DOE Hydrogen Program Review

Reviewing the first year of the President's Hydrogen Fuel Initiative

Hydrogen from Fossil Fuels

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Steps Taken on Path to Implementing Hydrogen Initiative

- Organizationally combined Program Offices for Hydrogen from Coal and Carbon Capture and Storage
- Restructured and focused existing R&D Program to be responsive to new and existing coal R&D priorities
- Completed series of workshops and discussions leading to the drafting of an R&D Program Plan — “Hydrogen from Coal”
- Distributed revised Sequestration Program Roadmap

Observation by the National Research Council*

- Fossil fuels will be one of the principal sources of hydrogen for the hydrogen economy
- Carbon capture and storage technologies will be required for successful utilization of fossil fuels in production of hydrogen
- Coupling between Hydrogen Program and Carbon Capture and Storage Program will be tightened

* Report — National Academy of Engineering, National Research Council, “The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs,” February 2004

Hydrogen from Natural Gas and Coal Programs are Linked by Similar Technology

- Novel and advanced technologies required to improve the efficiency of hydrogen production are similar or the same for both resources. These technologies include:
  - Development of ceramic membrane reactors, which would supply oxygen or synthesis gas and would eliminate the need for costly cryogenic oxygen plants
  - Membrane separation technology to separate hydrogen from synthesis gas
  - Technology development from associated coal programs can be utilized in natural gas (e.g., sequestration of CO_2)

Why Coal?

- NRC Study Recommendations*

Recommendation 8-3. Coal should be a significant component of any domestic R&D program aimed at producing large quantities of hydrogen for a possible U.S. hydrogen economy

Recommendation 8-4. Because there are a number of similarities between the integrated gasification combined-cycle process and the coal-to-hydrogen process, the committee endorses the continuation of both programs in tandem at budget levels that are determined to be adequate to meet the programs goals

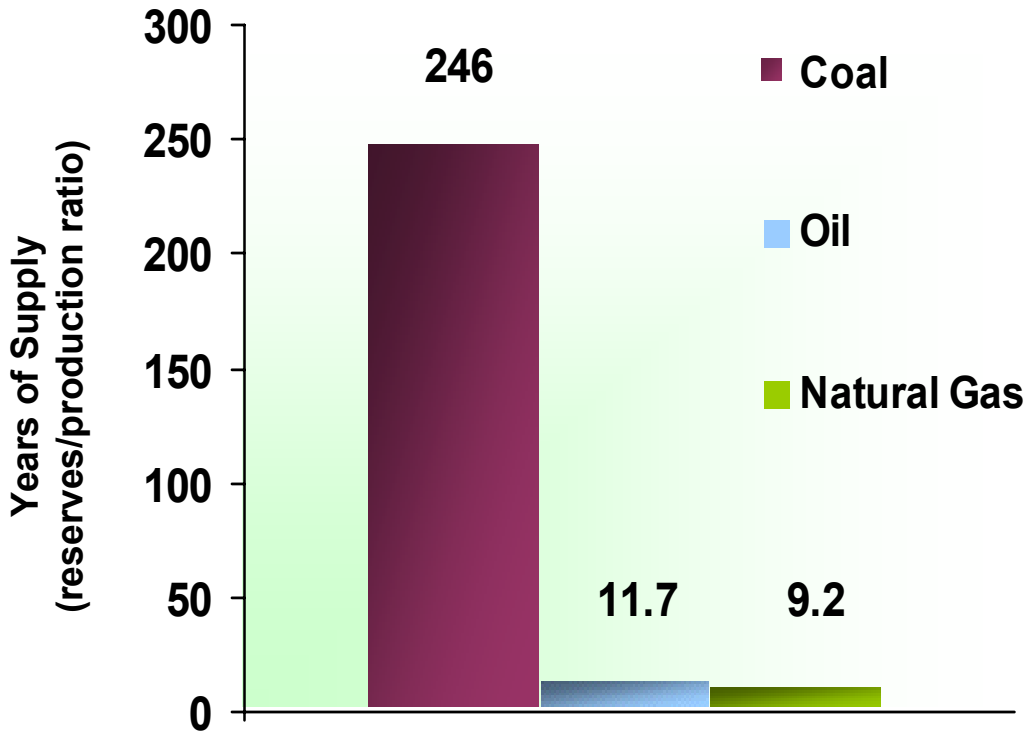
Recommendation 8-5. The committee commends the Department of Energy on its initiative in undertaking the FutureGen Project and recommends that the DOE move ahead with the project because of its promise of demonstrating coal-to-hydrogen production coupled with sequestration at a significant scale and its use as a large-scale testbed for related process improvements

* National Academy Of Engineering, National Research Council Report, "The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs," February 2004

Why Coal?

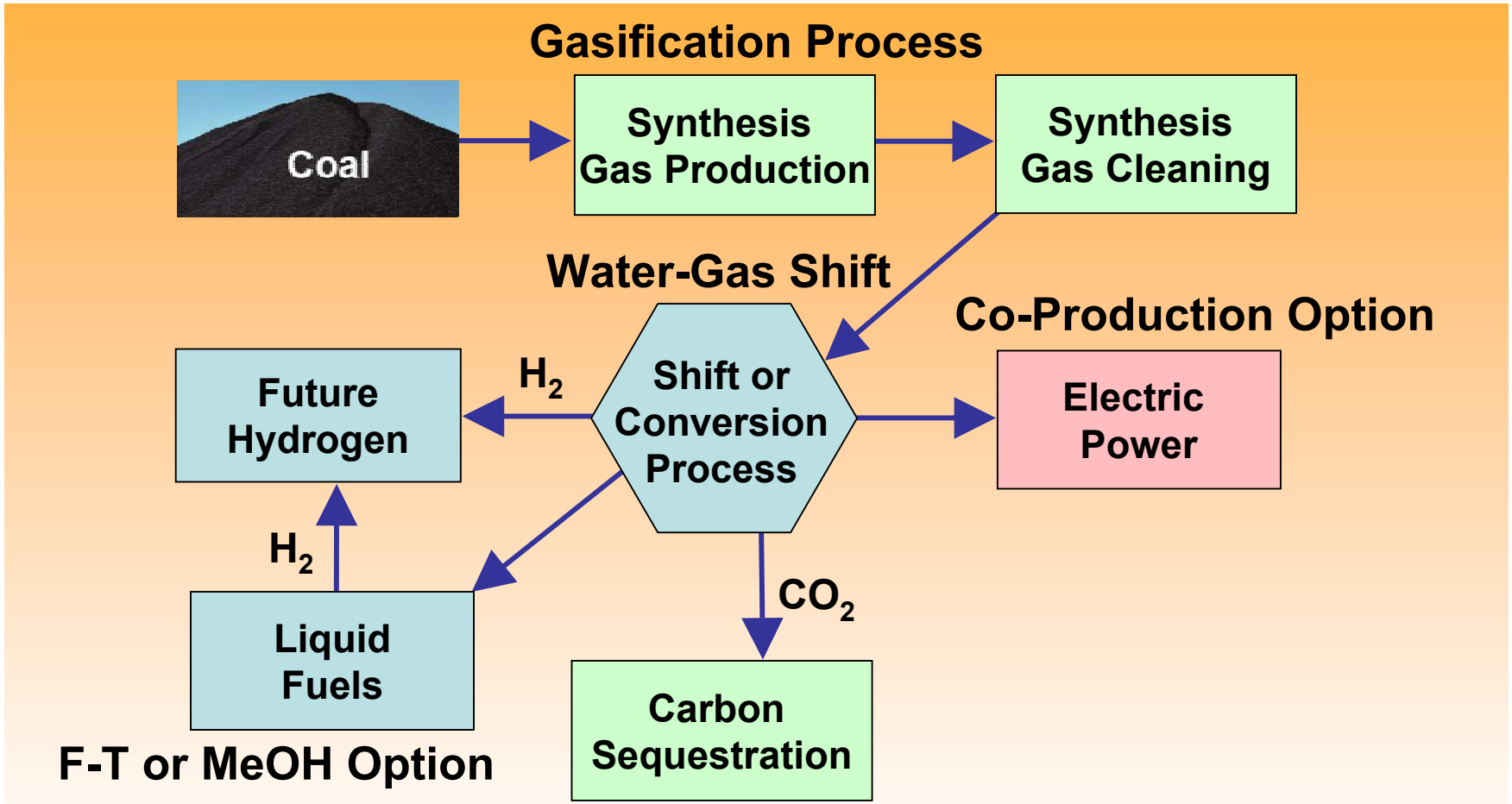
- Abundant reserves
- Low and stable prices
- Technology improvements
  - Could enable near-zero emissions of air pollutants/GHGs

U.S. Fossil Fuel Reserves/Production Ratio



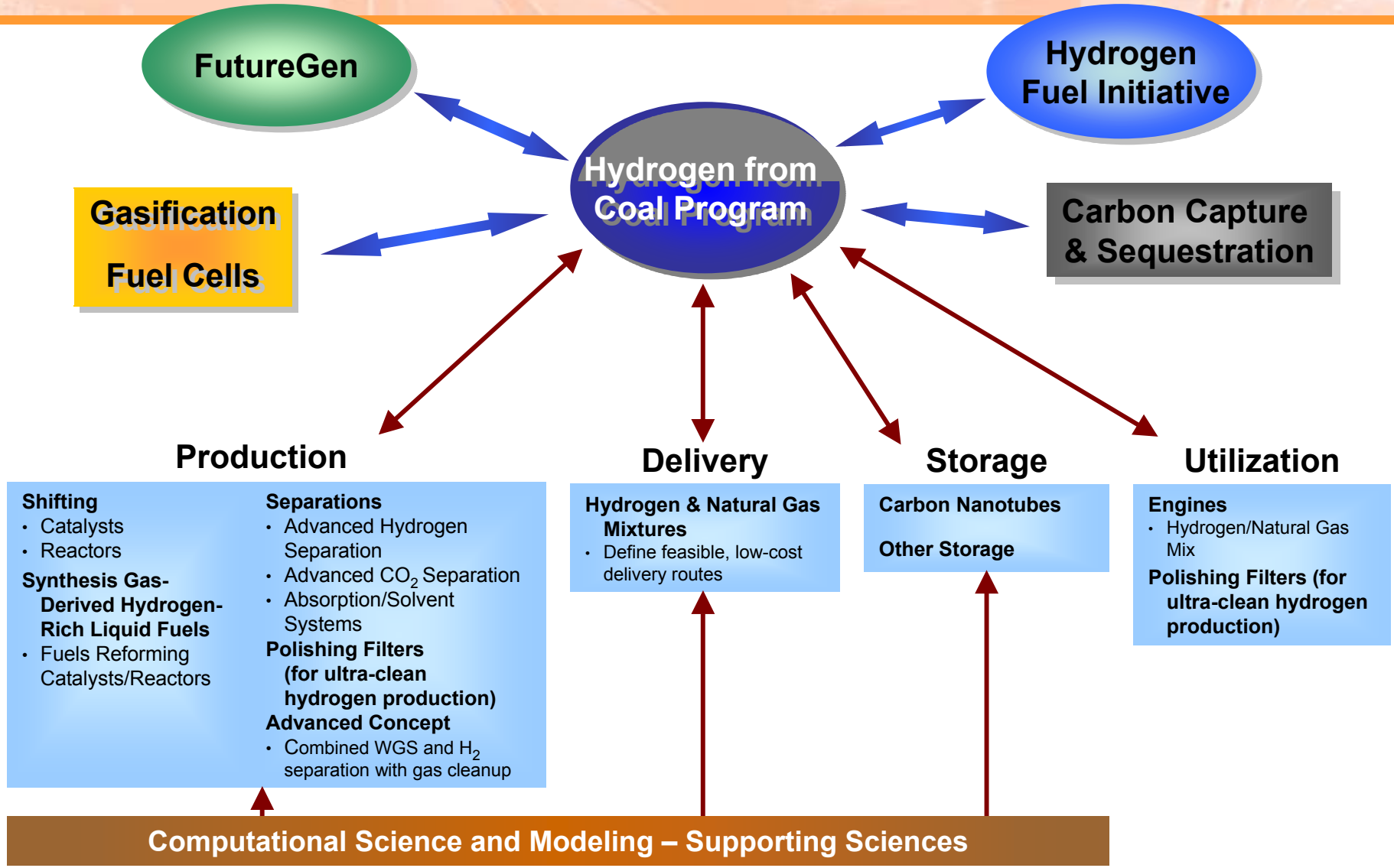
EIA-U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves: 2001 Annual Report, November 2002;
Coal: BP Statistical Review, June 2002, World Energy Council

Hydrogen is Cleanly Produced from Coal through Gasification

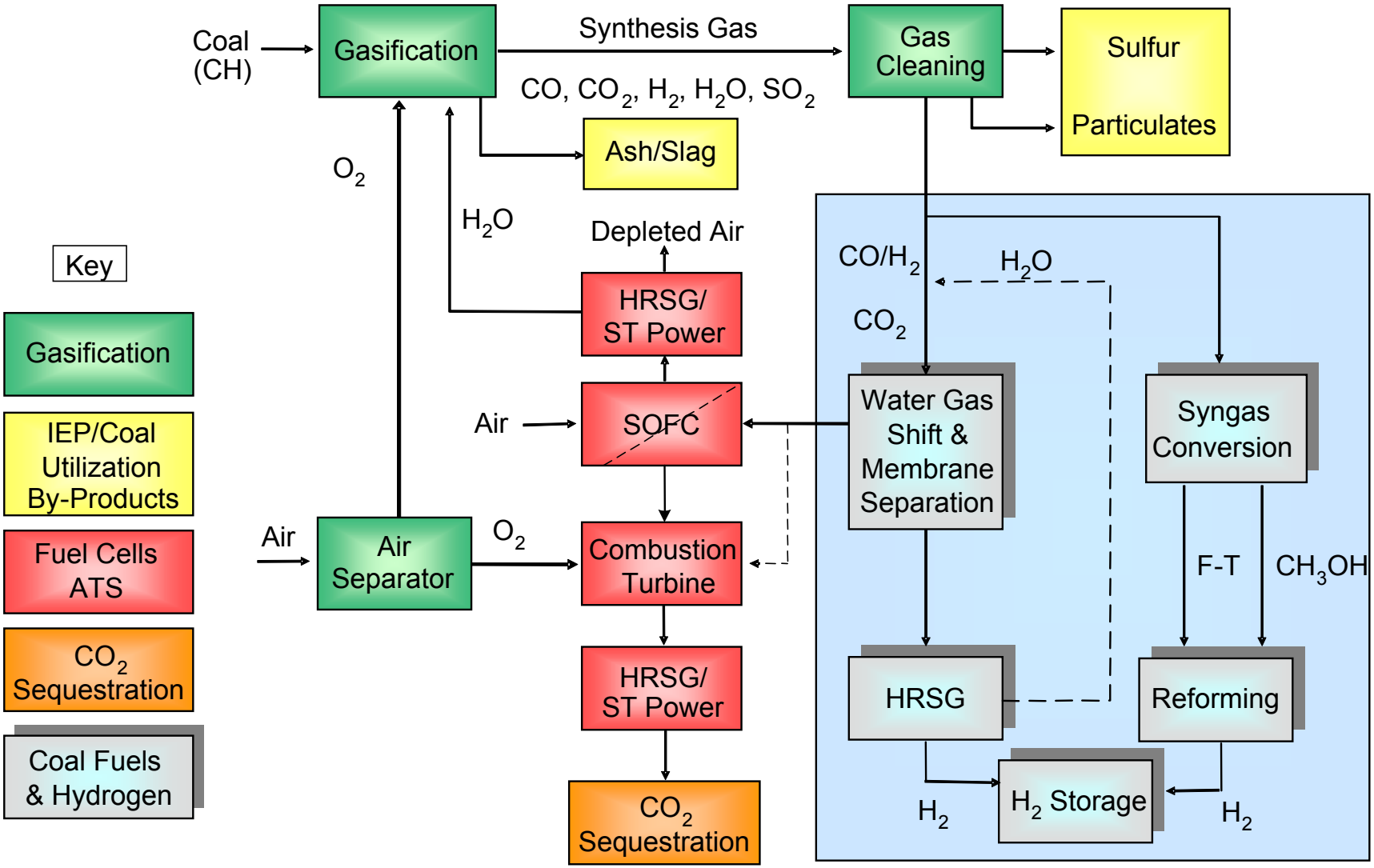


IGCC plants provide the option for efficient hydrogen production with the ability to co-produce electricity and clean liquid fuels.

The Hydrogen from Coal Program



Hydrogen from Coal Program Components and Product Areas

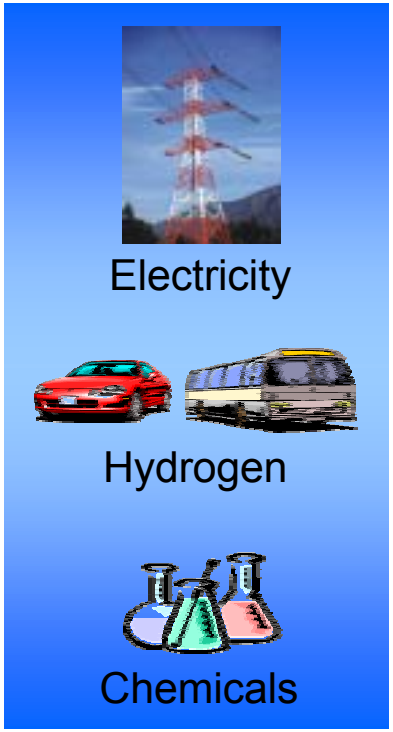


Hydrogen from Coal Program Elements

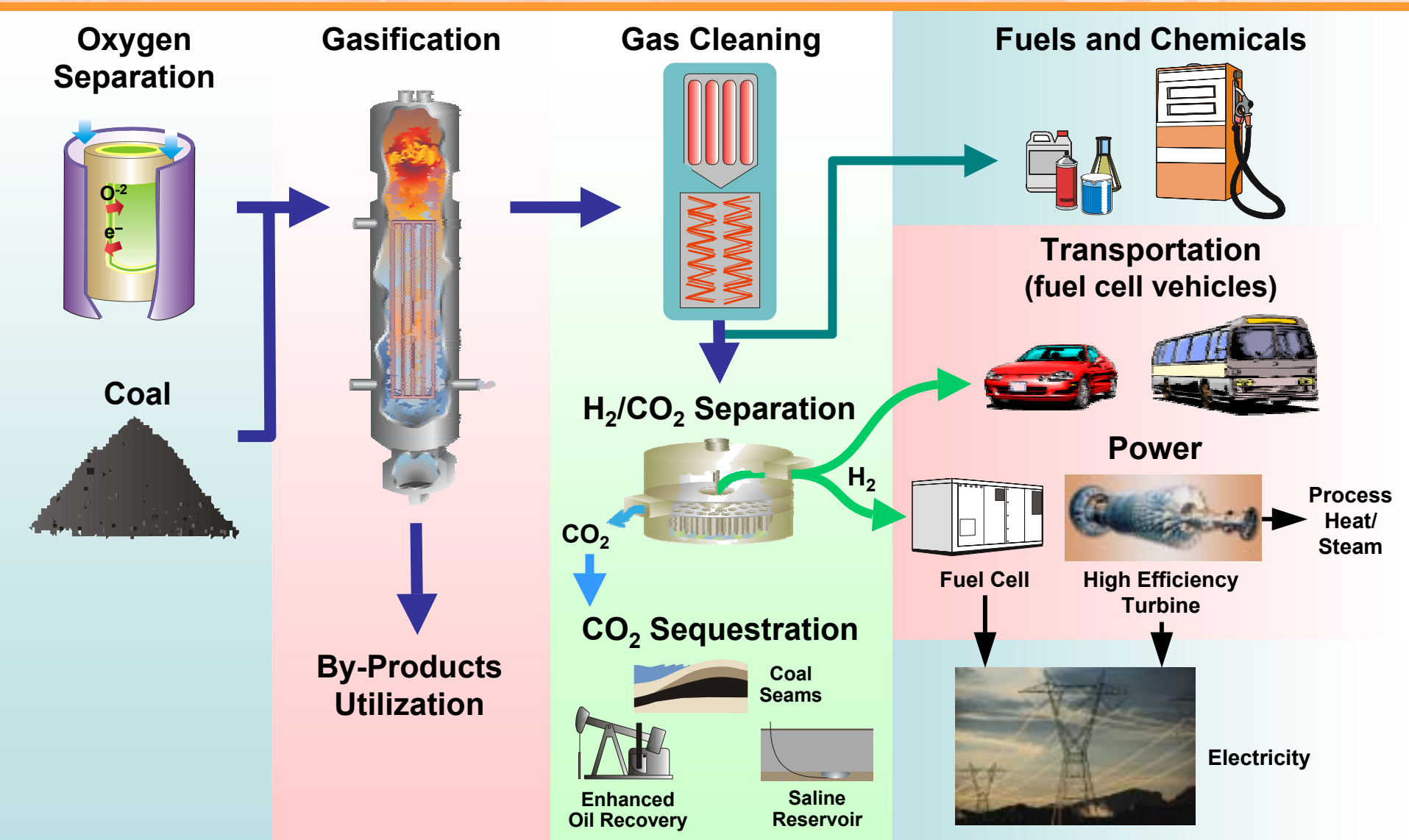
- Advanced water-gas shift
- Advanced separation systems
  - Hydrogen membrane separations
    - Microporous membranes
    - Palladium metallic
    - Dense Ceramic
  - Advanced CO_2 Separation
    - CO_2 separation membrane system
    - CO_2 hydrate separation system
    - Other systems
  - Absorption/solvent separation systems
- Ultra-clean hydrogen purification
- Advanced concepts
  - Integrated gas cleanup, water-gas shift, and hydrogen separation systems

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

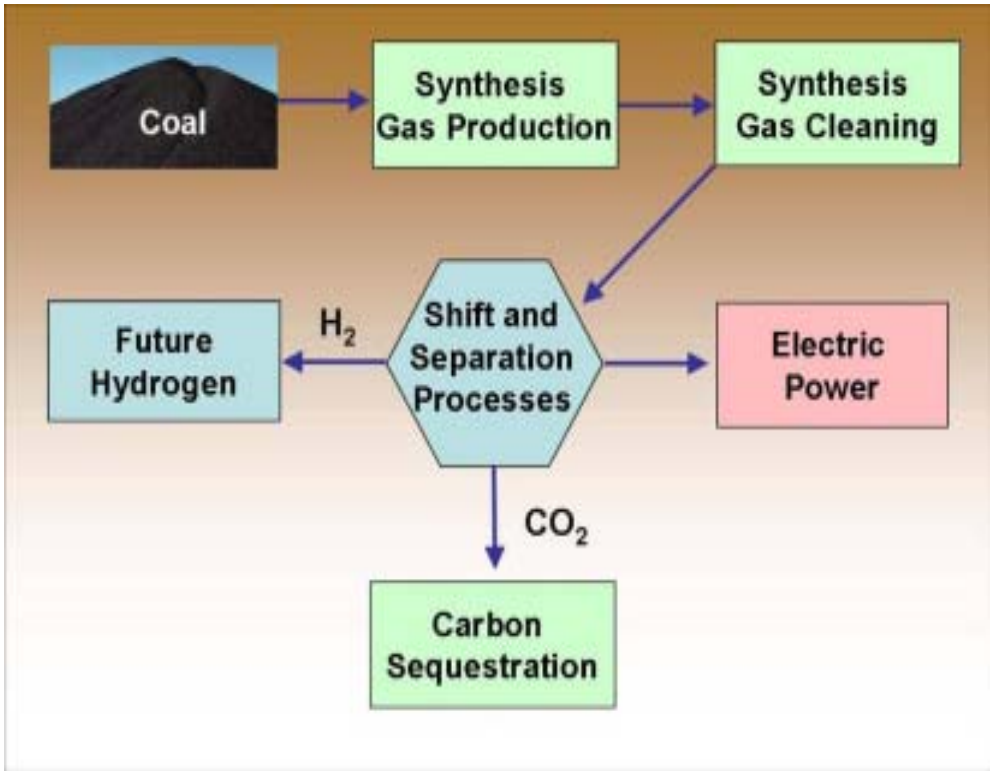


FutureGen Systems



FutureGen – Tomorrow's Energy Plant

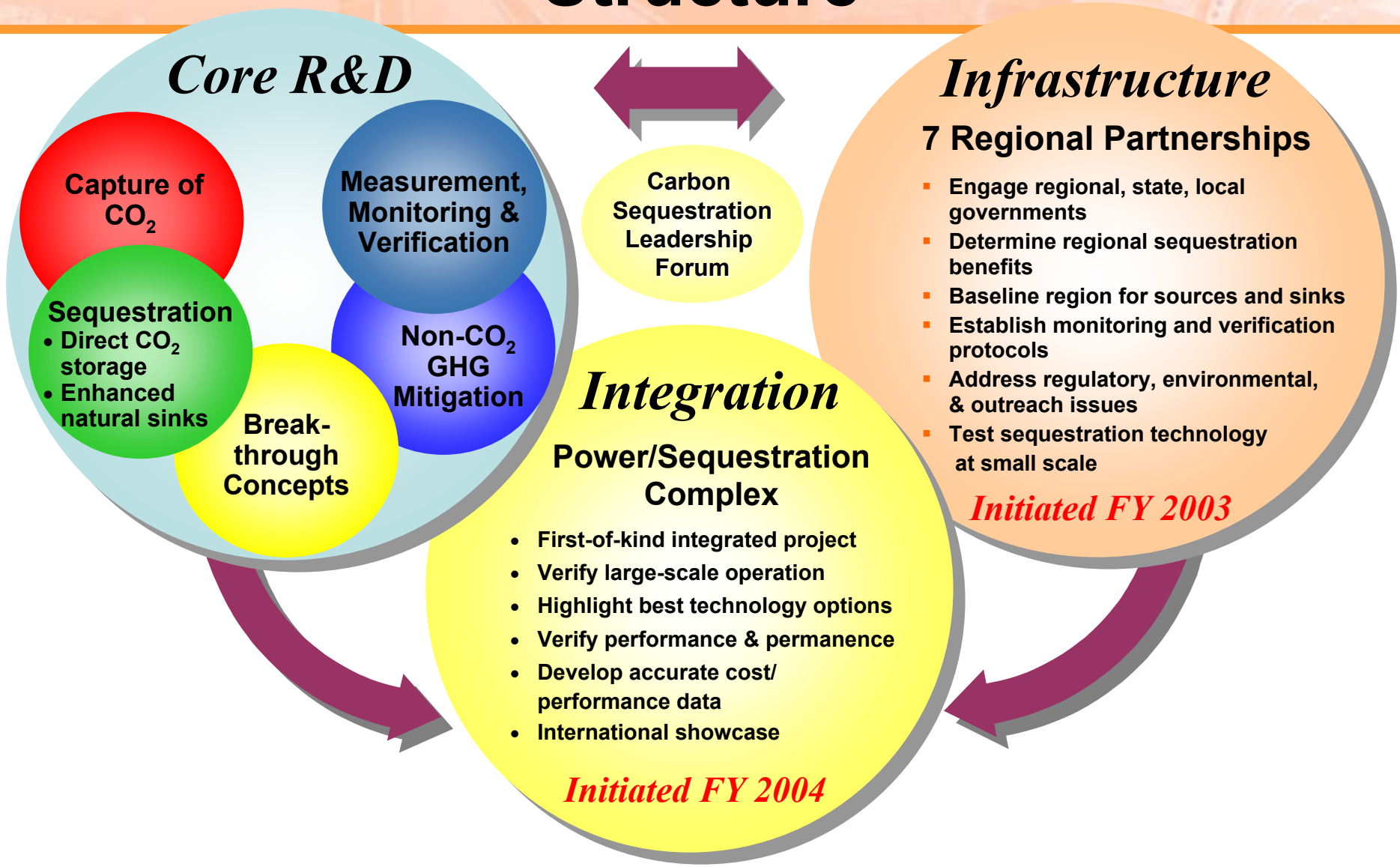
The World's First Power Plant to:



- Pioneer advanced hydrogen production from coal
- Emit virtually no air pollutants
- Capture and permanently sequester carbon dioxide

Objective: An international test facility for breakthrough technologies that address 3 Presidential initiatives:
(1) Hydrogen, (2) Clear Skies, (3) Climate Change Technology

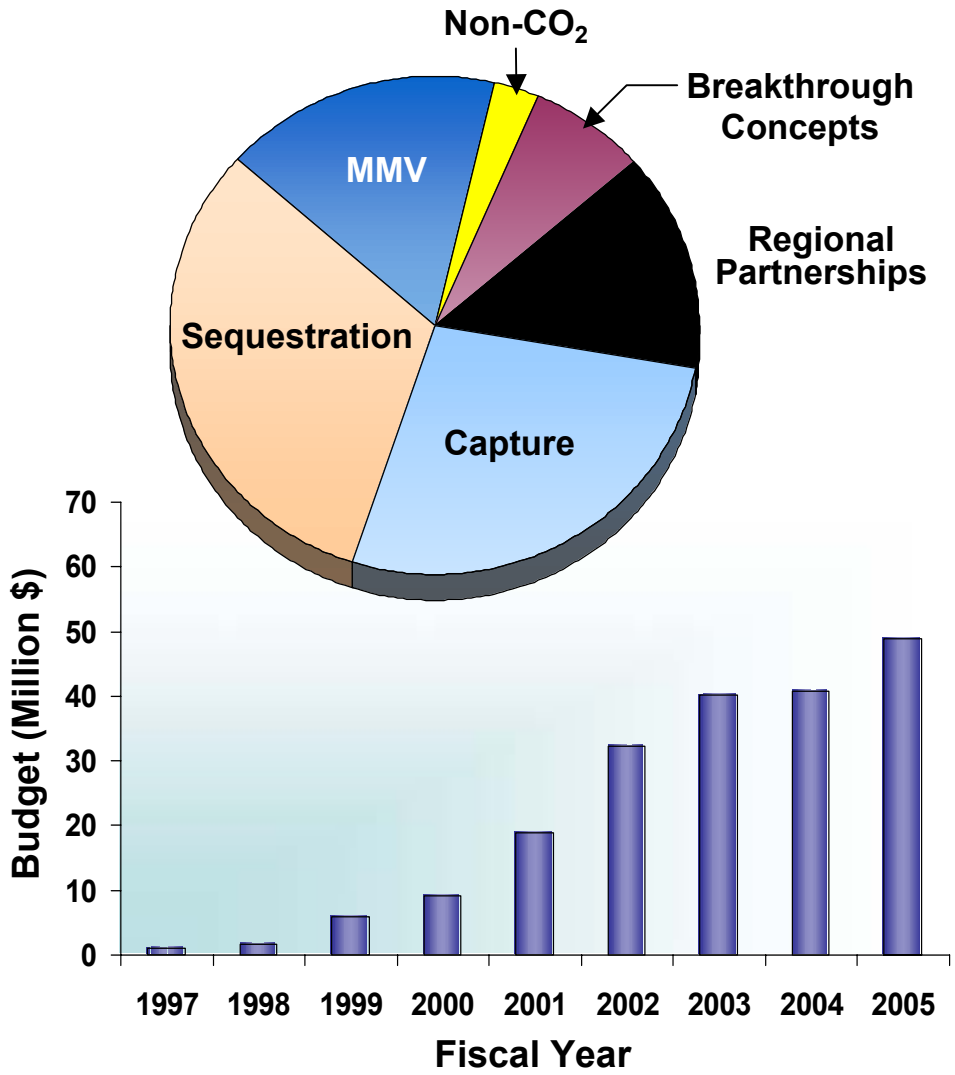
Carbon Sequestration Program Structure



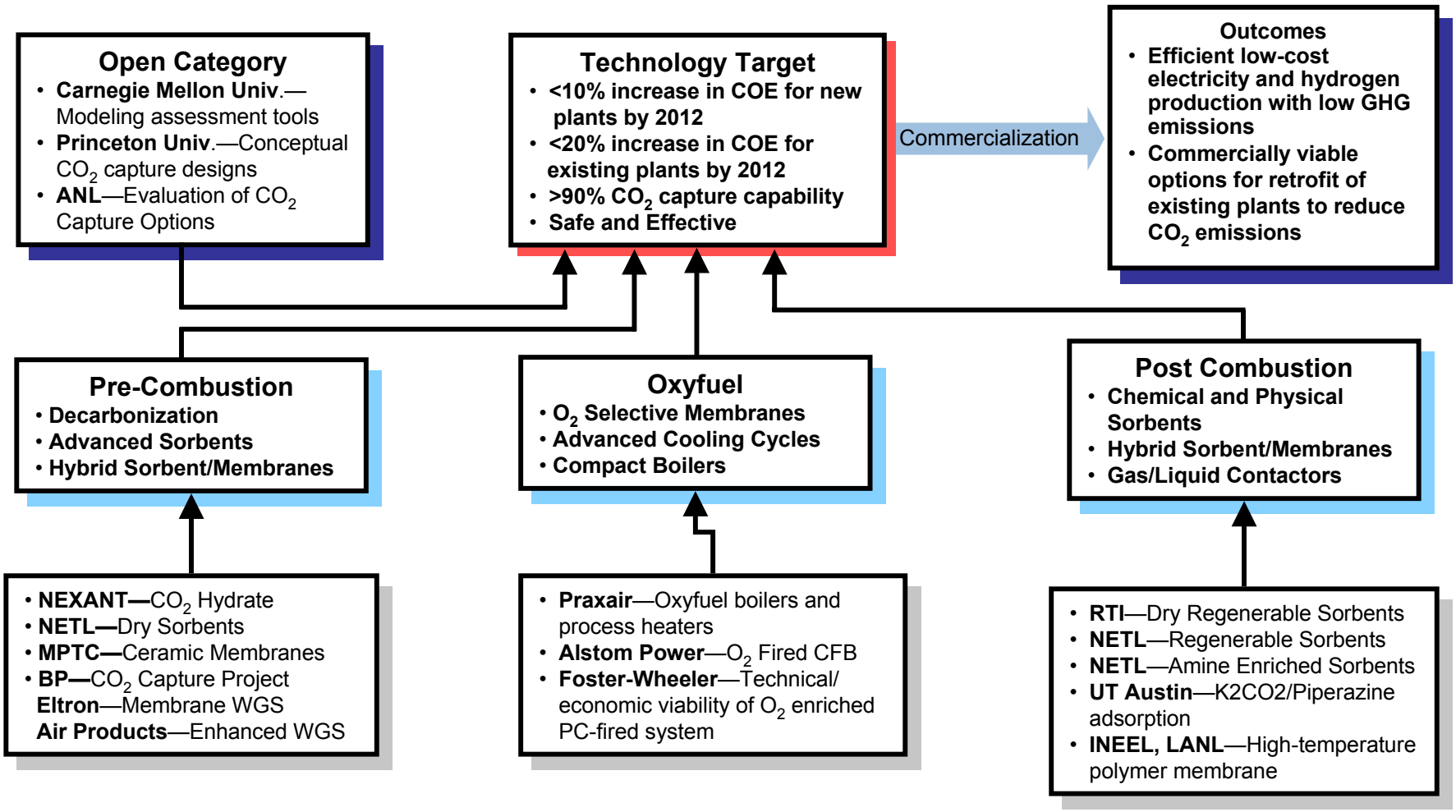
Portfolio Overview – FY2004

Separation & Capture From Power Plants Plays Key Role

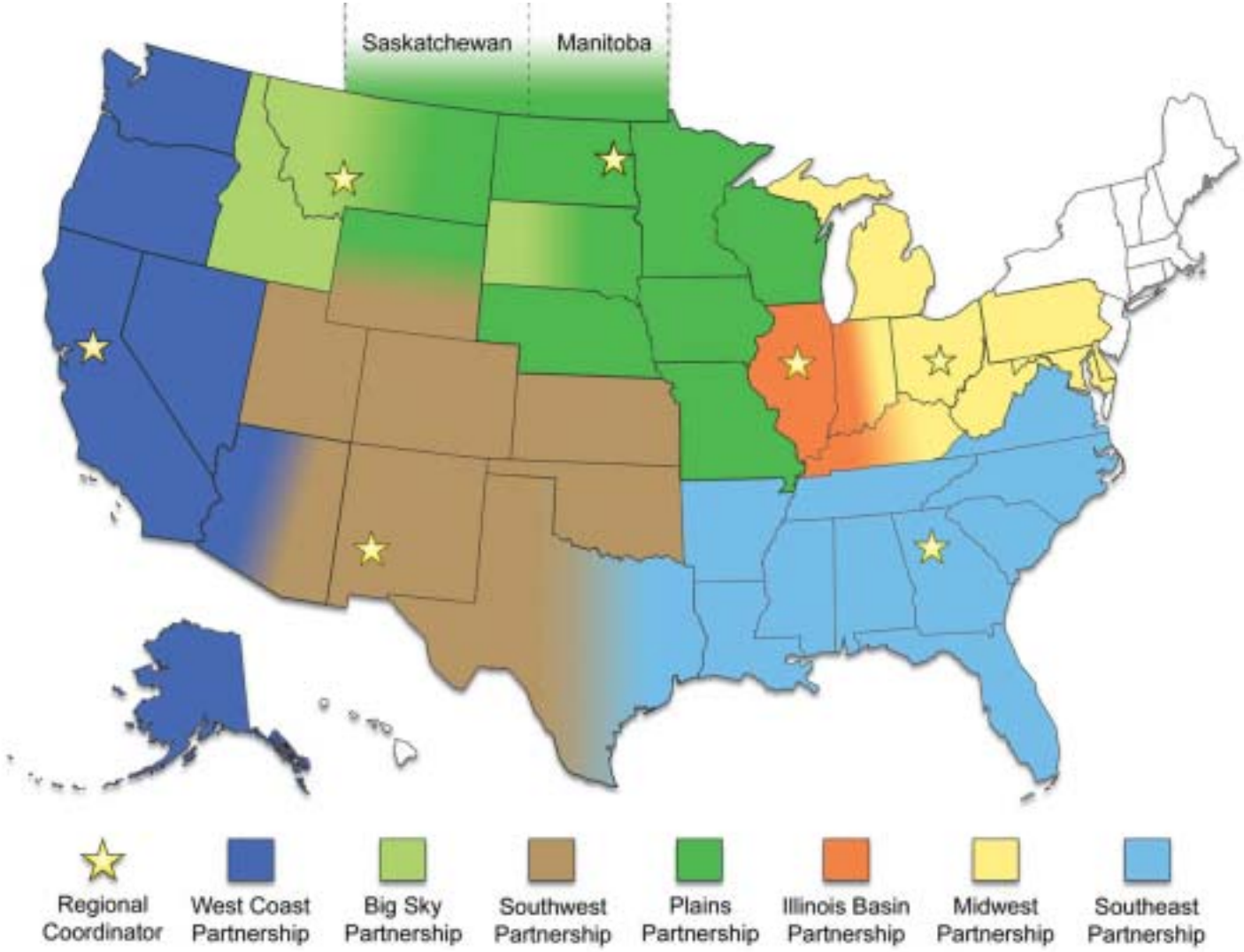
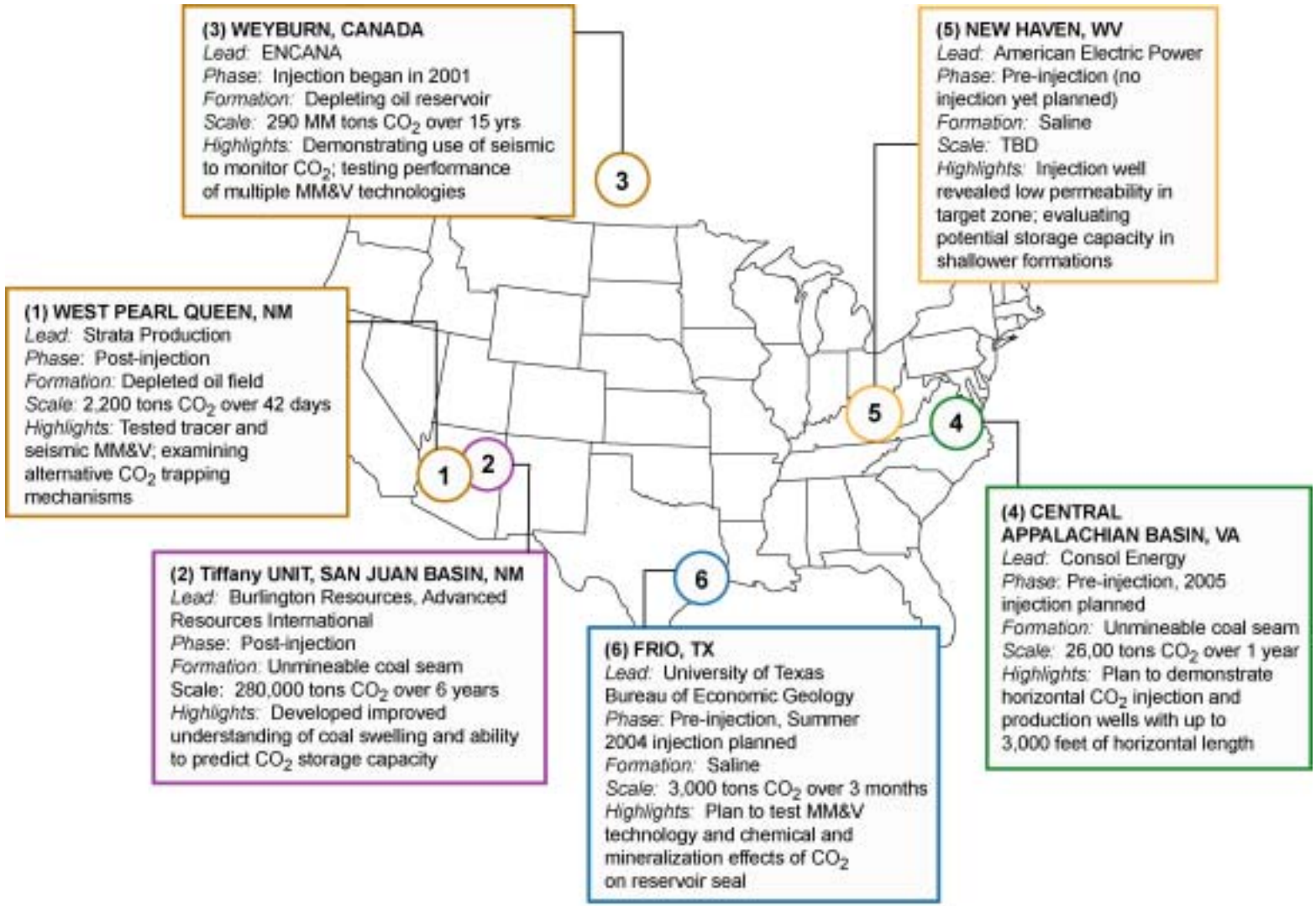
- Diverse research portfolio
  - 48 external projects
  - 16 focus area projects
  - BP & IEA consortia
- Strong industry support
  - ~ 36% cost share
- Total portfolio ~ $140M



Separation and Capture Overview



Seven Regional Carbon Sequestration Partnerships



Geologic Sequestration Field Tests Supported by the Sequestration Program