SECA, Coal, and FutureGen

8th Annual SECA Workshop

August 7 - 9, 2007
San Antonio, Texas

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Office of Fossil Energy
SECA Beginnings

- NETL-PNNL Strategic Alliance
  - August, 1999
- SECA Concept Development: SECA
  - September – October, 1999
- 1st SECA Annual Workshop, Baltimore, MD
  - June 1-2, 2000
Progressive Development Of SSFC Application

Power

Time / Year

Source: Gary McVay, PNNL, 12/01/1999
SECA Development: Progressive Applications

2005
- $800/kW
- Prototype (β-Unit)
  3 - 10 kW

2010
- $400/kW
- Commercial

2015
- Vision 21 Power Plants
  70-80% efficient plants
- Propulsion <$200?/kW

Source: Strakey, 2nd Annual SECA Workshop, 03/29-30/ 2001
So What Changed?

- Terrorist attacks on U.S.
- War in Afghanistan & Iraq
- World oil peaking concerns
- Rapid growth in non-OECD energy use
- Flat domestic gas production
- Global climate change concerns
- Etc., etc.

![Total U.S. Natural Gas Production](chart1.png)

![LNG Safety Perceptions](chart2.png)

![Global Climate Change Concerns](chart3.png)
Theme 1: Energy Security

Promoting America’s energy security through reliable, clean, and affordable energy.

1.1 *Energy Diversity* – Increase our energy options and reduce dependence on oil, thereby reducing vulnerability to disruption and increasing the flexibility of the market to meet U.S. needs.

1.2 *Environmental Impacts of Energy* 
Improve the quality of the environment by reducing greenhouse gas emissions and environmental impacts to land, water, and air from energy production and use.

1.3 *Energy Infrastructure* – Create a more flexible, more reliable, and higher capacity U.S. energy infrastructure.

1.4 *Energy Productivity* – Cost-effectively improve the energy efficiency of the U.S. economy.
250 Year Supply at Current Demand Levels!

U.S. Fossil Fuel Reserves / Production Ratio

- Coal: 258
- Oil: 11.7
- Natural Gas: 9.7

152 Added GW of Coal Capacity
AEO’07 (High Oil Price Case)
**Volume of CO$_2$ Produced**

- **1 million metric tons of CO$_2$:**
  - Every year would fill a volume of 32 million cubic feet
  - *Close to the volume of the Empire State Building*

- **U.S. emits roughly 6 billion tons (gigatons) of CO$_2$ per year**
  - Under an EIA reference case scenario cumulative CO$_2$ emissions 2004-2100 are expected to be 1 trillion tons
  - *Enough to fill Lake Erie with liquid CO$_2$ almost twice*
Regional Carbon Sequestration Partnerships

- 350 organizations
- 41 states (NY recently joined)
- 4 Canadian provinces
- 3 Indian nations
- Total of 34% cost share

Developing the Infrastructure for Wide-Scale Deployment
Regional Carbon Sequestration Partnerships
“Developing the Infrastructure for Wide Scale Deployment”

Characterization Phase
- 24 months (2003-2005)
- $16M DOE funds

Validation Phase
- 4 years (2005 - 2009)
- Field validation tests
  - 25 Geologic
  - 11 Terrestrial
- $100M DOE funds

Deployment Phase
- 10 years (2008-2017)
- Seven large volume injection tests
- ~$470M DOE funds
North America Geologic Storage Capacity
(> 500 Year Potential Storage Capacity for U.S. & Canada)

- **Deep Saline Formations**
- **Unmineable Coal Seams**
- **Oil & Gas Fields**

**Upper Capacity Estimates**

- Annual U.S. & Canada Emissions from Energy: ~ 6.8 Gigatonnes CO₂

Capacity Data from Carbon Sequestration Atlas of the United States and Canada, DOE-NETL, Feb 2007
Emissions Data from EIA, “International Carbon Dioxide Emissions and Carbon Intensity” extrapolated to mid-2007
DOE’s Office of Fossil Energy
Advanced (Coal) Power Systems Goals

- **2010:**
  - 45-50% Efficiency (HHV)
  - 99% SO$_2$ removal
  - NO$_x$ < 0.01 lb/MM Btu
  - 90% Hg removal

- **2012:**
  - 90% CO$_2$ capture
  - <10% increase in COE with carbon sequestration

- **2015**
  - Multi-product capability (e.g., power + H$_2$)
  - 60% efficiency (measured without carbon capture)
Capturing CO₂ with Today’s Technology is Expensive

Cost of Electricity Comparison

January 2007 Dollars, Coal cost $1.80/10⁶ Btu

FutureGen Objectives

World’s first near zero-emission, full-scale coal-based power plant to:

- Co-produce electricity & $H_2$ from coal
- Emit virtually no air pollutants
- Capture & permanently sequester CO$_2$ (1 million tonnes/yr)
- Integrate operations at full-scale (275 MWe) – a key step
**FutureGen Project**

**Supporting FutureGen is a Major Goal of the R&D Programs**

- A billion-dollar, 10-year project to create the world’s first coal-based, near-zero emission electricity plant with carbon capture and sequestration

- Industry-led project with government oversight & international participation
  - Signed Cooperative Agreement with DOE on Dec. 2, 2005
  - Project structuring to Jan. 2007
  - Design to July 2009
  - Construction to July 2012
  - Operations to July 2016
  - Site monitoring to July 2018

- Industry will choose project site & backbone technologies
  - Down-selected to four potential sites
**FutureGen Candidate Site Features**

**Conceptual Sequestration Design**

- **Mattoon**
  - Injection on-site
  - ~8,000 ft deep
  - Mt. Simon sandstone formation

- **Tuscola**
  - Injection off-site (~10 miles)
  - New pipeline to be constructed
  - ~8,000 ft deep
  - Mt. Simon sandstone formation

- **Brazos**
  - Injection at two sites (~25 and 33 miles)
  - New pipeline to be constructed
  - ~6,000 ft deep in the Woodbine formation
  - ~11,000 ft deep in the Travis Peak formation

- **Odessa**
  - Injection off-site (~56 miles)
  - Potential to use existing pipeline with minor upgrades
  - ~6,000 ft deep
  - Guadeloupe Sands
**FutureGen: Cutting-Edge Technologies**

- Can accommodate technology innovations with minimal modifications
  - Emerging from national or international R&D pipelines
  - Slipstream or full-scale tests
  - Over life of project

- Some emerging new technologies
  - Membrane-based \( \text{O}_2 \) and \( \text{H}_2 \) separation
  - High-efficiency hydrogen turbines
  - High-throughput gasifiers
  - Monitoring systems
  - **Fuel cells**

*FutureGen will be a global showcase of very best technology options for coal-based systems with near-zero carbon emissions*
**FutureGen**

IGCC Fuel Cell with Sequestration

- **Air** separation
- **H₂O** and **Coal** input to the **Gasifier**
- **SOFC** (Solid Oxide Fuel Cell) for CO₂, CO, H₂ generation
- **Sulfur Recovery** process
- **CO₂** separation
- **Marketable Ash/Slag By-product**
- **CO₂** sequestration into **Deep Saline Formation**
- Enhanced Oil Recovery from **Unmineable Coal Beds** and **Depleted Oil & Gas Reservoirs**
GE IGFC Study
Performance Summary

- 53.4% (HHV) Possible with IGFC
- CO₂ Separation penalty 2.7 points
**FutureGen Fuel Cell Test Configuration**

**Backbone Plant**
- ASU
- Coal Handling
- Coal Prep
- Gasifier
- Generator
- Combustion Turbine
- HRSG
- Steam Turbine
- Cond & Feedwater System

**Power Generation**
- Air
- N₂ to CT
- Oxidant
- Saturated steam
- BFW
- Coal powder or slurry
- Raw syngas
- Steam
- Slag
- Shuffled syngas
- Low Temp HX
- Sour Water Treatment
- Acid Gas Recovery
- Claus Process
- Compress
- and Drying

**Gasification**
- Crushed coal
- Coal
- Ash
- Water Gas Shift
- Steam
- Sour gas
- Recycle water
- Sulfur

**Gas Processing**
- CO₂
- Tail gas treatment

**Sub-scale fuel cell test platform**
- 3 x 5 MWe
- Syngas
- Fuel Cell 1
- Fuel Cell 2
- Fuel Cell 3
- Vent

**Syngas**

**H₂**

**CO₂**
SECA Coal-Based Systems Draft FOA

FIRANCIAL ASSISTANCE
FUNDING OPPORTUNITY ANNOUNCEMENT

U.S. Department of Energy
Office of Fossil Energy

Solid State Energy Conversion Alliance (SECA)
Coal-Based Systems

Funding Opportunity Number: DE-PS26-07NT43136

Announcement Type: Draft
CFDA Number: 81.089

Issue Date (DRAFT): JULY 17, 2007
Public Comments Deadline: JULY 31, 2007
Application Due Date: SEPTEMBER 10, 2007

This is a draft announcement issued for public comment only. The period of public comment will close 14 (fourteen) days after the issue date of this draft. The final announcement will be issued on or about 08/07/2007. The anticipated due date for applications submitted in response to the final Funding Opportunity Announcement is 09/10/07 at 8:00 PM Eastern Time.

http://www.netl.doe.gov/