Significant immediate emissions reductions
- ✓ Clean, safe, affordable energy and reliable base-load power
- ✓ Prolific economic impact
- ✓ NGCC capture technology development

CO_2 Capture

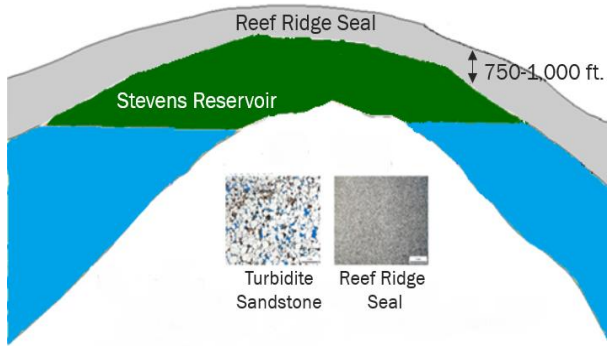
- ✓ FEED Study
- ➢ CAPEX Optimization
- ➢ Alternatives
- ➢ FID

Enhanced Oil Recovery



- ✓ Reservoir Designs & Forecasts
- ✓ Facility Pre-FEED
- ✓ Cost Analysis

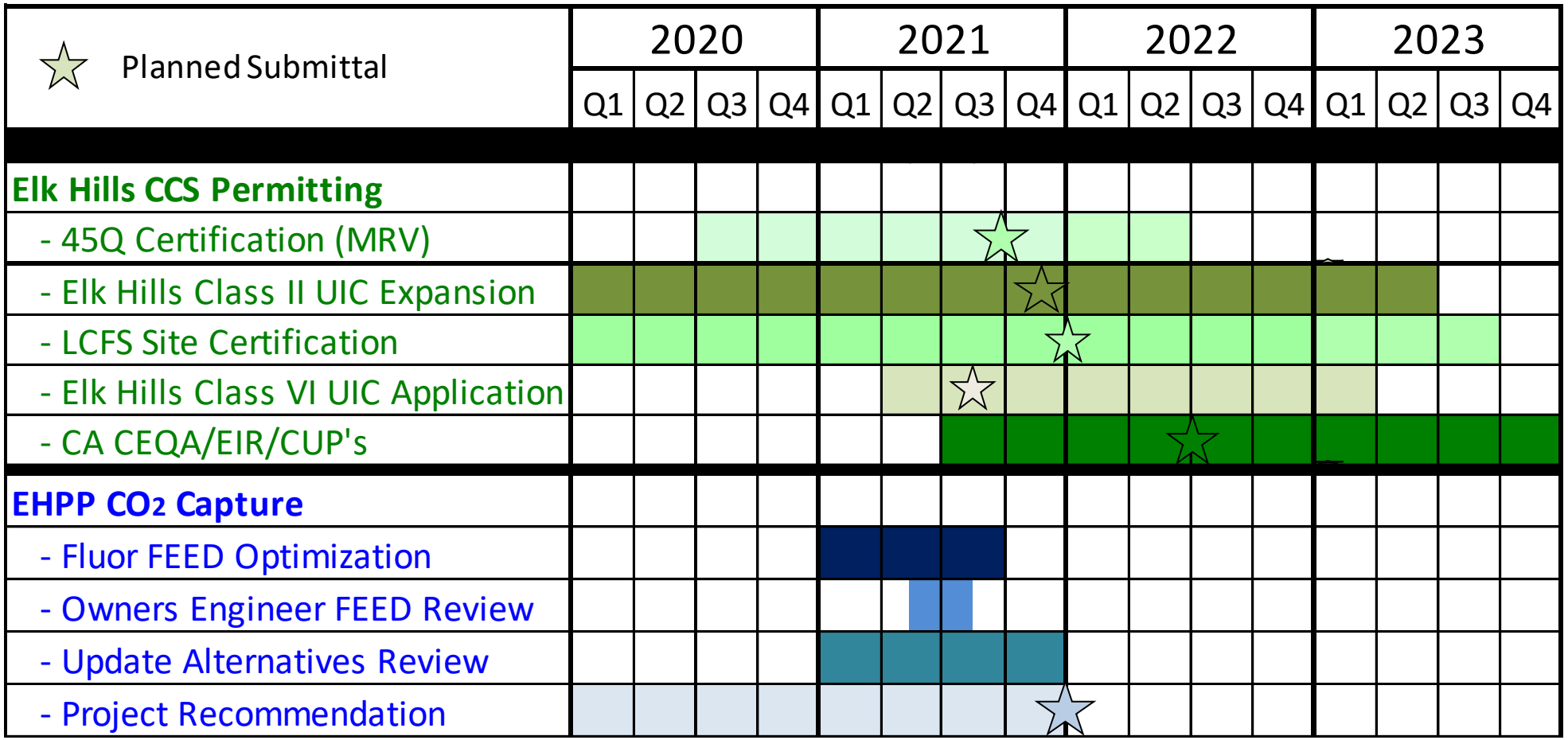
Storage & Regulatory



- ✓ Regulatory Outreach
- ➢ Permitting
- ➢ Site Certifications

Images from CRC

CalCapture Timeline



Capture Plant Economic Impacts

Study by IMPLAN Group, LLC. Data reflects US impacts per project design estimates 6/2020	Annual Jobs	Millions of $ Taxes
Capture Plant (3 yr. construction)	3,890	222
Capture Plant (20 yr. operation)	217	197

~16,000 Job-years

$420 million taxes

Estimates modeled prior to FEED study completion

Advantage CalCapture

A Fully Integrated Project

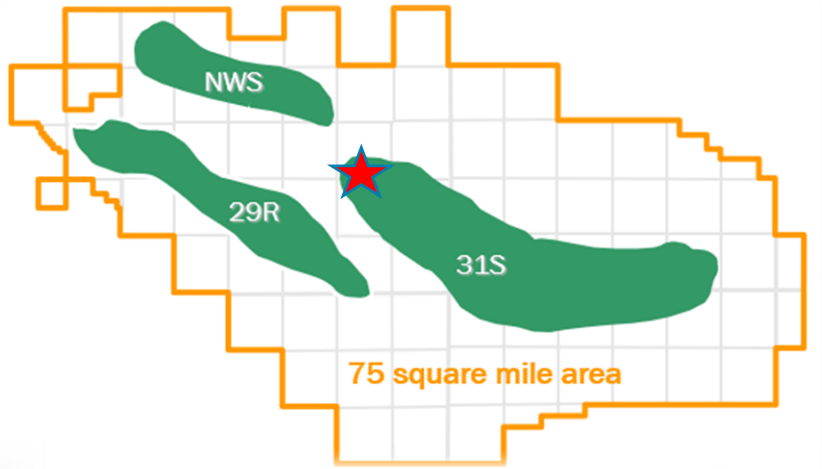
- ✓ CO_2 source on location with reservoirs
- ✓ CRC owns infrastructure/surface/pore space

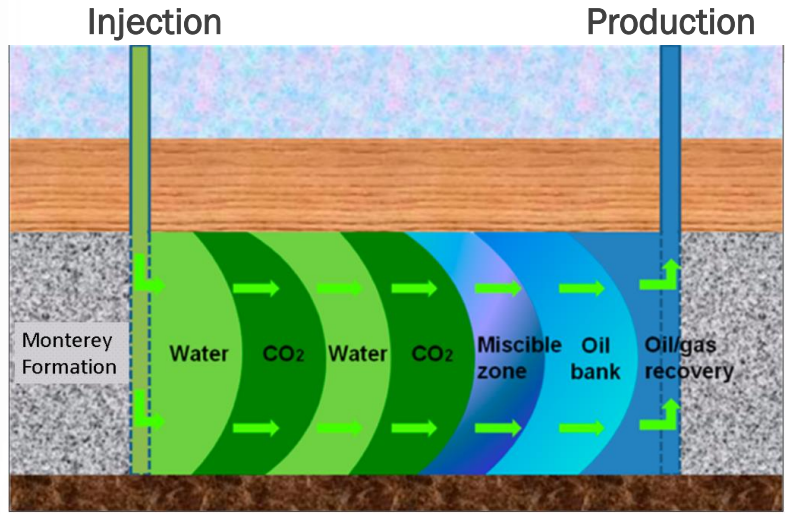
Commercial Readiness

- ✓ Uncertainty ranges understood
- ✓ Economics supported by carbon credits
- ✓ Successful regulatory engagement

Investment Opportunities

- ✓ Carbon capture plant
- ✓ EOR/Sequestration project participation





Images from CRC

Acknowledgment

Acknowledgment

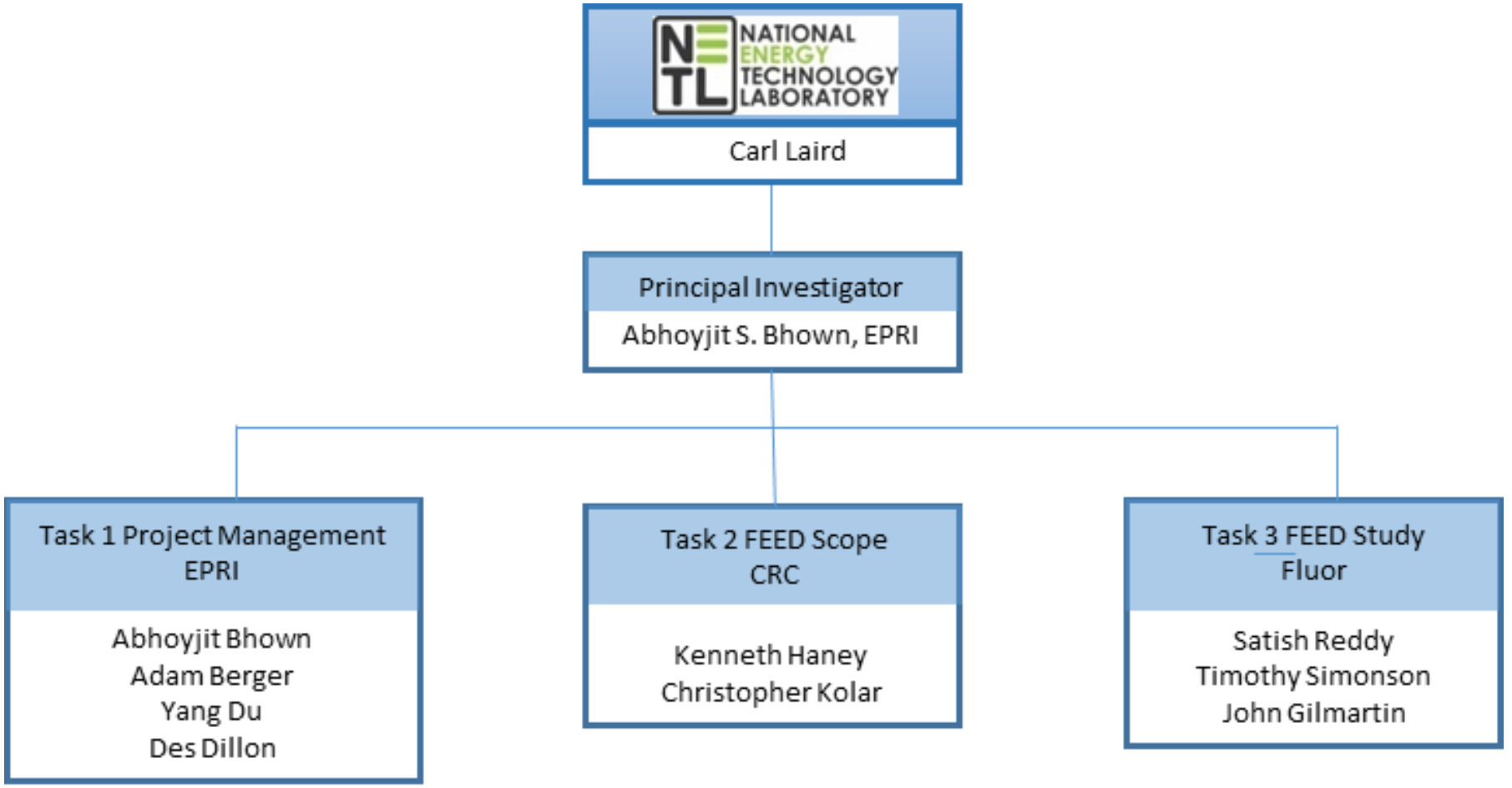
This material is based upon work supported by the Department of Energy under various DE-FE0031842.

Disclaimer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

APPENDIX

Organization Chart



Gantt Chart