FutureGen Status

7th Annual SECA WORKSHOP & PEER REVIEW

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National Energy Technology Laboratory
U. S. Department of Energy
FutureGen

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

- Pioneer advanced hydrogen production from coal
- Emit virtually no air pollutants
- Capture and permanently sequester carbon dioxide
- Integrate operations at full-scale – a key step to proving feasibility
250 Year Supply of Coal at Current Demand Levels

U.S. Fossil Fuel Reserves / Production Ratio

Large Potential Worldwide CO$_2$ Storage Capacity

- Deep Ocean
- Deep Saline Formations
- Depleted Oil & Gas Reservoirs
- Coal Seams
- Terrestrial

Capacity (Gigaton CO$_2$)

Maximum Capacity Potential

24 Gigatons

Annual World Emissions

Storage Options:
- IEA Technical Review (TRA), March 23, 2004
- Carbon Capture & Sequestration Program @MIT
- DOE/EIA, International Energy Outlook 2003, Table A10
Current “Best Case” Technologies Costly

*Using State-of-the-Art Scrubbing Technologies*

- 5 to 30% Parasitic energy loss
- 30 to 100% Increase in capital cost
- 25 to 100% Increase in cost of electricity

**Effect of CO₂ Capture on Capital Cost**
(% Increase Resulting From CO₂ Capture)

**Effect of CO₂ Capture on Cost of Electricity**
(% Increase Resulting From CO₂ Capture)

- 2012 Program Goals
Why IGCC/IGFC?

- Environmentally superior coal-based power
- Easily adapted for CO$_2$ sequestration
- High efficiency
- Fuel & product flexibility
- Promising “coal-to-hydrogen” option

*R&D in the pipeline is reducing cost & improving efficiency*
- Gasifier/refractory material
- Low-cost oxygen
- Gas separation membranes
- Fuel cell power
**FutureGen**

IGFC with Sequestration

- **Air** separated into **O₂** and **H₂O**
- **Coal** converted to **CO₂**, **CO**, and **H₂**
- **Sulfur Recovery** to produce **Marketable Sulfur**
- **Gas Cleaning** to remove impurities
- **CO₂ Separation** to recover **CO₂**
- **SOFC** anode and cathode
- **Sequestration** to store **CO₂**:
  - **Enhanced Coal Beds**
  - **Deep Saline Aquifer**
  - **Unmineable Coal Beds**
  - **Depleted Oil & Gas Reservoirs**
GE IGFC Study
Performance Summary

- 53.4% (HHV) Possible with IGFC
- CO₂ Separation penalty 2.7 points
**FutureGen** Will Build Upon Experience from Commercial-Scale Coal-Based IGCC Power Plants

**Wabash River**
- W. Terre Haute, IN
- 296 MWe (gross); 262 MWe (net)
- Operations began 11/95

**Tampa Electric**
- Mulberry, FL
- 315 MWe (gross); 250 MWe (net)
- Operations began 9/96
FutureGen Will Build on Two Non-Integrated One Million TPY CO₂ Sequestration Projects

**Weyburn CO₂ EOR Project**
- Pan Canadian Resources
- 200-mile CO₂ pipeline from Dakota Gasification Plant
- Enhanced Oil Recovery in Canada

**Sleipner North Sea Project**
- Statoil
- CO₂ sequestered - Utsira Formation
- Currently monitoring CO₂ migration
- Separates CO₂ from natural gas
- $36–50 / tonne CO₂ tax
### Cutting-Edge Candidate R&D Technologies for *FutureGen*

<table>
<thead>
<tr>
<th>Traditional Technology</th>
<th>Research Invention Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Gasifier</td>
<td>Advanced Transport Reactor</td>
</tr>
<tr>
<td>Cryogenic Air Separation</td>
<td>$O_2$ Membranes</td>
</tr>
<tr>
<td>Gas Stream Clean-Up</td>
<td>Warm Gas Cleanup - Transport Desulfurizer</td>
</tr>
<tr>
<td>Amine Scrubbers</td>
<td>$H_2$ Membranes, “Clathrate” $CO_2$</td>
</tr>
<tr>
<td>Syngas Turbine</td>
<td>Ultra-Low $NO_x$ Hydrogen Turbine</td>
</tr>
<tr>
<td>Fuel Cell ($4,000/kW)</td>
<td>SECA Fuel Cell ($400/kW Design)</td>
</tr>
<tr>
<td>EOR Based</td>
<td>Sequestration Technology</td>
</tr>
<tr>
<td>Plant Controls</td>
<td>“Smart” Dynamic Plant Controls &amp; $CO_2$ Management Systems</td>
</tr>
<tr>
<td>System Integration</td>
<td>“First of a Kind” System Integration</td>
</tr>
</tbody>
</table>
FutureGen Industrial Alliance, Inc.
Signed Cooperative Agreement with DOE on Dec. 2, 2005

- American Electric Power
- AngloAmerican
- BHP Billiton
- China Huaneng Group
- CONSOL Energy
- Foundation Coal
- Peabody Energy
- PPL
- Rio Tinto Energy America
- Southern Company
**FutureGen Project Schedule**

- **Dec. 2, 2005**
  - Siting, NEPA, and Permitting
  - Project Structuring & Conceptual Design
  - Phase 2 Cooperative Agreement Negotiations

- **Jan 31, 2007**
  - Final Design
  - NEPA ROD July 2007

- **Jan 31, 2008**
  - Initial Full Scale Plant Operations

- **July 2009**
  - Construction Start

- **July 2012**
  - Operations Start

- **July 2016**
  - Full Scale Plant Operation Continues

- **July 2018**
  - Site Monitoring

**Phase 2 Cooperative Agreement Negotiations**
- Limited Cooperative Agreement Awarded Jan 31, 2007
- Full Scope Cooperative Agreement Awarded
- Final Site Selection Long Lead Time Orders September, 2007
- NEPA ROD July 2007

- **Phase 2 Cooperative Agreement Negotiations**
  - Cooperative Agreement Negotiations
  - Preliminary Design

- **Final Design**
  - Full Scope Cooperative Agreement Awarded
  - Final Site Selection Long Lead Time Orders September, 2007
  - NEPA ROD July 2007

- **Plant Start-Up & Shakedown**
  - Plant Start-Up & Shakedown

- **Initial Full Scale Plant Operations**
  - Initial Full Scale Plant Operations

- **Full Scale Plant Operation Continues**
  - Site Monitoring

- **Site Monitoring**
  - Site Monitoring

**NETL**

Strakey - SECA - 09-13-06
**FutureGen Funds / Estimated Costs**

<table>
<thead>
<tr>
<th>Cost Elements</th>
<th>$ Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Definition, Baselining &amp; NEPA</td>
<td>81</td>
</tr>
<tr>
<td>Plant Procurement &amp; Construction</td>
<td>480</td>
</tr>
<tr>
<td>Shakedown &amp; Full-Scale Operation</td>
<td>188</td>
</tr>
<tr>
<td>Sequestration (Design &amp; Construction)</td>
<td>191</td>
</tr>
<tr>
<td>Site Monitoring</td>
<td>10</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$950</strong></td>
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**DOE**  620  
**Industry**  250  
**International**  80
FutureGen Status

- Industry-led cooperative project with government oversight & international participation
- Industry will choose project site, backbone technologies, etc.
- DOE has invited other nations to join FutureGen
- Gov’ts of India & South Korea have each pledged $10 Million
FutureGen Public Scoping Meetings

Jewett, TX – Aug. 22, 2006
Odessa, TX – Aug. 24, 2006
Tuscola, IL – Aug. 29, 2006
Mattoon, IL – Aug. 31, 2006
Visit the *FutureGen* Websites

- **NETL website:**
  - [www.netl.doe.gov](http://www.netl.doe.gov)

- **Office of Fossil Energy website:**
  - [ww.fe.doe.gov](http://ww.fe.doe.gov)

- **FutureGen Alliance website:**
  - [www.futuregenalliance.org](http://www.futuregenalliance.org)