Briefing on Hydrogen Production from Coal and Carbon Dioxide Sequestration

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U.S. Department of Energy

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Outline

- Hydrogen from Coal
  - Hydrogen from Coal Technology Coordination
  - Hydrogen from Coal Program
  - Budget and Project Portfolio
- Carbon Dioxide Sequestration Program
  - Carbon Management Technology Options
  - Carbon Sequestration Program Structure
  - Regional Partnerships
  - Sequestration Program Budget Statistics
  - Carbon Sequestration Activities
    - Projects in progress
    - Carbon Sequestration Leadership Forum (CSLF)
    - International Energy Agency Greenhouse Gas (IEA GHG) Programme
- FutureGen
- Summary
- More Information

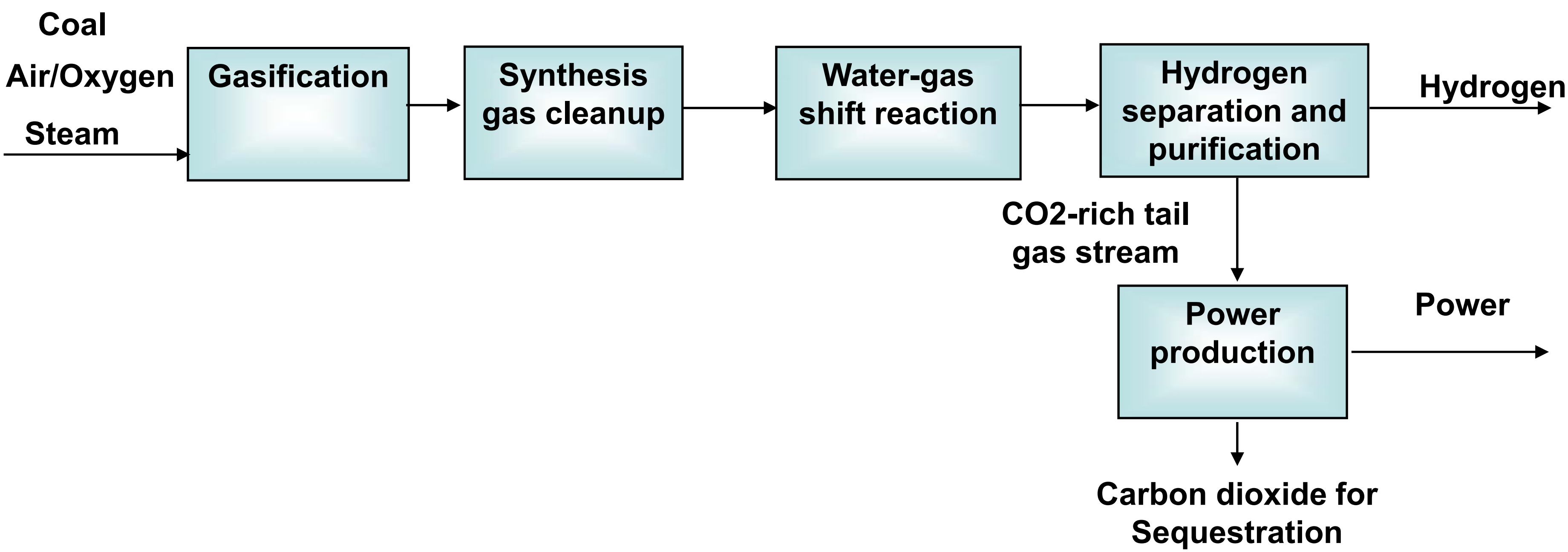
Hydrogen Production . . .
How Important is Coal?

Key Findings from the National Academy of Engineering study "The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs"... both general, and those specific to coal:

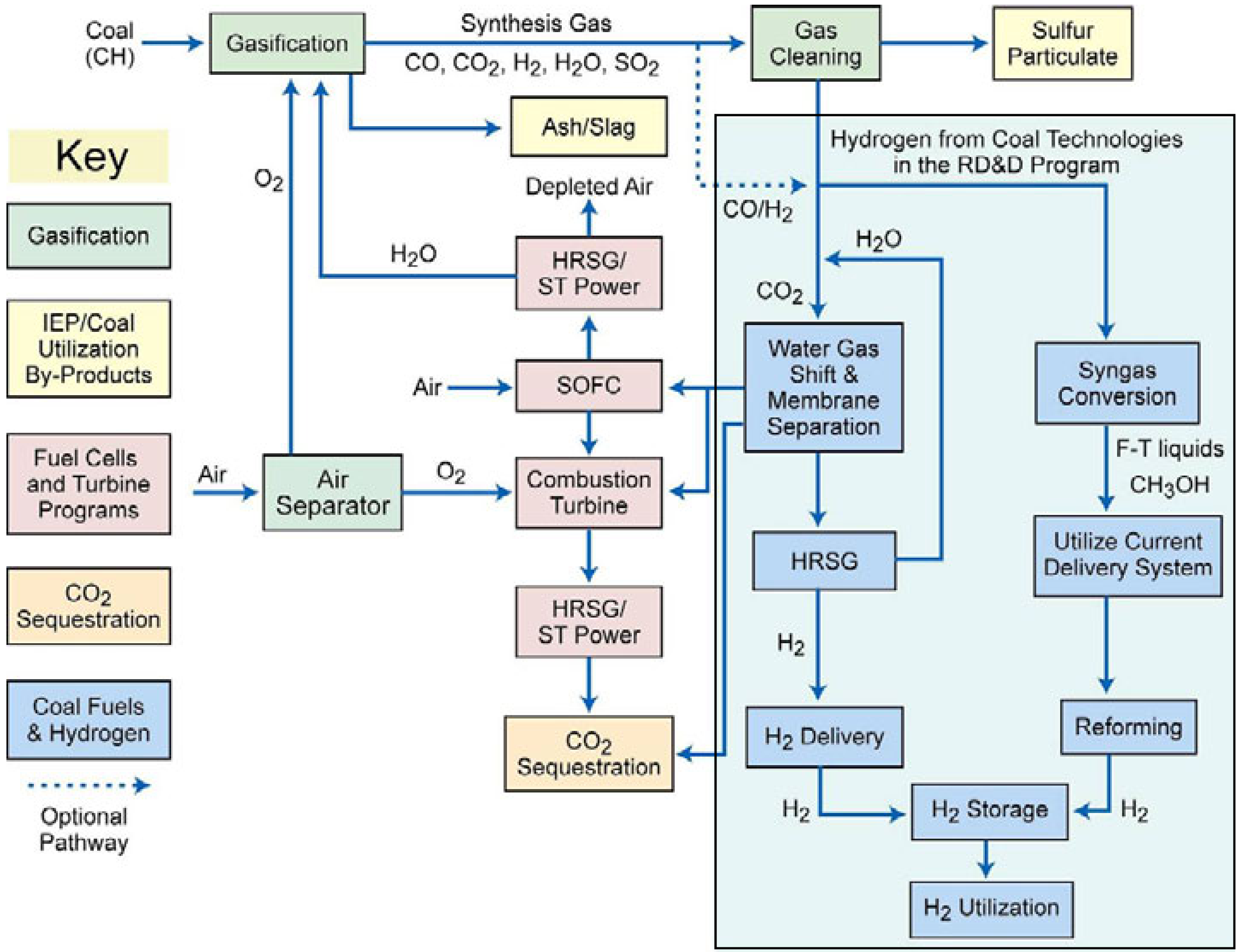
- Hydrogen could fundamentally transform the U.S. energy system; therefore a robust, ongoing hydrogen program is important
- Fossil fuels will be one of the principal sources of hydrogen for the hydrogen economy. . . but carbon capture and storage technologies will be required
- The U.S. has vast coal resources. . .hydrogen from coal can be inexpensive. . .and . . .coal must be a significant component of R&D aimed at making very large amounts of hydrogen

Hydrogen Production from Coal – Facilitator for Carbon Capture and Storage

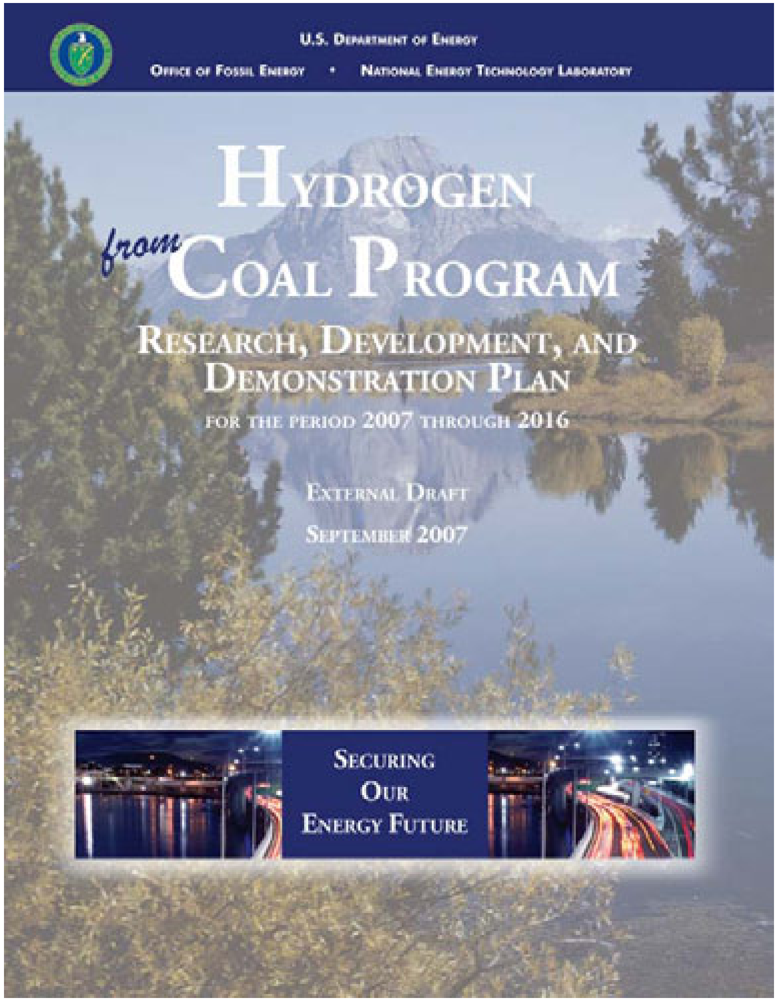
- The separation and purification of hydrogen from coal-derived mixed gas streams facilitates carbon dioxide capture and storage



Hydrogen from Coal Technology Coordination



Hydrogen from Coal RD&D Plan

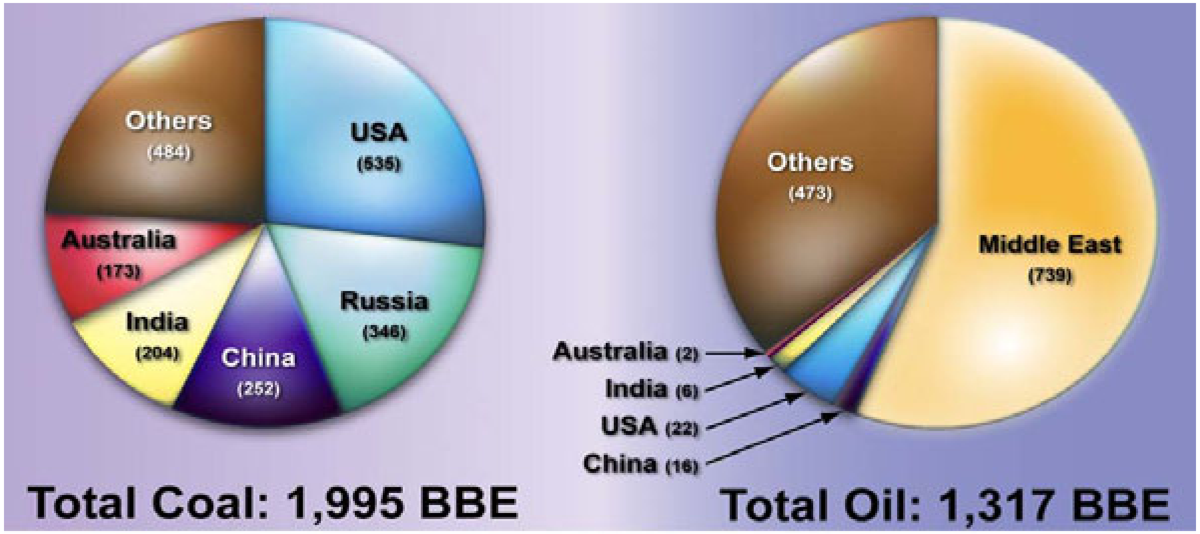


- Addresses H_2 from Coal Program:
  - Goals
  - Milestones
- Defines:
  - H_2 from coal pathways
  - Research areas
  - Technical targets
  - RD&D activities

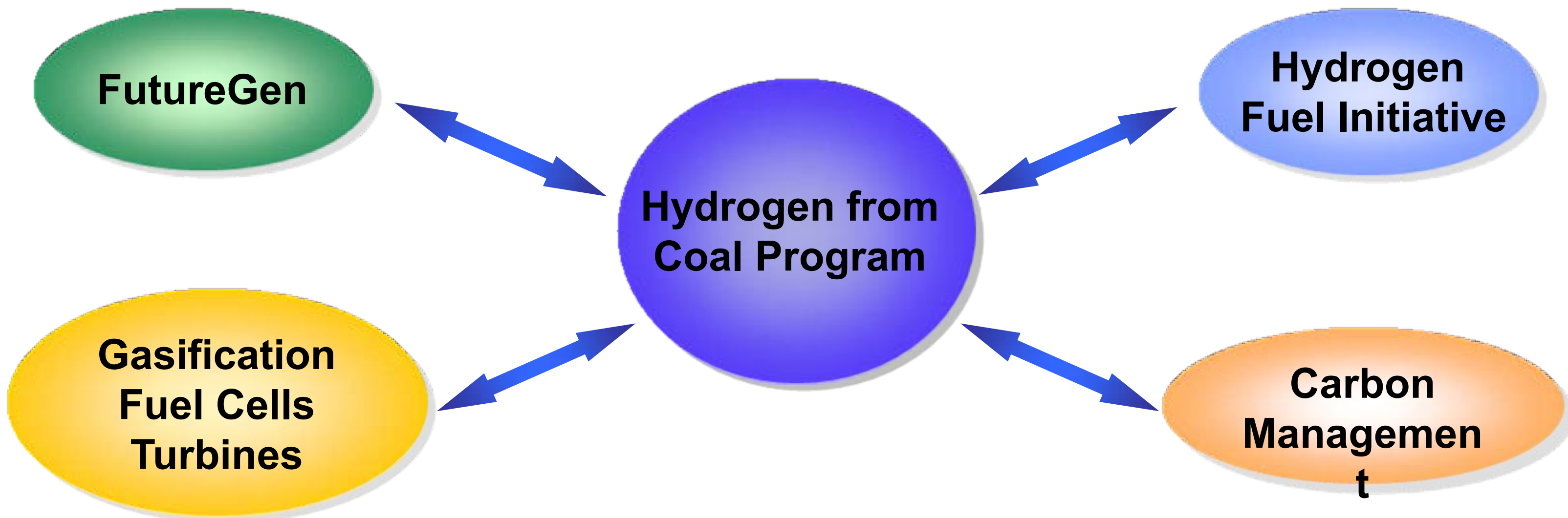
Why Hydrogen from Coal?

- Huge U.S. coal reserves
- Hydrogen can be produced cleanly from coal and provide large, affordable quantities of H_2
- Sequestration technology will remove CO_2
- Bridge to renewable H_2 production

World Coal and Oil Reserves, Billion Barrels Oil Equivalent (BBE)

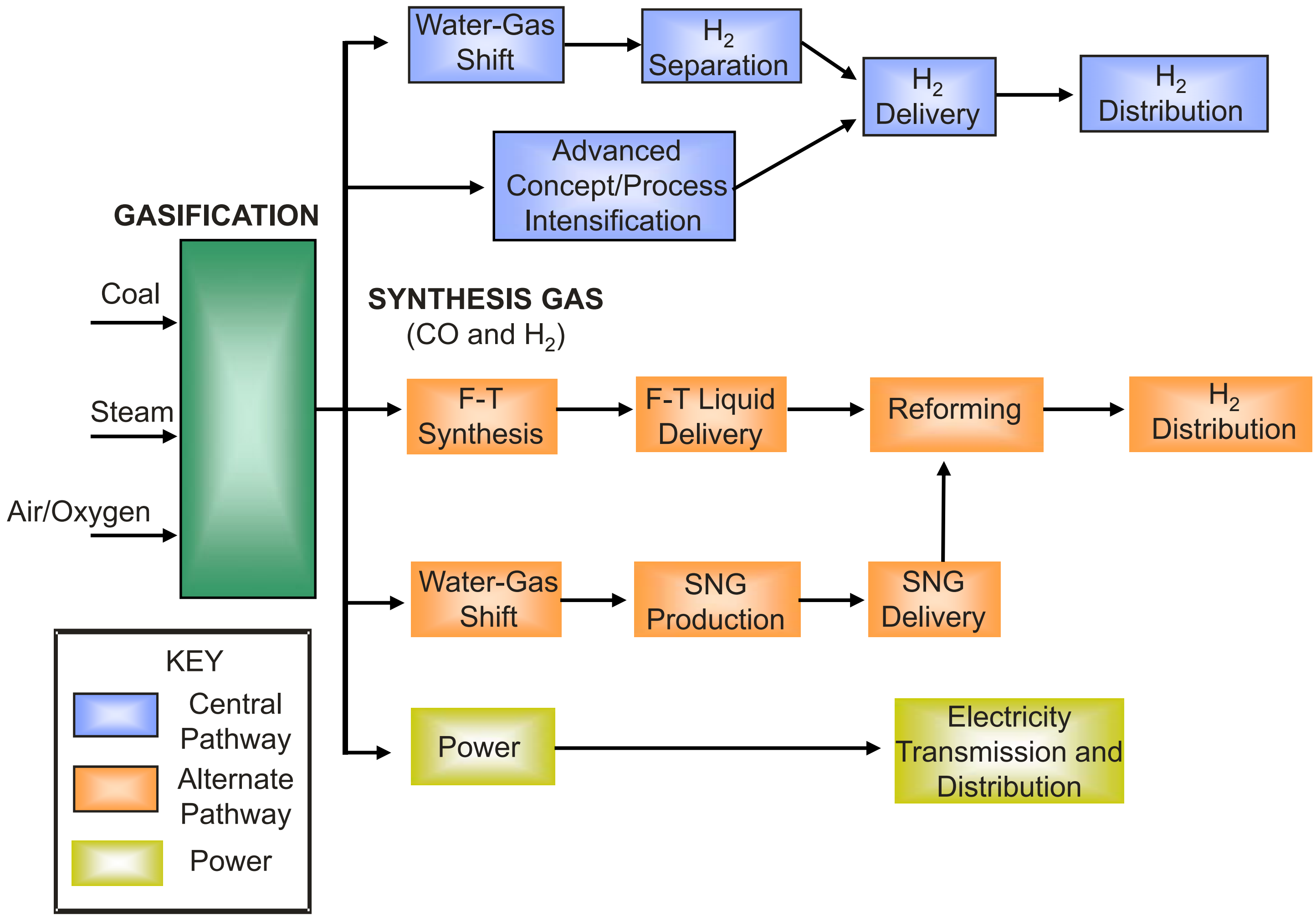


The Hydrogen from Coal Program



- The Hydrogen Fuel Initiative is a $1.2 billion RD&D program to develop hydrogen production, storage, delivery, and utilization technologies
- FutureGen is an integrated sequestration and hydrogen research initiative to test advanced technologies in a world-scale co-production plant
- Hydrogen from Coal Program coordinates with associated DOE programs for Gasification, Fuel Cells, Turbines, and Carbon Management

Hydrogen from Coal Pathways



Hydrogen From Coal Mission and Goals

Mission: Facilitate the transition to a sustainable hydrogen economy through the development of advanced and novel technologies that produce hydrogen from coal, our largest domestic fossil resource

- **Central Production Pathway Goal**
  - **By 2016, prove the feasibility of a 60% efficient, near-zero emissions, coal-fueled hydrogen and power co-production facility that reduces the cost of hydrogen by 25% compared to current coal-based technology**
- **Alternate Production Pathway Goal**
  - **By 2014, make available an alternative hydrogen production pathway, including a product reforming system, for decentralized hydrogen production from high-hydrogen content liquids and/or SNG**

H_2 from Coal Production Technology Challenges

- **Reduce the cost / Improve efficiency**
  - Clean synthesis gas production
    - Advanced gasification
    - Oxygen production
    - Advanced gas cleaning
  - Water-gas shift
  - Hydrogen separation & purification
  - Process intensification
- **Capture and sequester carbon**
- **Integrate technologies into FutureGen**

Hydrogen from Coal RD&D Program Technologies

Hydrogen from Coal Program Elements

H_2 Production Central Pathway

Produce high-purity hydrogen for fuel cell applications

Primary Thrusts

- Hydrogen Separation Membranes and Membrane Reactors
- Process Intensification
- Advanced Concepts

Alternate Production Pathway

Produce high-hydrogen content liquids and SNG that can utilize existing infrastructure and be reformed into H_2

Primary Thrusts

- Liquid Fuels and SNG Production
- Fuels Reforming Testing
- Polygeneration of High Value Carbon-Based Materials

Other Supported Research Thrusts

Utilization

- Advanced Engines

Storage

- High H_2 Affinity Materials

Computational Science & Modeling / Systems Analysis / Supporting Sciences

Budget and Project Portfolio

($ million)	FY04	FY05	FY06	FY07	FY08 Request	FY08 House	FY08 Senate
H2 from Coal Program Budget	5.0	17.0	21.0	23.6	10.0	10.0	30.0

Research Area*	Number of Projects
Membrane research	6
Membrane module scale-up	1
Membrane reactors & process intensification	9
CO_2 removal	1
Novel sorbent	1
Polishing filters	1
Polygeneration	2
Liquid H_2 carriers	7
SNG production and reforming	2
Storage	2
Utilization	6
TOTAL	***38***

*Complementary projects are supported by the Gasification and Sequestration Programs.

Carbon Dioxide Sequestration

Carbon Management Technology Options

Pathways for Reducing GHGs – CO_2

Reduce Carbon Intensity
- Renewables
- Nuclear
- Fuel Switching

Improve Efficiency
- Demand Side
- Supply Side

Sequester Carbon
- Capture & Store
- Enhance Natural Sinks

All options needed to:
- Affordably meet energy demand
- Address environmental objectives

What is Carbon Sequestration?

Capture and storage of CO_2 and other GHGs that would otherwise be emitted to the atmosphere

Capture can occur

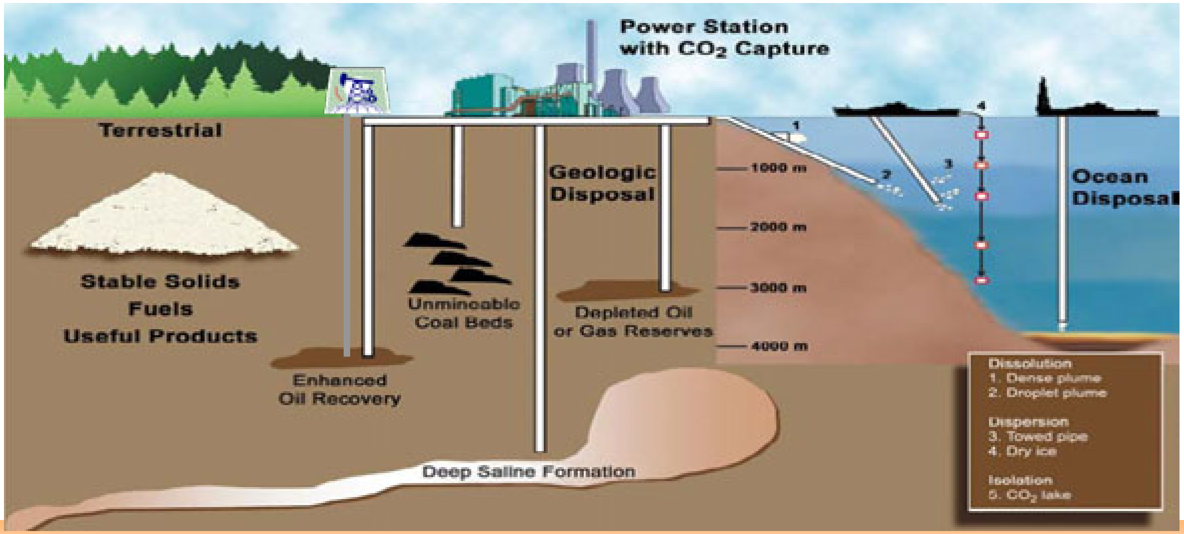
- **when absorbed from air**
- **at the point of emission**

Expensive to capture

- **Increased capital cost, parasitic energy loss**
- cost of energy increase 25-80%

Storage locations include

- **underground reservoirs**
- **converted to solid materials**
- **trees, grasses, soils, or algae**
- **dissolved in deep oceans**



Requirements for Sequestration

- Environmentally acceptable
  - No legacy for future generations
  - Respect existing ecosystems
- Safe
  - No sudden large-scale CO_2 discharges
- Verifiable
  - Ability to verify amount of CO_2 sequestered
- Economically viable
- ***EPA Regulations on Underground Injection Control***

Overcoming Barriers to Carbon Capture and Storage

- Capture Costs
  - Capital Investments
  - Increases in COE
- Lack of Infrastructure
- Regulatory Requirements
- Public Acceptance
- Human Capital Resources

- FE/NETL Sequestration Program is overcoming these barriers through:
  - Core R&D
  - Technology/Infrastructure Development
  - Government/Industry Partnerships
  - International Collaborations

DOE's Carbon Sequestration Program Goal

The amount of CO_2 captured represents 90 percent of the carbon in the fuel fed to the power plant or other energy system.

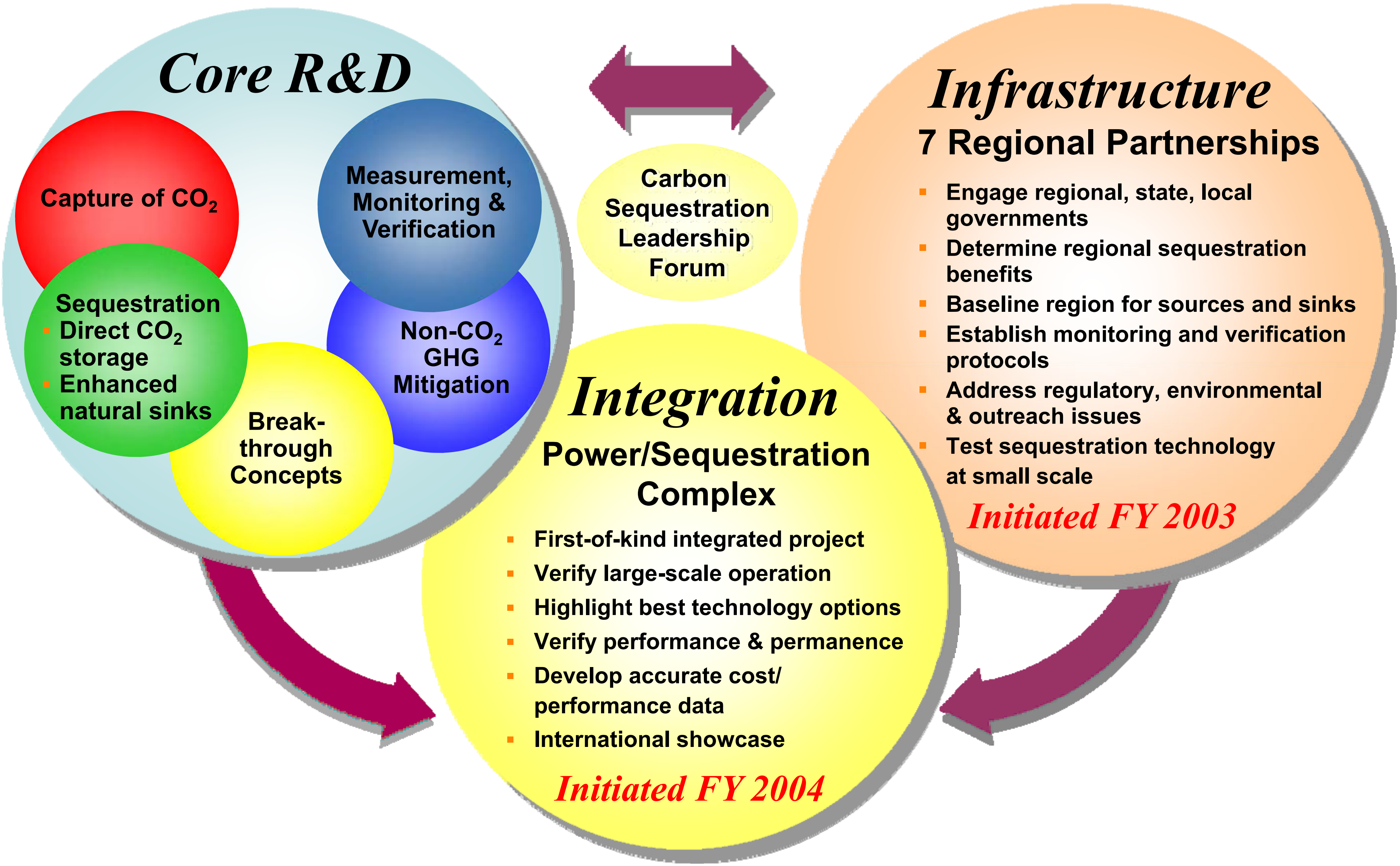
After 100 years, less than 1 percent of the injected CO_2 has leaked or is otherwise unaccounted for.

Develop fossil fuel conversion systems that offer 90% CO_2 capture with 99% storage permanence at less than 10% increase in cost of energy services by 2012.

A 10 percent cost of energy increase will not significantly impact the economy or unduly affect U.S. competitiveness in international markets.

The Program seeks to have pilot-scale unit operation performance results from a combination of CO_2 capture, MM&V, and storage system components that will meet this goal.

Carbon Sequestration Program Structure



Core R&D Program – R&D Pathways

Capture	▪ Post-combustion capture ▪ Oxygen combustion ▪ Pre-combustion capture ▪ Chemical looping
Sequestration	▪ Depleting oil reservoirs ▪ Unmineable coal seams ▪ Saline formations ▪ Enhanced terrestrial uptake
MM&V	▪ Advanced soil carbon measurement ▪ Subsurface measurements ▪ Remote sensing/above-ground MM&V ▪ Fate and transport models
Breakthrough Concepts	▪ Advanced capture ▪ Bio-accelerated sequestration ▪ Niches
Non-CO_2 GHG	▪ Landfill methane capture and use ▪ Mine ventilation methane capture

Regional Carbon Sequestration Partnerships
"Developing the Infrastructure for Wide Scale Deployment"

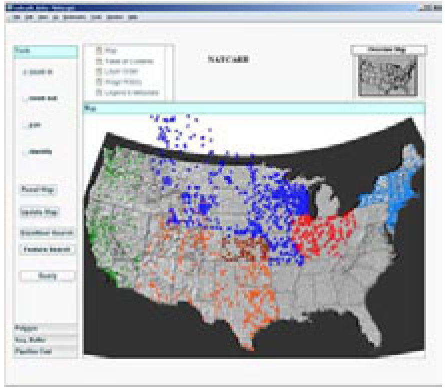
- 350+ Organizations
- 41 States
- 4 Canadian Provinces
- 3 Indian Nations
- Total of 34% cost share

Regional Partnerships Addressing Key Issues

- **Geologic capacity estimates**
- **Site selection criteria**
- **Reservoir modeling and validation**
- **Monitoring, mitigation, and verification (MMV)**
- **Operational considerations**
- **Economics of sequestration**
- **Develop Best Practice Management Plans (BPMP)**

Regional Partnership Update

"Developing the Infrastructure for Wide Scale Deployment"



Phase I (Characterization)

- 7 Partnerships (40 states)
- 24 months (2003–2005)

Phase II (Field Validation)

- 4 years (2005–2009)
- All seven Phase I partnerships continued
- $100 million federal funds
- $45 million in cost share

Phase III (Deployment)

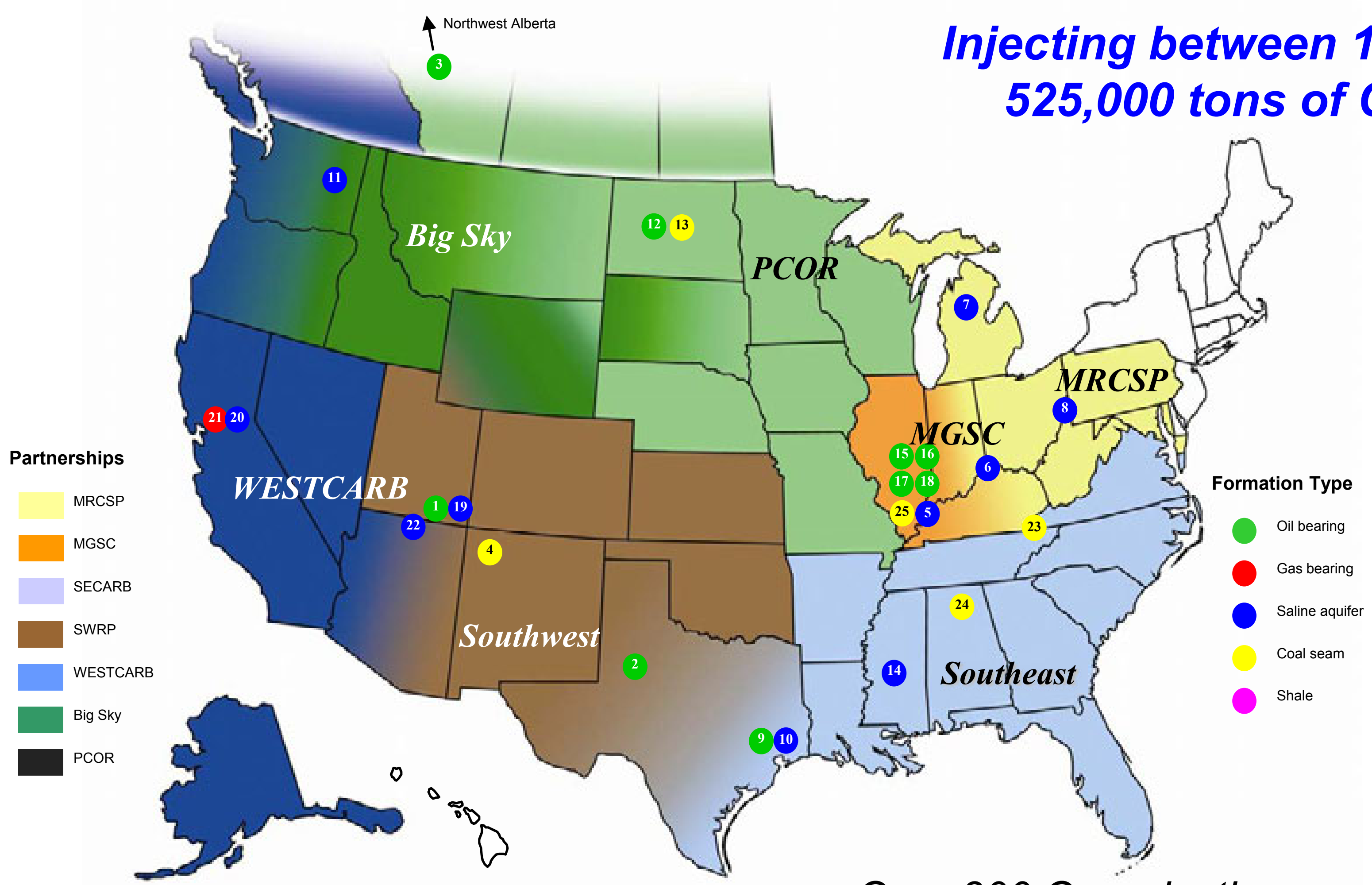
- 10 years (2008-2017)
- Large Scale Injection Tests in Different Geology
- Injection rates up to one million tons per year for several years

Phase I Highlights

- Thousands of Years of Storage Capacity Identified during Characterization Phase
  - Coal Seams and Shales- ~ 18 GT
  - Oil and Gas Reservoirs - ~27 GT
  - Saline Formations - >5,000 GT
- Value Added Products in Potential Sinks
  - Oil – 16 billion barrels of oil during sequestration in favorable fields
  - Coal Seams – 126 TCF CBM during sequestration in unmineable coal seams
- NATCARB and Regional Atlases Available Online

Regional Carbon Sequestration Partnerships
Phase II Geologic Field Tests

Injecting between 1,000 – 525,000 tons of CO_2



Over 300 Organizations

In Addition to Geologic - 10 Terrestrial Test

Projects that are part of the Regional Carbon Sequestration Partnership

#	Partnership	Geologic Province	Total CO_2 Injection (tons CO_2)	Approximate Depth (ft)
1	SRCSP	Paradox Basin	525,000	5,800
2	SRCSP	Permian Basin	300,000	5,700
3	PCOR	Keg River Formation	250,000	4,900
4	SRCSP	San Juan Basin	75,000	3,000
5	MGSC	Illinois Basin	10,000	5,000-10,000
6	MRCSP	Cincinnati Arch	10,000	8,000-10,000
7	MRCSP	Michigan Basin	10,000	4,000
8	MRCSP	Appalachian Basin	10,000	2,500-4,000
9	SECARB	Gulf Coast	7,500	8,000
10	SECARB	Gulf Coast	7,500	10,000
11	Big Sky	Grand Ronde Basalt	3,000	2,700
12	PCOR	Duperow Formation	3,000	1,000
13	PCOR	Williston Basin	3,000	>500
14	SECARB	Mississippi Salt Basin	3,000	7,500
15	MGSC	Illinois Basin	2,500	1,200-2,800
16	MGSC	Illinois Basin	2,500	Up to 3,150
17	MGSC	Illinois Basin	2,500	2,800-3,150
18	MGSC	Illinois Basin	2,500	2,800-3,150
19	SRCSP	Paradox Basin	2,000	6,000
20	WESTCARB	Central Valley CA	2,000	5,000
21	WESTCARB	Central Valley CA	2,000	4,000
22	WESTCARB	Kaiparowits Basin	2,000	8,000
23	SECARB	Central Appalachian	1,000	1,000
24	SECARB	Black Warrior Basin	1,000	2,300-5,000
25	MGSC	Illinois Basin	750	1,000

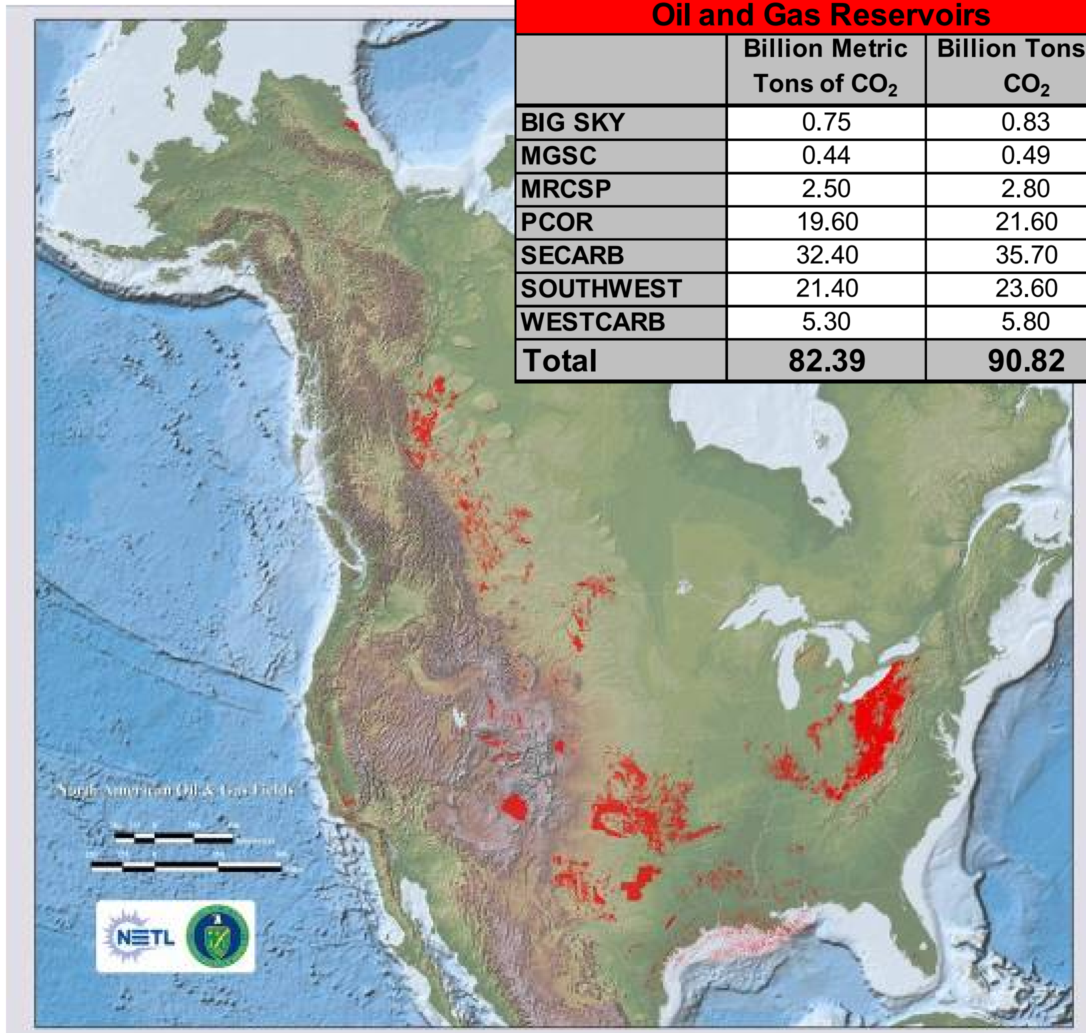
Capacity Calculations for National Estimates

- NETL, RCSPs, and NATCARB worked together to establish common assumptions and methodologies for CO_2 capacity estimates
- Details available in *Methodology for Development of Carbon Sequestration Capacity Estimates* document
- Three types of geologic formations:
  - Oil and gas reservoirs
  - Unmineable coal seams
  - Deep saline formations
- Capacity estimates produced using these methodologies are based on technically available capacities that have not been reduced by economic constraints, land use, or regulatory constraints.

Oil and Gas Reservoirs

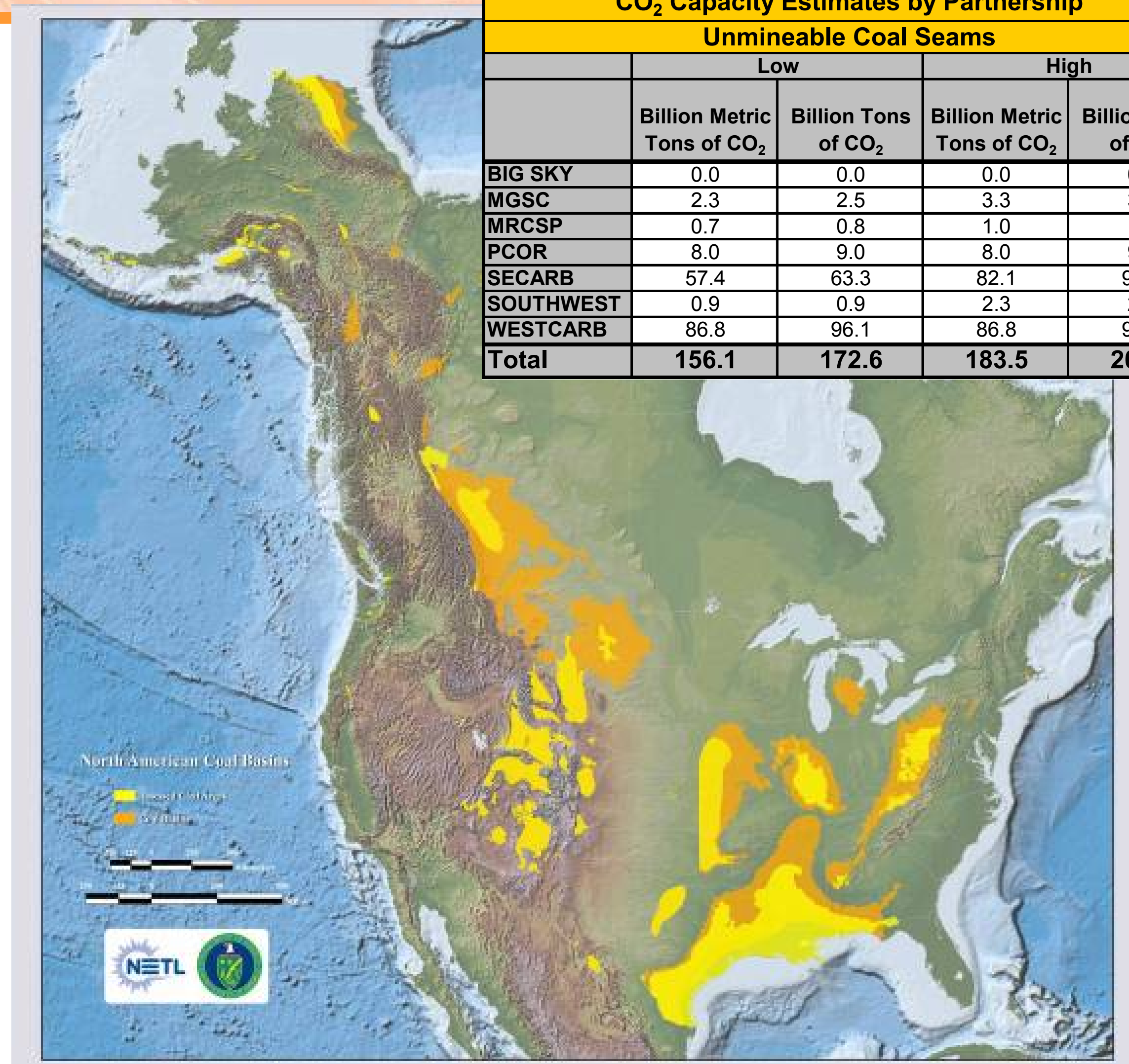
- Mature oil and gas reservoirs held crude oil and natural gas over millions of years
- Layer of permeable rock with dome shaped layer of non-permeable rock (caprock)
- Value added benefit - CO_2 can enable incremental oil to be recovered - EOR
- CO_2 allows recovery of additional 10-15% of OOIP

CO_2 Capacity Estimates by Partnership		
Oil and Gas Reservoirs		
	Billion Metric Tons of CO_2	Billion Tons of CO_2
BIG SKY	0.75	0.83
MGSC	0.44	0.49
MRCSP	2.50	2.80
PCOR	19.60	21.60
SECARB	32.40	35.70
SOUTHWEST	21.40	23.60
WESTCARB	5.30	5.80
Total	**82.39**	**90.82**



Unmineable Coal Seams

- Unmineable coal seams are too deep or too thin to be mined economically
- Coalbed methane (CBM) can be recovered by sweeping the coalbed with CO_2
- Depending on the rank of the coal, 3-13 molecules of CO_2 adsorbed for each molecule methane released

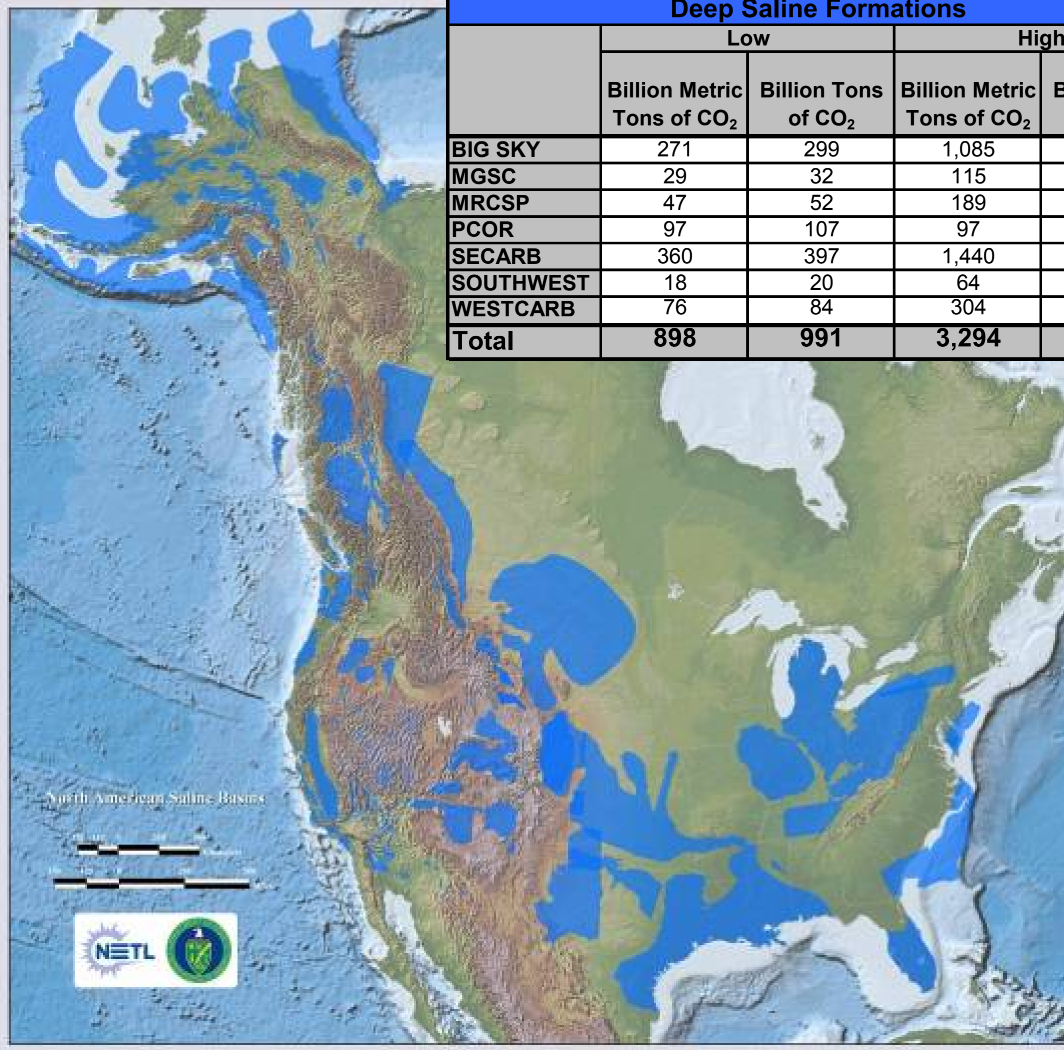


CO_2 Capacity Estimates by Partnership				
Unmineable Coal Seams				
	Low		High	
	Billion Metric Tons of CO_2	Billion Tons of CO_2	Billion Metric Tons of CO_2	Billion Tons of CO_2
BIG SKY	0.0	0.0	0.0	0.0
MGSC	2.3	2.5	3.3	3.6
MRCSP	0.7	0.8	1.0	1.1
PCOR	8.0	9.0	8.0	9.0
SECARB	57.4	63.3	82.1	90.5
SOUTHWEST	0.9	0.9	2.3	2.5
WESTCARB	86.8	96.1	86.8	96.1
Total	**156.1**	**172.6**	**183.5**	**202.8**

Deep Saline Formations

- Saline formations are layers of porous rock that are saturated with brine
- Represent enormous potential for CO_2 storage
- Saline formations contain minerals that can react with injected CO_2 to form solid carbonates over a long period of time

CO_2 Capacity Estimates by Partnership — Deep Saline Formations	Low		High	
	Billion Metric Tons of CO_2	Billion Tons of CO_2	Billion Metric Tons of CO_2	Billion Tons of CO_2
BIG SKY	271	299	1,085	1,196
MGSC	29	32	115	127
MRCSP	47	52	189	208
PCOR	97	107	97	107
SECARB	360	397	1,440	1,587
SOUTHWEST	18	20	64	71
WESTCARB	76	84	304	335
Total	**898**	**991**	**3,294**	**3,631**



CO_2 Sources and Storage Potential

CO_2 Capacity Estimates by Partnership		
Deep Saline Formations		
	Low	High
	Billion Metric Tons of CO_2	Billion Metric Tons of CO_2
BIG SKY	271	1,085
MGSC	29	115
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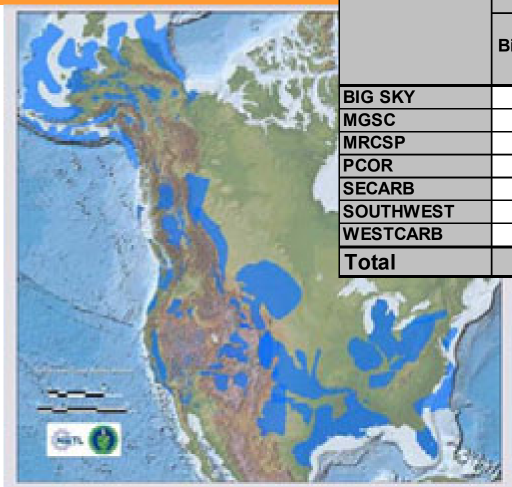

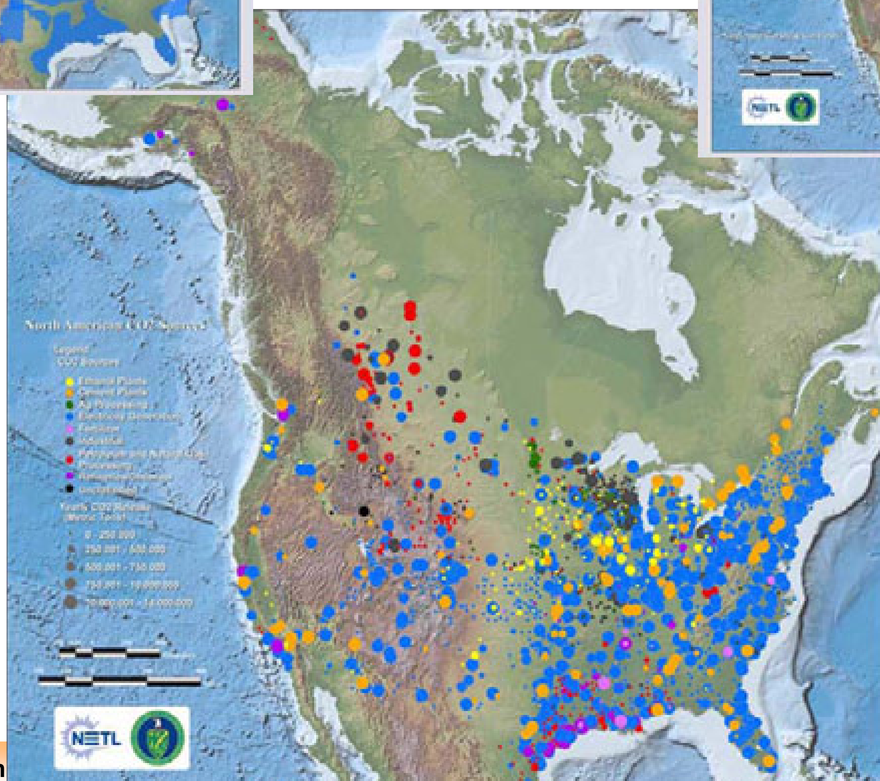

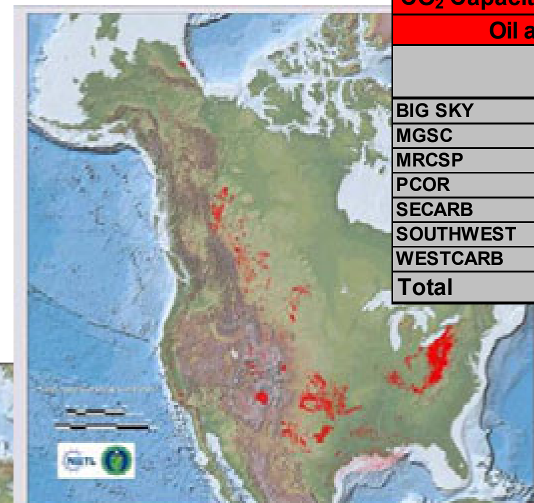

CO_2 Capacity Estimates by Partnership	
Oil and Gas Reservoirs	
	Billion Metric Tons of CO_2
BIG SKY	0.75
MGSC	0.44
MRCSP	2.50
PCOR	19.60
SECARB	32.40
SOUTHWEST	21.40
WESTCARB	5.30
Total	**82.39**

CO_2 Capacity Estimates by Partnership		
Unmineable Coal Seams		
	Low	High
	Billion Metric Tons of CO_2	Billion Metric Tons of CO_2
BIG SKY	0.0	0.0
MGSC	2.3	3.3
MRCSP	0.7	1.0
PCOR	8.0	8.0
SECARB	57.4	82.1
SOUTHWEST	0.9	2.3
WESTCARB	86.8	86.8
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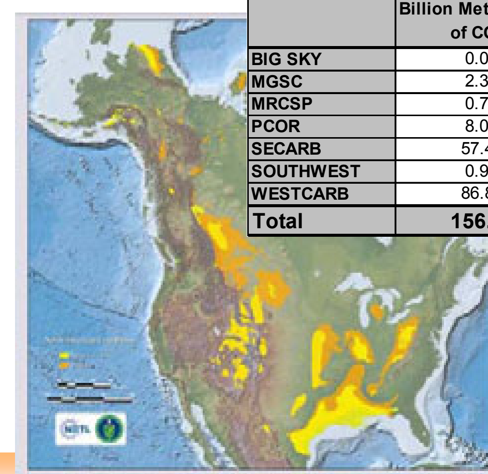
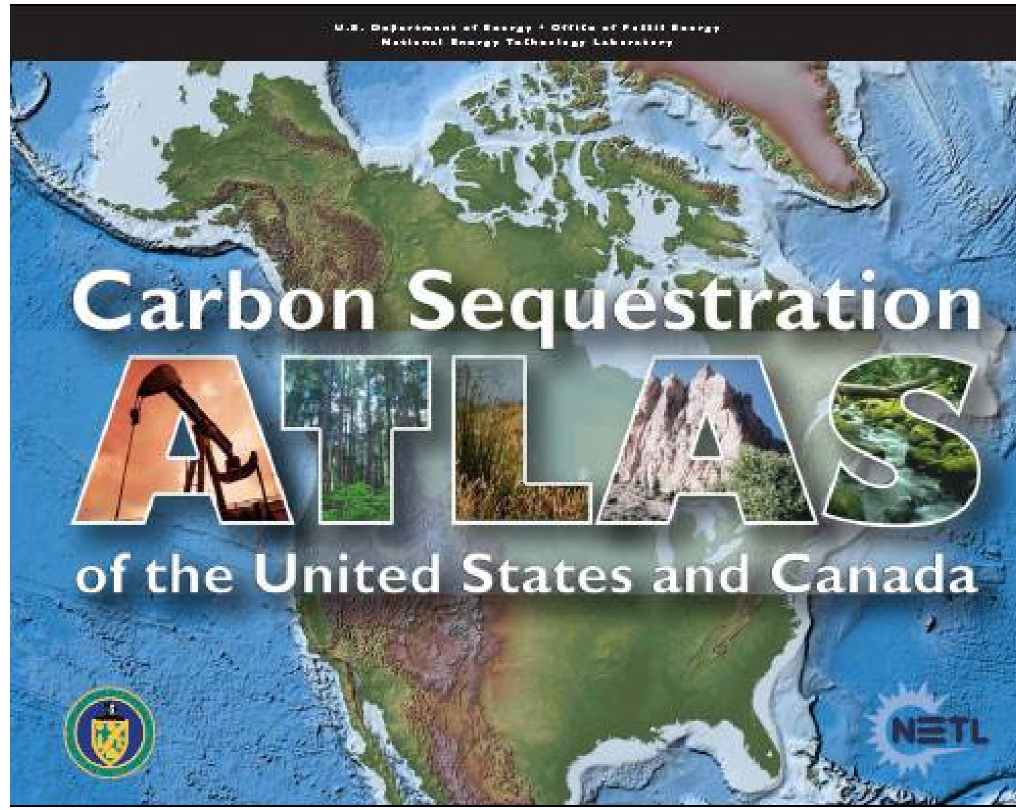


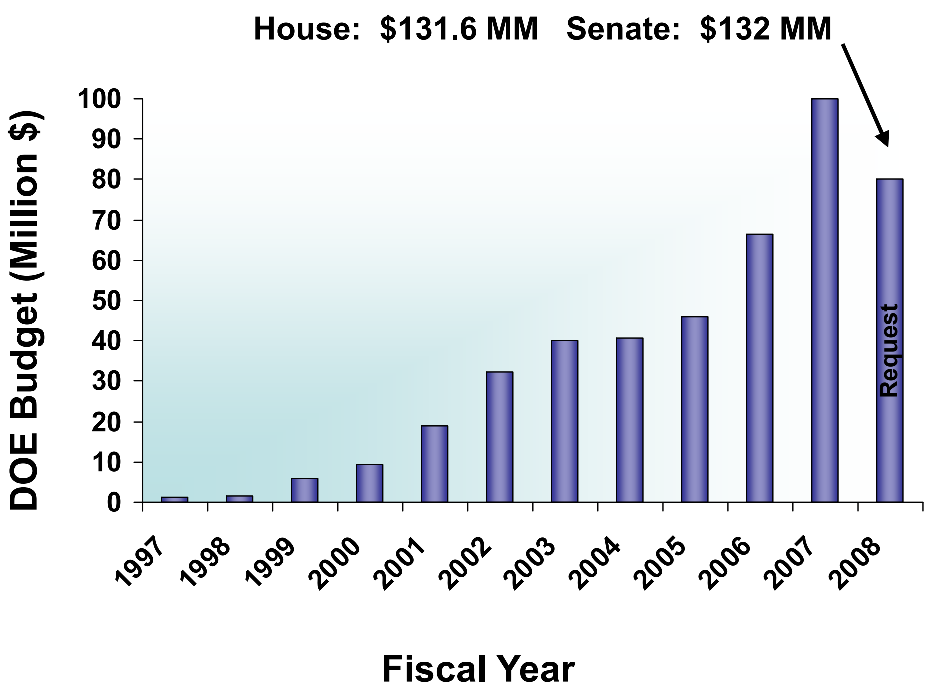
Carbon Sequestration Atlas of the United States and Canada

- DOE releases the first version of the Carbon Sequestration Atlas of the U.S. and Canada
- Result of cooperation and coordination among carbon sequestration experts from local, state, and government agencies, as well as industry and academia
- Atlas presents the first coordinated assessment of carbon capture and storage (CCS) potential across the majority of the U.S. and portions of western Canada
- Atlas provides introduction to CCS process, summarizes DOE's Carbon Sequestration Program, and gives information about the CCS contributions from each Regional Carbon Sequestration Partnership (RCSP)



- All data were collected before December 2006
- Data sets are not comprehensive, however, it is anticipated that CO_2 capacity estimates and formation maps will be updated as new data are acquired

Sequestration Program Statistics FY2007

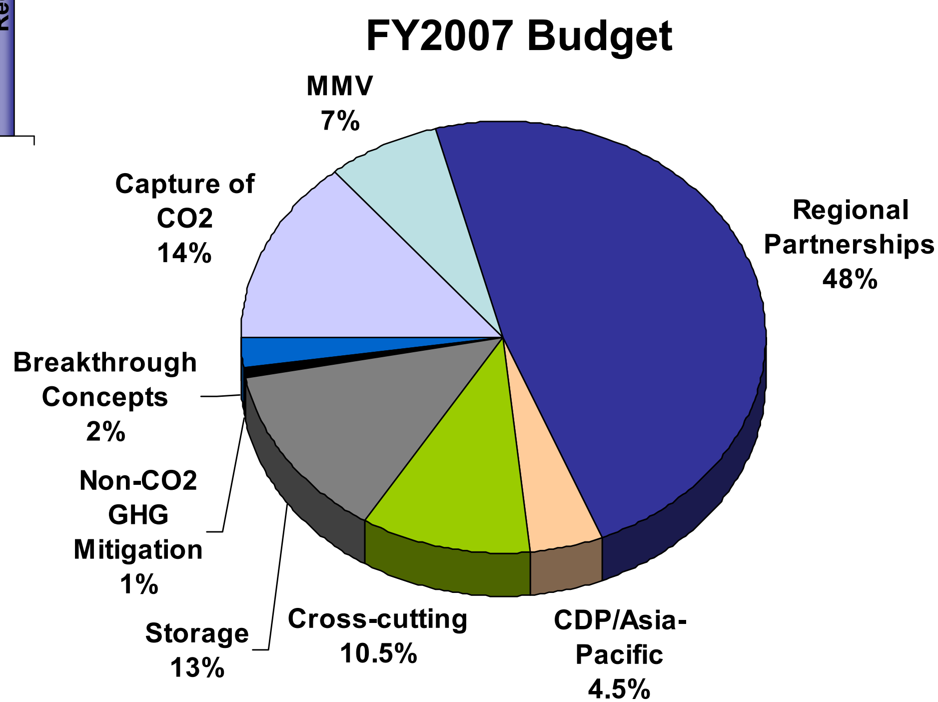


Strong industry support

~ 39% cost share on projects

Federal Investment to Date

~ $360 Million



Diverse research portfolio

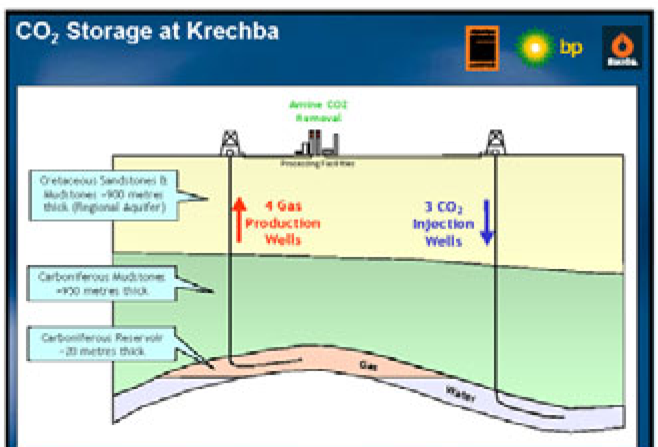
~ 70 Active R&D Projects

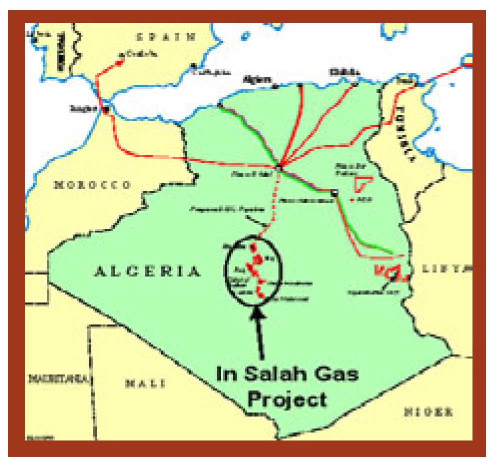
Regulatory Framework for Injection of CO_2 into Geologic Formations Underway

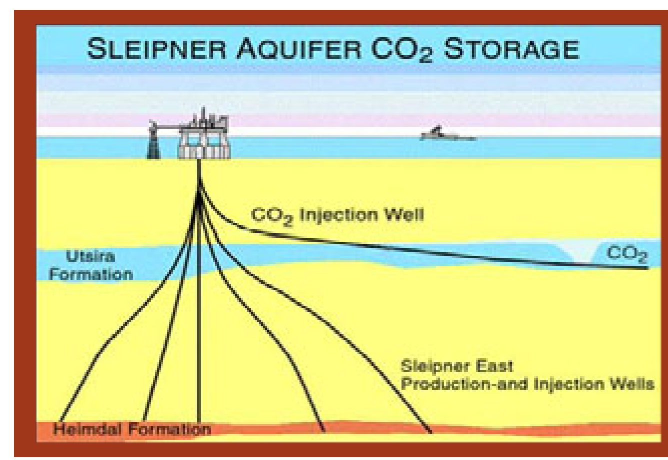
- EPA to propose regulations under the Safe Drinking Water Act Underground Injection Control (UIC) Program
- Workshop held Dec. 2007
- 2nd Workshop in February 2008
- Proposed Rule – July 2008
- Public Comment Period for Proposed Rule – July-October 2008
- Notice of Data Availability (if appropriate) – 2009
- Final UIC Rule for Geologic Sequestration of CO_2 – late 2010/early 2011

Geologic Sequestration Is Already Under Way

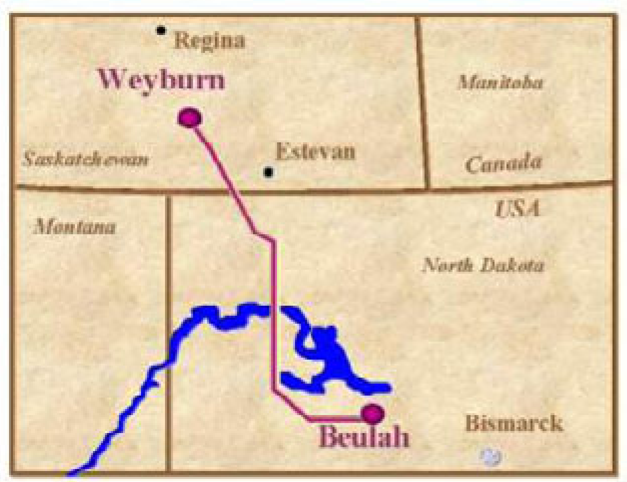
- Statoil injects $1x10^6$ tons per year at Sleipner
- BP to inject $0.8x10^6$ tons per year at In Salah
- EnCana EOR project with CO_2 storage in the Weyburn field





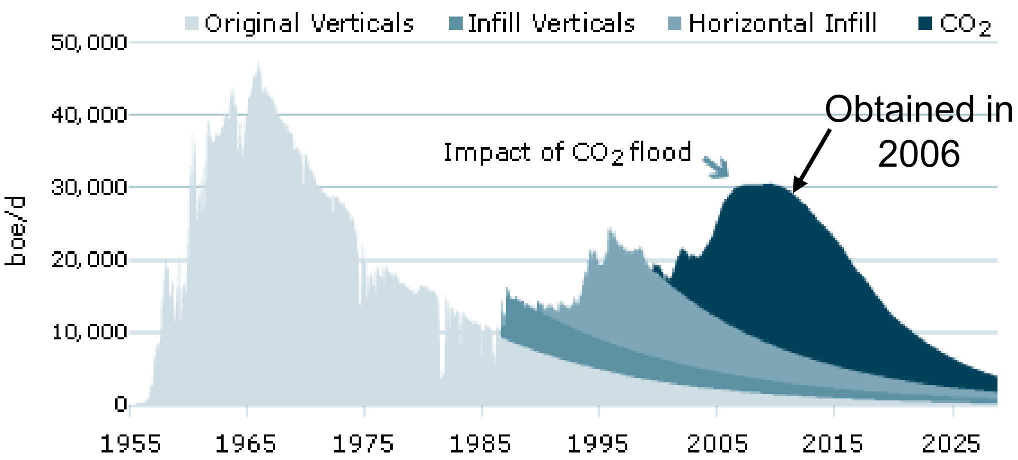


Measurement, Monitoring & Verification
Weyburn Enhanced Oil Recovery (EOR) Project



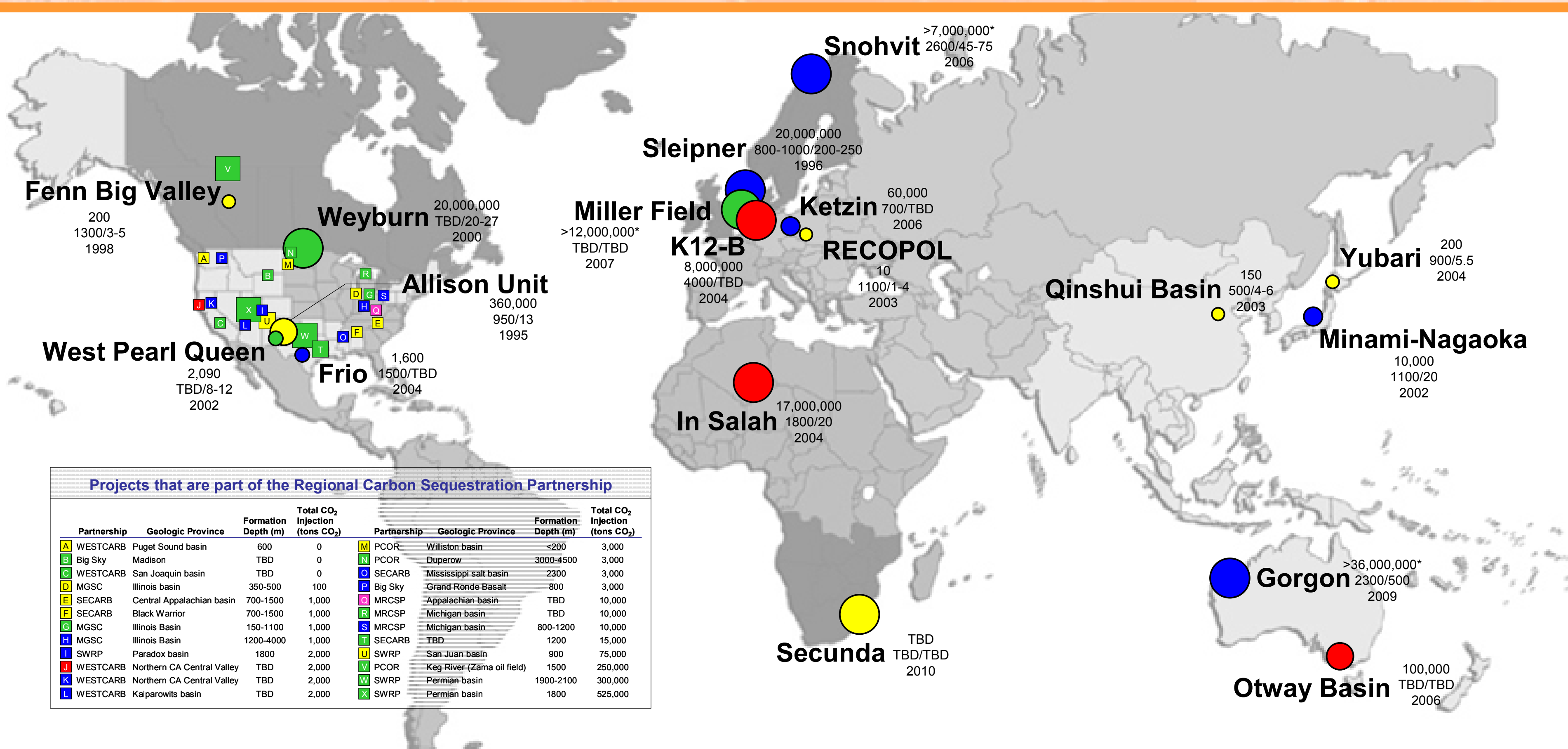
- 4 year monitoring project using latest modeling & geophysical techniques
- Injecting 1 million metric ton CO_2 per year for 20 years
- Equivalent to ~ 150 MW average, coal power plant

- Combining CO_2 storage research with oil production
- Assess long term fate of CO_2 sequestered via EOR
- 200-mile CO_2 pipeline from Dakota Gasification Plant



Participants: EnCana, Apache, IEA GHG Programme (DOE)

Worldwide CO_2 Storage Projects



Projects that are part of the Regional Carbon Sequestration Partnership

	Partnership	Geologic Province	Formation Depth (m)	Total CO_2 Injection (tons CO_2)
A	WESTCARB	Puget Sound basin	600	0
B	Big Sky	Madison	TBD	0
C	WESTCARB	San Joaquin basin	TBD	0
D	MGSC	Illinois basin	350-500	100
E	SECARB	Central Appalachian basin	700-1500	1,000
F	SECARB	Black Warrior	700-1500	1,000
G	MGSC	Illinois Basin	150-1100	1,000
H	MGSC	Illinois Basin	1200-4000	1,000
I	SWRP	Paradox basin	1800	2,000
J	WESTCARB	Northern CA Central Valley	TBD	2,000
K	WESTCARB	Northern CA Central Valley	TBD	2,000
L	WESTCARB	Kaiparowits basin	TBD	2,000

	Partnership	Geologic Province	Formation Depth (m)	Total CO_2 Injection (tons CO_2)
M	PCOR	Williston basin	<200	3,000
N	PCOR	Duperow	3000-4500	3,000
O	SECARB	Mississippi salt basin	2300	3,000
P	Big Sky	Grand Ronde Basalt	800	3,000
Q	MRCSP	Appalachian basin	TBD	10,000
R	MRCSP	Michigan basin	TBD	10,000
S	MRCSP	Michigan basin	800-1200	10,000
T	SECARB	TBD	1200	15,000
U	SWRP	San Juan basin	900	75,000
V	PCOR	Keg River (Zama oil field)	1500	250,000
W	SWRP	Permian basin	1900-2100	300,000
X	SWRP	Permian basin	1800	525,000

LEGEND

Storage formation, color (see right)

Project Name

Total CO_2 injection, tons CO_2*
Formation depth/thickness, meters
Injection start date, years

Project size, diameter (see right)

* Assumed minimum project life of 10 years

Storage formation

- Oil field
- Gas field
- Saline aquifer
- Coal seam
- Shale

Project size (total CO_2 injection)

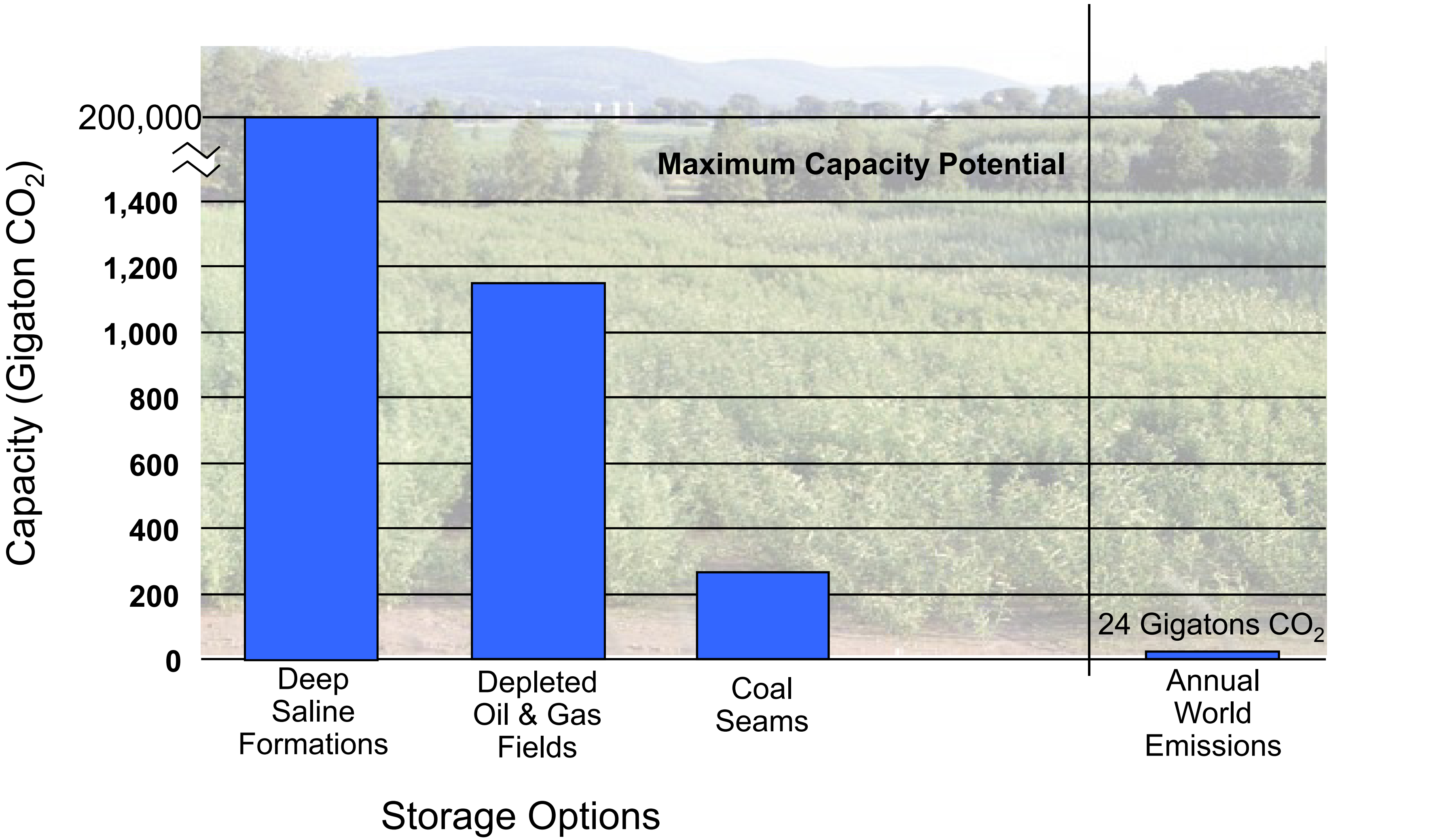
- Commercial (greater than 1 $MMtCO_2$)
- Large pilot (100 $ktCO_2$ to 1 $MMtCO_2$)
- Pilot (11 $ktCO_2$ to 99 $ktCO_2$)
- Micro-pilot (10 $ktCO_2$ or less)

Worldwide CO_2 Storage Projects

	Project Name	Injection Start Date	Total CO_2 Injection (tons CO_2)	Approximate Depth (ft)		Project Name	Injection Start Date	Total CO_2 Injection (tons CO_2)	Approximate Depth (ft)
1	Carson	2011	40,000,000[a]	TBD	10	Allison Unit	1995	360,000	3,100
2	Gorgon	2009	>36,000,000[b]	7,500	11	Otway Basin	2006	100,000	6,500
3	Sleipner	1996	20,000,000	2,600-3,300	12	Ketzin	2006	60,000	2,300
4	Weyburn	2000	20,000,000	4,800	13	Minami-Nagaoka	2002	10,000	3,600
5	Miller Field	2009	18,000,000[c]	13,000	14	West Pearl Queen	2002	2,100	TBD
6	In Salah	2004	17,000,000	5,900	15	Frio	2004	1,600	4,900
7	K12B	2004	8,000,000	13,000	16	Fenn Big Valley	1998	200	4,300
8	Snohvit	2006	>7,000,000[d]	8,500	17	Yubari	2004	200	2,950
9	Secunda	2010	TBD	TBD	18	Qinshui Basin	2003	150	1,650
					19	RECOPOL	2003	10	3,600

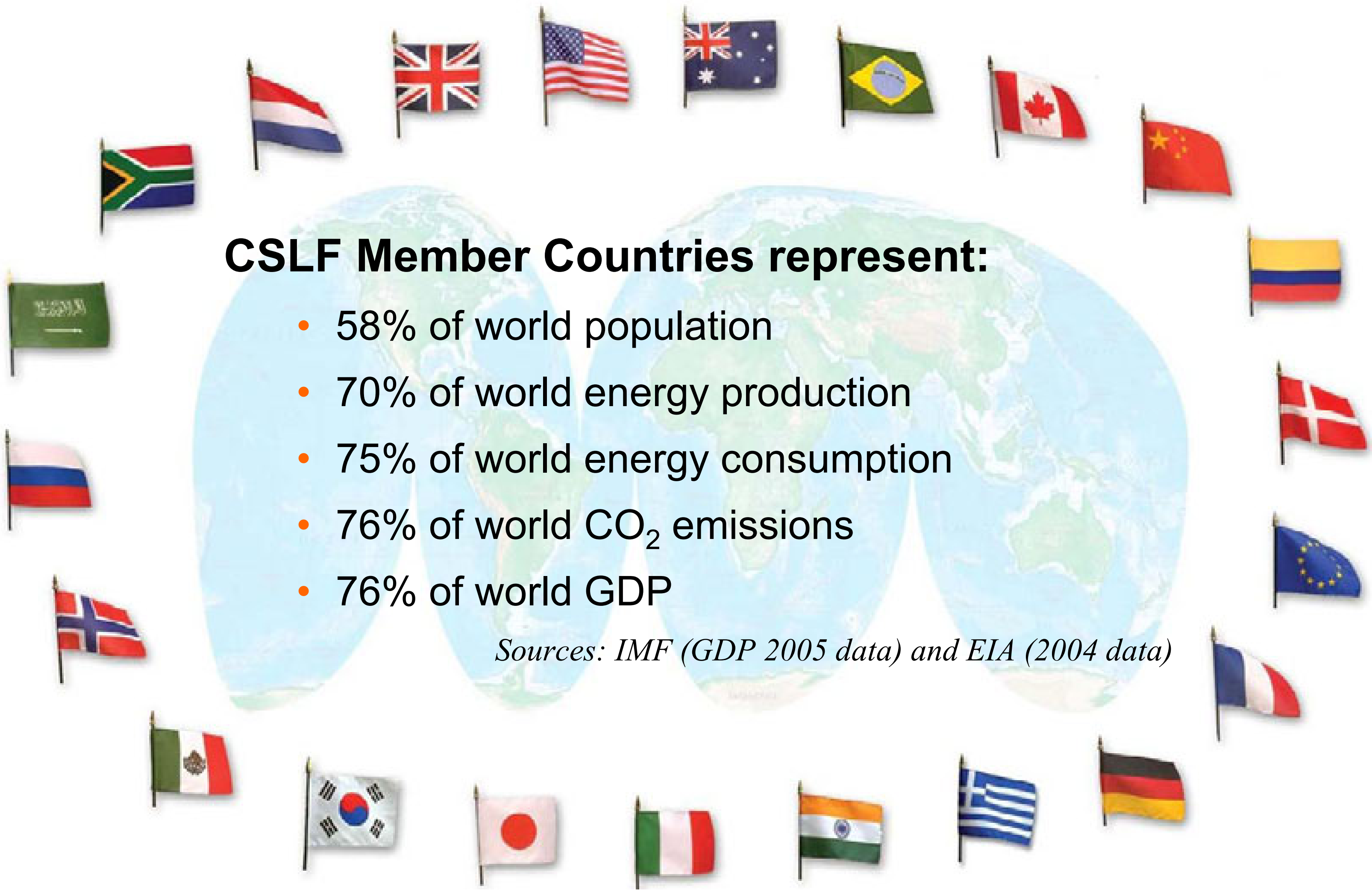
Worldwide Geologic Storage Capacity

(Thousands of Years of Potential Storage Capacity)



Storage Options: IEA Technical Review (TR4), March 23, 2004
World Emissions: DOE/EIA, International Energy Outlook 2003, Table A10

CSLF Members



CSLF Member Countries represent:

- 58% of world population
- 70% of world energy production
- 75% of world energy consumption
- 76% of world CO_2 emissions
- 76% of world GDP

Sources: IMF (GDP 2005 data) and EIA (2004 data)

Carbon Sequestration Leadership Forum

- **An international climate change initiated focused on development of improved cost-effective technologies for the separation and capture of carbon dioxide for its transport and long-term safe storage**
- **Established:** *June 2003*
- **Member Nations:** *21 plus EU*
- **Registered Stakeholders:** *100*
- **Active Projects:** *17*
- **Completed Projects:** *2*
- **Organizational/Operational data at www.cslforum.org**

International Energy Agency Greenhouse Gas (IEA GHG) R&D Programme

- IEA GHG works to improve understanding of how to:
  - Reduce emissions of greenhouse gasses from power plants and other sources
    - Organized in 1991
    - Carries out technical and economic evaluations of technology
    - Estimates costs on transparent, consistent, and comparative basis
    - Identifies technology gaps and duplications of effort on global basis
    - Maintains awareness of progress and developments
  - Sponsored by 15 countries, the European Commission, and 15 industrial sponsors
  - Organizational/Operational data at www.ieagreen.org.uk

International Energy Agency Greenhouse Gas (IEA GHG) Participation

IEA GHG brings together contributions and perspectives of its national and industrial representatives involve both developed and developing countries

Countries

- Australia
- Canada
- Denmark
- Finland
- France
- Germany
- Japan
- Korea
- The Netherlands
- New Zealand
- Norway
- Sweden
- Switzerland
- United Kingdom
- United States of America

Industries

- Alstom
- Babcock + Wilcox Co.
- BG Group
- BP
- Chevron Corporation
- ENI Technologies SpA
- E.ON AG
- EPRI
- ExxonMobil
- Repsol YPF
- RWE AG
- Shell International
- Statoil
- Total
- Vatten Fall

FutureGen Project

Key Features

- Commercial-scale 275-MWe plant
- 1 million tons/year CO_2 captured and sequestered
- Co-production of H_2 and electricity
- “Living laboratory” to test and validate cutting-edge technologies
- Public-private partnership
- Stakeholder involvement
- International participation

FutureGen Membership

- FutureGen Industrial Alliance
  - American Electric Power
  - Anglo American
  - BHP Billiton
  - China Huaneng Group
  - Consol Energy
  - E.ON
  - Foundation Coal
  - Luminant
  - Peabody Energy
  - PPL Corporation
  - Rio Tinto
  - Southern Company
  - Xstrata Coal
- International Government Participation
  - United States
  - India
  - South Korea
  - Continuing discussions with other interested parties

FutureGen Project

Value Proposition

- Supports a technology-based climate change strategy
  - Mitigates the financial risks of climate change
- Validates the cost and performance of an integrated near- zero emission coal-fueled power plant
  - Advances IGCC technology
  - Advances carbon capture, sequestration, and hydrogen production technologies
  - Sets groundwork for CO_2 sequestration siting and licensing
- Creates the technical basis to retain coal in U.S. energy mix with a long-term goal of zero emissions
- Enables the public and private sector to share the cost and risk of advanced technology demonstration
  - Platform for emerging technology demonstration

Summary

- Hydrogen from coal can play a key role in the future hydrogen economy and contribute to GHG emission reductions
- When used in tandem with carbon sequestration, the central station production of hydrogen from coal would result in virtually no greenhouse gas and pollutant emissions
- Hydrogen from Coal R&D Program will reduce production costs and can provide technology to test in FutureGen
  - Goals are to reduce cost and complexity of processes, 25% cost reduction in hydrogen production cost is achievable
- Initial bench-scale success in H_2 separation membranes shows progress toward 2015 technical targets
- Alternative production pathway provides options and contributes to liquid-carriers and SNG technology

Summary

- Current knowledge strongly supports carbon sequestration as a successful technology to dramatically reduce CO_2 emissions
  - Current science and technology gaps appear resolvable
- Deployment issues, including regulatory, legal, and operational concerns, can be addressed through development of operational protocols advised by science
- Large-scale tests are crucial to understanding successful deployment of carbon capture and sequestration and creating appropriate policy/economic structures
  - No test to date is sufficient with respect to scale, duration, monitoring, and analysis

More Information

- Hydrogen from Coal RD&D Plan
  http://www.fe.doe.gov/programs/fuels/publications/programplans/2007_Hydrogen_Program_Plan.pdf
- FutureGen
  http://www.fe.doe.gov/programs/powersystems/futuregen/index.html
- NETL Hydrogen from Coal Website
  http://www.netl.doe.gov/technologies/hydrogen_clean_fuels/index.html
- DOE/FE Carbon Sequestration Program
  http://www.fe.doe.gov/programs/sequestration/index.html
- NETL Carbon Sequestration Program
  http://www.netl.doe.gov/technologies/carbon_seq/index.html