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Global Energy Technology Strategy Program

Carbon Sequestration as a National and Global Strategy—When Is It Needed?

Second Annual Climate Change Research Conference: California Energy Commission

And

First Scientific Conference

West Coast Governors' Global Warming Initiative

From Climate to Economics and Back

Mitigation and Adaptation Options for California and the Western States

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Battelle

Office of Science
U.S. DEPARTMENT OF ENERGY

JGCRI
Joint Global Change Research Institute

UNIVERSITY OF MARYLAND

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Overview

- Background
- Strategic Context
- CO_2 Capture and Storage (CCS) Components and Pathways
- Timing of Deployment
- Scale and Geographic Distribution of Geologic Storage
  - Global
  - USA
- Scale of Potential CO_2 Capture and Storage
- CCS and Commercial Biomass
- Summary

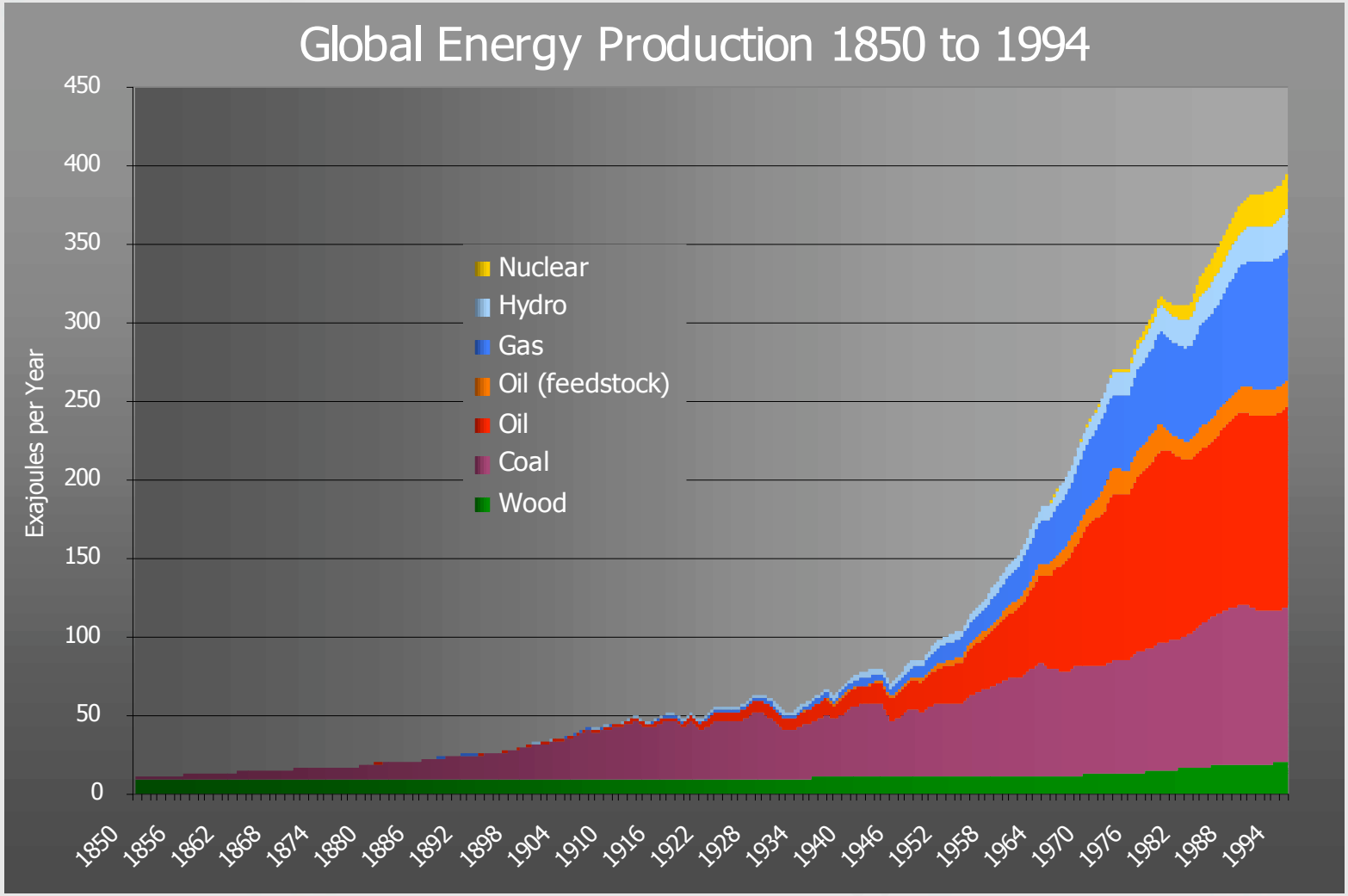
A Note on Measurement
CO_2 Versus C

- 1 ton C = 44/12 tons of CO_2
  = $3^2/_3$ tons of CO_2
  = ~4 tons of CO_2

- \$1/ton CO_2= \$$3^2/_3$ tons of C
  = ~\$4 tons of C

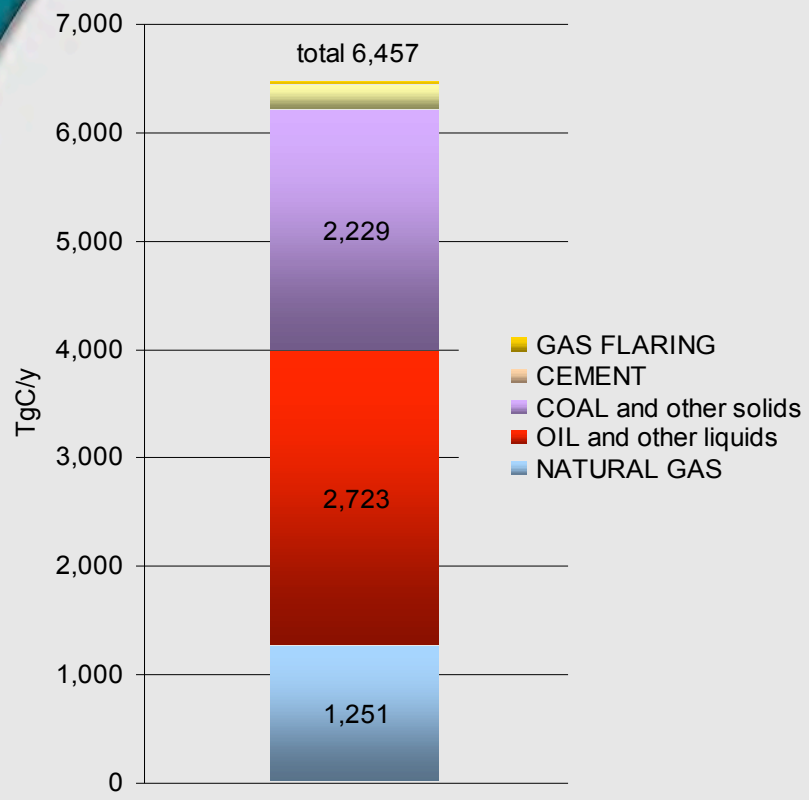
Both appear in the literature and both appear in this presentation.

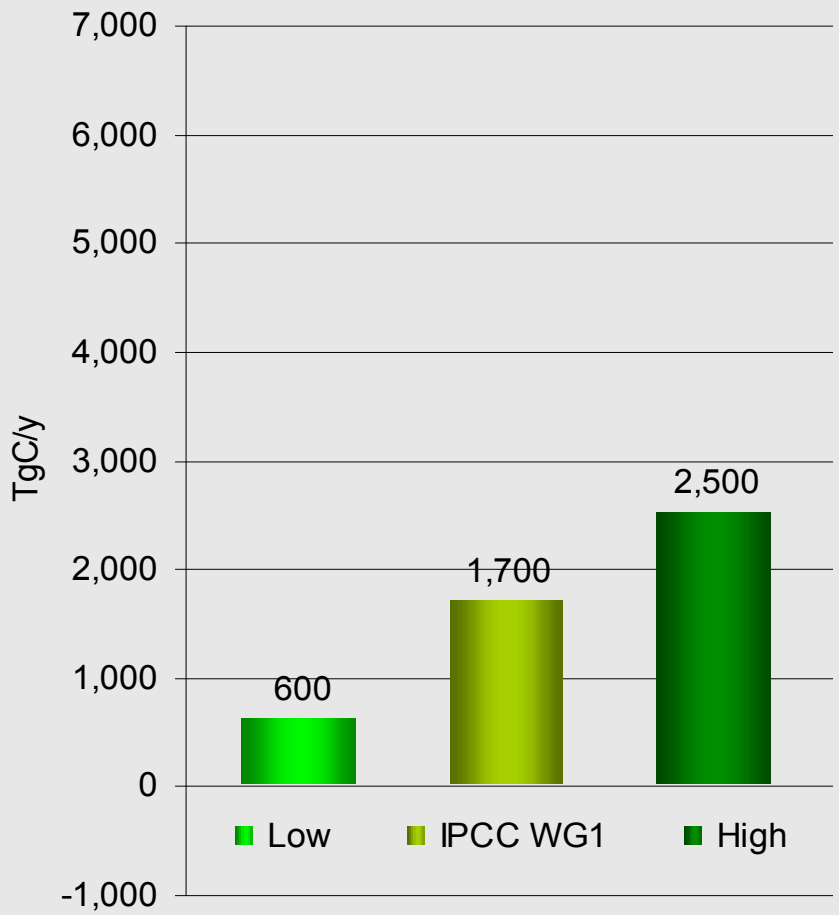
The Present Global Energy System is Fossil Fuel Based



Source: IIASA

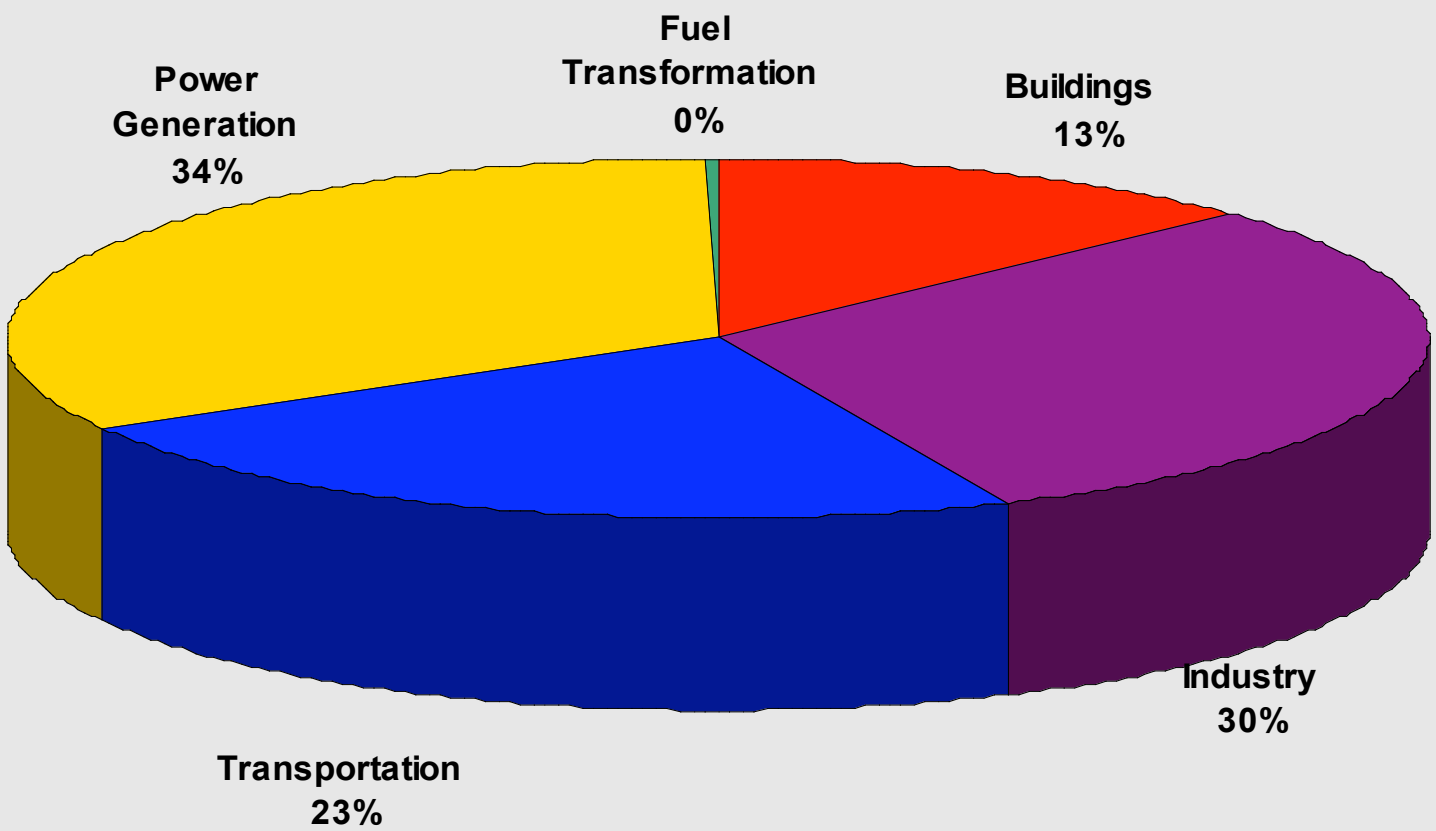
Fossil Fuel and Land-Use Change Carbon Emissions 1999





Source: Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory.

Distribution of Global Fossil Fuel CO_2 Emissions by Sector—2005

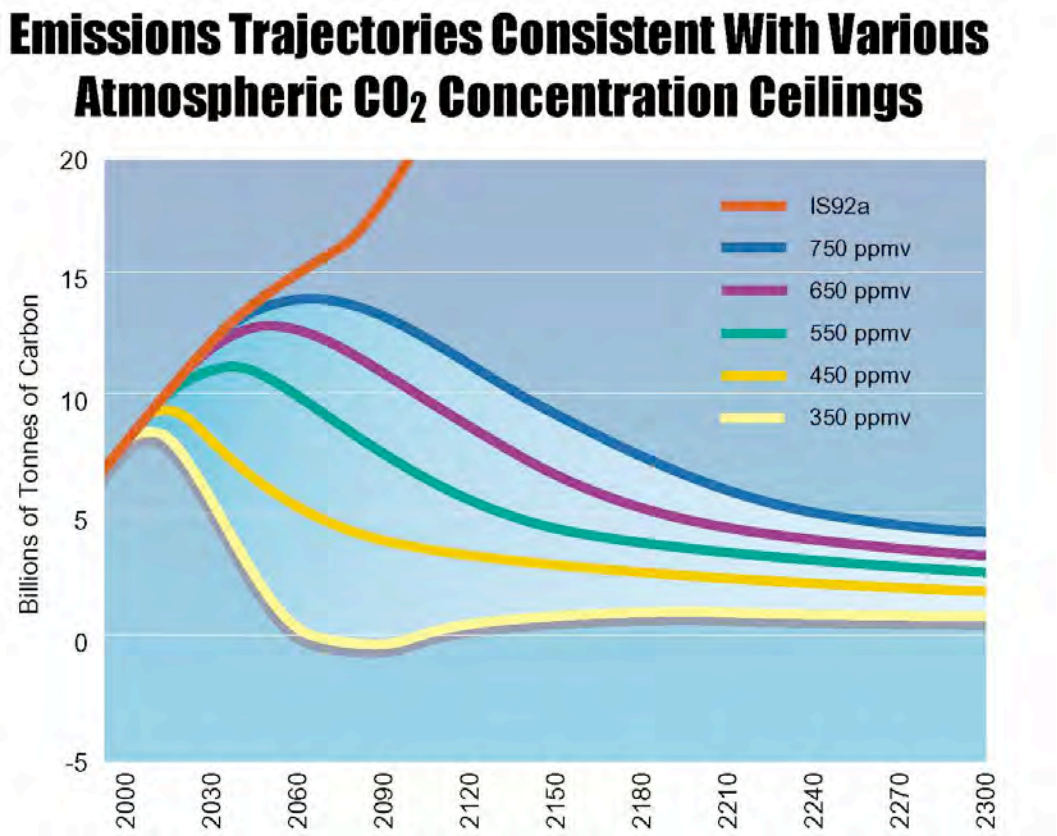


Total Emissions
7,640 PgC/y

Stabilizing CO_2 Concentrations

- Stabilization of greenhouse gas **concentrations** is the goal of the Framework Convention on Climate Change.

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



- Climate change is a
- **long-term**, century to millennial problem—**with implications for today**. It will not be solved with a single treaty, single technology, by a single country, or by a quick fix.

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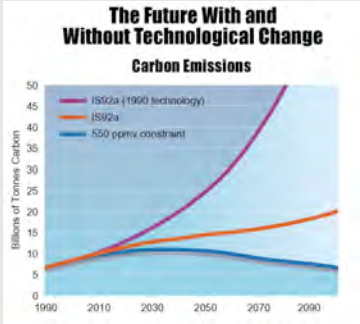
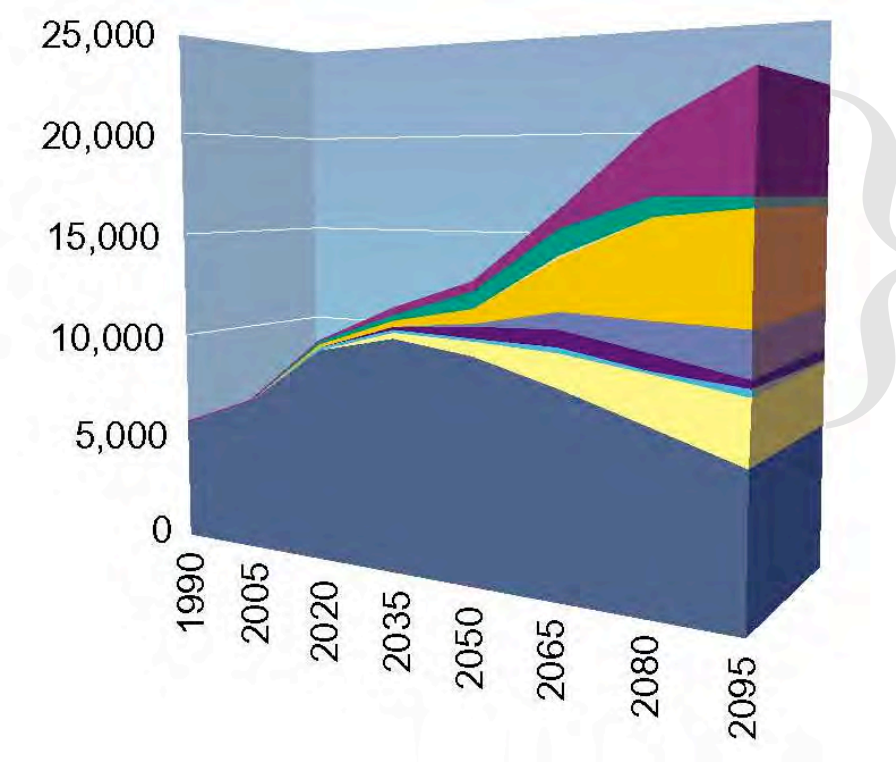
No single technology stabilizes CO_2 concentrations. In a portfolio of technologies CCS may help control the cost of stabilizing CO_2 concentrations.





Filling The Technology Gap

- Conservation
- Soil Carbon Sequestration
- Synfuel-Carbon Capture and Sequestration
- Carbon Capture and Sequestration from Hydrogen Production
- Central Power-Carbon Capture and Sequestration
- Solar and Hydro
- Nuclear
- Biomass
- 550 ppmv Emissions

Three Components of CCS Technology

- CO_2 capture
- CO_2 transport
- CO_2 storage

Technology to perform all three tasks already exist, BUT not at scale.

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!

CCS Deployment

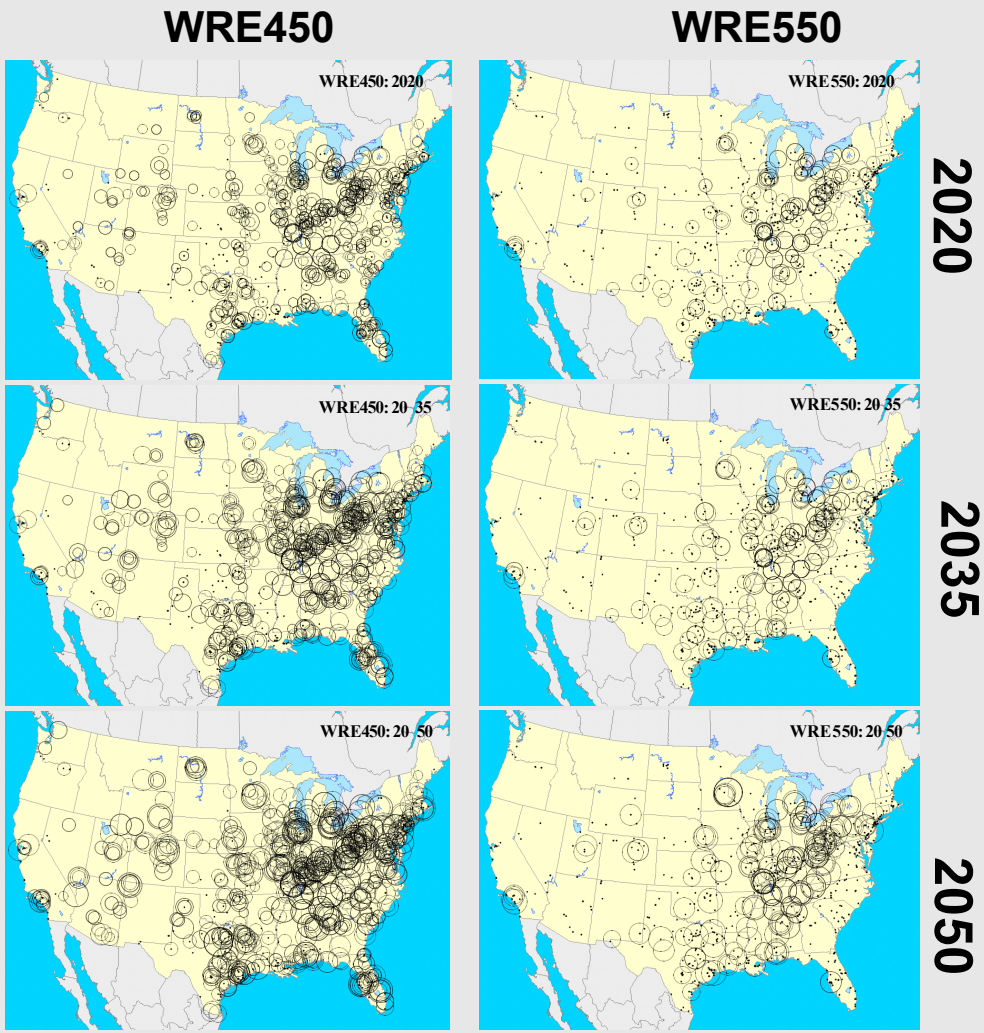
Today and 2050 (on 550 ppmv path)

Cumulative Global 2005-2050 CCS Deployment 30,000 $MtCO_2$

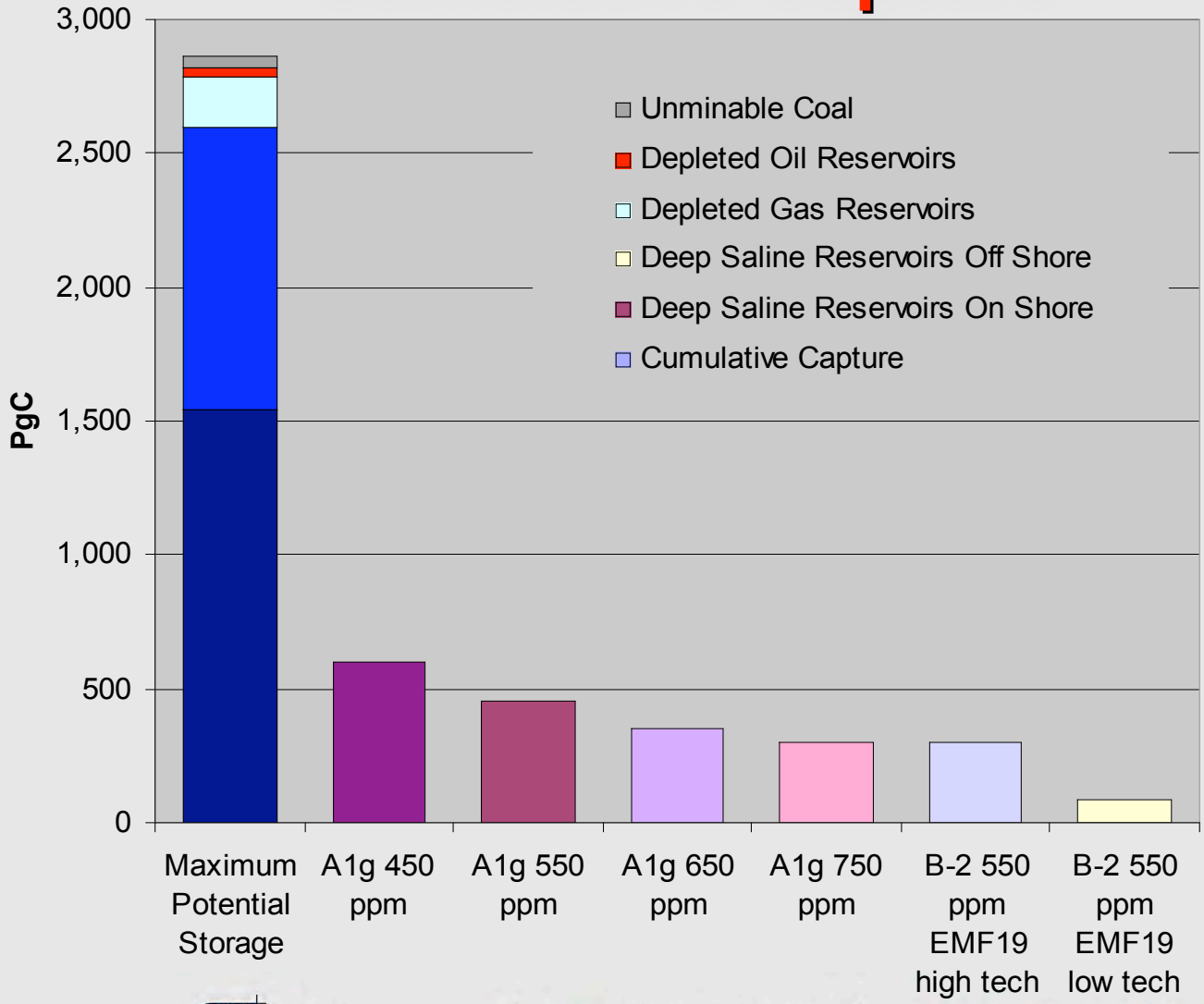
Cumulative USA (2005-2050) CCS Deployment 8,000 MtCO2

Take Home Messages
CCS

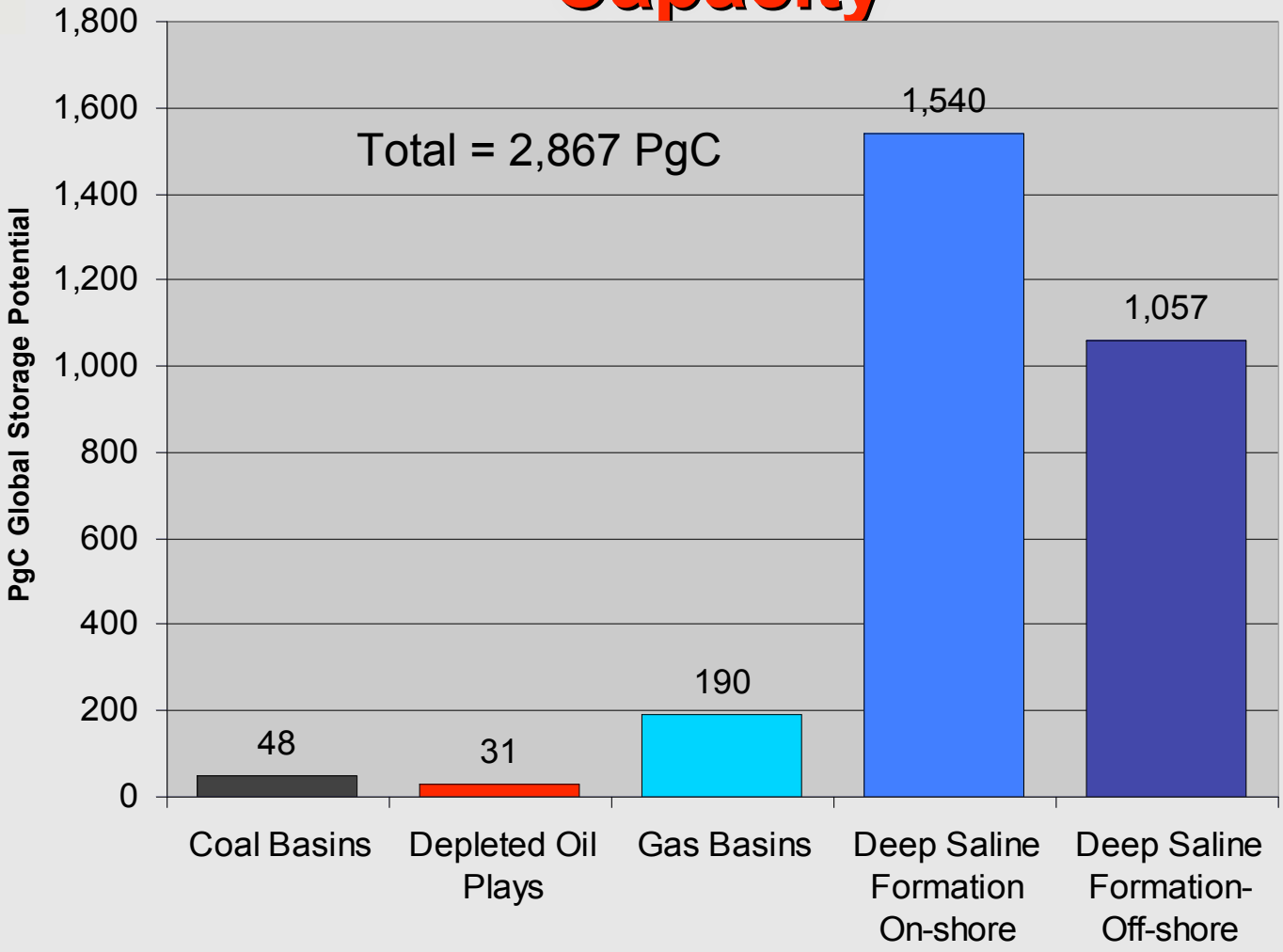
- The potential deployment of CCS technologies could be truly massive. The potential deployment of CCS in the US could entail:
  - 1,000s of power plants and industrial facilities capturing CO_2, 24-7-365.
  - 1,000s of miles of dedicated CO_2 pipelines.
  - 100s of millions of tons of CO_2 being injected into the subsurface annually.
  - The deployment will be so large that it is hard to imagine how positive prices for CO_2 (i.e., buyers willing to pay for pipeline quality CO_2) can be sustained.



Comparison of Storage to Cumulative Capture

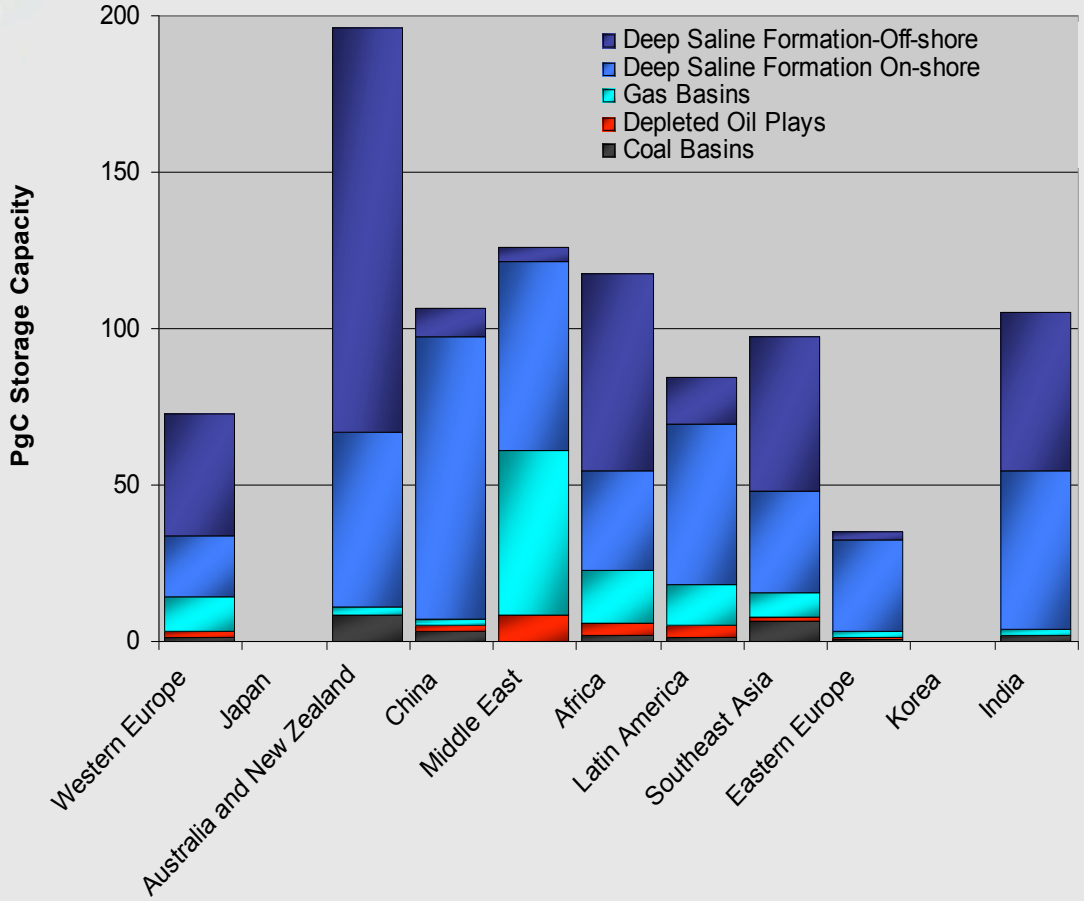


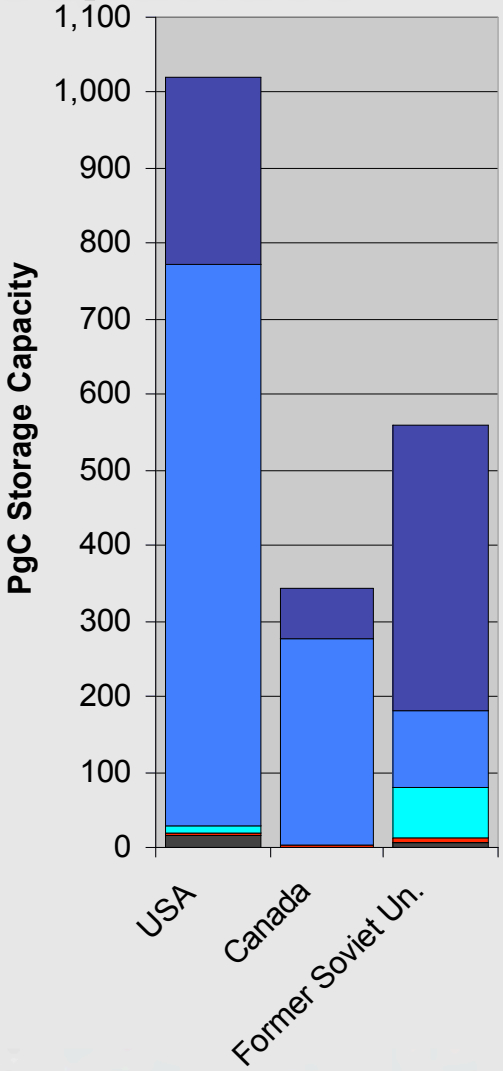
Dooley, et al. Estimate of Global Potential Reservoir Capacity



Dooley, et al. Estimate of Regional Potential Reservoir Capacities

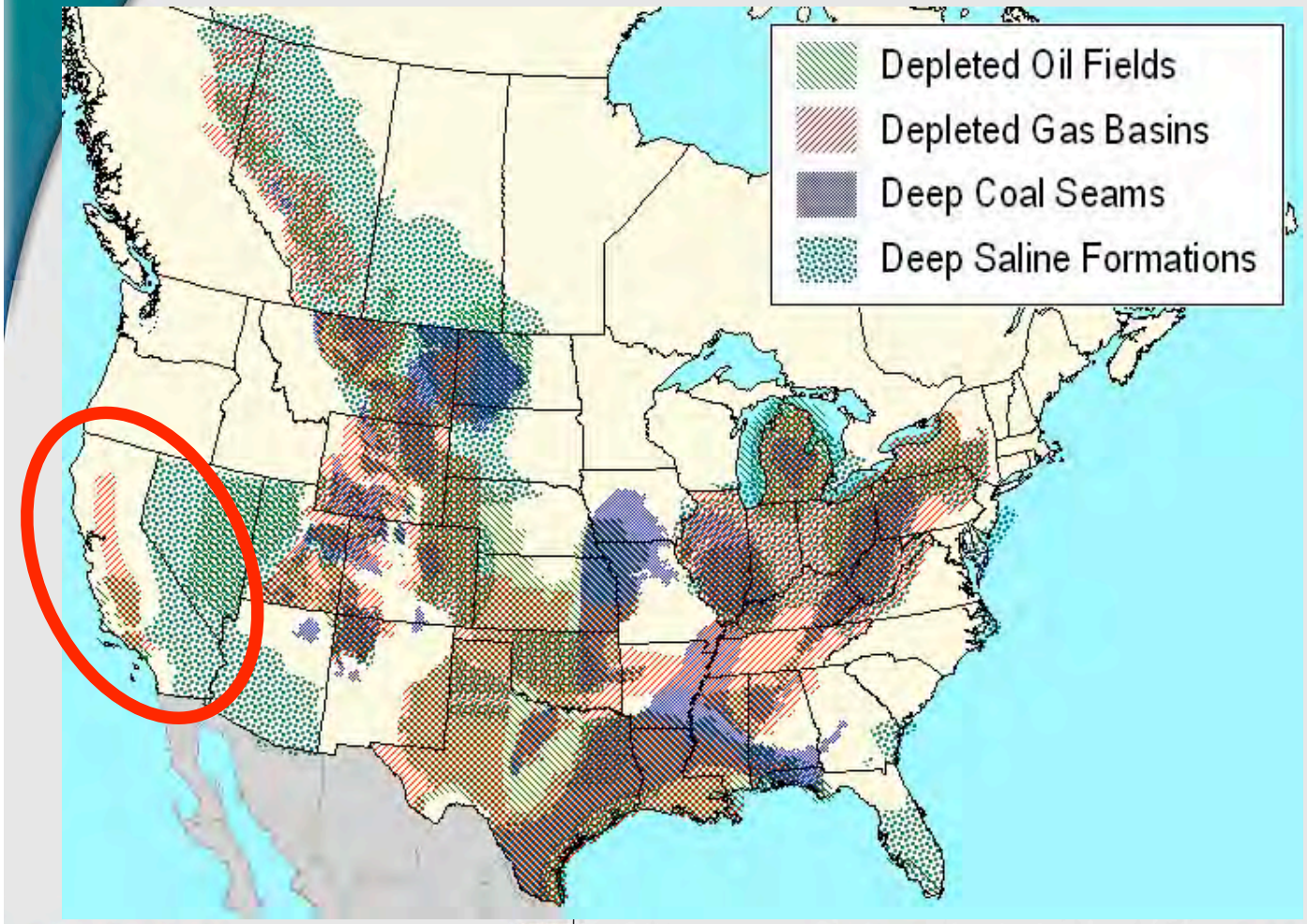
Total = 2,867 PgC





Recent Work Has Looked at the USA and Canada

Where Is the Storage Reservoir Capacity?



3,800 $GtCO_2$ US and Canadian Geologic CO_2 Storage Reservoirs Theoretical Capacity

- 3730 $GtCO_2$ in deep saline formations (DSF),
- 65 $GtCO_2$ in deep unminable coal seams,
- 40 $GtCO_2$ in depleted gas fields, and
- 13 $GtCO_2$ in depleted oil fields with potential for enhanced oil recovery (EOR)

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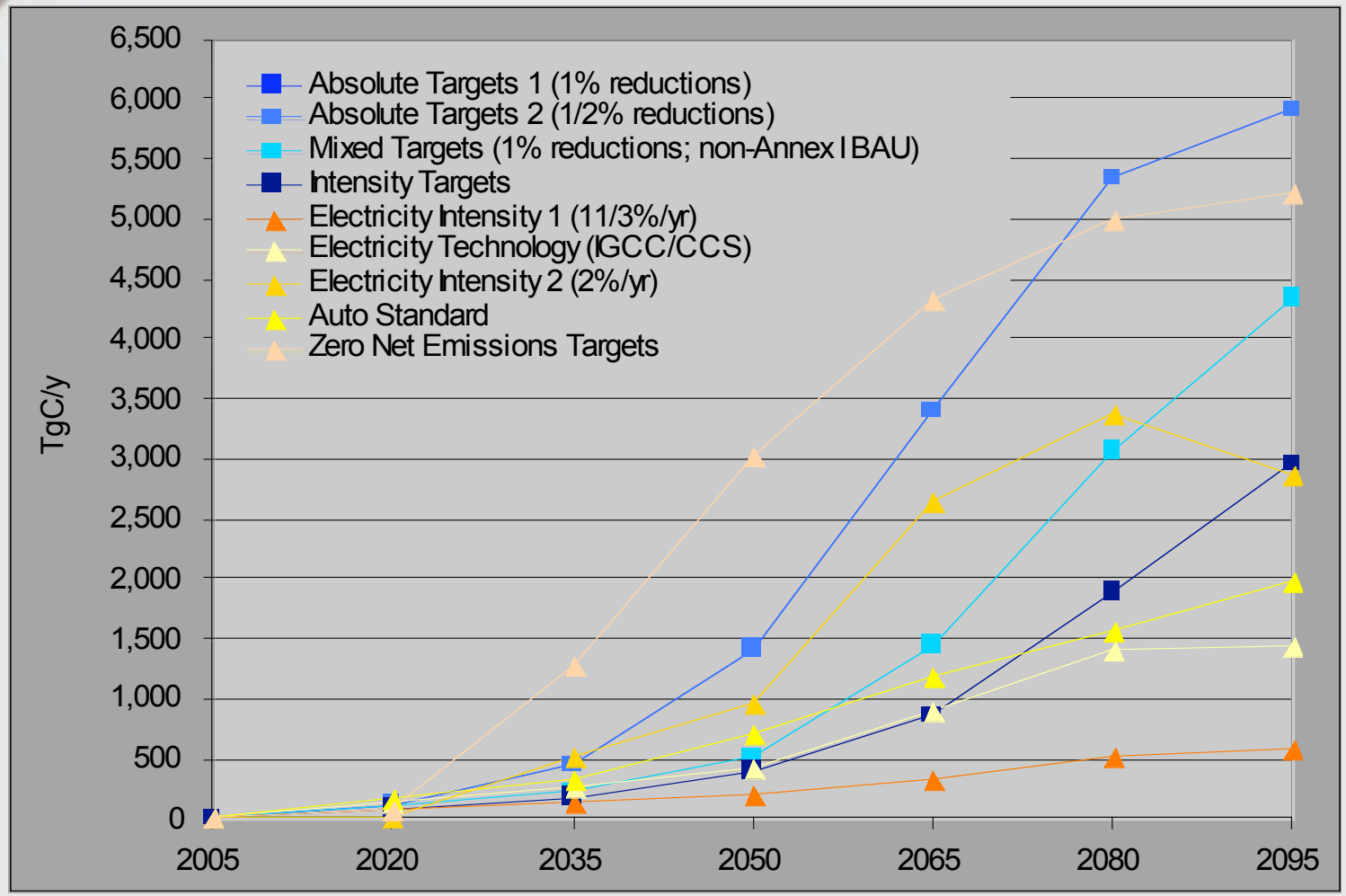
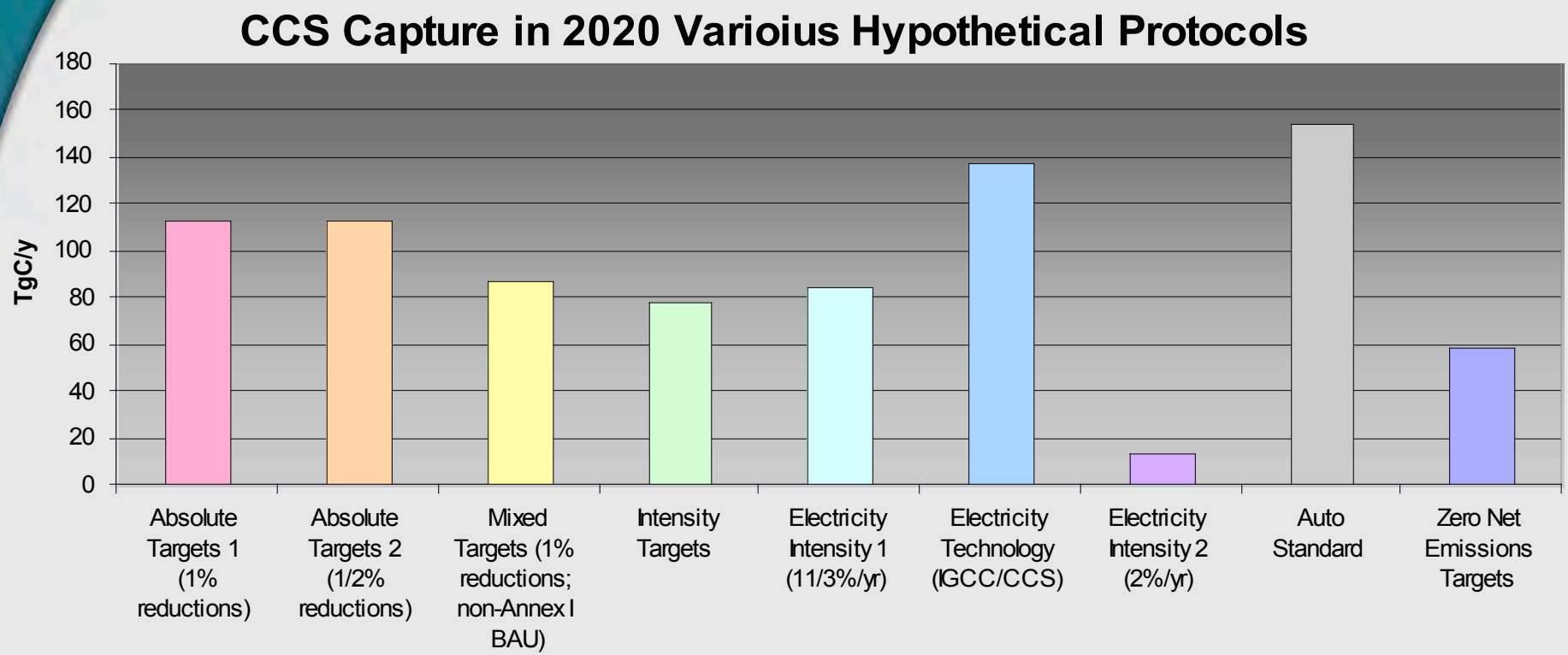
Cost Estimates for CCS

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

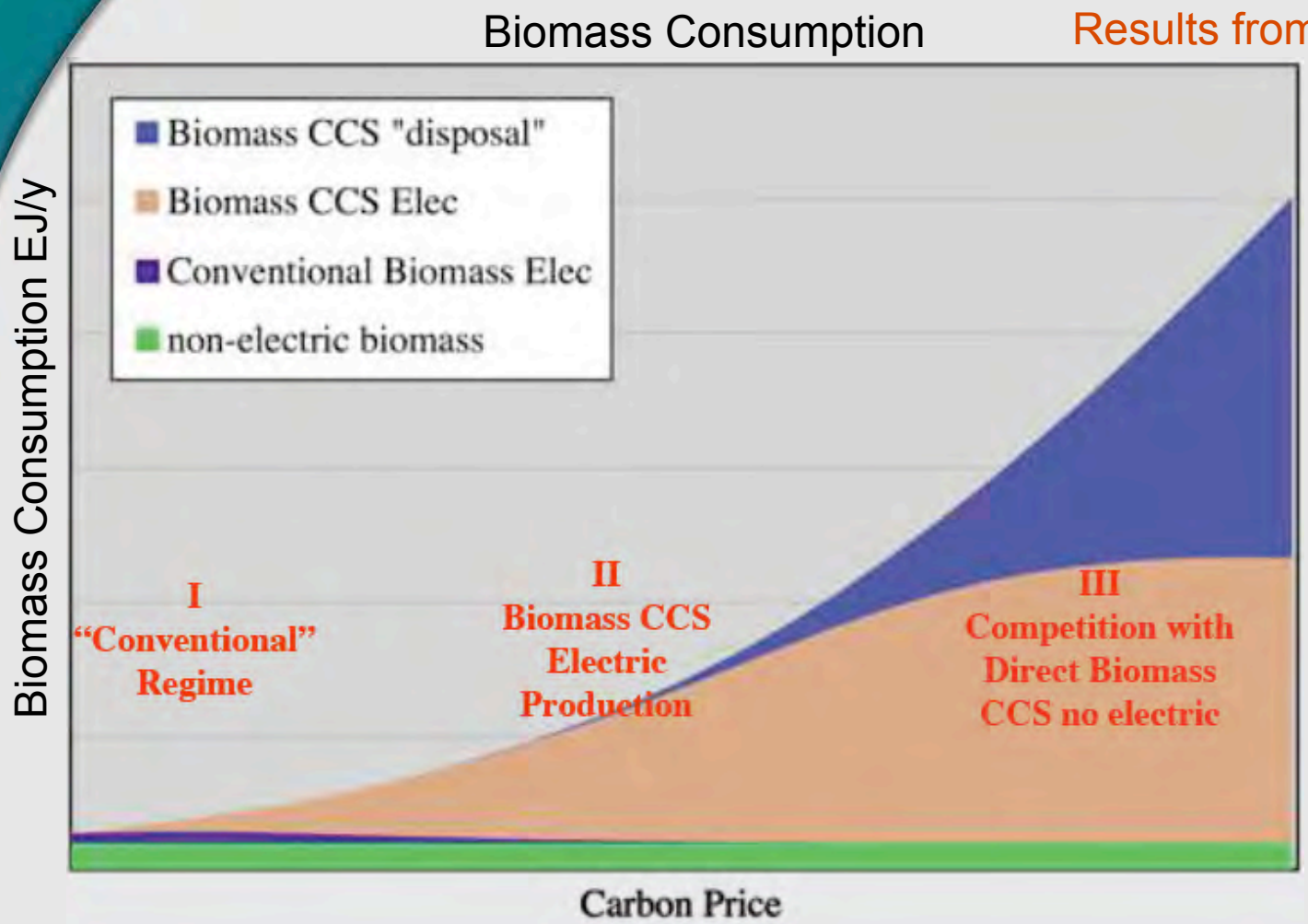
Pocantico Process



Pocantico CCS Capture in 2020



Biomass with CCS



Results from a "toy" model

At high carbon prices direct sequestration of biomass carbon (without electric generation) competes for biomass supply.

This drives biomass prices up, and tends to stabilize the share of biomass electric generation with CCS

Terrestrial sequestration options would still come at low carbon prices (not shown).

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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, implying a major challenge for a technologies which are not presently deployed at scale.

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- For more information www.pnl.gov/gtsp

Discussion