FutureGen

Technologies for Carbon Capture and Storage and Hydrogen and Electricity Production

Office of Fossil Energy

U. S. Department of Energy

Washington, DC

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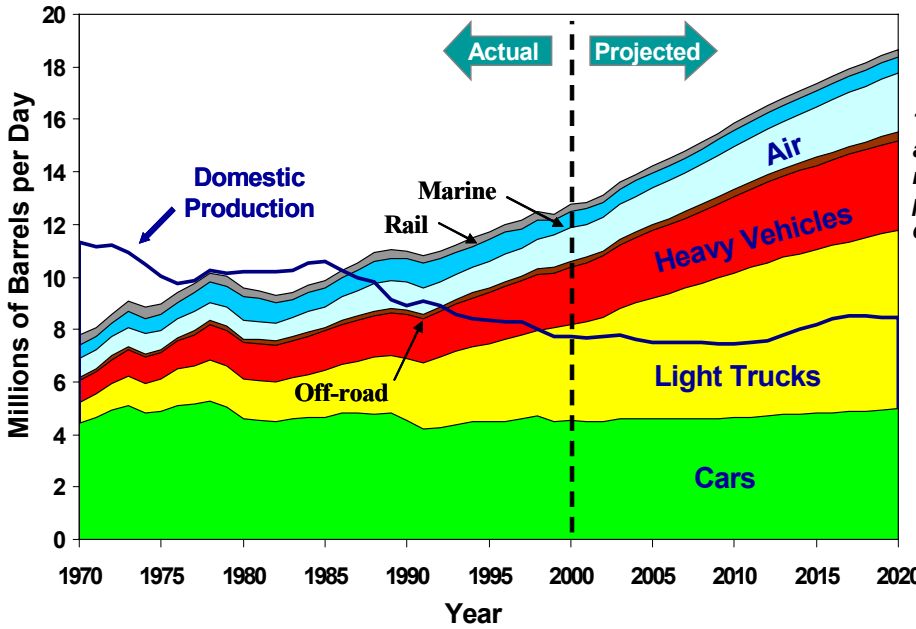
Presentation Agenda

- 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



Transportation alone now uses more oil than is produced domestically

Source: Transportation Energy Data Book: Edition 21, DOE/ORNL-6966, September 2001, and EIA Annual Energy Outlook 2002, DOE/EIA-0383(2002), December 2001

Tomorrow's Hydrogen

Why is Hydrogen from Coal Important?

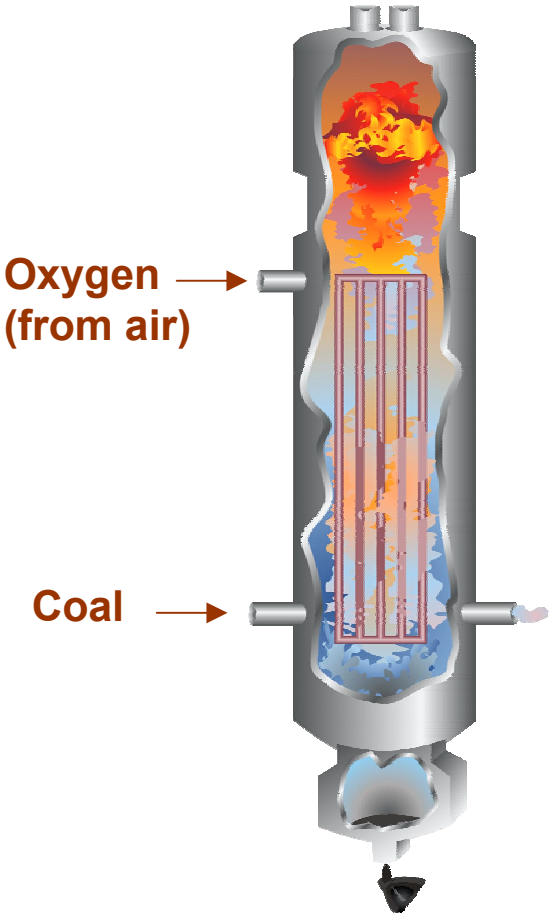
- 95% of U.S. hydrogen comes from natural gas;
- Future "Hydrogen Economy" must have more diversified sources;
- Over longer term, hydrogen will likely come from renewables, nuclear power, fusion, etc.

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.

→ Hydrogen + Carbon Gases (CO_2, CO)

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

2011 An alternative hydrogen delivery system will be optimized and available

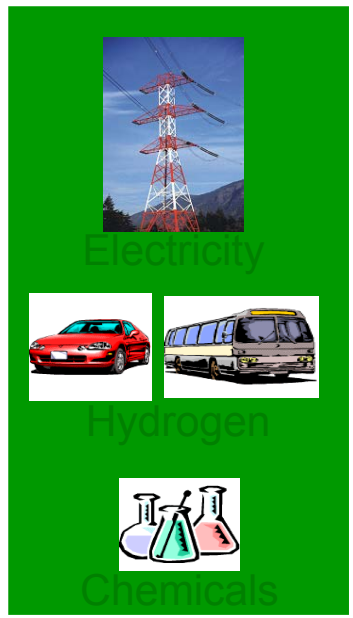
2013 Modules to reduce the cost of hydrogen and synthesis gas production from natural gas by 25% will be available

2015 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)
  - CO_2 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

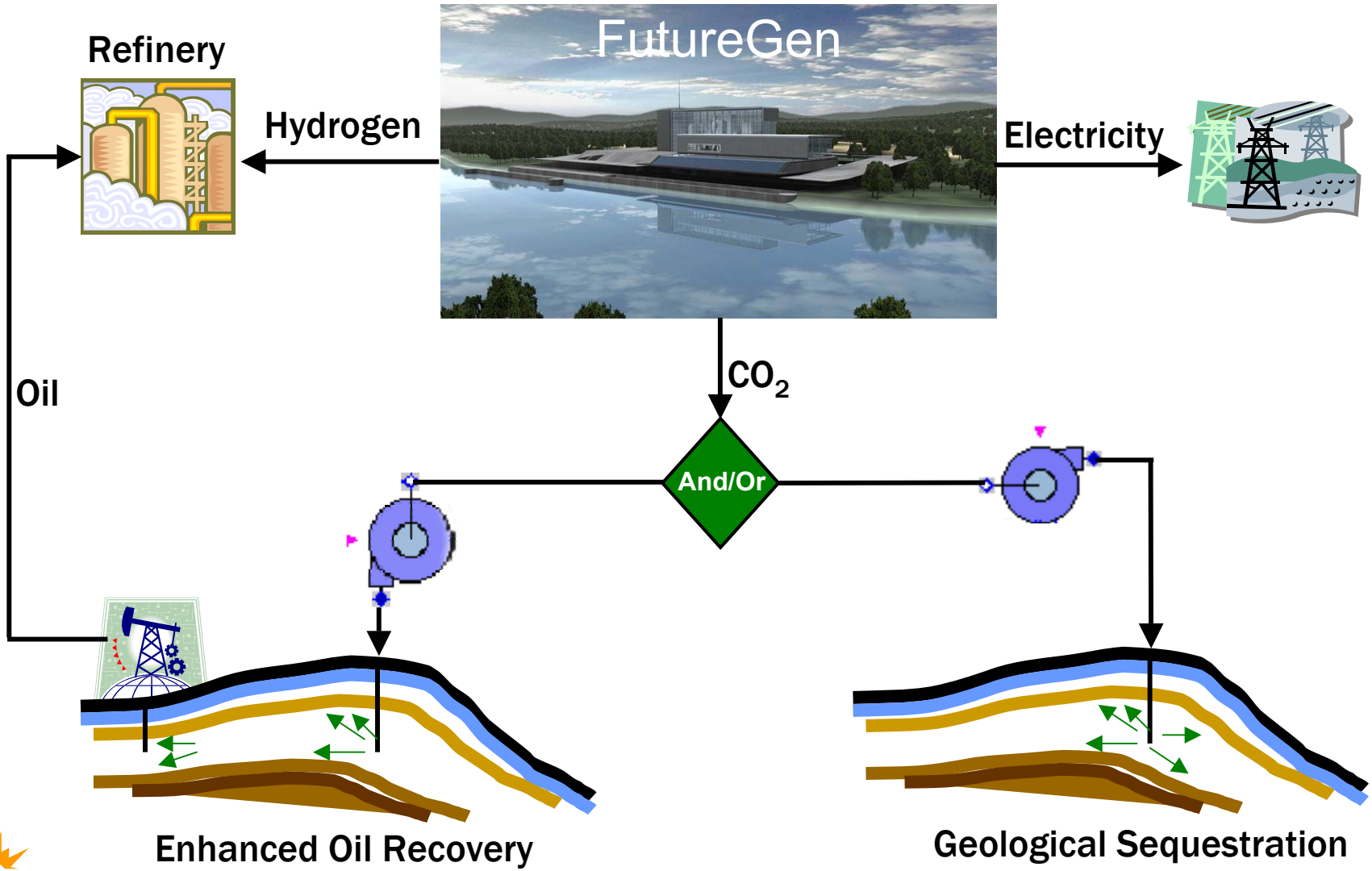
Goals of the Project

- Design, construct and operate a prototype plant that produces electricity and hydrogen with near-zero emissions
- Sequester at least 90% of the CO_2 emissions
- Prove the effectiveness, safety and permanence of CO_2 sequestration
- Establish technology standards and protocols for CO_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



FutureGen Systems

FutureGen Process

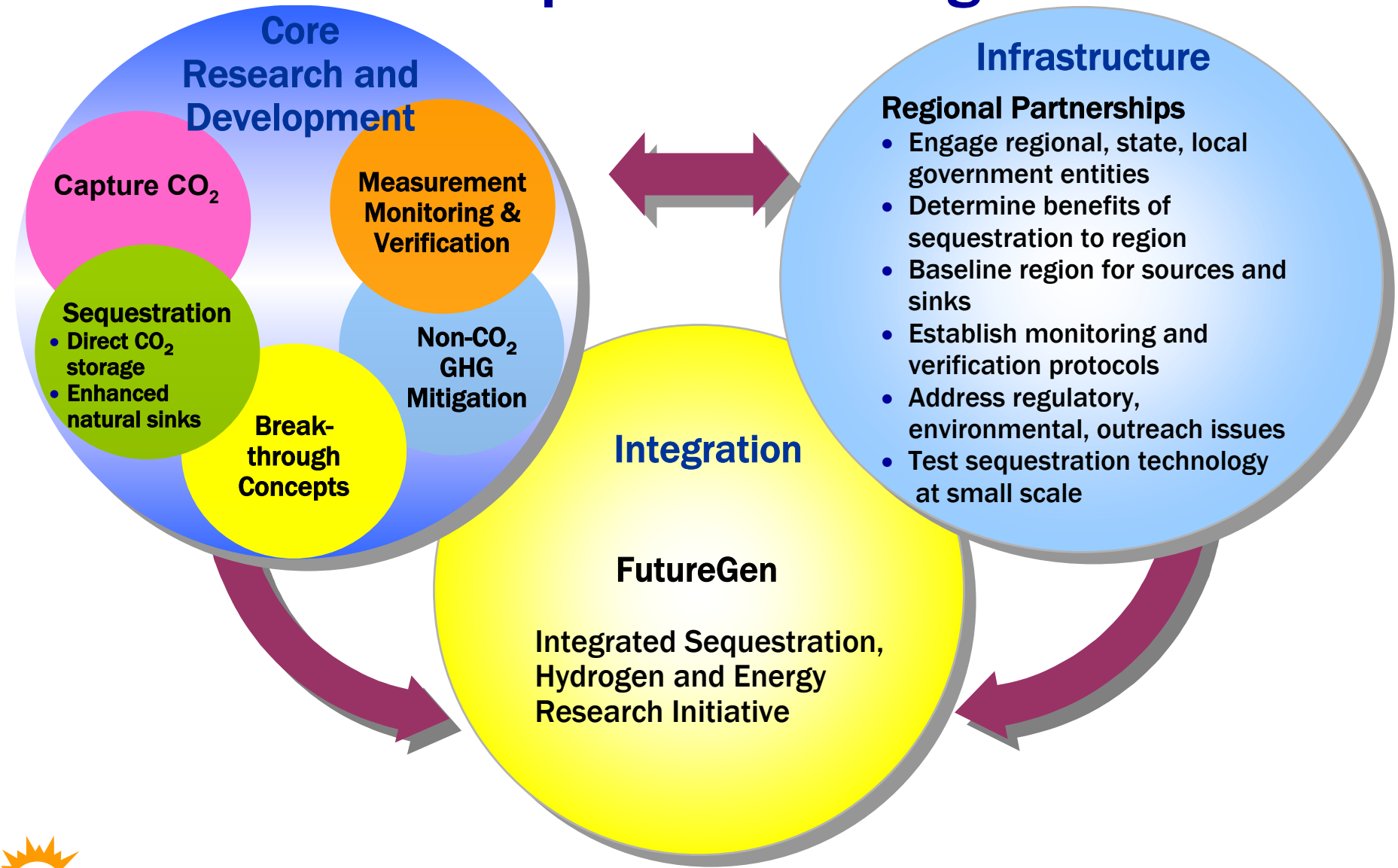
Project Definition
1. Domestic [U.S.]
2. International

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

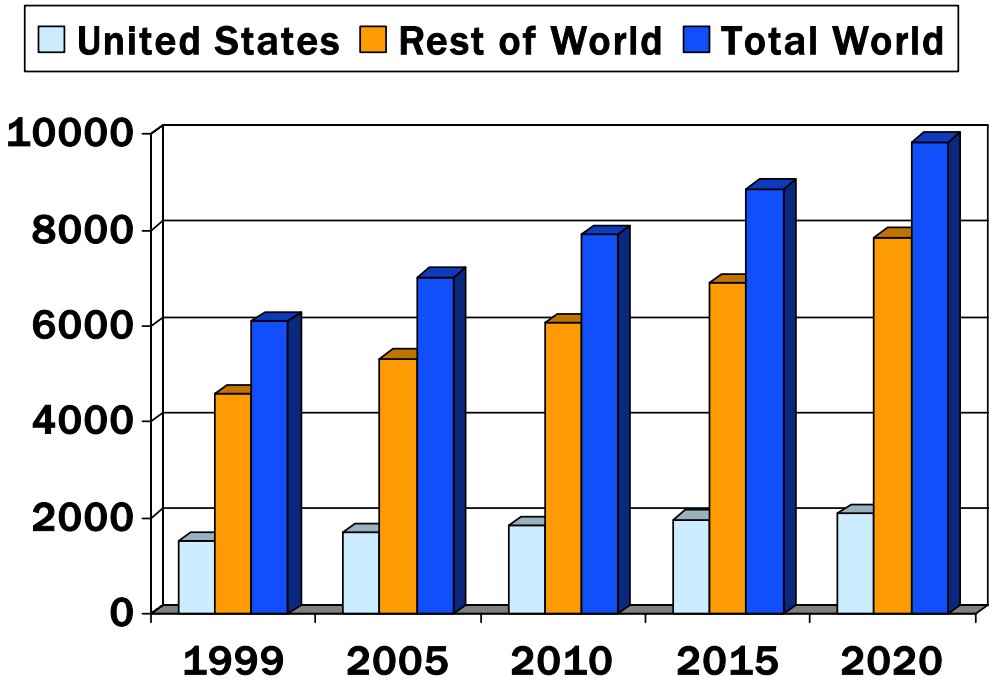


Why Capture CO_2 and Store It?

- Has the potential to remove enough carbon to stabilize CO_2 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

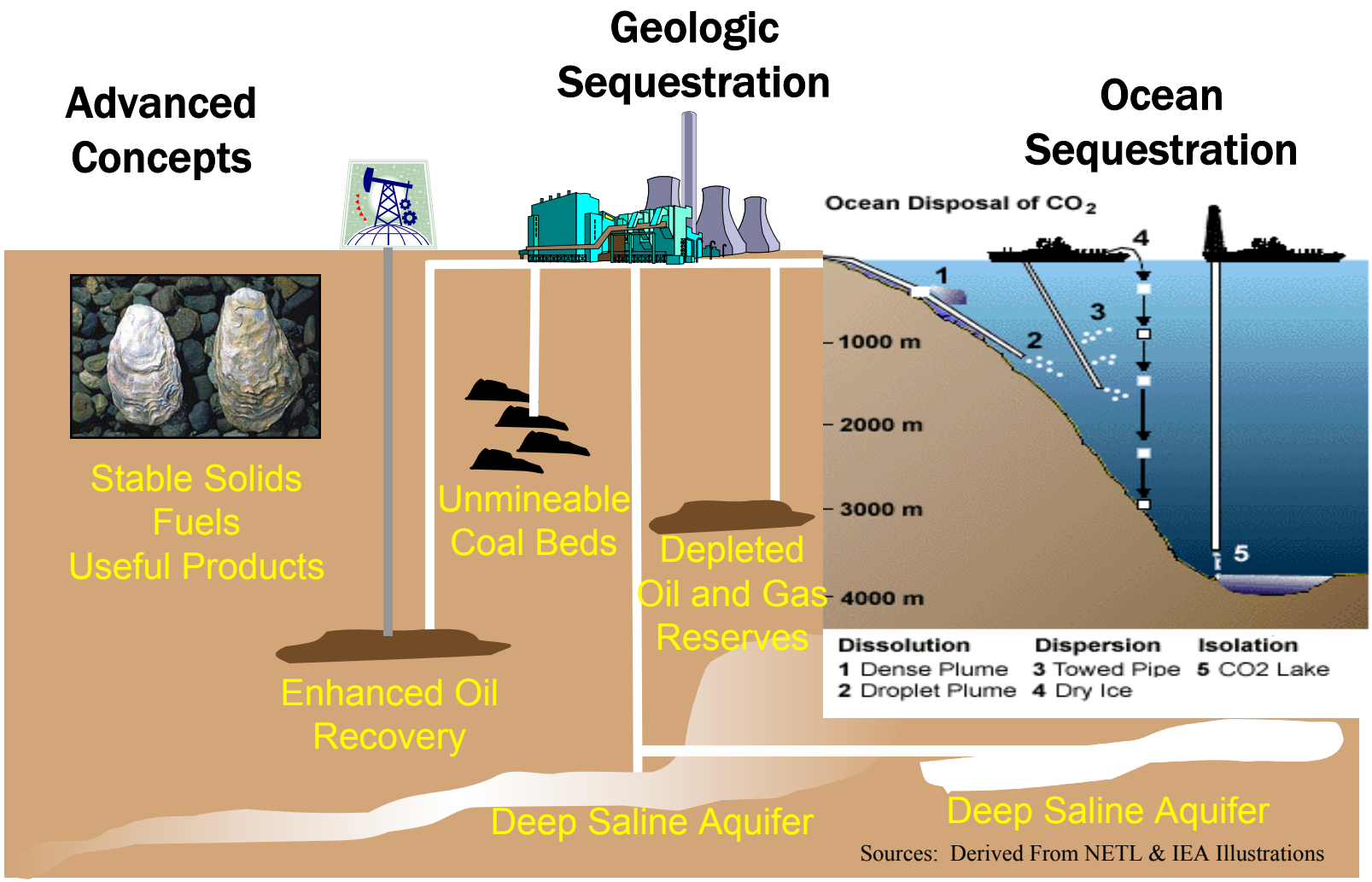
World CO_2 Emissions

(Million Metric Tones Carbon Equivalent)



Source: *International Energy Outlook 2002*, Energy Information Administration, Table A-10, p. 189

CO_2 Capture and Storage



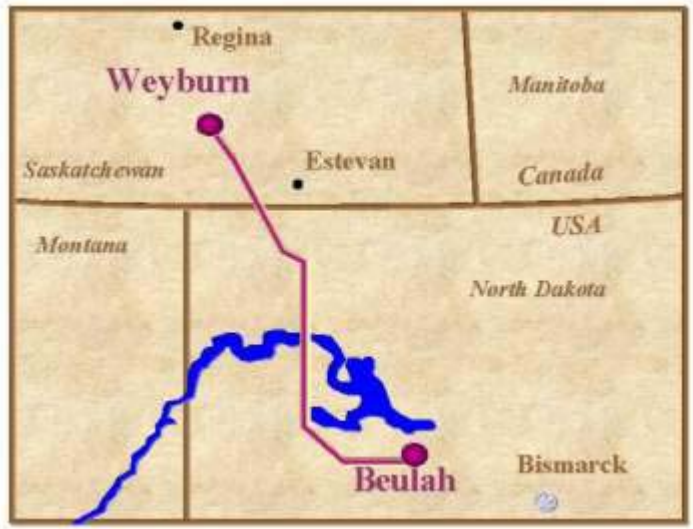
Capture and Store < *10% Increase in Cost of Energy*

Carbon Sequestration Leadership Forum—More Than FutureGen

- **Weyburn CO_2 Enhanced Oil Recovery Project**
  - Validate the capacity, movement and fate of CO_2 used in enhanced oil recovery in Saskatchewan, Canada
- **Sleipner North Sea Project**
  - Norwegian project to strip CO_2 from natural gas extracted from a production well and re-inject the CO_2 into the Utrisa formation –a saline aquifer 1,000 meters underneath the sea bed
- **CO_2 Capture Project**
  - The CO_2 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

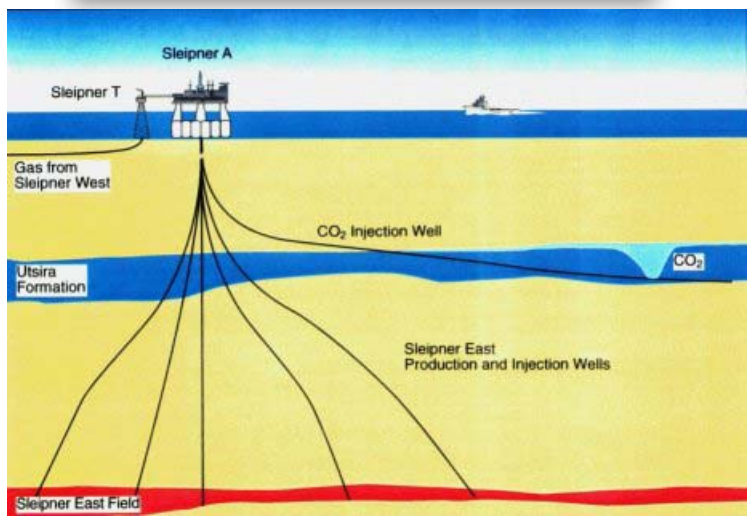
Example: Weyburn CO_2 EOR Project

- 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 CO_2 from a 200-mile CO_2 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 CO_2 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 CO_2 Monitoring and Storage Project coordinated by 20 research organizations in the US, UK, Canada, France, and Italy.



Example: Sleipner North Sea Project

- CO_2 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 CO_2 storage on deep saline aquifers in the world. At today's production rate, about 1 million metric tons of CO_2 is extracted annually.
- The Saline Aquifer CO_2 Storage (SACS) Project to monitor the injected CO_2 established in 1998, and includes participation from Norway, U.S, EU, The Netherlands, Denmark, UK, Australia, Canada, Japan, and industrial partners.



Example: CO_2 Capture Project

- Is a joint project comprising nine (PanCanada) of the world's leading energy companies.
- Aims to reduce the cost of CO_2 capture from combustion sources.
- Is developing methods for safely storing CO_2 underground.
- Is working together with governments, NGO's, and other stakeholders to deliver technology that is cost-effective and meets the needs of society.
- CO_2 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.html
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