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Global Energy Technology Strategy Program

Energy Technology, Stabilizing Climate Change, and CO_2 Capture and Storage

WestCarb

Public Outreach Meeting

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27 October 2004

Joint Global Change Research Institute

Portland, OR

Battelle Office of Science U.S. DEPARTMENT OF ENERGY JGCRI Joint Global Change Research Institute UNIVERSITY OF MARYLAND

Pacific Northwest National Laboratory

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EPRI

California Energy Commission

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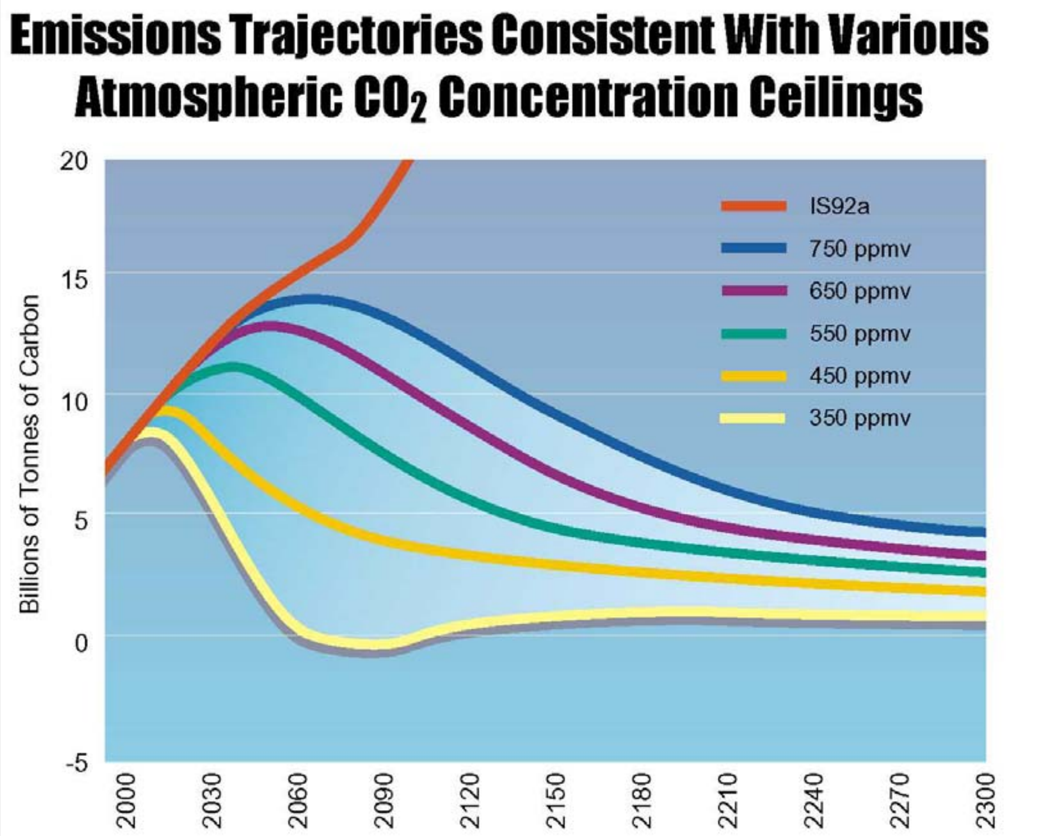
Some Major Points

- Climate change is a long-term issue—century to millennium scale—with implications for today.
- Energy is central. A broad portfolio including energy efficiency, renewable energy, and nuclear power is essential to manage the risk of climate change.
- Several potential additions to the technology portfolio could dramatically reduce the cost of stabilizing CO_2 concentrations—e.g. CO_2 Capture and Storage.
- CCS could not only enable the continued large scale use of fossil fuels, but also enable H_2 to reduce CO_2 emissions and in conjunction with commercial biomass creates the potential for a negative emission energy technology!
- The scale of technology deployment, e.g. carbon capture & storage, could be HUGE.

Stabilizing CO_2 Concentrations

- Stabilization of greenhouse gas **concentrations** is the goal of the Framework Convention on Climate Change
- Stabilizing the concentration of CO_2 is a very long term problem



- Stabilization means that GLOBAL emissions must peak in the decades ahead and then decline indefinitely thereafter.

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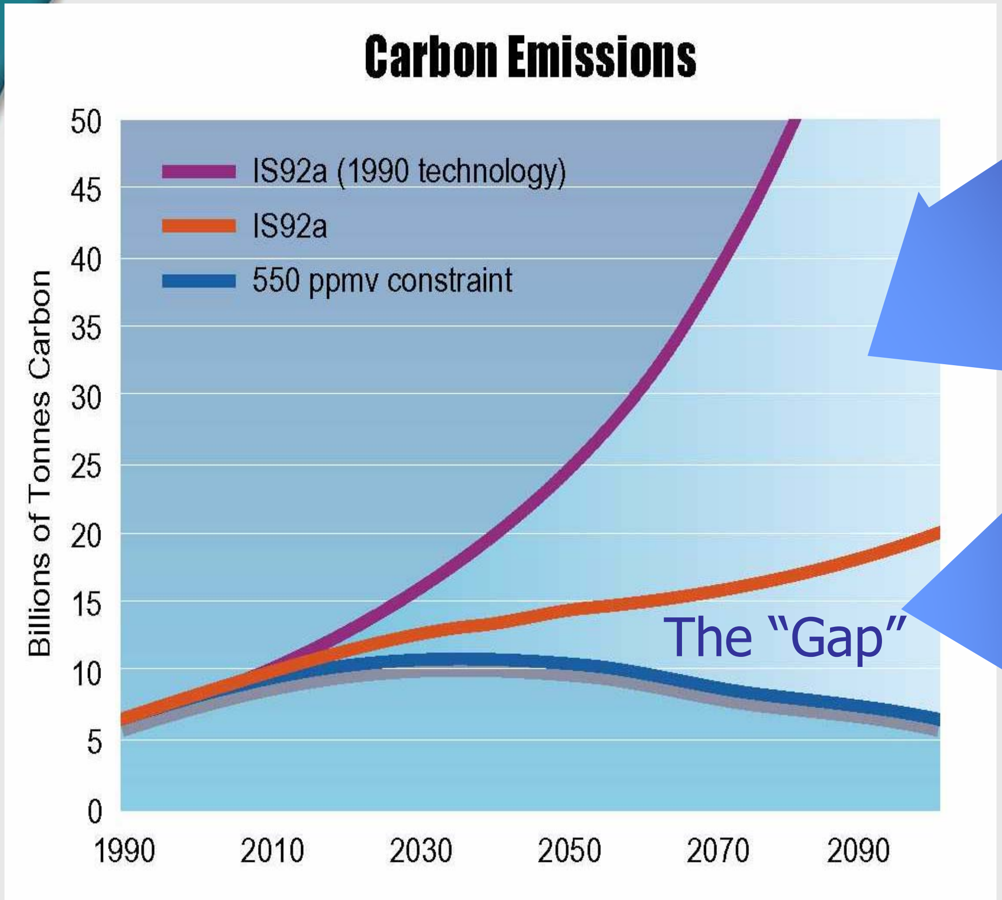
Stabilizing CO_2 Base Case and "Gap" Technologies



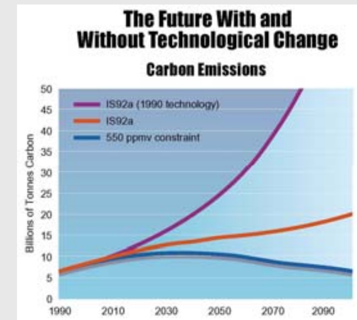
Assumed Advances In

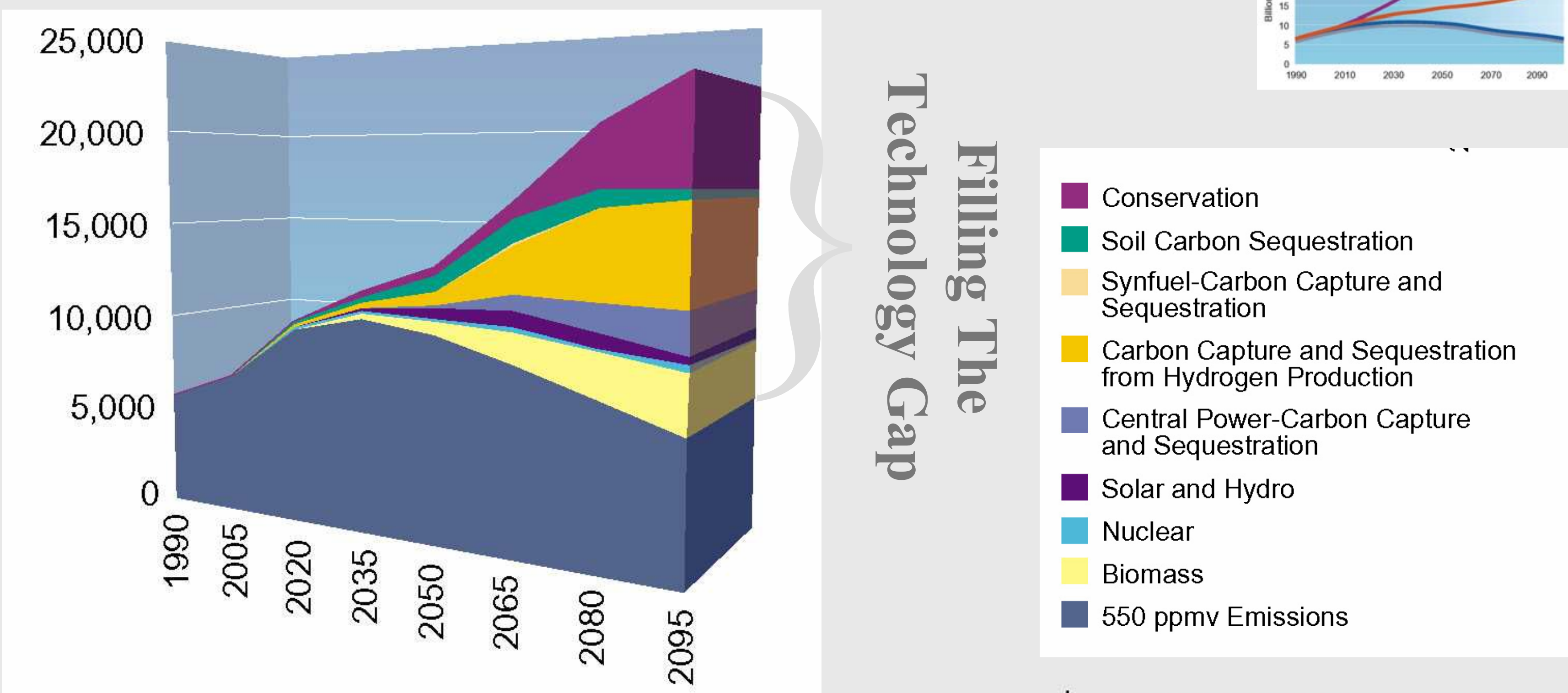
- Fossil Fuels
- Energy intensity
- Nuclear
- Renewables

Gap technologies

- E.g. CCS

Technology Breakthroughs Are Essential to Stabilizing Concentrations and Controlling Costs. For Example …





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There Are No "Silver Bullets" When It Comes to Stabilization

- Energy Intensity Improvements
  - Industry
  - Buildings
  - Transportation
- Wind and Solar
- Biotechnology
  - Soils
  - Biomass crops
  - Advanced biotechnology
- Nuclear
  - Fission
  - Fusion
- Carbon Dioxide Capture and Storage
  - Geologic
  - Terrestrial (soils, trees)
- Advanced Transformation Systems
  - Electricity
  - Hydrogen
  - Bio-derivative fuels
- Non-CO_2 Greenhouse Gases

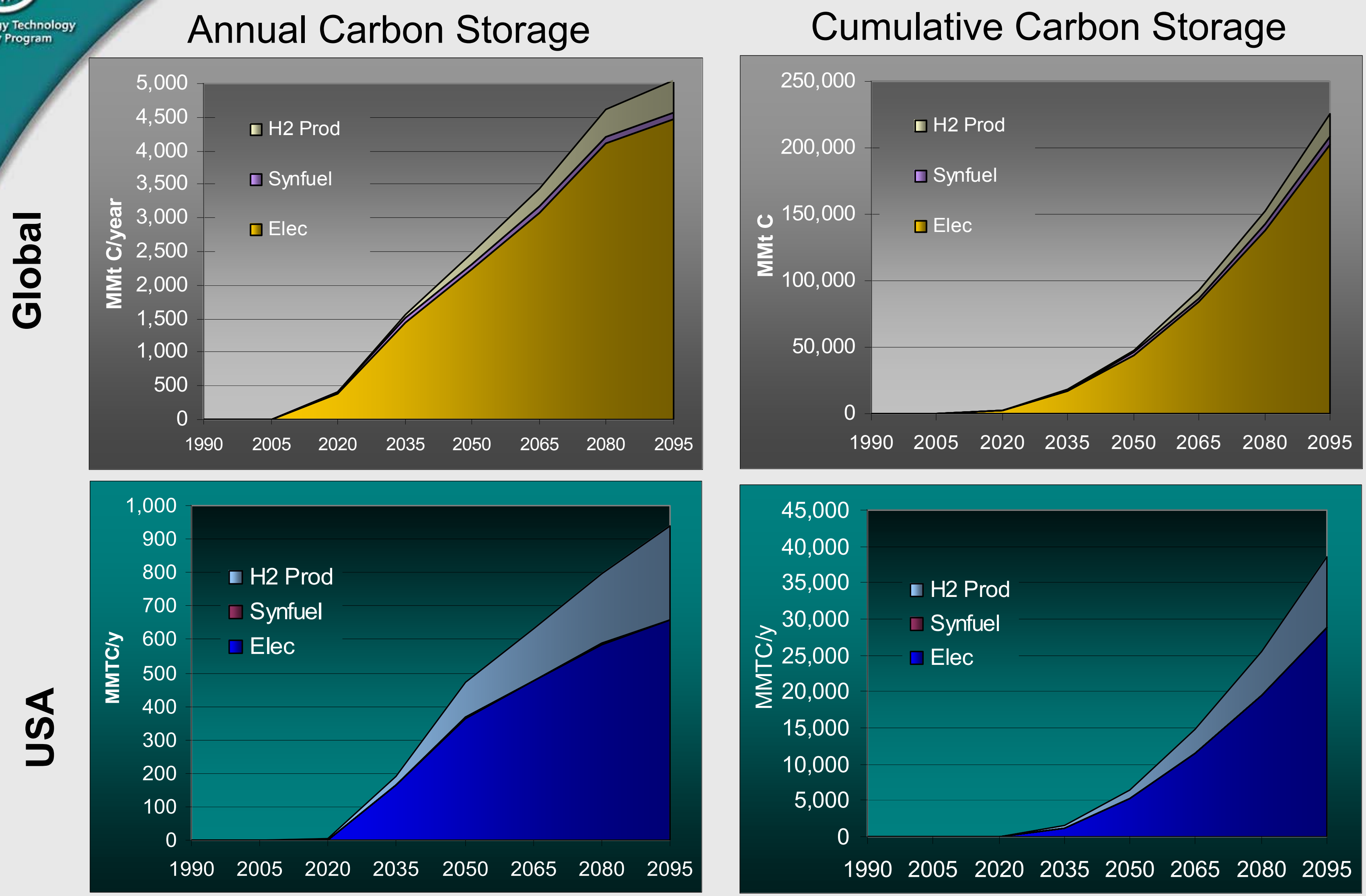
Carbon capture and storage already exists.

CCS Pathways

CO_2 capture and storage can be combined with technologies that reach across the economy.

- Capture from power plants,
- Capture in the production of H_2, and
- Capture from commercial biomass.
  - Since biomass obtained its carbon from the air, it has no net effect of the concentration in the atmosphere, but
  - If the carbon is removed and stored, either in the production of electricity or production of H_2, then the biomass energy actually removes carbon on net from the atmosphere!

How Big?



PNNL MiniCAM Output, EMF-19, B2 scenario with CCS and H2

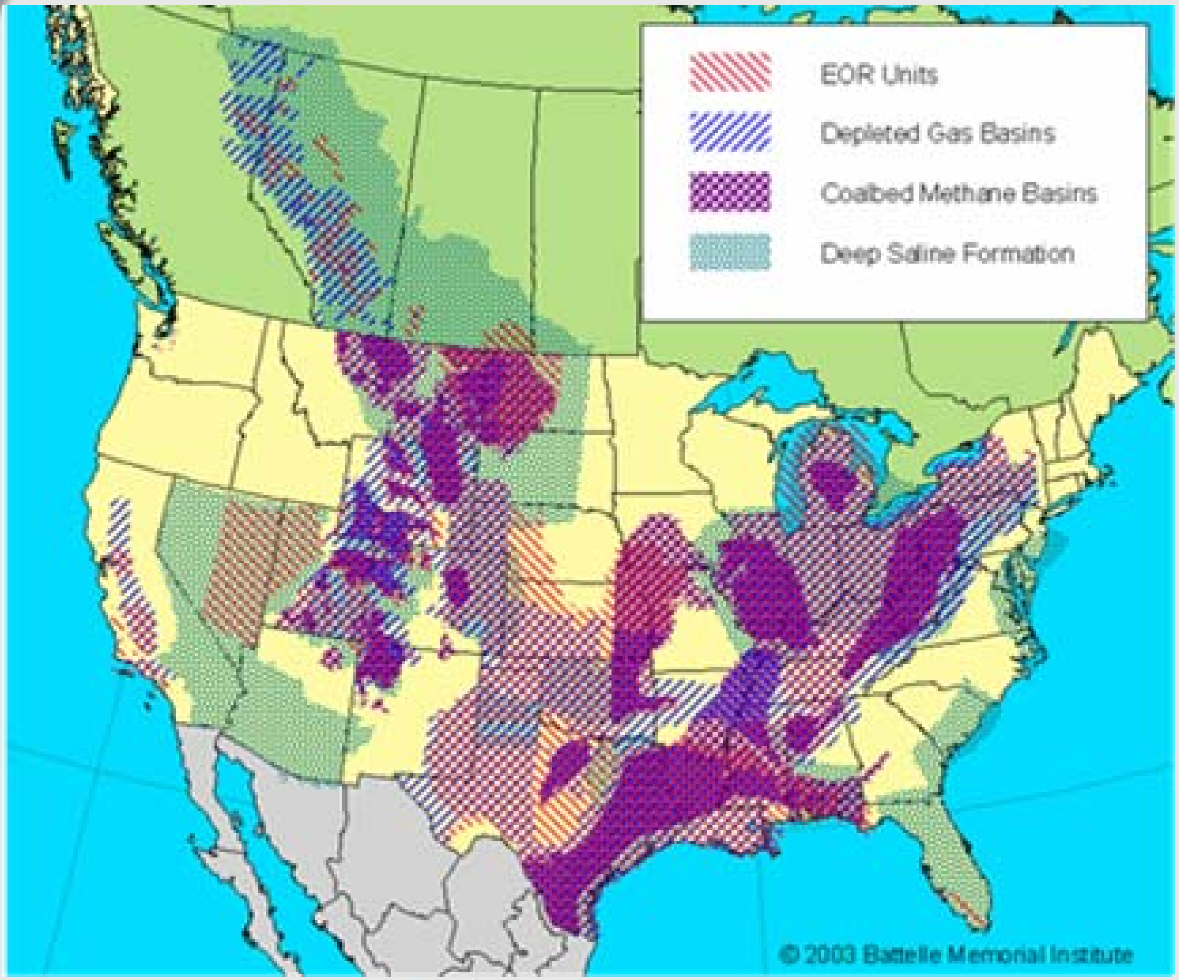
Is There Storage Available?

Carbon Storage Reservoir	Range (PgC)
Deep Saline Reservoirs	*87 to 2,727*
Depleted Gas Reservoirs	*136 to 300*
Depleted Oil Reservoirs	*41 to 191*
Unminable Coal	*>20*
Basalt Formations	*>1,000*
Deep Ocean	*1,400 to 27,000*

Source: Herzog et al. (1997), Freund and Ormerod (1997), PNNL (2001).

Recent Work Has Looked at the USA and Canada

Where Is the Storage Reservoir Capacity?



- 3,800 GtCO2 US and Canadian Geologic CO_2 Storage Reservoirs Theoretical Capacity
  - 3730 GtCO2in deep saline formations (DSF),
  - 65 GtCO2 in deep unminable coal seams,
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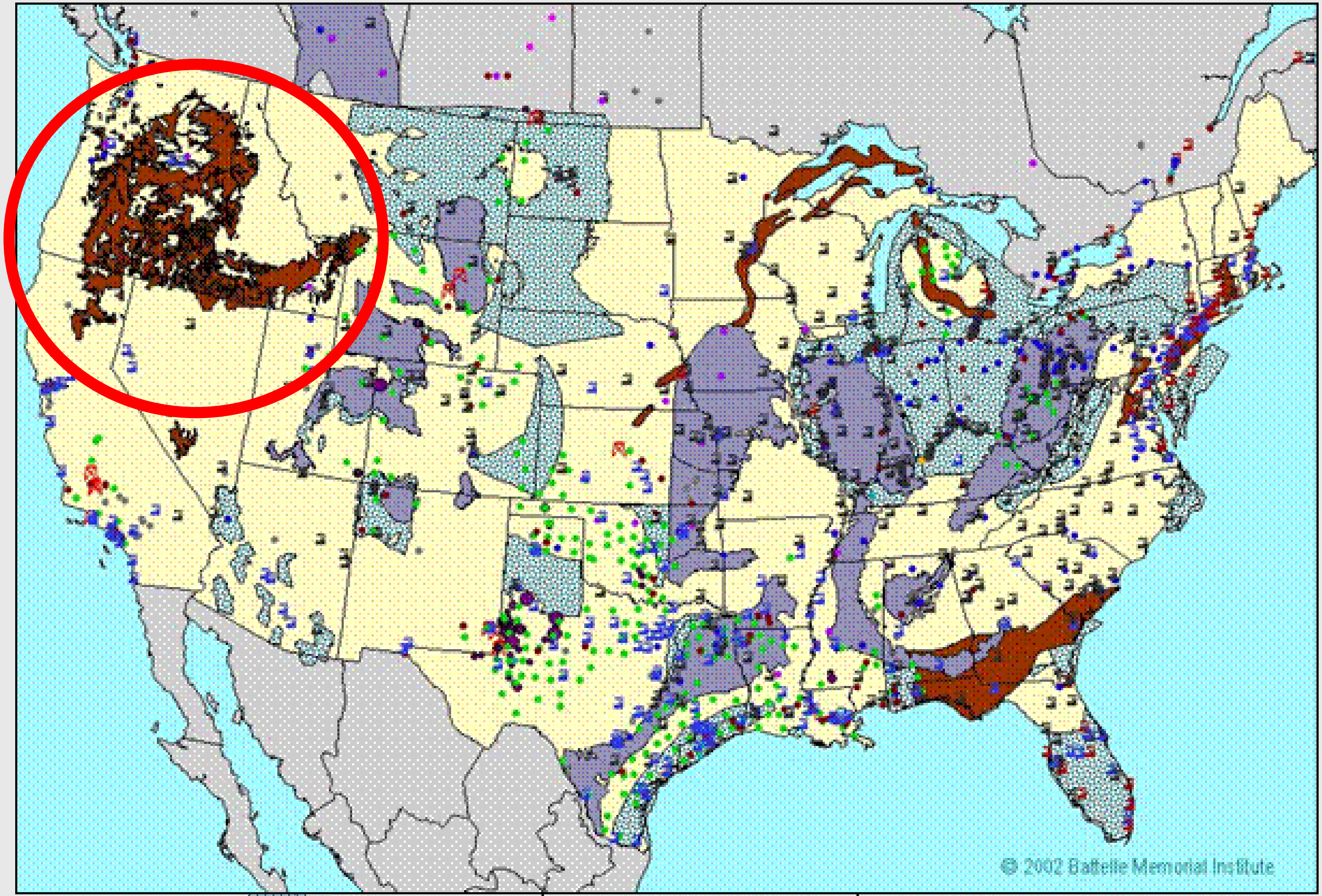
Potential Storage in the Pacific Northwest—Basalt Flows

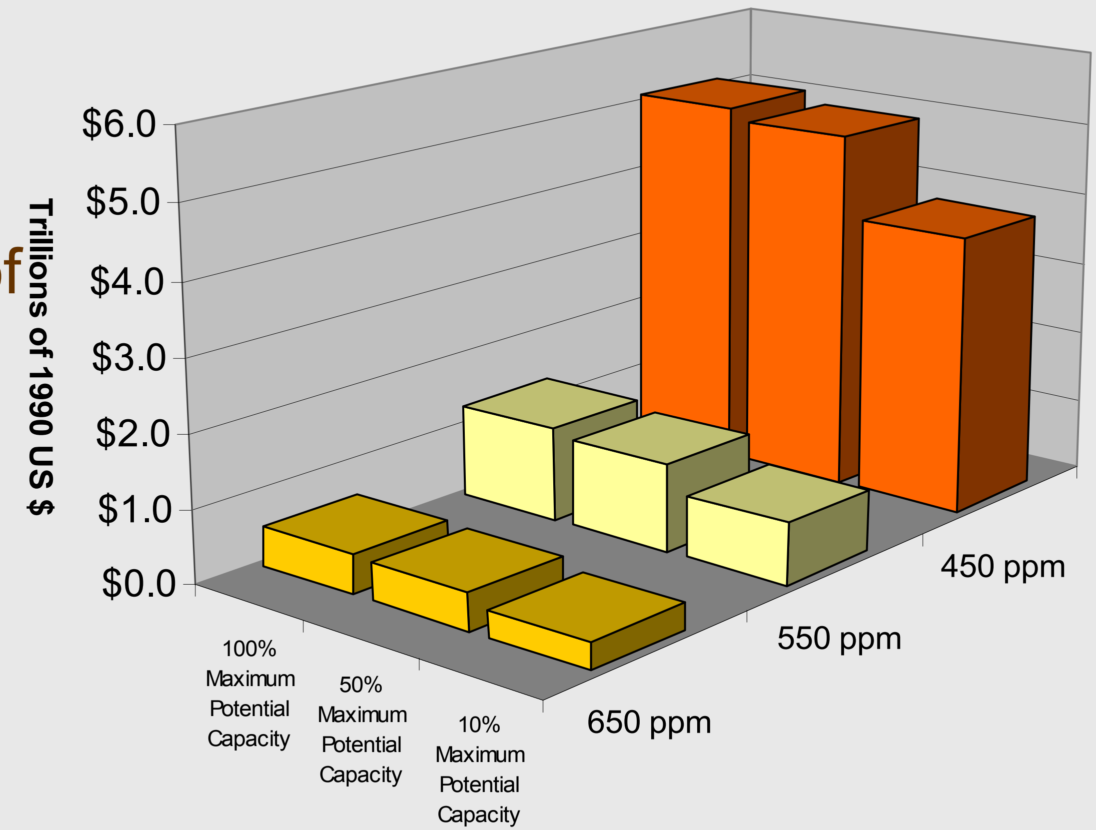


Cost Estimates for CCS

Costs component	***Cost range $/tCO_2$ avoided*** *($/tC avoided)*	***Potential for cost reduction up to 2020***
Capture (including separation and compression)	$13 – $74 ($48 - $272)	20 - 30 %
Capture from industrial sources (including separation and compression)	$0 - $116 ($0 - $426)	Limited
Geological or ocean storage (including measurement, monitoring and verification)	$5 – $10 ($18 – $37)	Considerable for new technologies, limited for commercially viable injection

What's It Worth?

Technology is the largest lever we have on the cost of stabilizing greenhouse gas concentrations—*The Value of Capture & Sequestration*



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Summing Up

- Climate change is a long-term issue—century to millennium scale—with implications for today.
- A broad portfolio including energy efficiency, renewable energy, and nuclear power is essential to manage the risk of climate change.
- Several potential additions to the technology portfolio could dramatically reduce the cost of stabilizing CO_2 concentrations—e.g. CO_2 Capture and Storage.
- CCS could not only enable the continued large scale use of fossil fuels, but also enable H_2 to reduce CO_2 emissions and in conjunction with commercial biomass creates the potential for a negative emission energy technology!
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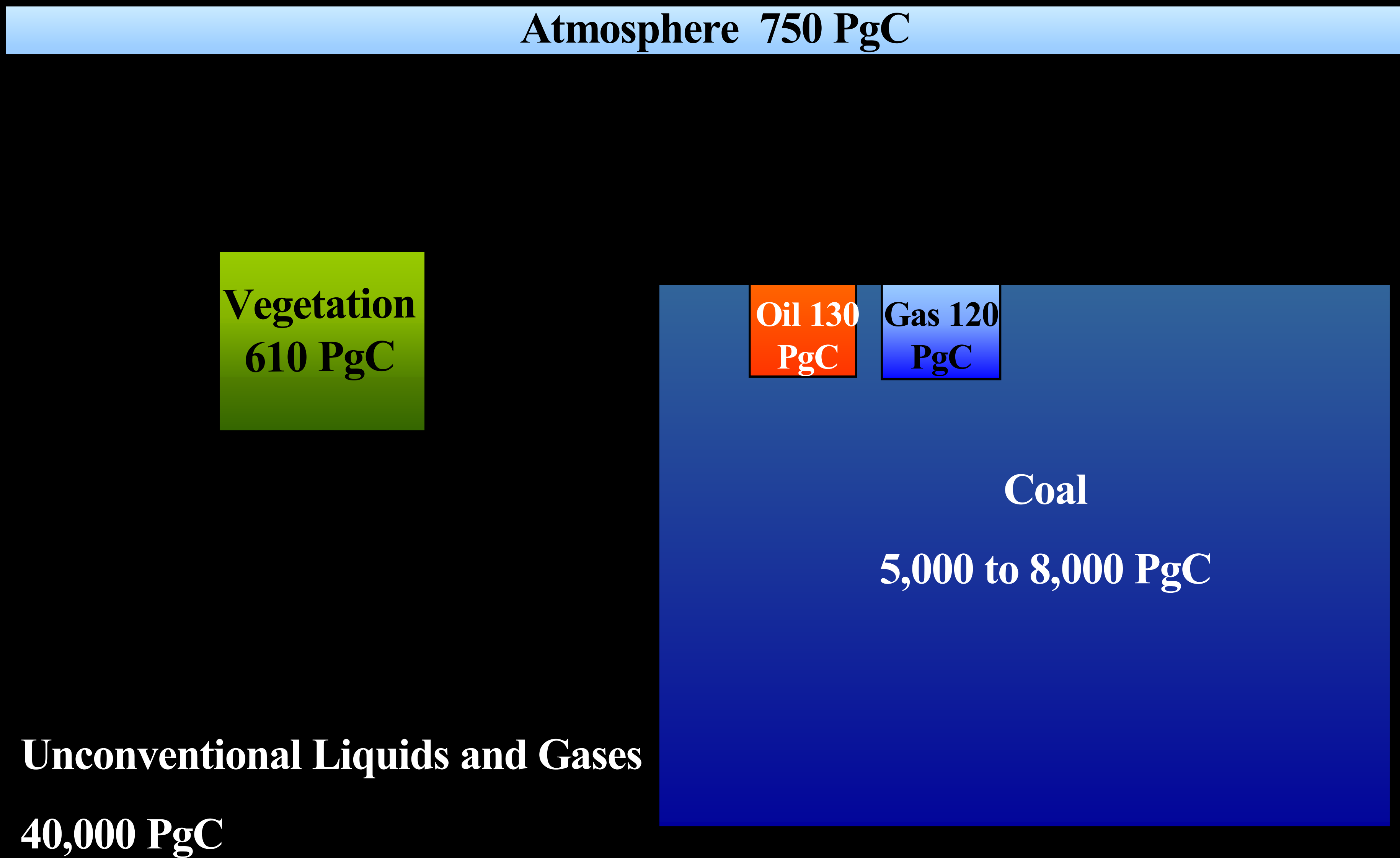
END

Will the Problem Go Away on Its Own?

Won’t the limited conventional oil and gas resource force a transition in the near term to a world based on energy efficiency and renewable and nuclear energy forms?

FOSSIL FUEL RESOURCES

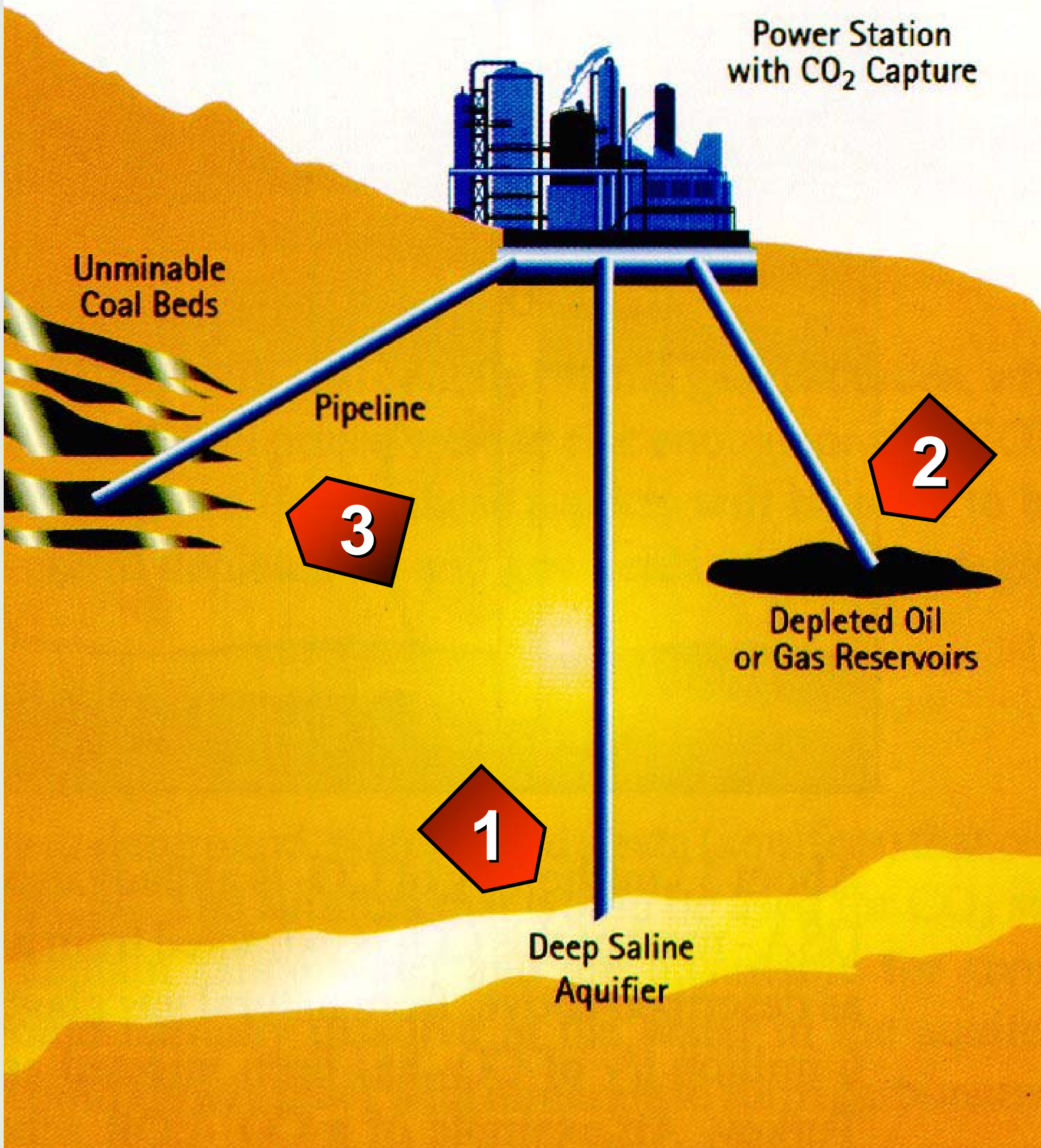


Cost of CCS Will Depend on Many Factors

- Technology for Capture
  - Retrofit versus new capacity
  - Add-on to an existing pulverized coal plant or a new integrated gasification combined cycle plant designed from the outset to capture CO_2.
  - Coal or Gas plant?
- Storage Opportunities
  - Are the reservoirs near by?
  - Enhanced oil recovery?
  - Coalbed methane production?
  - Deep saline reservoir?
- The National and Regional Market

Geologic Disposal

1. Deep saline formations
2. Oil & gas reservoirs
3. Unmined coal beds



(IEA Greenhouse R&D Programme, 2001)

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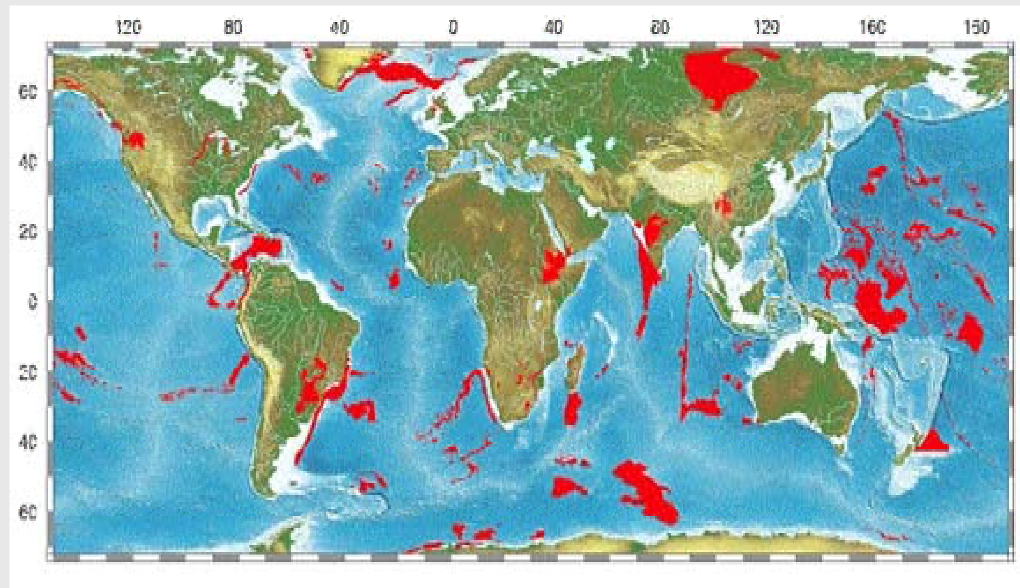
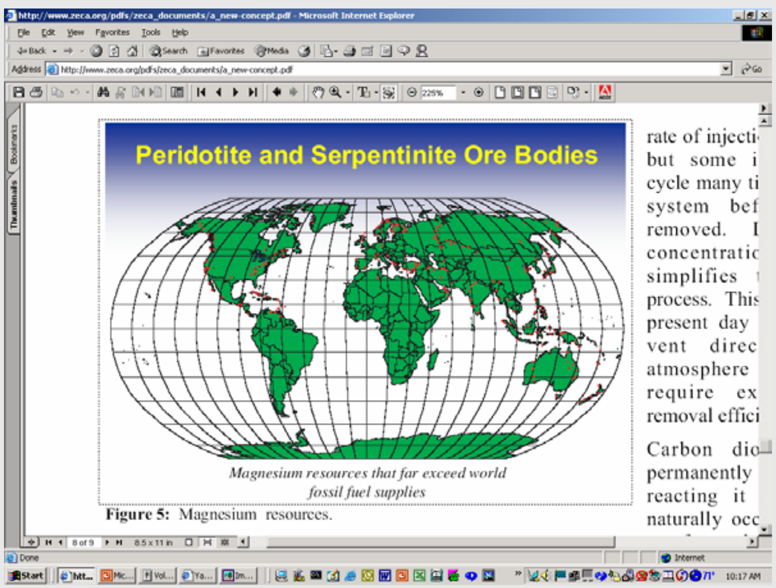
Geologic Disposal

There are other reservoirs that need to be explored…

Deep Basalt Flows



Ex situ Mineralization



Ocean Disposal

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Important Research Is Needed to Answer Key Questions About CO_2 Capture and Storage

- How much will CO_2 capture cost? How much can costs be lowered?
- Where to store the CO_2?
- Will the CO_2 remain where it is put?
- How much does CCS lower the cost of meeting an environmental goal?

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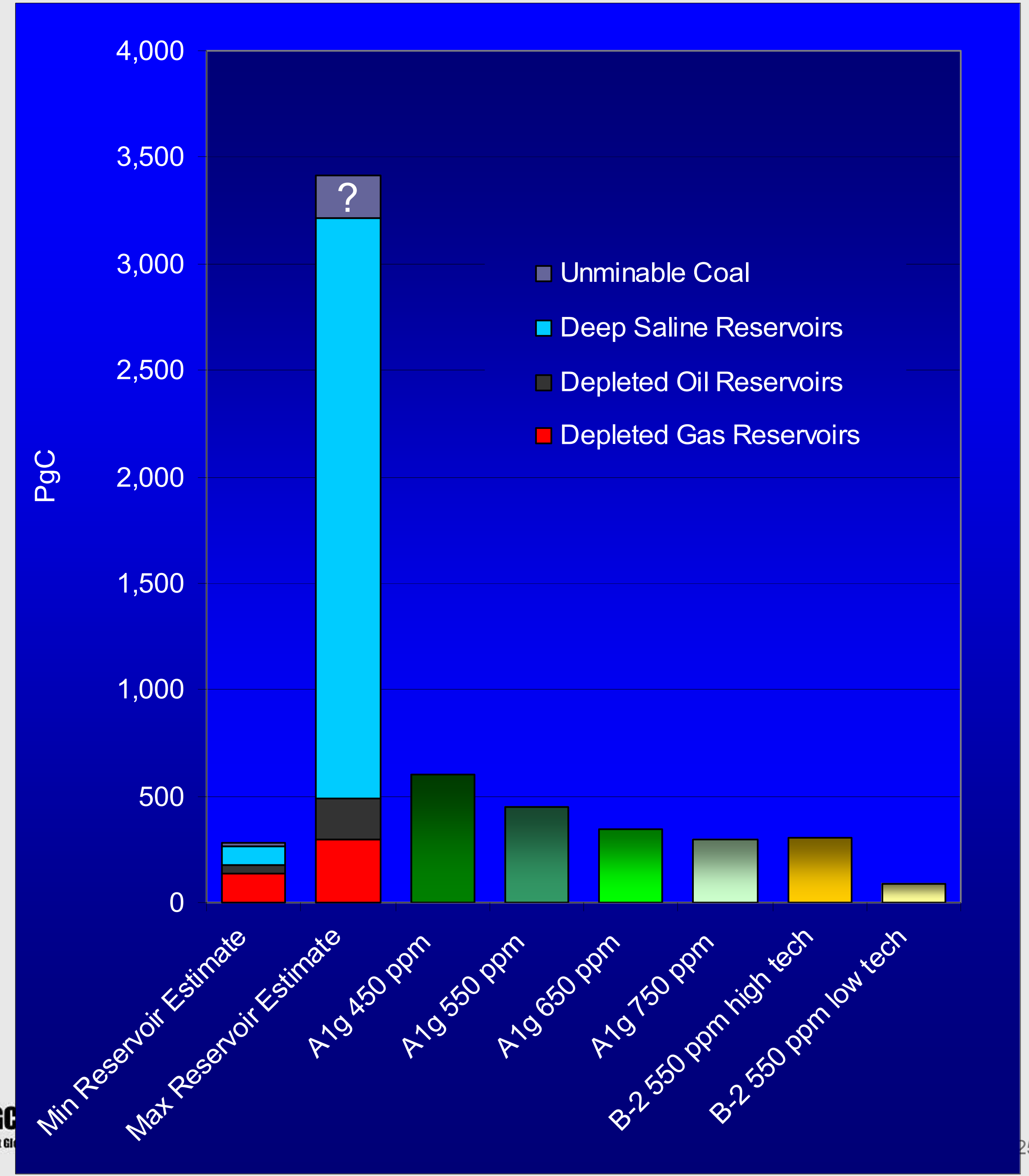
Storage Estimates Compared to Carbon Dioxide Capture Estimates—Regionally Unconstrained Storage



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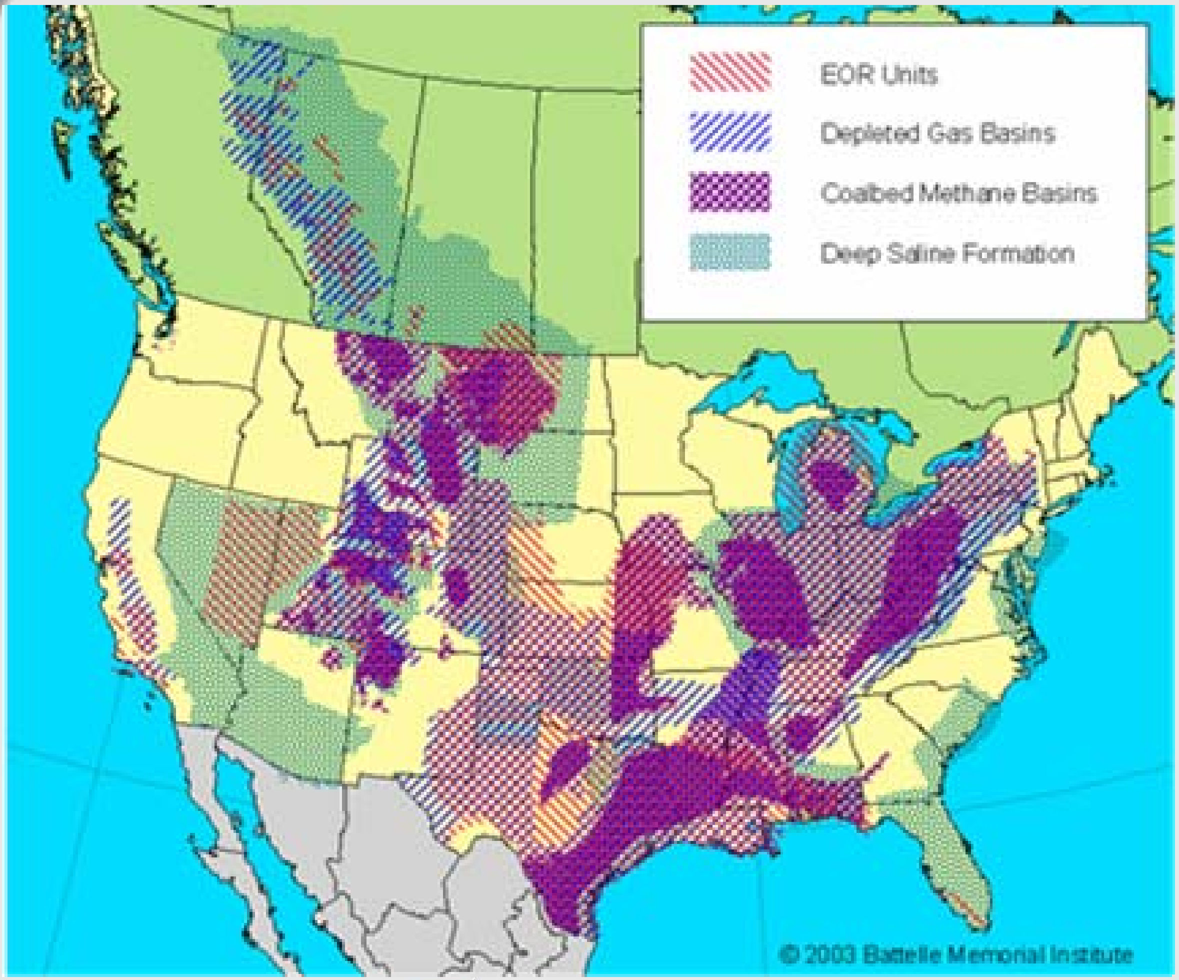

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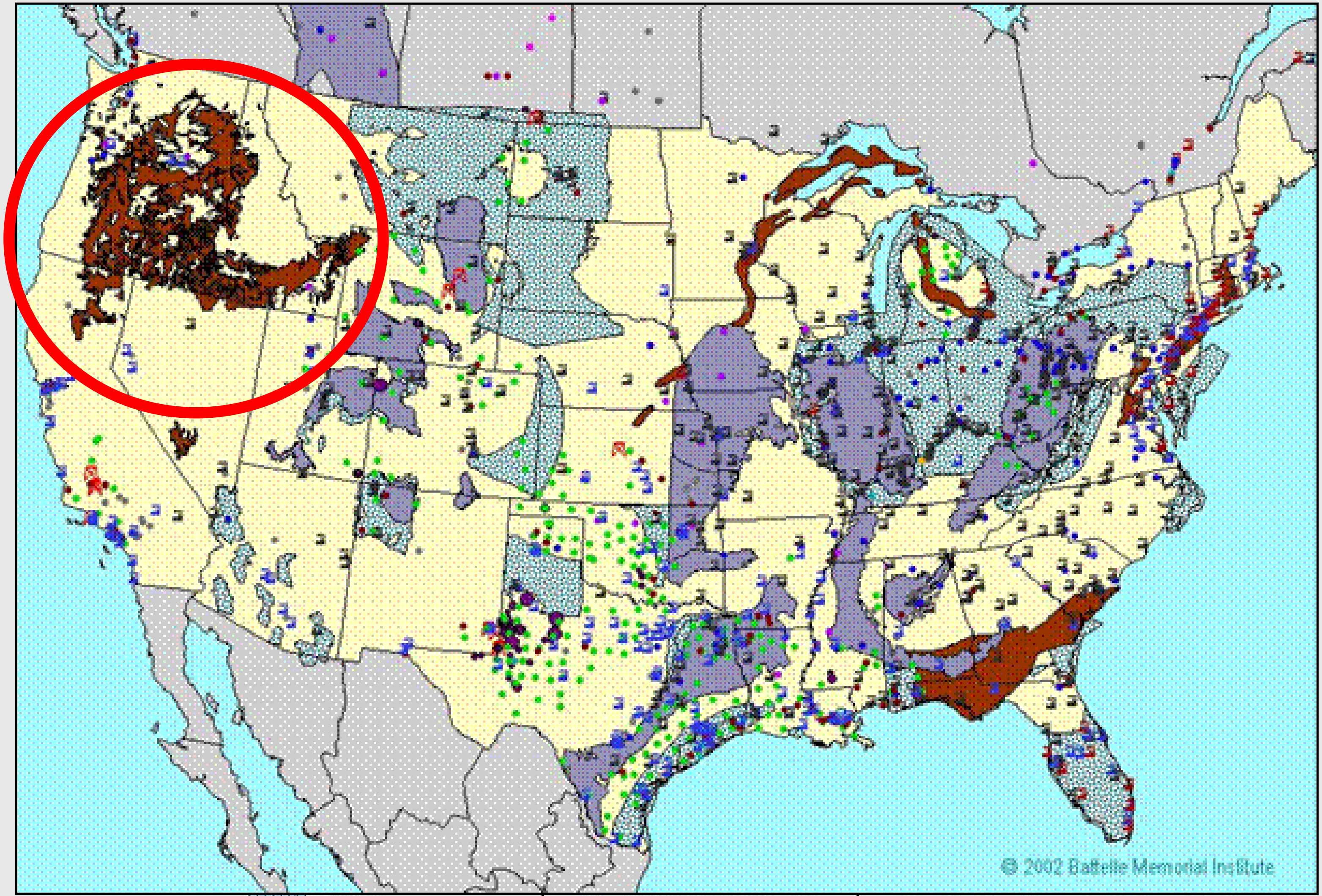
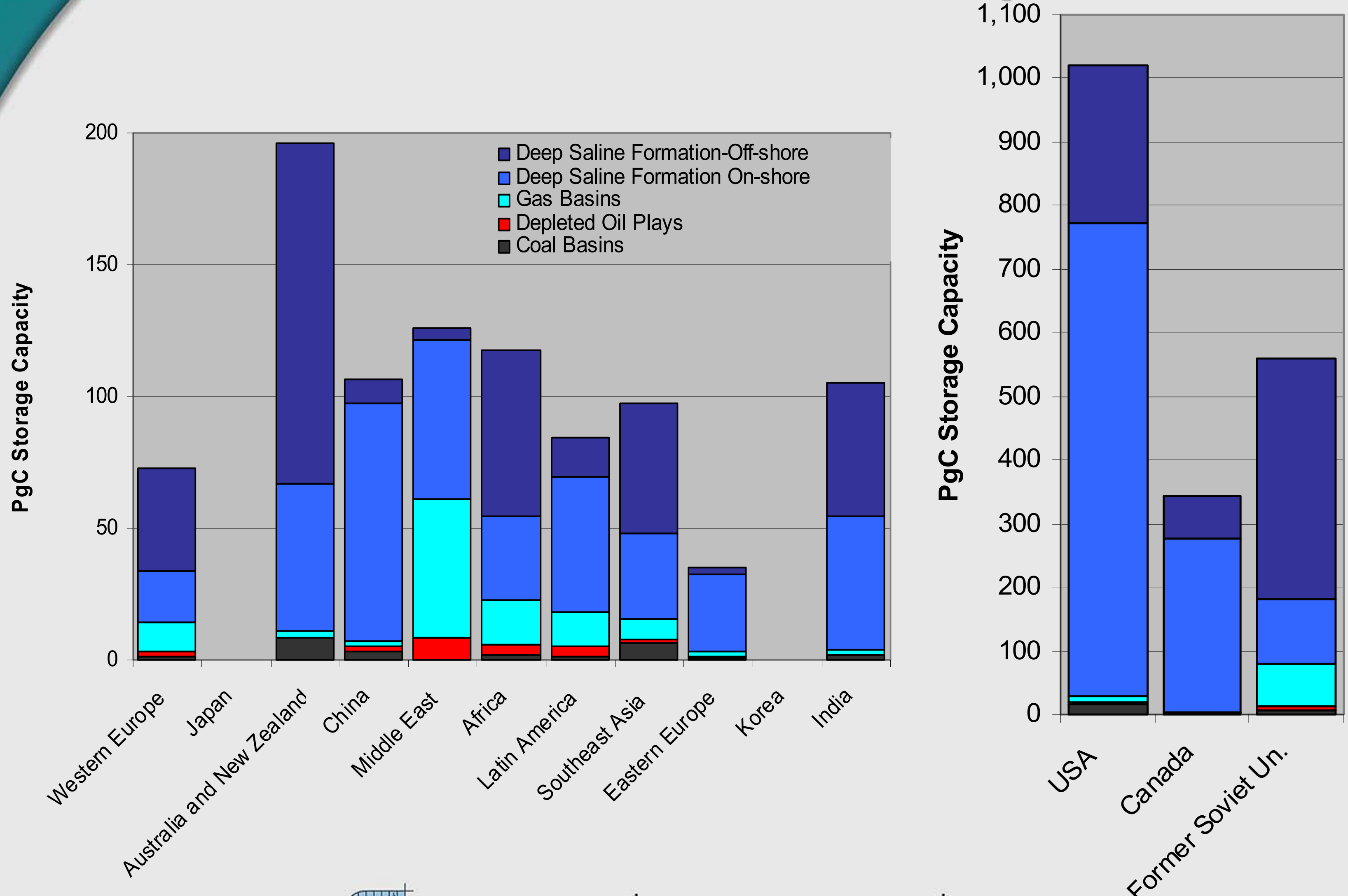
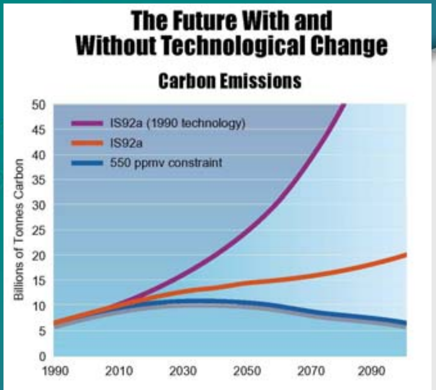
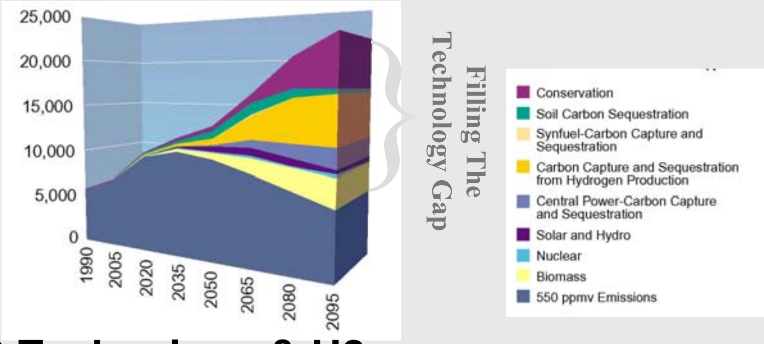


Dooley, et al. Estimate of Regional Potential Reservoir Capacities

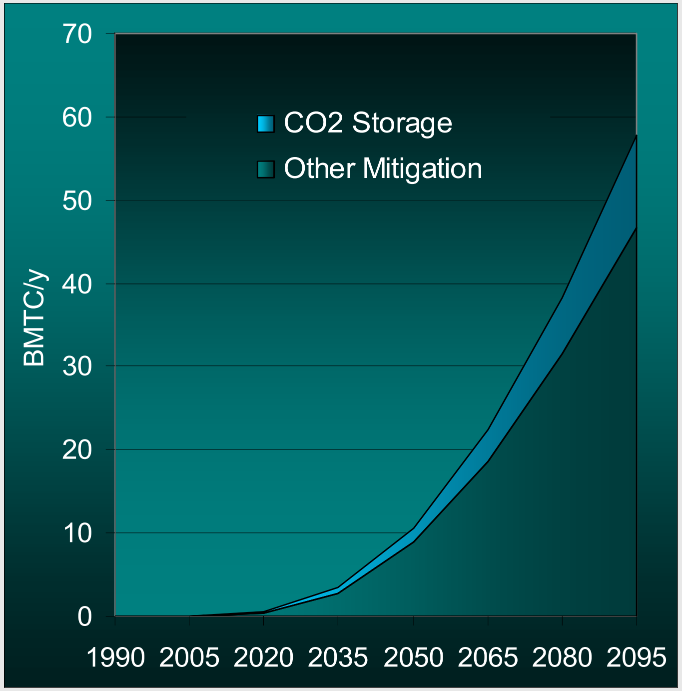


Is CCS A "Silver Bullet"?

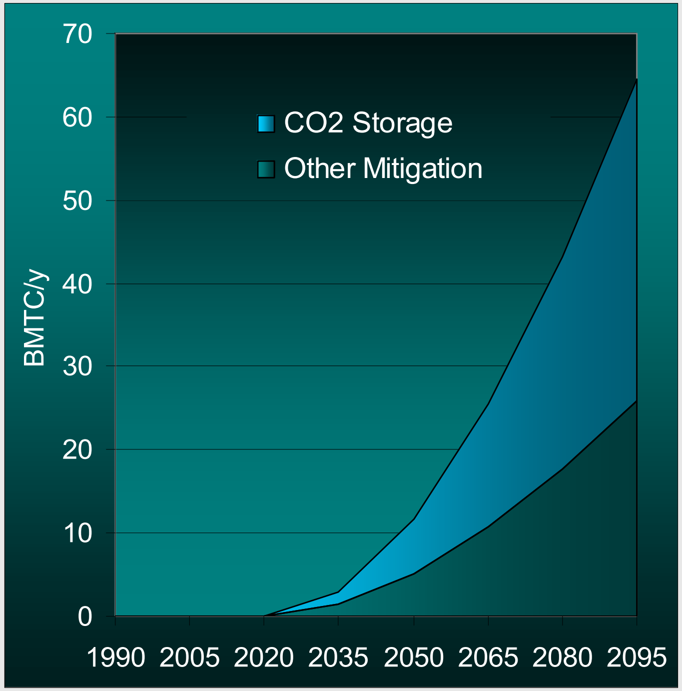




Moderate CCS Cost & No H2



Advanced CCS Technology & H2



USA Cumulative CO_2 Storage: Two Possible Cases