CARBON CAPTURE & SEQUESTRATION TECHNOLOGIES

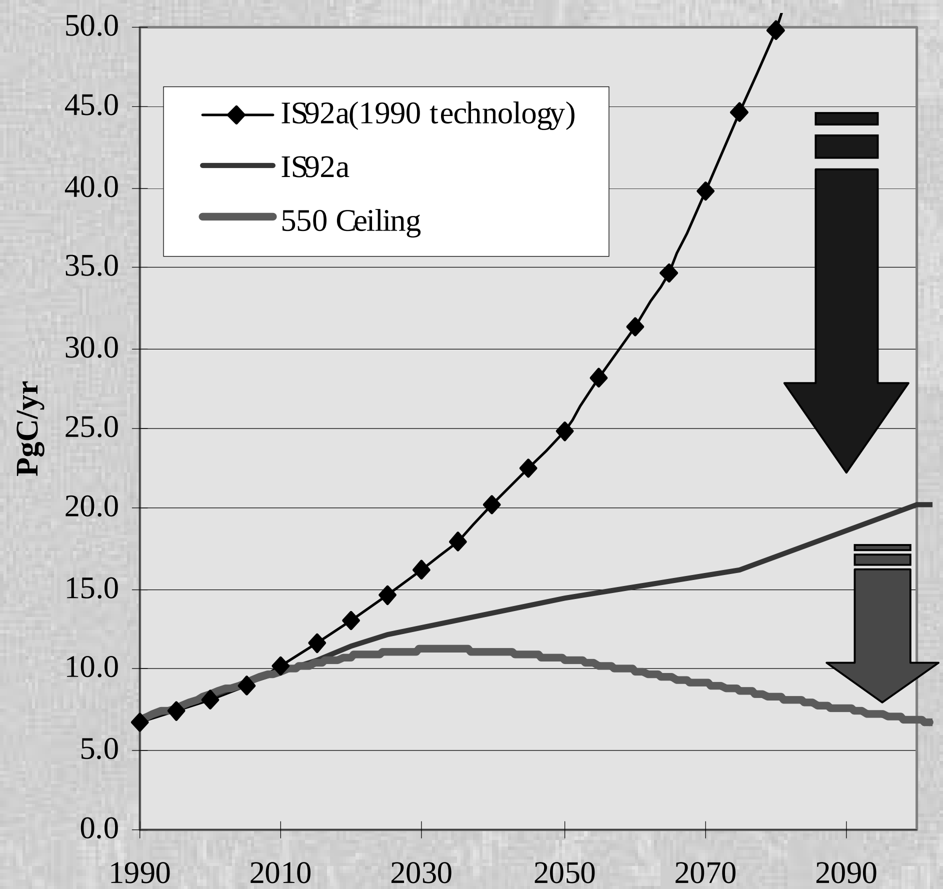
J. Edmonds, J.J. Dooley, and S.H. Kim

Battelle

THE ROADMAP

- **Greenhouse gas emissions may not control themselves.**
- Climate policy may happen.--*There are smart and dumb ways to proceed. The smart ways involve getting both the policy and the technology right--the GTSP*.
- There are no silver bullets--*Expanding the set of options to include carbon capture and sequestration can help limit the cost of any ceiling on CO_2 concentrations.*
- Managing greenhouse emissions means managing carbon.
- Carbon can be captured, transported, and sequestered in many ways.
- Carbon Capture Options
- Carbon Sequestration Opportunities

Energy Technologies Currently in the Pipeline Are Not Enough for Stabilization



This gap could be filled by <u>fully developed</u>:

Solar

Nuclear

Efficient Fossil Electric

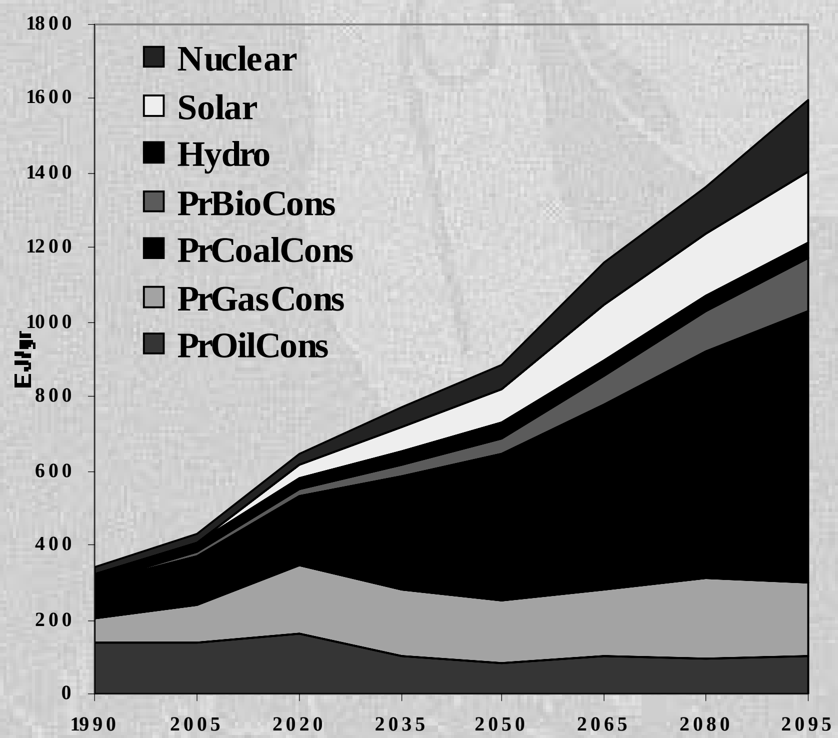
Advanced Transportation

End Use Efficiency

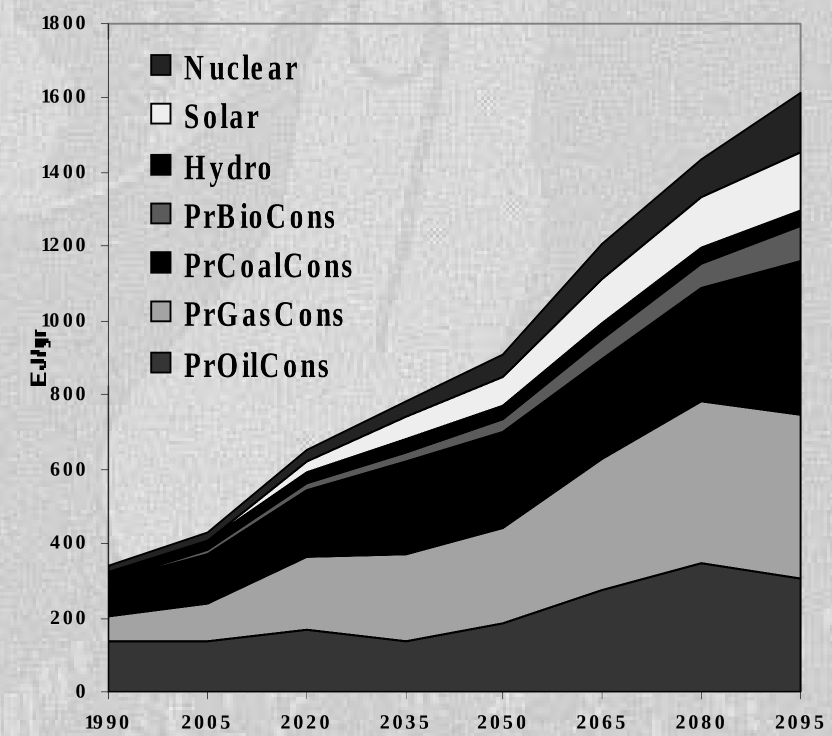
<u>But stabilization requires additional Carbon S&T!</u>

TWO REFERENCE EMISSIONS FUTURES

Coal-based World



Abundant Oil and Gas



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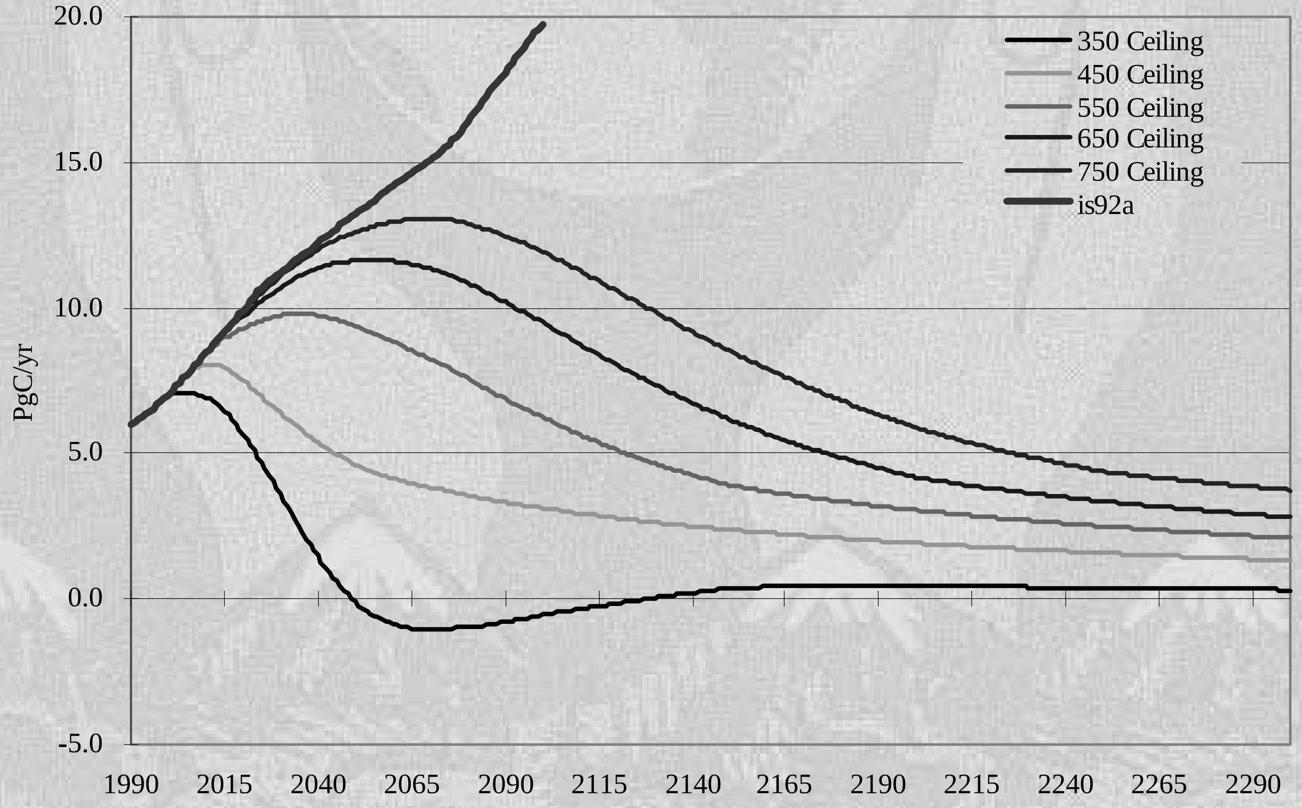
“Atmospheric stabilization” does not imply an end to ALL free venting of GHGs, but it does mean that we must start doing things in a much different way



HOW MUCH EMISSIONS MITIGATION?

It depends on the carbon concentration limit.

	Billions of tonnes of carbon emissions mitigation 2000 to 2100	percent IS92a scenario
450 ppmv	809	53%
550 ppmv	480	31%
650 ppmv	284	19%
750 ppmv	175	11%

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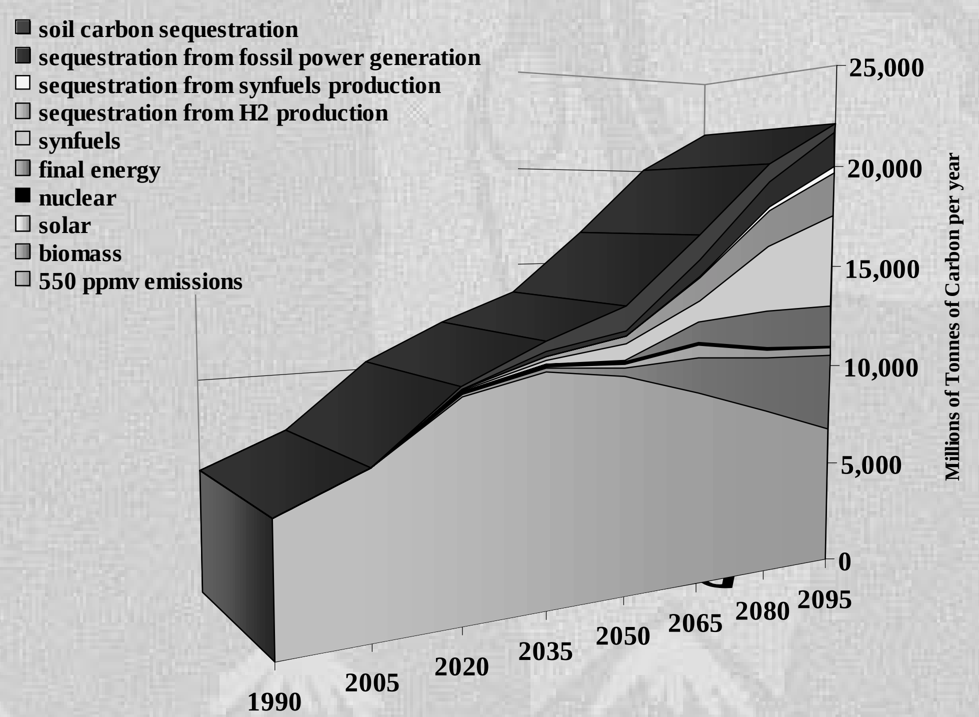
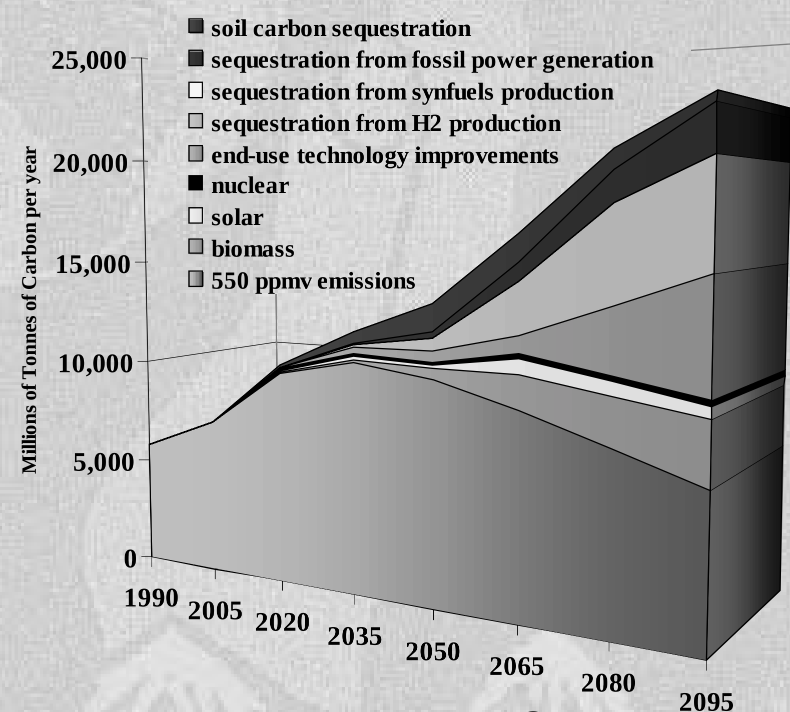
Filling the Global Gap



CBF 550



AOG 550

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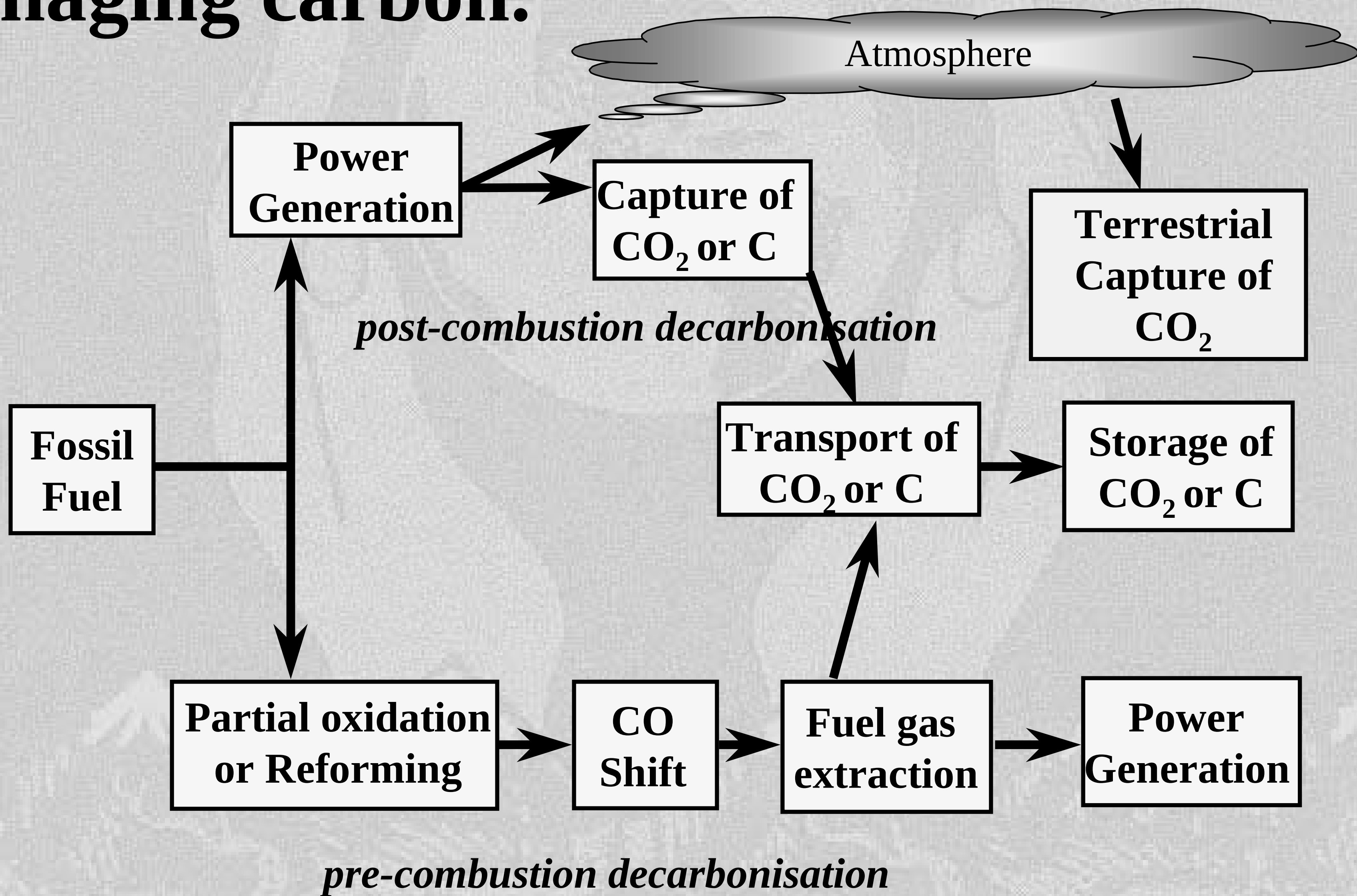

SOILS AND FOREST WON'T BE ENOUGH

	Billions of tonnes of carbon emissions mitigation 2000 to 2100	percent IS92a scenario
450 ppmv	809	53%
550 ppmv	480	31%
650 ppmv	284	19%
750 ppmv	175	11%

	Billion tonnes of C
Soils	40 to 80
Forests	90 to 180

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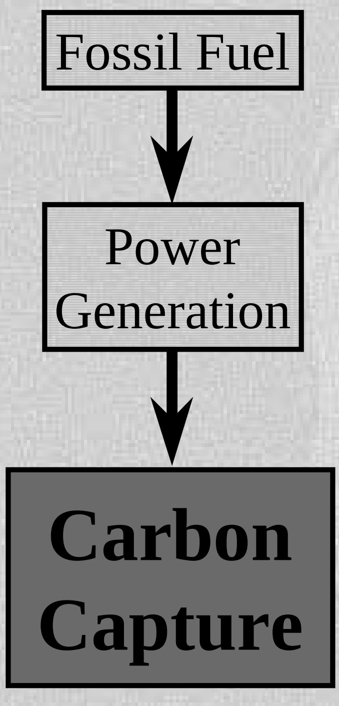
The Economics of CO_2 Capture and Transport

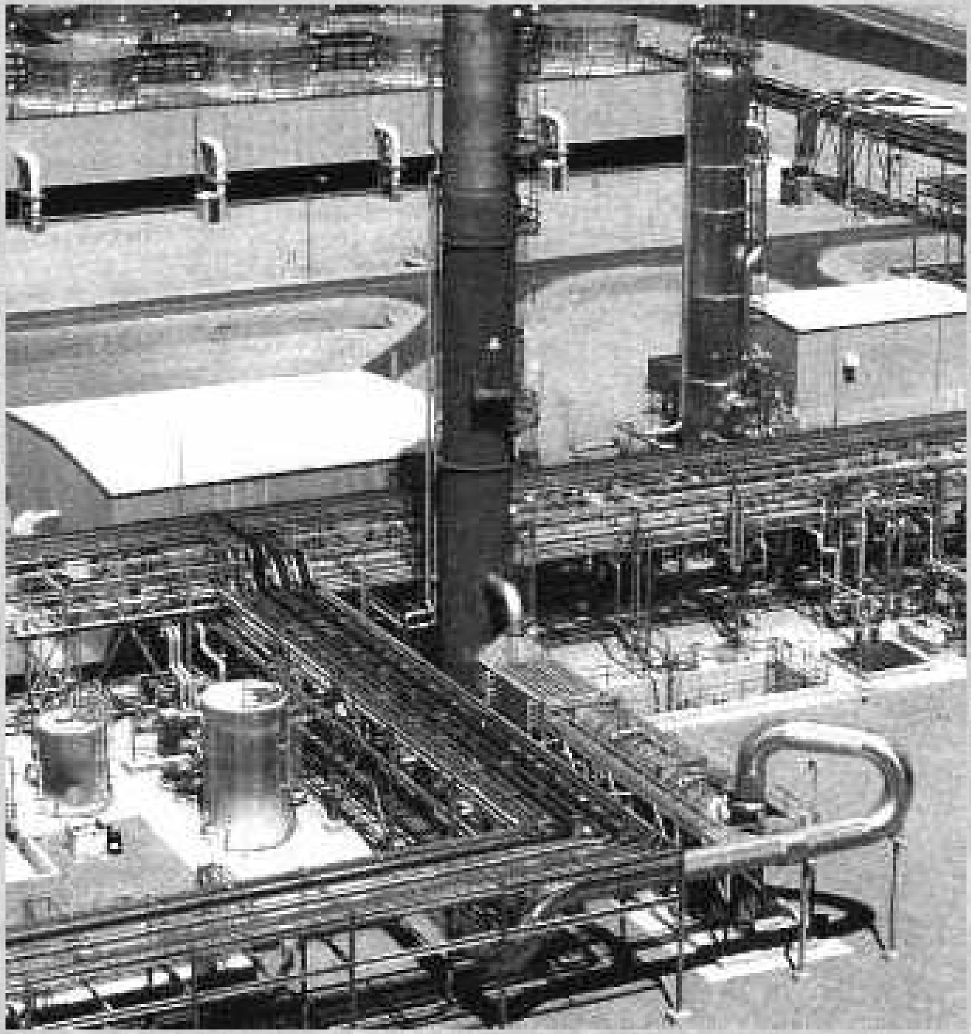
Howard Herzog

MIT Energy Laboratory

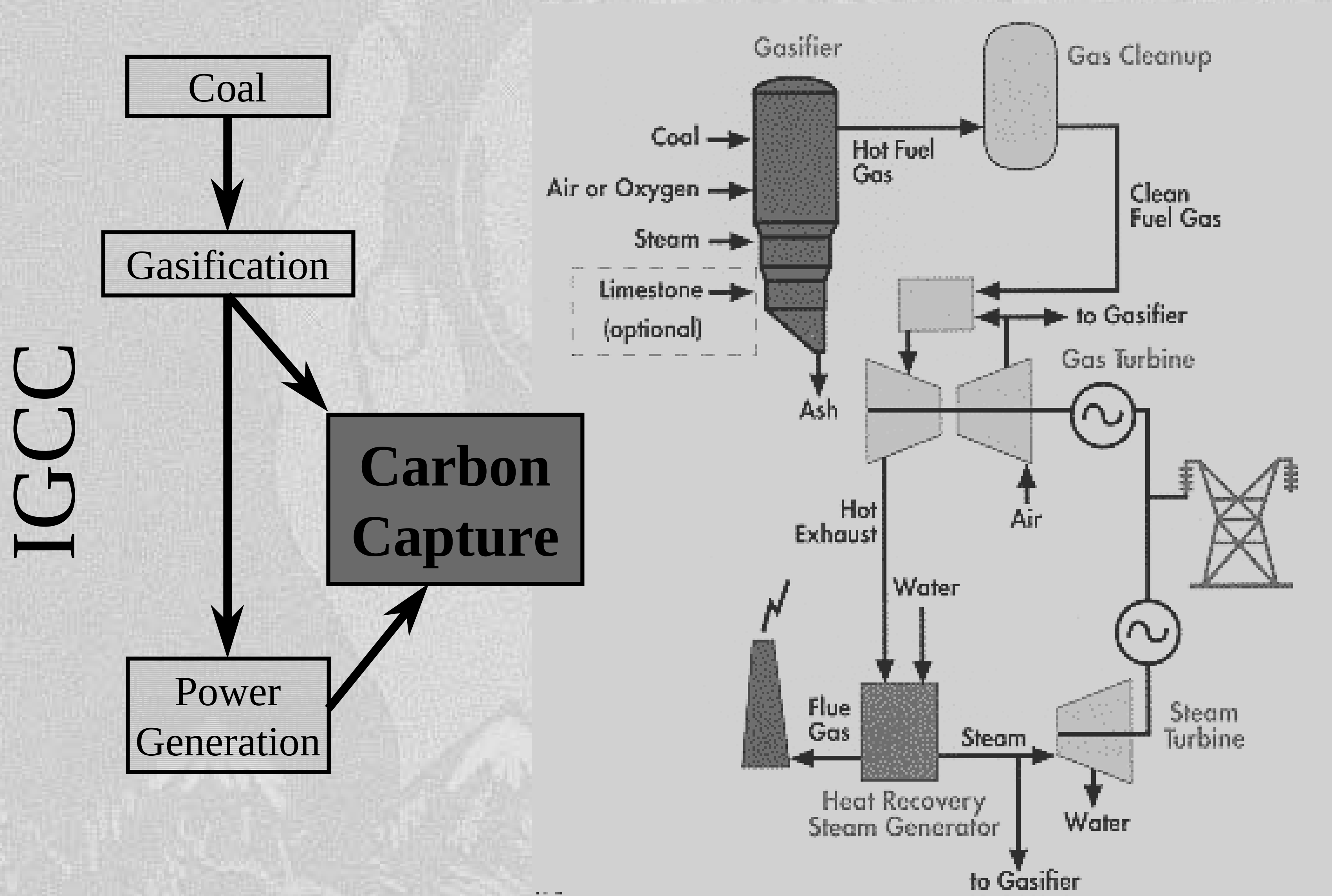
February 29, 2000

Post-Combustion Decarbonisation





Pre-Combustion Decarbonisation



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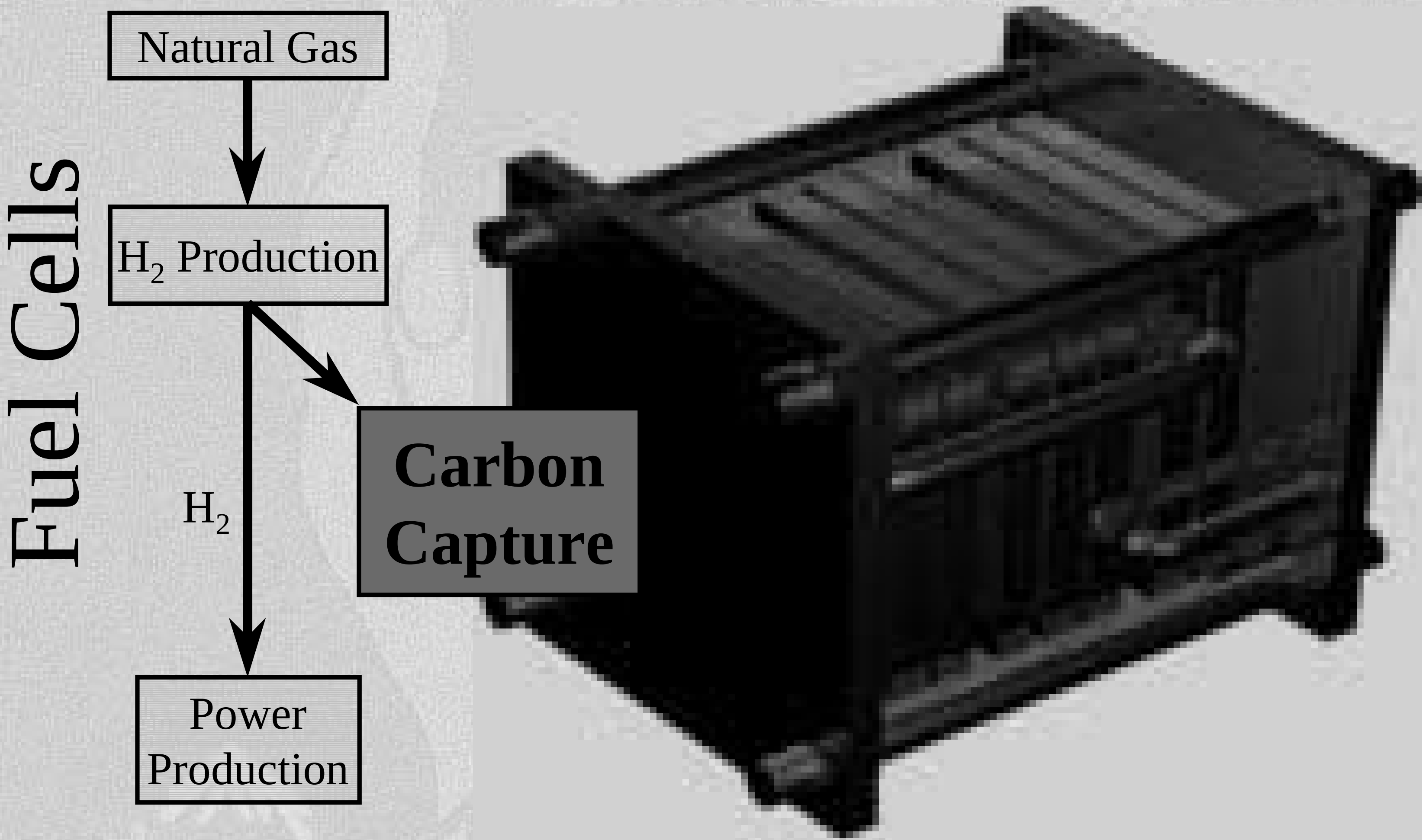


THE ROADMAP

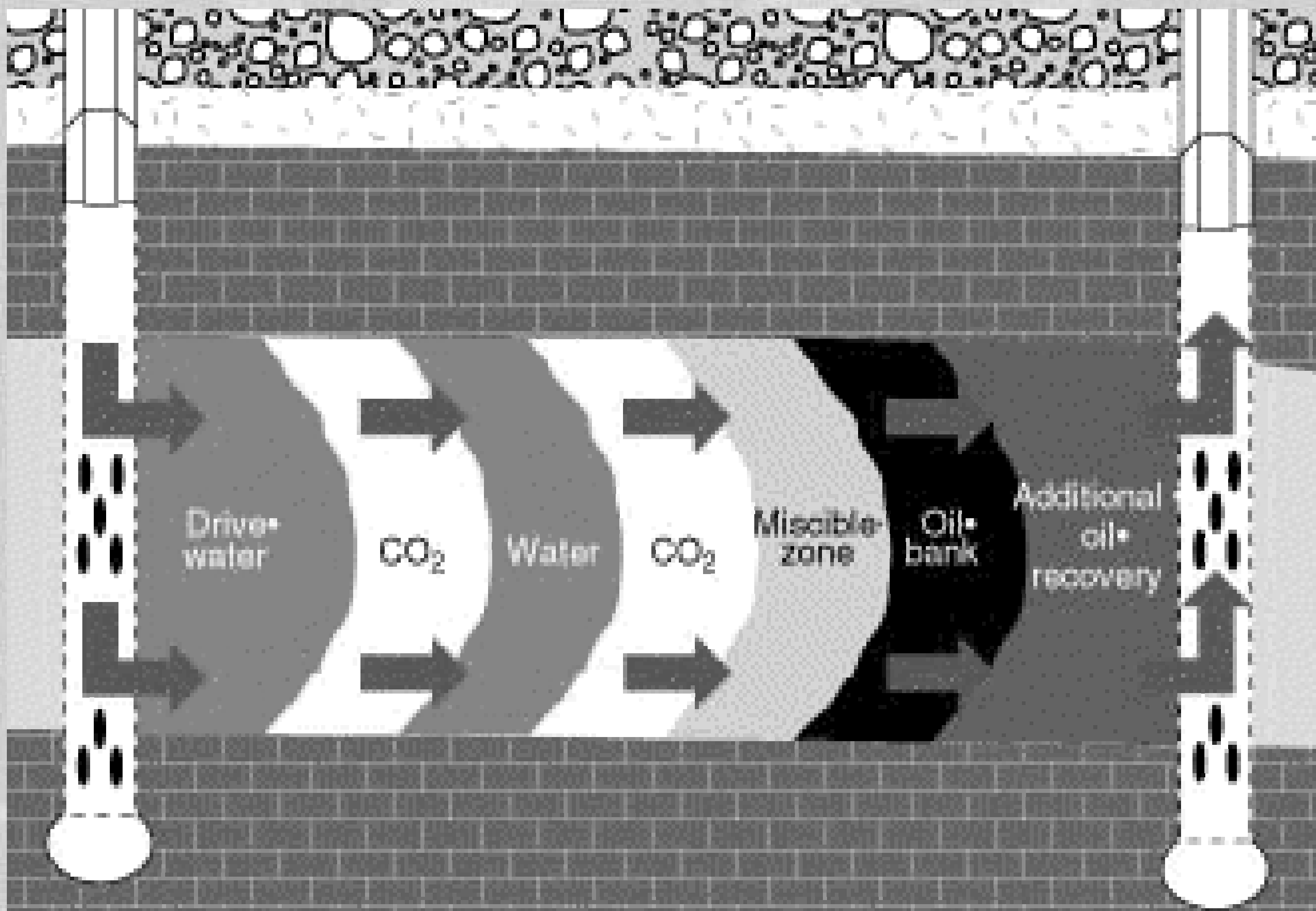
- Motivation
- Carbon Capture Options
- **Potential Reservoirs**
  - Depleted Oil and Gas Wells
  - Enhanced Oil Recovery
  - Coal Bed Methane
  - Saline Reservoirs
  - Oceans
- Sequestration Requirements
- Geographic Location in the United States
- Cost

Five Potential Reservoirs

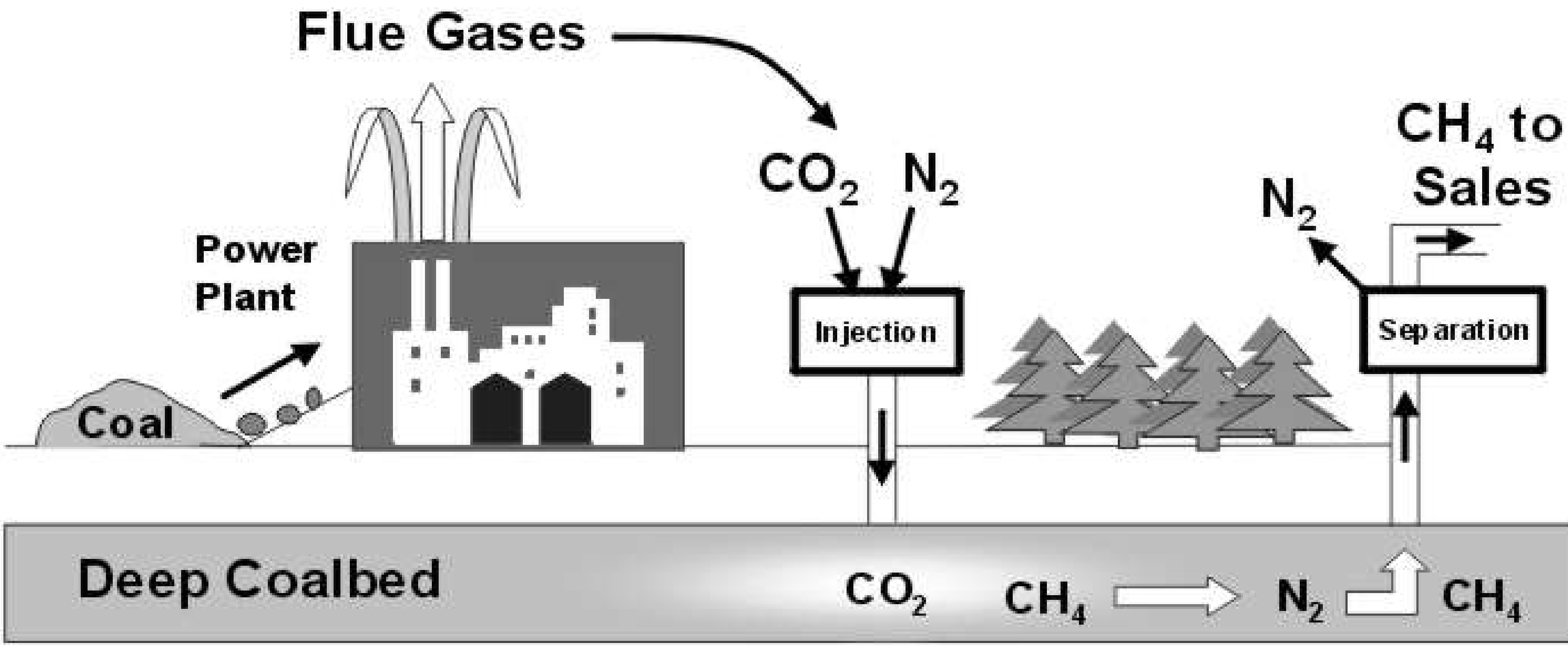
Global Carbon Storage Reservoirs	Range (billions of tonnes C)	
	Low	High
Deep Ocean	1,391	27,000
Deep Aquifers	87	2,727
Depleted Gas Reservoirs	136	300
Depleted Oil Reservoirs	41	191
Coal Seams	>20	

Herzog et al. 1997, and Freund 1999.

Enhanced Oil Recovery

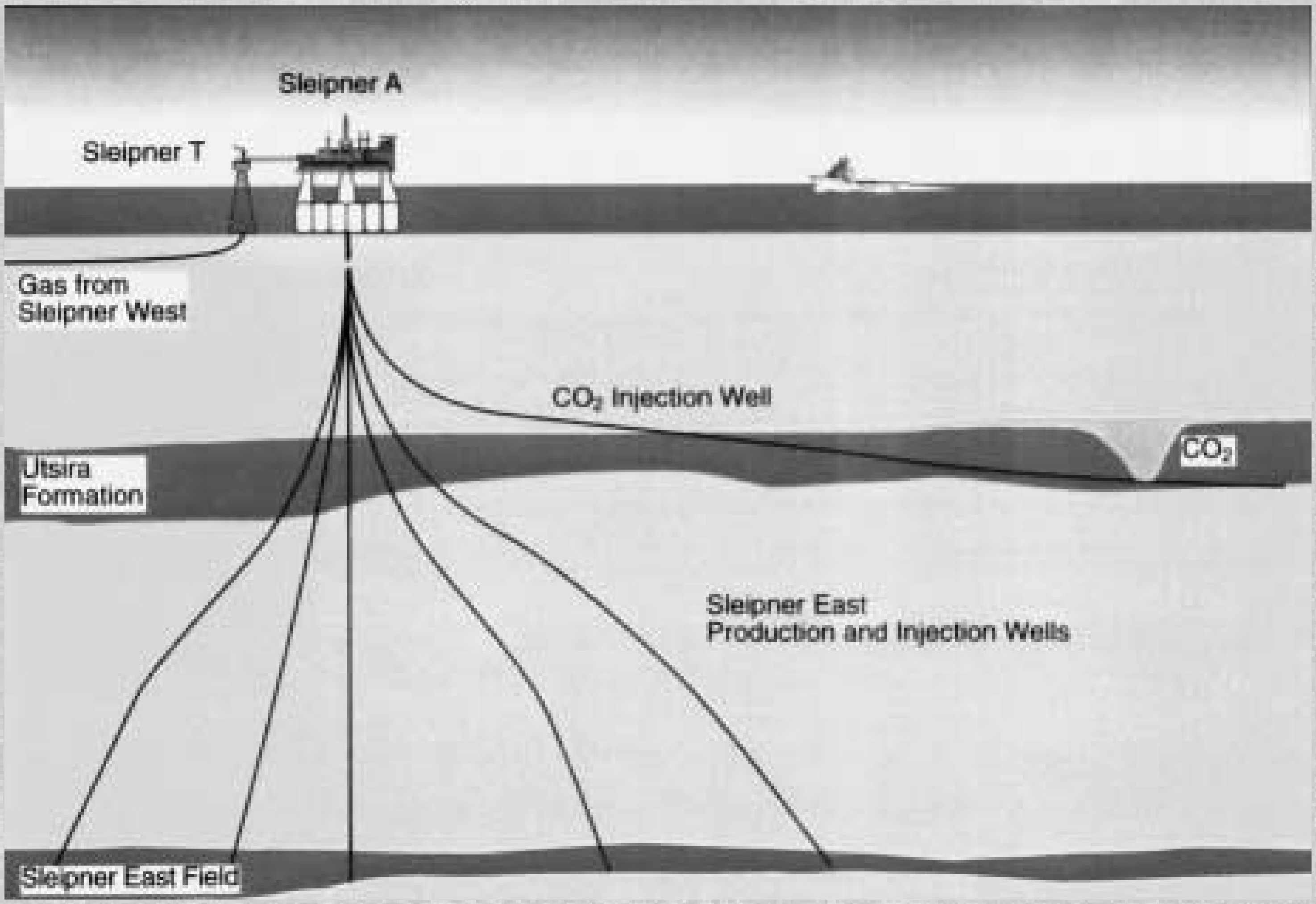


Enhanced Coal Bed Methane Recovery

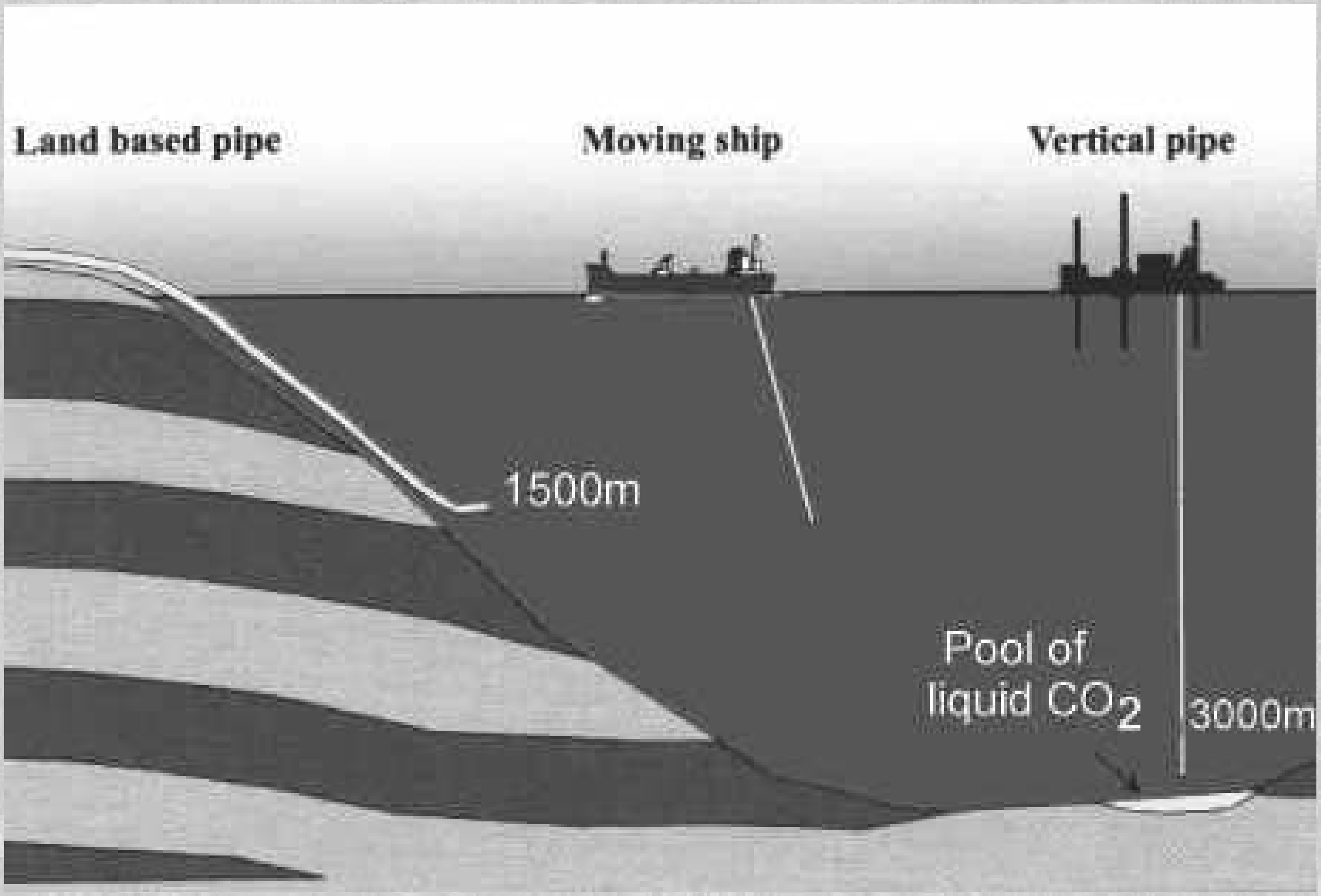


Enhanced coalbed methane recovery with sequestration of CO_2

Deep Saline Aquifers



The Ocean



Land based pipe
Moving ship
Vertical pipe
1500m
Pool of liquid CO_2
3000m

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The amount of carbon possibly needing to be stored is enormous.

We estimate that cumulative total of the carbon needing to be sequestered from the two protocols to be:

- Technology Graduation = 190 Billion tonnes C
- Tradable Permit = 111 Billion tonnes C

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Global estimates of CO_2 storage capacity & cost

Global Carbon Storage Reservoirs	Range ($/tonneC)	
	Low	High
Deep Ocean	$2.75	$13.50
Deep Aquifers	$3.50	
Depleted Gas Reservoirs	$6.00	
Depleted Oil Reservoirs	$6.00	
Coal Seams	<0	$135.00

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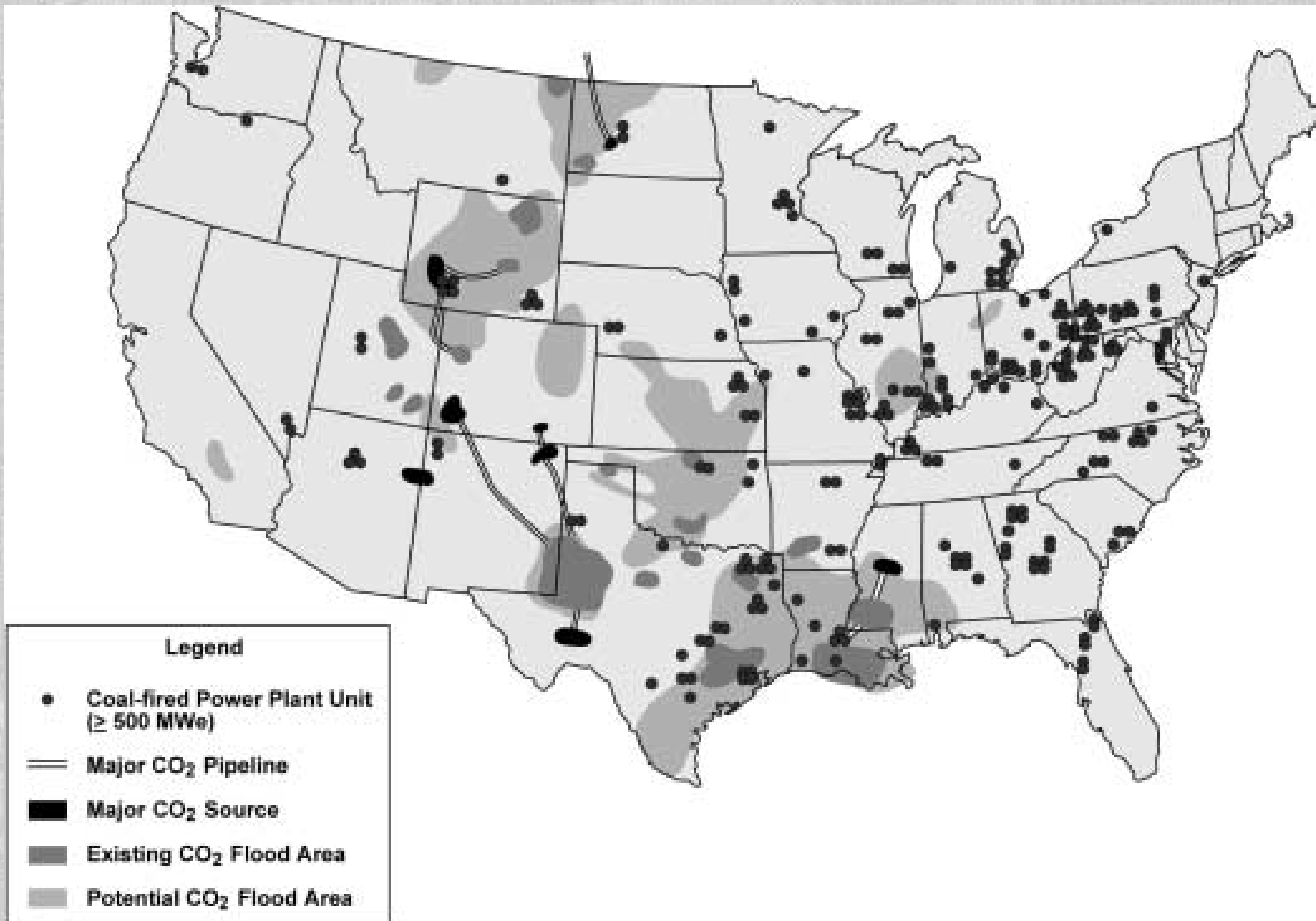
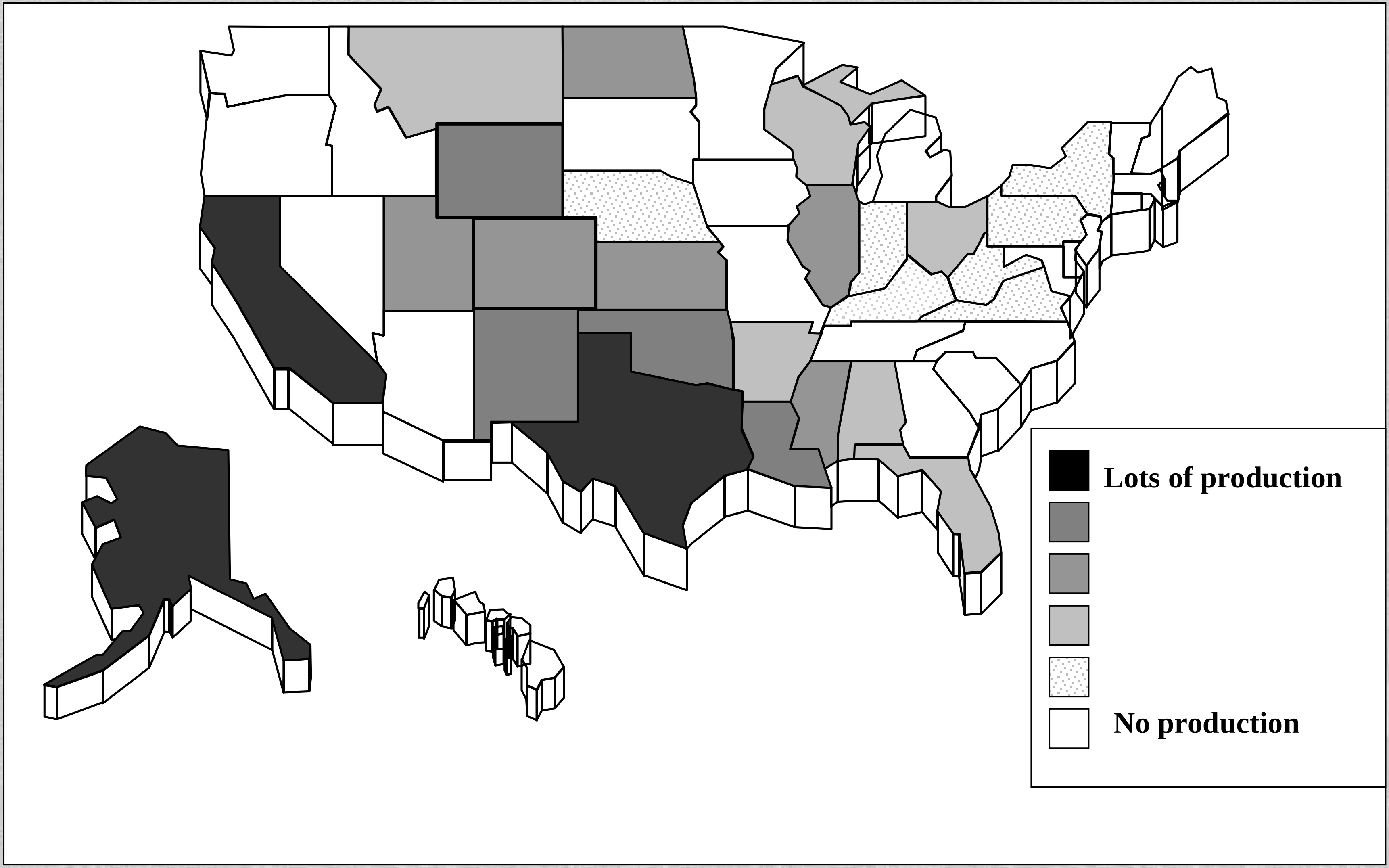
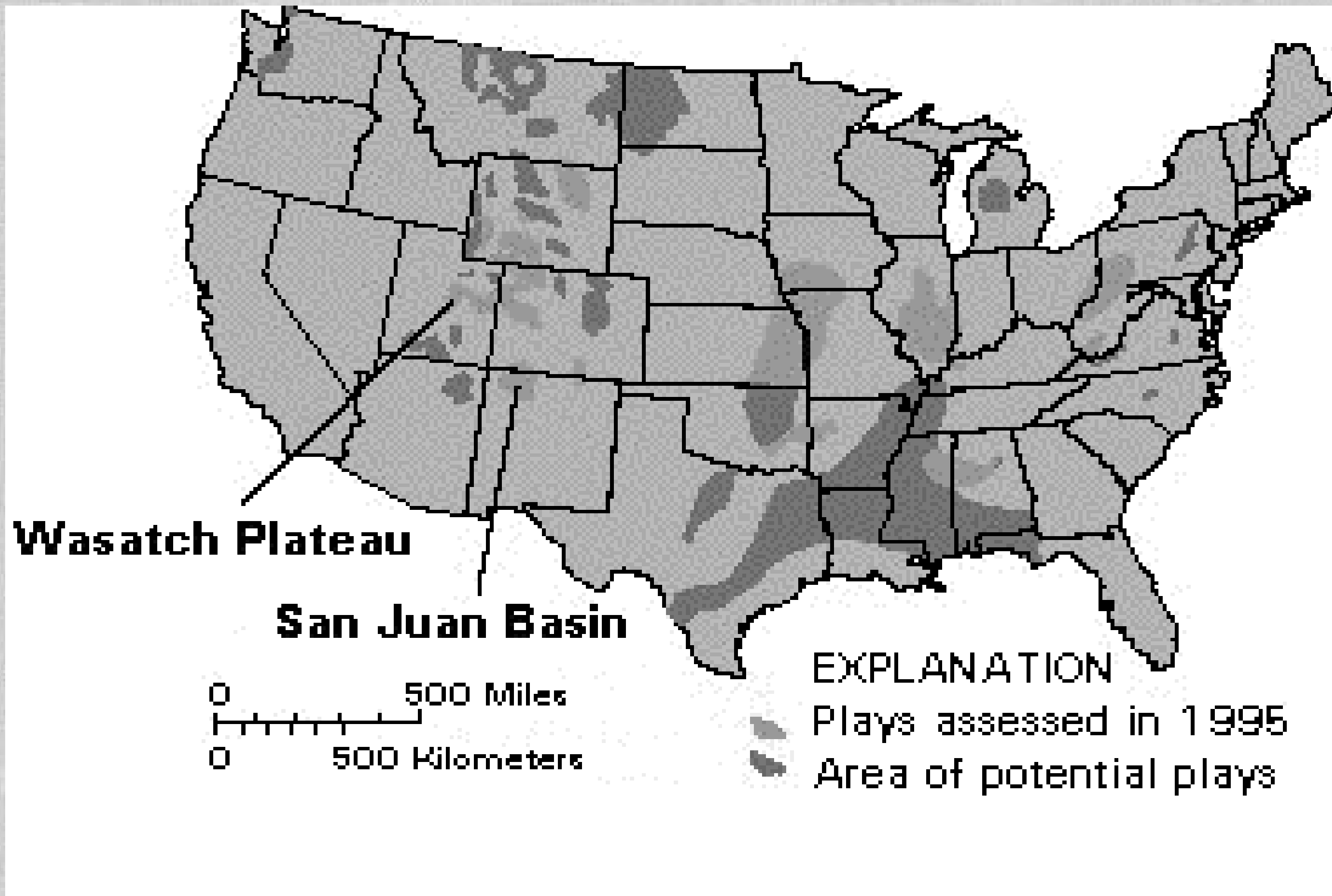
United States has many geologic reservoirs at its disposal, e.g., enhanced oil recovery.



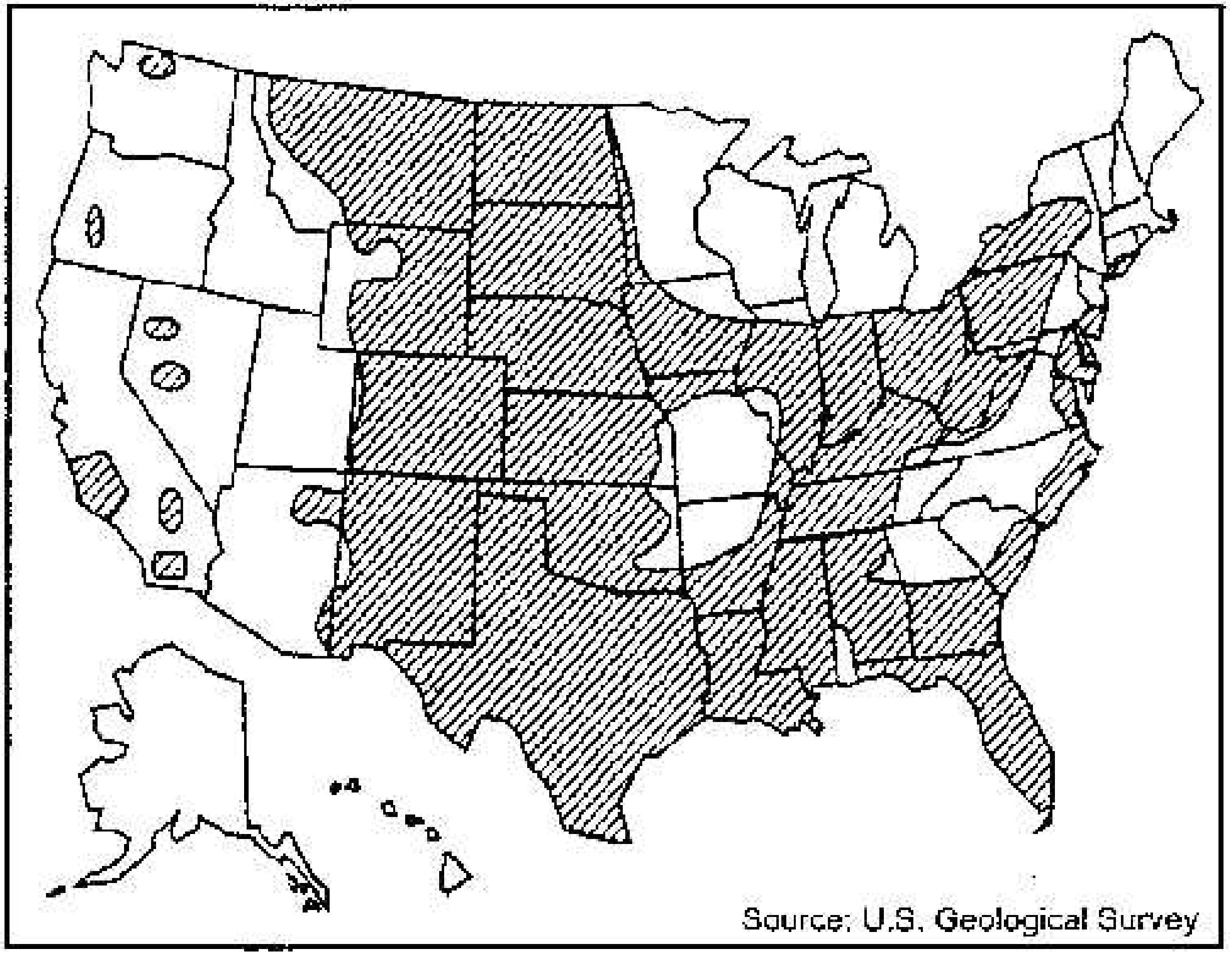
Oil and gas production areas within the past 20 years.



Areas with potential for coalbed methane recovery



Deep Saline Aquifers with the Potential for CO_2 Sequestration in the US *(Bergman and Winter, 1995)*



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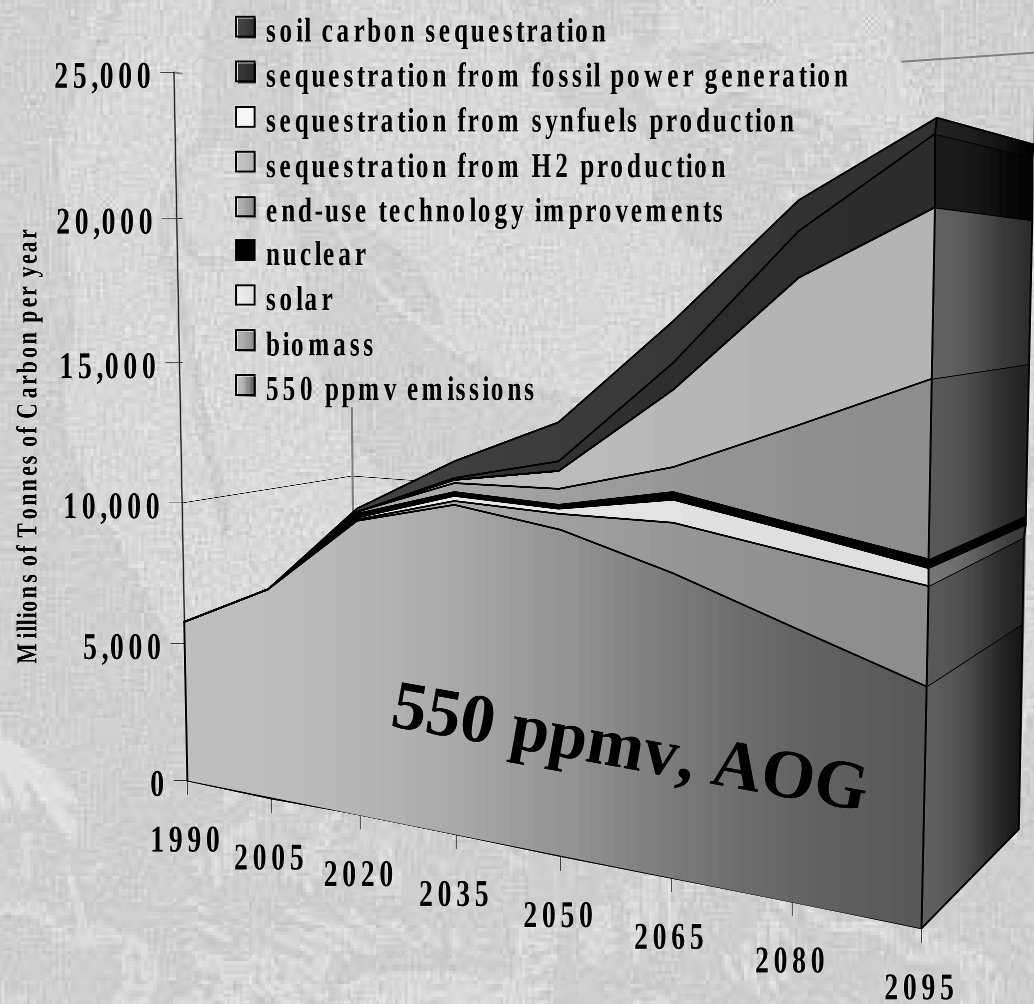
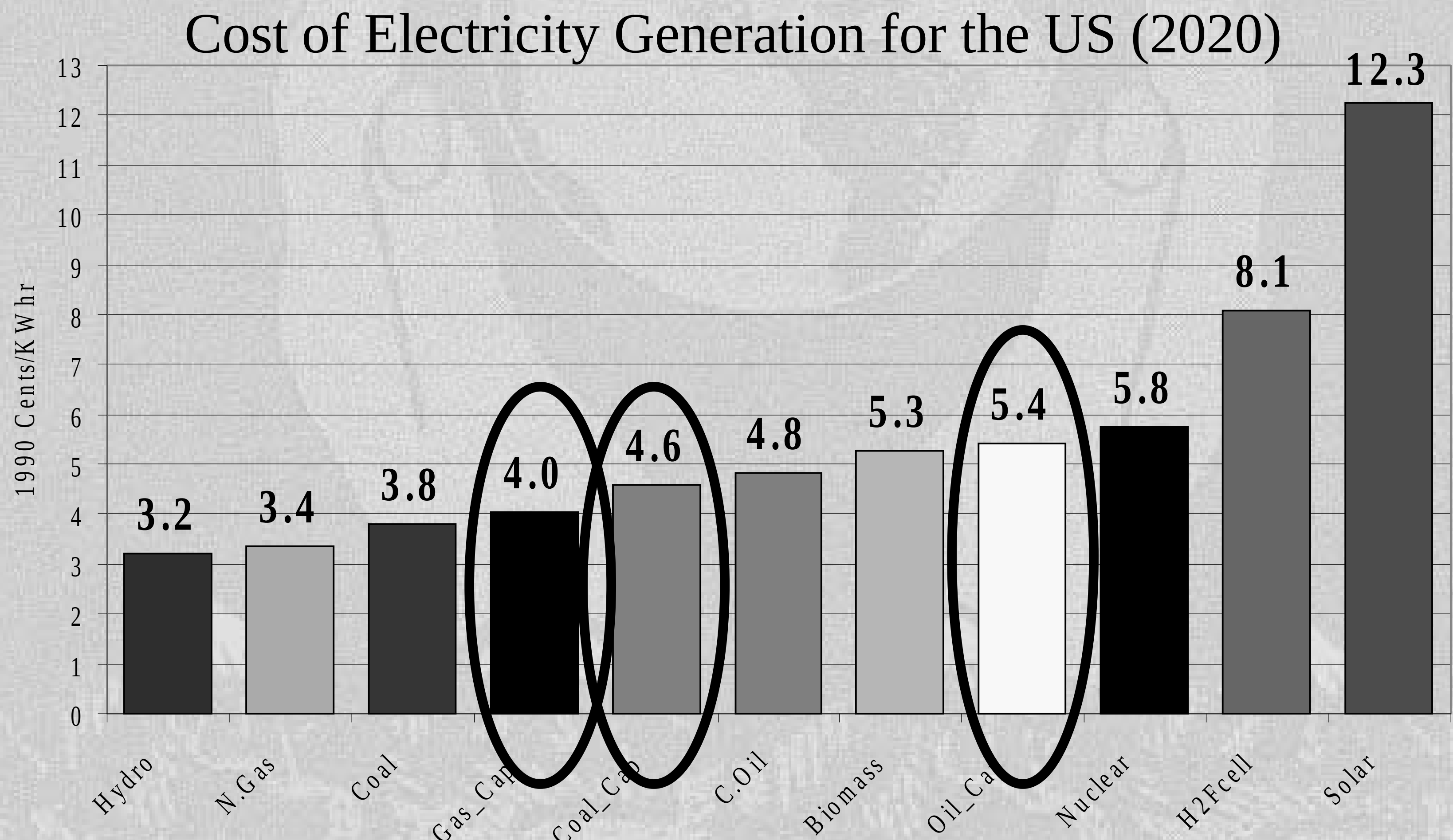
Engineered carbon sequestration can make a tremendous contribution to addressing climate change



Carbon capture systems can be significantly cheaper than many other competing energy technologies



What we don't know?

- **What are the environmental impacts associated with engineered sequestration?**
- **How long will the CO_2 stay in these reservoirs?**
- **What is the distribution of these reservoirs around the world?**
- **Is geologic sequestration of CO_2 any better or worse than any other mitigation option?**

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