Presentation Agenda

- FE Hydrogen Program
- FutureGen
- Carbon Sequestration Leadership Forum (CSLF)
Key Drivers

- Decreasing domestic supply will lead to increased imports from less stable regions
- Conventional petroleum is finite; production will peak and irreversibly decline due to continually increasing demand
- Improving environmental quality
  - Meeting air emission regulations
  - Greenhouse gas emissions

Tomorrow’s Hydrogen

Why is Hydrogen from Coal Important?

• 95% of U.S. hydrogen comes from natural gas;
• Future “Hydrogen Economy” must have more diversified sources;
• Over longer term, hydrogen will likely come from renewables, nuclear power, fusion, etc.

But coal can also be a major feedstock:

• Most abundant U.S. fossil fuel (250-yr supply)
• Can be environmentally clean source of hydrogen
• Coal-to-hydrogen costs must be lowered and affordable methods developed to sequester the “left behind” carbon
Tomorrow’s Energy Plant

Converting Coal into Gas is Key

- 99%+ of Clear Skies pollutants (sulfur/nitrogen/mercury) can be cleaned from gasified coal;
- Hydrogen is a primary product;
- Carbon gases are in concentrated form for easier capture and sequestration.

No coal-to-gas plant in the world today is configured to optimize hydrogen production or carbon capture.

The prototype plant would be the world’s 1st.
Key Goals of the Office of Fossil Energy Hydrogen Program

- **2010**: An alternative hydrogen delivery system will be optimized and available.
- **2011**: Modules to reduce the cost of hydrogen and synthesis gas production from natural gas by 25% will be available.
- **2012**: Zero emission plant that co-produces hydrogen and electric power, with sequestration, to reduce the cost of hydrogen from coal by 25% will be demonstrated.

The goals of the FE Hydrogen Program will drive the budget needs for the program.
Vision for Energy Plants of the Future

- Remove environmental concerns associated with the use of fossil fuels for production of electricity, transportation fuels and chemicals through technology

- Characteristics of future energy plants
  - “Near-zero” emissions (coal as clean as gas)
  - CO₂ sequestration ready
  - Flexible (feed stocks, co-products, siting)
  - Highly energy efficient
  - Affordable (competitive with other energy options)
  - Industrial Ecology (waste into by-products)
  - Reduced water requirements
  - Timely deployment of new technology
  - Sustainable
Confluence of Presidential Initiatives

- Hydrogen Fuel Initiative
- Clear Skies Initiative
- Global Climate Change Initiative

Integrated Sequestration, Hydrogen and Energy Research Initiative
What is FutureGen?

- The world’s first plant [prototype] to:
  - Capture and permanently sequester carbon dioxide
  - Emit virtually no air pollutants [zero emissions]
  - Pioneer advanced processes to produce hydrogen from coal

- FutureGen announced on 27 February 2003
  - President Bush
  - Energy Secretary Abraham

http://fossil.energy.gov/techline/tl_cslf_print.html
http://fossil.energy.gov/techline/tl_futuregen1_print.html
http://fossil.energy.gov/events/speeches/03_sec_futuregen_022703.shtml
Goals of the Project

- Design, construct and operate a prototype plant that produces electricity and hydrogen with near-zero emissions
- Sequester at least 90% of the CO\textsubscript{2} emissions
- Prove the effectiveness, safety and permanence of CO\textsubscript{2} sequestration
- Establish technology standards and protocols for CO\textsubscript{2} measuring, monitoring and verification
- Validate the engineering, economic and environmental viability of advanced coal-based, near-zero emission technologies for commercial readiness in 2015
Features of the Project

- Coal-fueled gasification process that produces electricity and hydrogen—275 MW$_{e}$ [net equivalent output]
- Commercial scale of 1 million tons per year of CO$_2$ captured and sequestered
- Total project cost estimated at $1 billion
- Cost-shared by U. S. Department of Energy [maximum 80%] and industry [minimum 20%]
- Open to international participation through the Carbon Sequestration Leadership Forum
Project Concept

- Refinery
- Hydrogen
- CO₂
- Enhanced Oil Recovery
- Geological Sequestration
- FutureGen
- Electricity
- Oil
- And/Or

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FutureGen Systems

Oxygen

Gasification

Gas Cleaning

Power

Transportation

Coal

Oxygen Membrane

Gasifier

Gas Stream Cleanup

H₂/CO₂ Separation

H₂

Fuels and Chemicals

Fuel Cell Vehicles

High Efficiency Turbine

Fuel Cell

Process Heat/Steam

Electricity

Fuel Cell Vehicles

Coal Seams

Saline Reservoir

Enhanced Oil Recovery

Products/Byproducts Utilization

CO₂ Sequestration

Oxygen

Fuel

Gasification

Gas Cleaning

Byproducts Utilization

Coal

Oxygen Membrane

Gasifier

Gas Stream Cleanup

H₂/CO₂ Separation

H₂

Fuels and Chemicals

Fuel Cell Vehicles

High Efficiency Turbine

Fuel Cell

Process Heat/Steam

Electricity

Coal Seams

Saline Reservoir

Enhanced Oil Recovery

Products/Byproducts Utilization

CO₂ Sequestration

Oxygen

Fuel
FutureGen Process

Project Definition
1. Domestic [U.S.]
2. International

Integration
FutureGen
- First-of-kind integrated project
- Verify large-scale operation
- Highlight best technology options
- Verify performance and permanence
- Develop cost and performance data
- International showcase
U. S. Carbon Sequestration Program

Core Research and Development
- Capture CO₂
- Sequestration
  - Direct CO₂ storage
  - Enhanced natural sinks
- Integration

Breakthrough Concepts
- Measurement Monitoring & Verification
- Non-CO₂ GHG Mitigation

Infrastructure
- Regional Partnerships
  - Engage regional, state, local government entities
  - Determine benefits of sequestration to region
  - Baseline region for sources and sinks
  - Establish monitoring and verification protocols
  - Address regulatory, environmental, outreach issues
  - Test sequestration technology at small scale

FutureGen
Integrated Sequestration, Hydrogen and Energy Research Initiative
Why Capture CO₂ and Store It?

- Has the potential to remove enough carbon to stabilize CO₂ concentrations in the atmosphere
- Maintains the role of domestic fossil fuel resources in the Nation’s energy future for transportation and power generation
- Has the potential to be the lowest cost carbon management option

World CO₂ Emissions
(Million Metric Tones Carbon Equivalent)

CO₂ Capture and Storage

Advanced Concepts

Geologic Sequestration

Ocean Sequestration

Capture and Store < 10% Increase in Cost of Energy

Sources: Derived From NETL & IEA Illustrations
Carbon Sequestration Leadership Forum—
More Than FutureGen

- **Weyburn CO₂ Enhanced Oil Recovery Project**
  - Validate the capacity, movement and fate of CO₂ used in enhanced oil recovery in Saskatchewan, Canada

- **Sleipner North Sea Project**
  - Norwegian project to strip CO₂ from natural gas extracted from a production well and re-inject the CO₂ into the Utrisa formation – a saline aquifer 1,000 meters underneath the sea bed

- **CO₂ Capture Project**
  - The CO₂ Capture Project is an international effort funded by nine of the world's leading energy companies. This project intends to address the issue of reducing emissions in a manner that will contribute to an environmentally acceptable and competitively priced continuous energy supply for the world
Example: Weyburn CO₂ EOR Project

- Approximately 650 production and water injection wells on a 70-square mile oil field operated by EnCana Resources.
- A 20-year enhanced oil recovery (EOR) project begun in 2000 using CO₂ from a 200-mile CO₂ pipeline from Dakota Gasification Plant—$20.5 million cooperative agreement with Canadian Federal and Saskatchewan Provincial Governments. Provides for 130 million barrels of oil and storage of about 20 million metric tons of CO₂ over 20-year lifetime.
- US (DOE), EU, Japan, Alberta Government, private companies (e.g., BP, Chevron-Texaco, etc.) have joined, providing another $20 million. IEA CO₂ Monitoring and Storage Project coordinated by 20 research organizations in the US, UK, Canada, France, and Italy.
Example: Sleipner North Sea Project

- CO₂ stripped from natural gas produced at Statoil’s Sleipner gas field in the North Sea and injected into a sand layer called the Utrisa formation, some 1,000 meters under the sea bed.

- Project, begun in 1996, is the first commercial application of CO₂ storage on deep saline aquifers in the world. At today’s production rate, about 1 million metric tons of CO₂ is extracted annually.

- The Saline Aquifer CO₂ Storage (SACS) Project to monitor the injected CO₂ established in 1998, and includes participation from Norway, U.S, EU, The Netherlands, Denmark, UK, Australia, Canada, Japan, and industrial partners.
Example: CO₂ Capture Project

- Is a joint project comprising nine (PanCanada) of the world's leading energy companies.
- Aims to reduce the cost of CO₂ capture from combustion sources.
- Is developing methods for safely storing CO₂ underground.
- Is working together with governments, NGO's, and other stakeholders to deliver technology that is cost-effective and meets the needs of society.
- CO₂ capture and geologic storage are bridging technologies that will help move society towards cleaner fuels in the future.
- Technologies developed by this project will be used in many different industries and applications around the world.

http://www.co2captureproject.org/overview/overview.htm
Web Sites For Additional Information

GENERAL
www.fe.doe.gov
www.netl.doe.gov
www.eia.doe.gov
www.epa.gov
www.climatescience.gov

SPECIFIC
http://fossil.energy.gov/techline/tl_cslf_print.htm
http://fossil.energy.gov/techline/tl_futuregen1_print.html
http://fossil.energy.gov/events/speeches/03_sec_futuregen_022703.shtml

http://www.netl.doe.gov/coalpower/sequestration/index.html