



**Battelle**

*The Business of Innovation*

## **The Role of Carbon Sequestration in a Carbon-Constrained Energy Future**

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**Second Carbon Sequestration Leadership Forum**

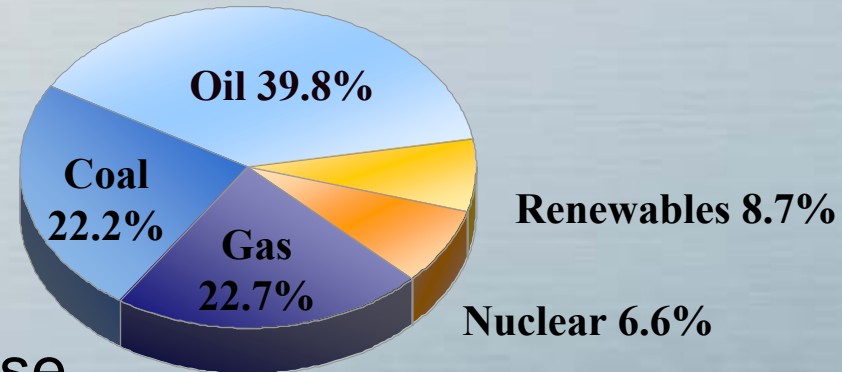
**Melbourne, Australia**

**September 13, 2004**

# About Energy Facts

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- Fossil fuels provide 85% of the world's energy
  - Affordable
  - Abundant



- Energy demand will likely increase
  - 2.4 billion people with no access to commercial energy
  - Populations expected to expand
- Many in the world are not willing to completely forgo the benefits of fossil fuels in favor of the environment

# About UNFCCC

## Facts

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- UNFCCC has nearly 200 signatory countries and establishes the ultimate goal:
  - ...the stabilization of greenhouse gas concentrations...
  - ...at a level that would prevent dangerous...interference with the climate system...
  - ...and to enable economic development to proceed in a sustainable manner.

**Concentrations  
not  
Emissions**



**Don't  
Know What is  
Dangerous**

**Economic  
Development  
Matters**

# About Emissions

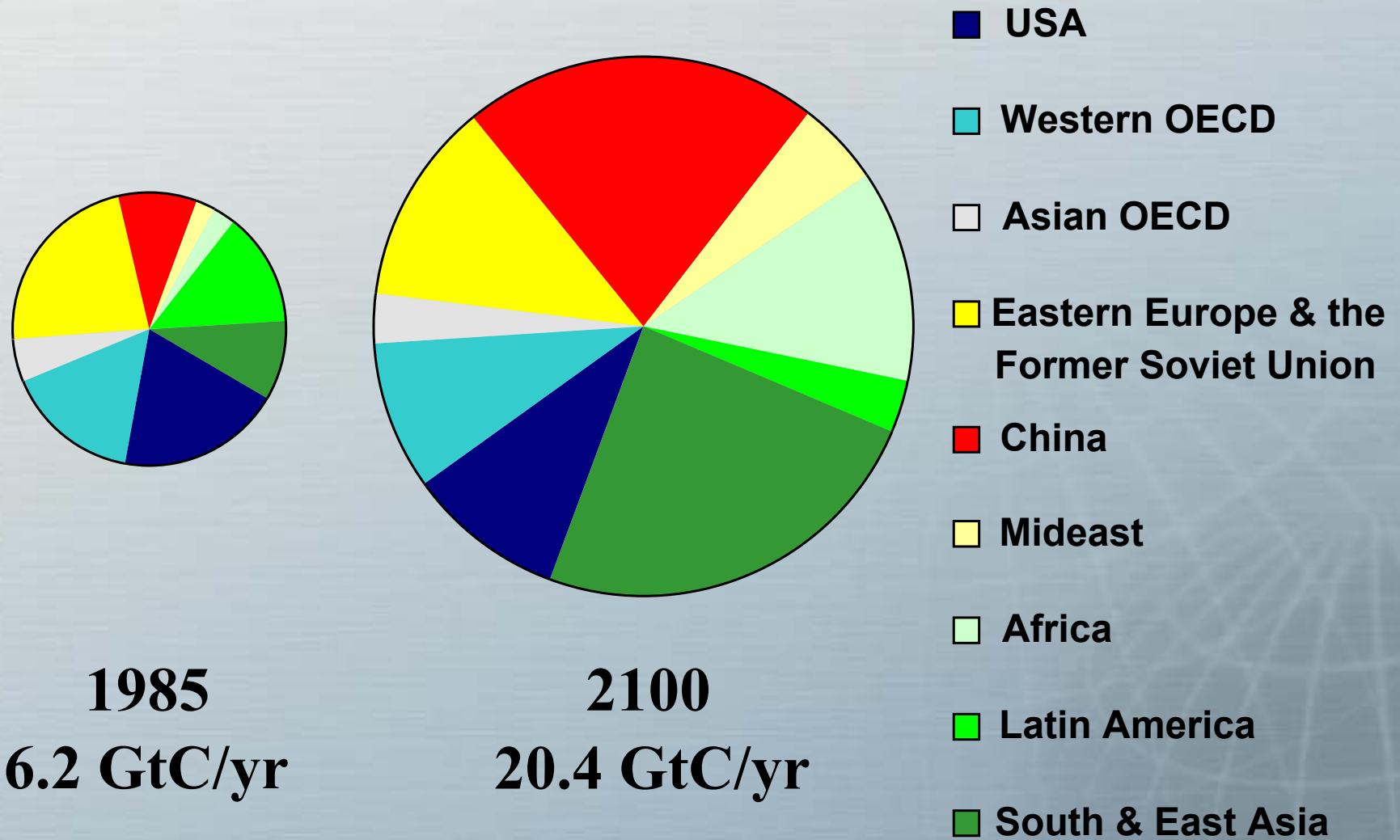
## Facts

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- Stabilization of greenhouse gas concentrations implies the need for a net “zero-emissions” world
  - Fundamental transformation of the global energy system
- Must peak and decline
  - Slow the growth
  - Peak
  - Decline
- Energy Demand will likely increase
  - 2X to 5X+ this century

# Future of Global Emissions

## Not All Regions Are Equal



# A Gigatonne is...

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**The combined weight of 5.3 billion people  
(if they all weighed as much as the  
heaviest American football player)**

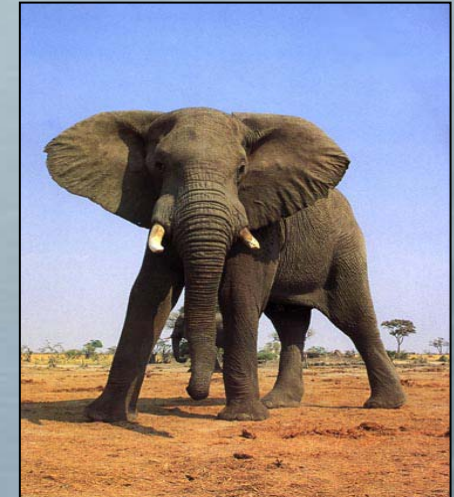


**Aaron Gibson (#78)**

**6211 Sydney Opera Houses**



**142,857,142 African elephants**





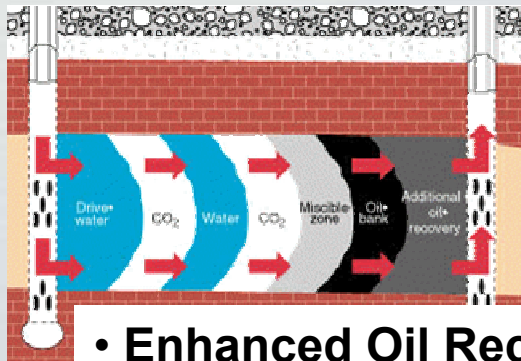
# A Gigatonne of Mitigation Is...

Technology	1 Gigaton Carbon / year (1 billion tons C / year)
Nuclear	500 new 1GW nuclear plants
Efficiency	2 billion cars operating at 40 mpg instead of 20 mpg
Wind	150 x current US capacity
Solar	10,000 x current US solar generation
Biomass	Convert a barren area >15 times the size of Iowa's farmland to biomass

**Today's Technology Can't Meet the Challenge Alone!!!**

# Carbon Sequestration

## Scientists are Exploring Many Options

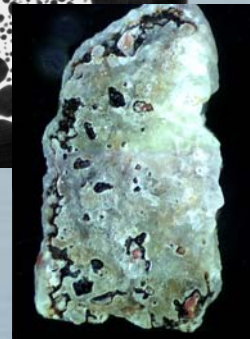
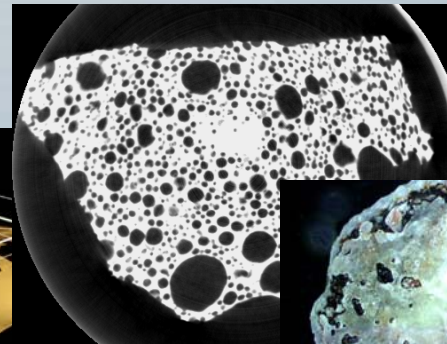
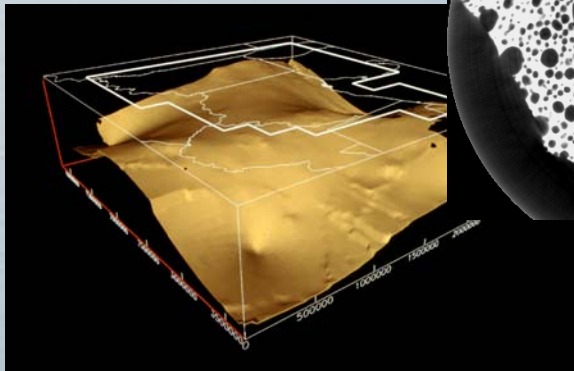


- Enhanced Oil Recovery
- Enhanced Coal Bed Methane



### Terrestrial

- Forests
- Soils
- Other Ecosystems



### Deep Saline Formations

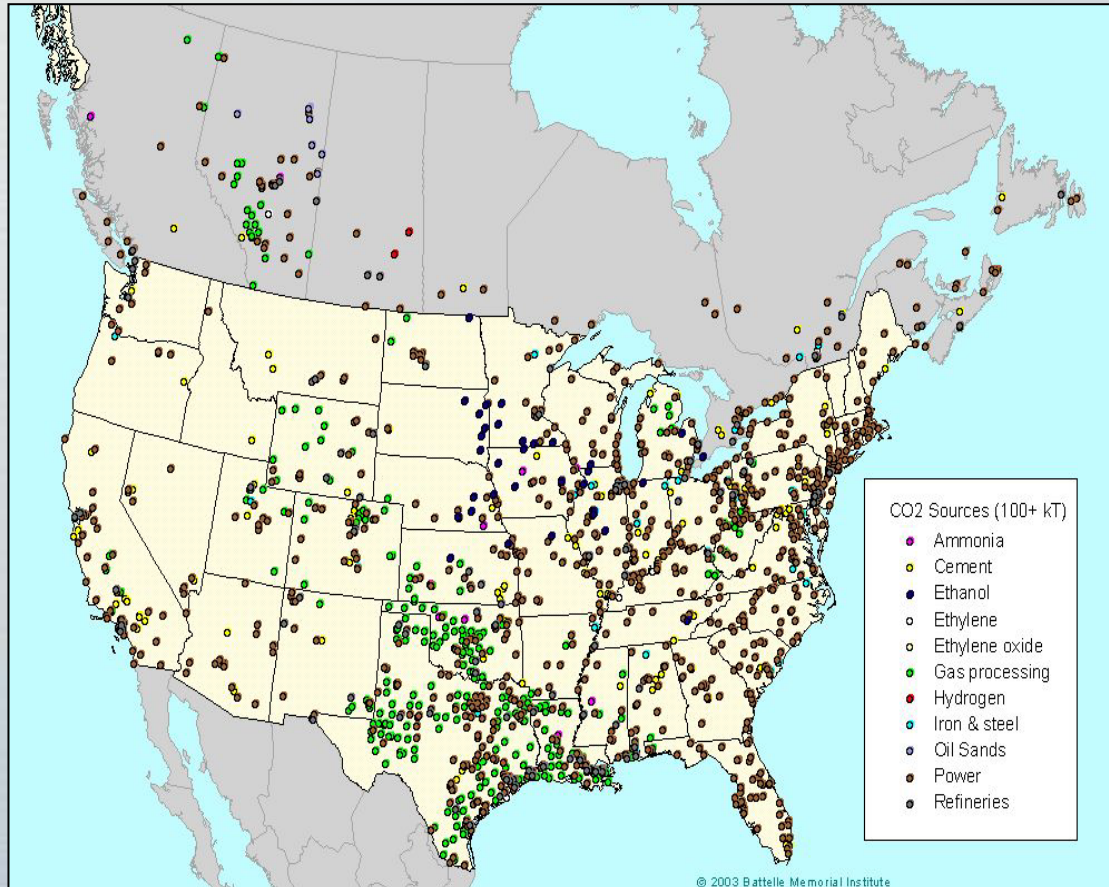
- Sandstone
- Carbonate
- Basalt

*Each will have its own stakeholder issues!*



# CO<sub>2</sub> Point Sources are Diverse

## US and Canada

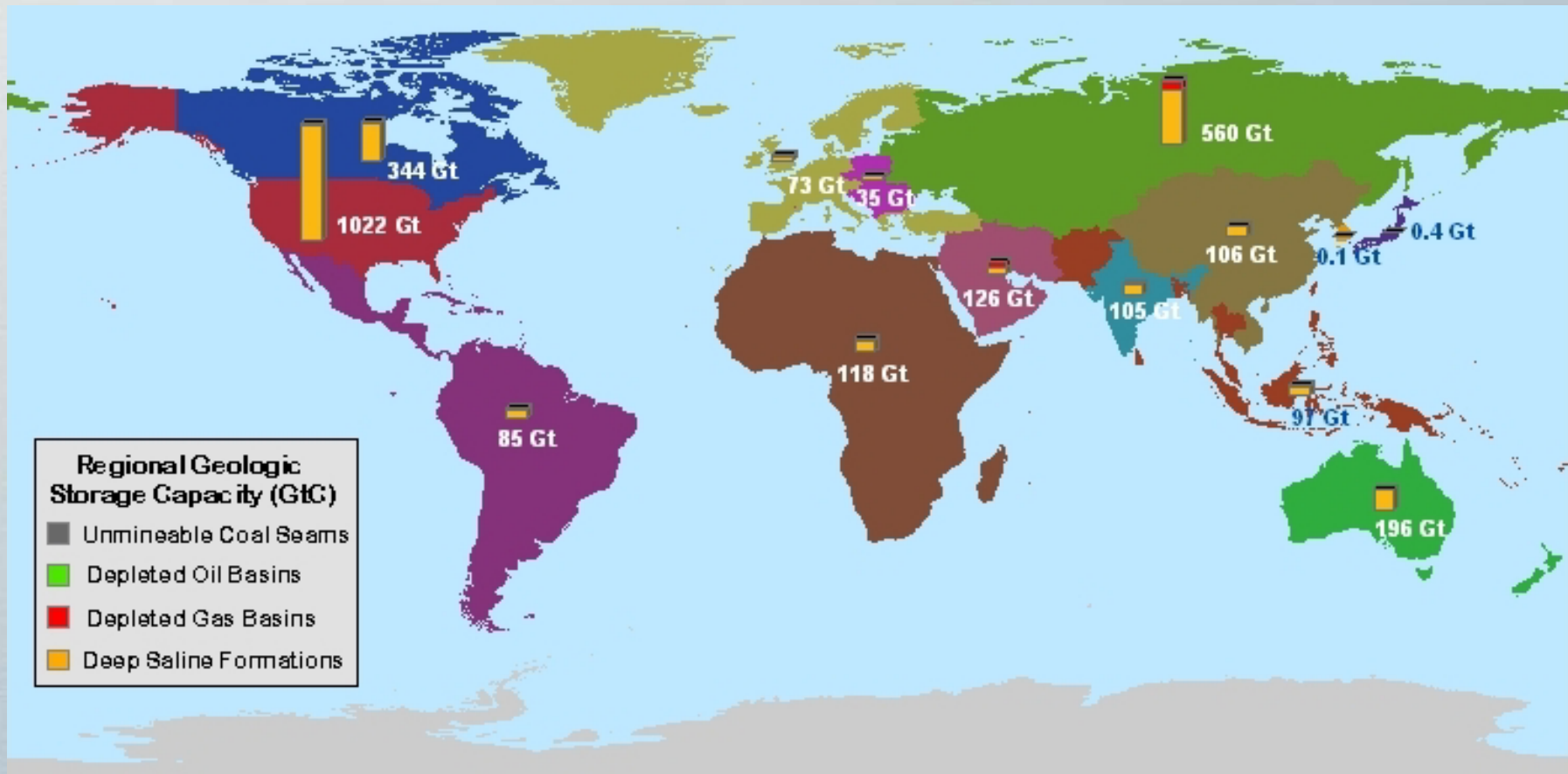


- 1185 electric power plants
  - 543 coal
  - 526 gas
  - 95 oil
  - 21 biomass
- 25 ammonia refineries
- 124 cement kilns
- 47 ethanol plants
- 43 ethylene plants
- 8 ethylene oxide plants
- 447 gas processing facilities
- 40 H<sub>2</sub> production facilities
- 53 iron & steel foundries
- 9 oil sands areas
- 154 petroleum refineries

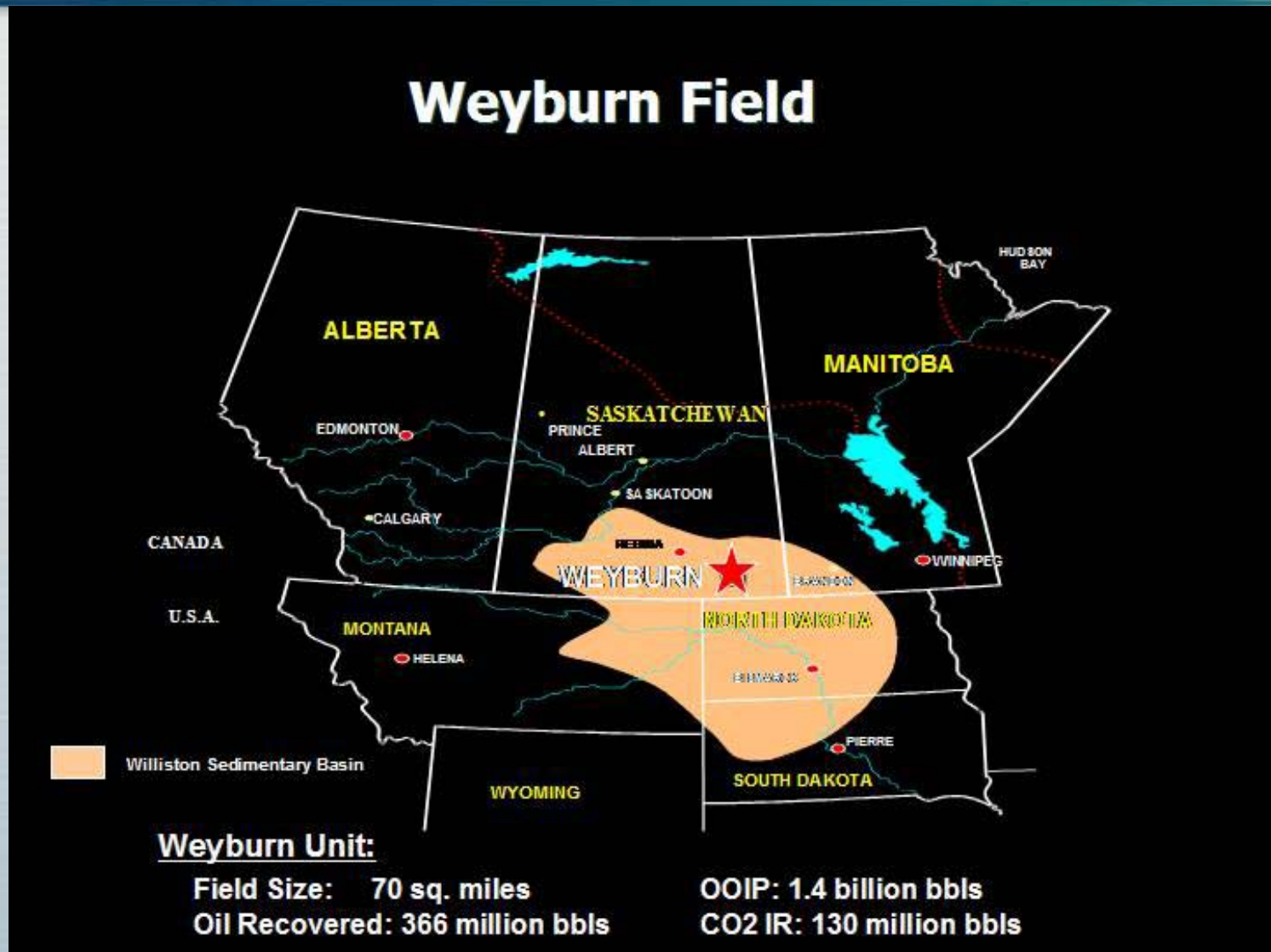
# Global CO<sub>2</sub> Storage Capacity

## *A Very Heterogeneous Natural Resource*

Gigatons of Carbon

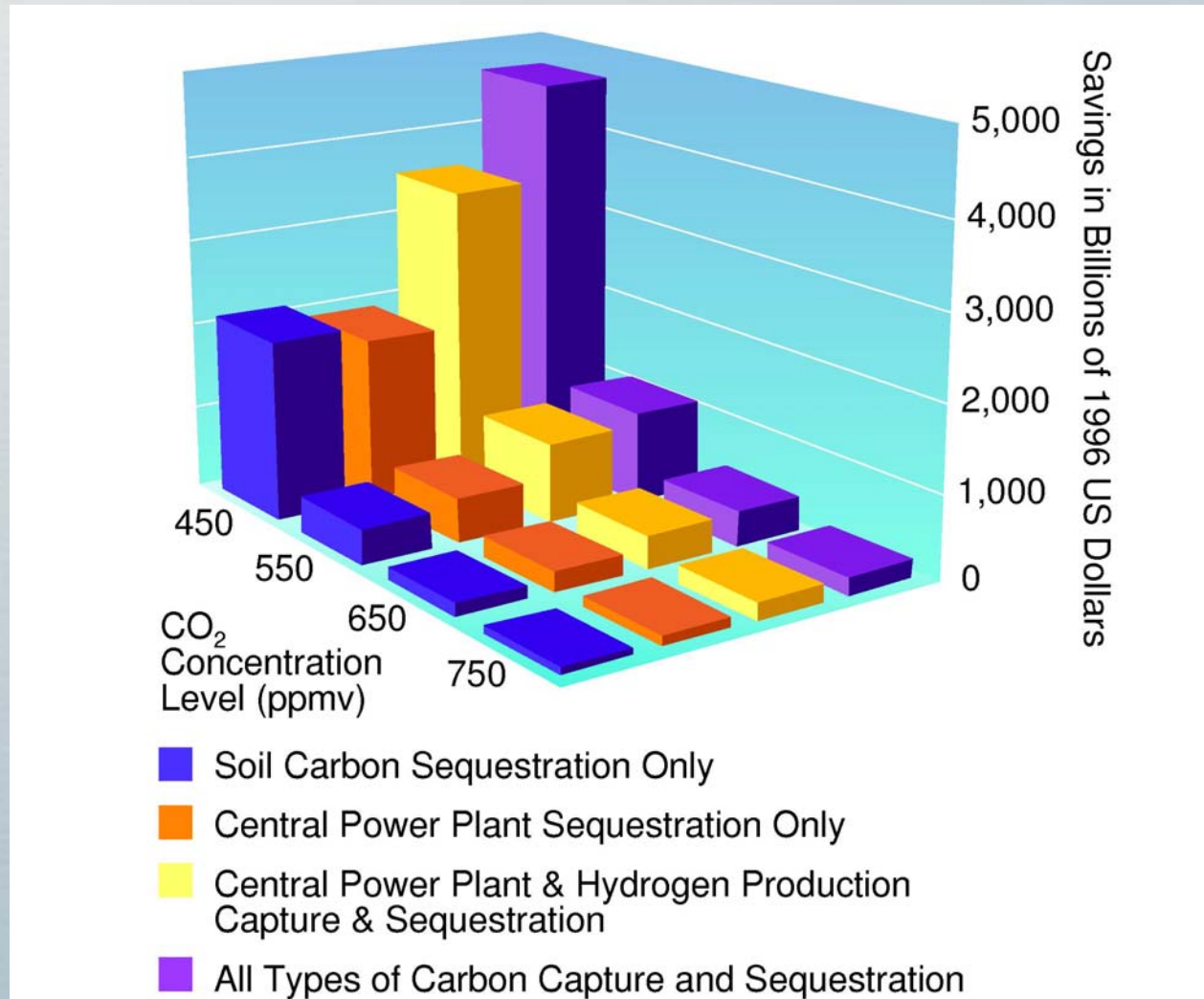


# There's much to build upon Around the Globe



References: Various

# Sequestration Reduces Costs By 100s of Billions to Trillions of Dollars

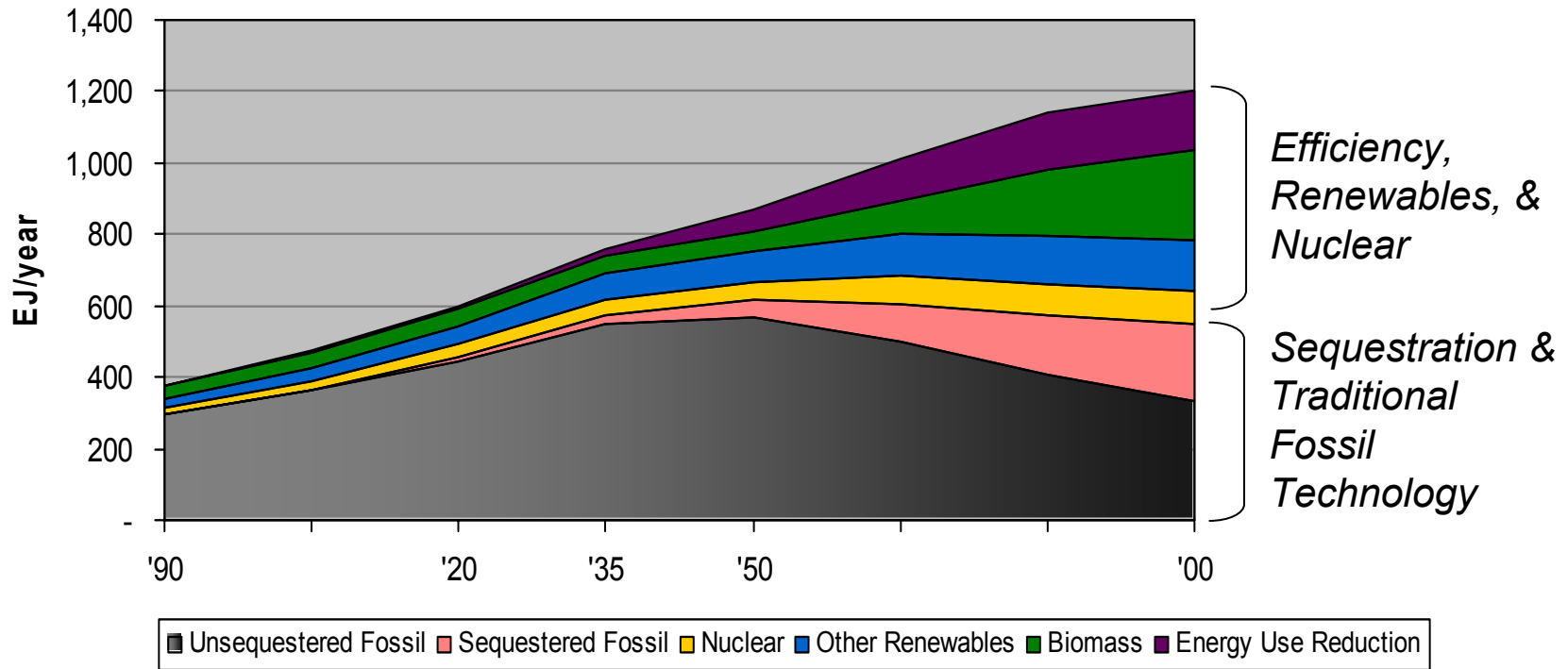




# One Possible Energy Future

## *All types of energy are important*

Primary Energy Demand  
IPCC Scenario B2  
with 550 Carbon Constraint





# ~~Concluding Thoughts~~ Thoughts to Begin With....

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- UNFCCC the environment and sustaining economic development
- There is no silver bullet technology, a lot of options are needed
- Sequestration could reduce the cost of stabilization by \$100Bs to trillions
- Permanence of storage will be an important issue
  - Social acceptability
  - Financial acceptability
- Different sequestration solutions will be appropriate for different countries, at different points in time, and have different stakeholder issues
- Open dialogue will be critical