Carbon Capture with Fuel Cell Power Plants

United States Energy Association
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Agenda

• FuelCell Energy
  • Fuel Cells and Carbon Capture
  • DOE Office of Fossil Energy Program

• ExxonMobil
  • Carbon Capture and Sequestration Experience
  • Fuel Cell Technology

• Summary
Delivering clean and innovative solutions for the supply, recovery & storage of energy

- More than 50 installations globally with the world’s leading companies
- Installations and operations on 3 continents
- Billions of KWh’s of ultra-clean power delivered
- American designed & manufactured
Energy Mix Shifts to Lower-Carbon Fuels

Global Energy Mix
Percent

- 2015
- 2040

Other Renewables
Wind & Solar
Nuclear
Coal
Gas
Oil

Energy-Related CO₂ Emissions by Region
Billion Tonnes

- 2010
- 2025
- 2040

Non-OECD
China
OECD
U.S.

Source: 2017 ExxonMobil Energy Outlook
Long-Term Stabilization Requires Transformation

- Efficiency / Reduce Demand
- Decarbonize Global Economy
- Negative GHG Emissions
Value Drivers

• Conventional carbon capture approaches are energy intensive – typically consume ~20% of host power plant output
• Carbonate fuel cells can be configured to capture CO$_2$ as a side reaction of power generation
• Power generation during carbon capture adds value stream that improves carbon capture economics

Current Actions

• US DOE Office of Fossil Energy contract with FCE for development and pilot demonstration of capture from coal source
• FCE and ExxonMobil evaluation of capture from natural gas turbine exhaust stream

*350MW Plant for capture from coal systems, developed in DOE program*

Based upon work supported by the Department of Energy under Award Number DE-FE0026580
SureSource™ Fuel Cells

Core of Carbon Capture
- Designed for Industrial and Utility Power Applications
- Refined from DOE supported initial development
- Power generation without combustion
- Key DFC attributes allow for unique adaptations:
  - Internal Reforming
  - Carbonate Electrolyte

*Provides CO₂ transfer mechanism that allows for concentration and capture*
• Carbonate electrochemical process transfers CO$_2$ from Air Electrode (Cathode) to Fuel Electrode (Anode)
• CO$_2$ is easily separated from Anode exhaust gas because it is no longer diluted with air
Fuel Cell Based CC Applications

- **Large-scale CC from coal-fired plants**
  - Ultimate objective of DOE-supported development
- **CC from distributed natural gas plants**
  - Provide low-carbon baseload or peaking Plants.
- **CC from industrial processes**
  - Reduced carbon footprint from processes such as cement production
- **CC and Enhanced Oil Recovery (EOR)**
  - On-site generation from associated gas with CO$_2$ capture for EOR
- DOE funded project to demonstrate capture from coal power generation
- Opportunity to use pilot to demonstrate natural gas capture under ExxonMobil Joint Development program
- Southern selected Plant Barry as best site choice
  - Coal and natural gas power generation
  - Plot space availability
  - Existing flue connection supporting past carbon capture projects
  - Supportive management and staff
- Project will be single SureSource 3000-based capture system
  - 90% capture from 3MW of coal exhaust
Example of Near Term System

• Carbon Capture Fuel Cell Farm with 12 SureSource 3000\textsuperscript{tm}-based capture systems
  • 18 MW at 90% capture (500 tons/day from coal flue plus 200 tons/day from fuel cell ng)
  • 27 MW at 70% capture (700 tons/day from coal flue plus 300 tons/day from fuel cell ng)
• 3 acres total site
• Potential to expand incrementally as needed
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ExxonMobil
CO₂ Capture and Storage Background

- Power generation and industrial operations are major sources of CO₂.
- Amine CO₂ capture technology is proven.
- Storage technology is proven, at small scale.

**Natural Gas Power Plant**

- CH₄ → Combustor → Power → Flue gas
- Flue gas: 4-6% CO₂, 1 bar, 140°C

**Liquid Amine CO₂ Capture Plant**

- Flue gas enters the Capture Plant.
- Rich amine is added and absorbed CO₂ is captured.
- CO₂ is then extracted and sent for EOR or sequestration.
- CO₂ concentration >95%, 150 bar, ~3,500x increase in CO₂.

Note: CO₂ source data from EPA.
ExxonMobil’s CCS Experience

• Working interest in approximately 25% of the world’s CCS capacity
  – ~7 million metric tons CO₂ captured for sequestration annually

• Current CCS efforts focus on:
  – Developing technologies to reduce CO₂ capture costs
  – Advocating for sound policy
Why fuel cell carbon capture?

- Commercially available technology
- Modular design
- Lower costs - generates power while capturing CO\(_2\)
- Applicable to natural gas & coal-fired power plants
- Domestic fuel source with minimal CO\(_2\) emissions
- American ingenuity for global application
Potential CO₂ Capture Using Carbonate Fuel Cells

- Fuel cell carbon capture enables typical 500 megawatt (MW) gas-fired power plant to generate additional 120 MW of power
- Potential to capture 90 percent of a natural gas-fired power plant’s CO₂ emissions
- Further potential to produce up to 150 million cf/day of hydrogen
Summary

• Making a domestic fuel source even more environmentally friendly
• Utilizing commercially proven fuel cell technology
• Modular and lower costs
• Invented in America
• Collaboration brings together world-leaders in respective industries