



# CO<sub>2</sub> under the ground off the ground

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*Young Professional Dag, Groningen, 15 juni 2009*

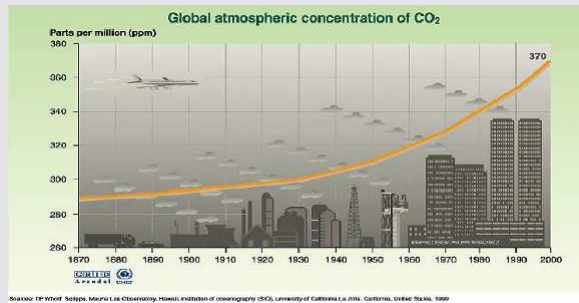
Founding partners



Associated partners



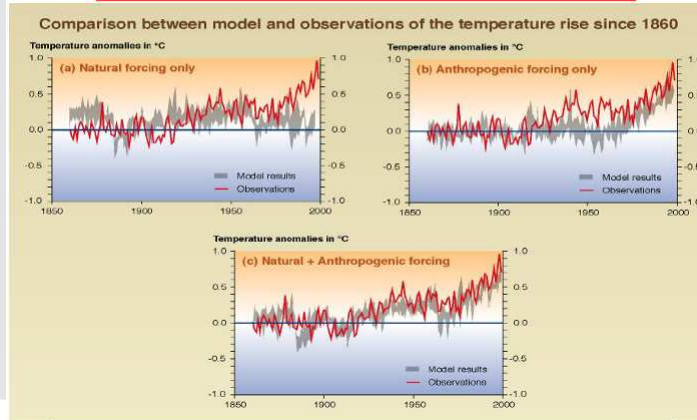
## Climate Change



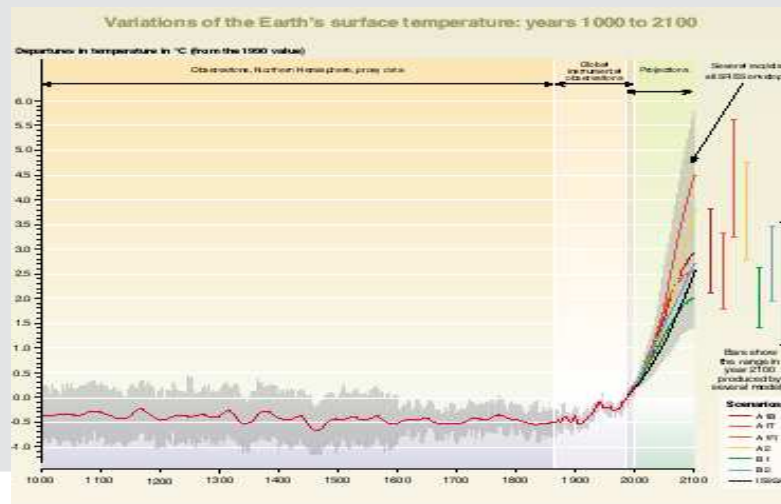


## Climate models

**Most of the observed warming in the past 50 years is attributable to human activities**

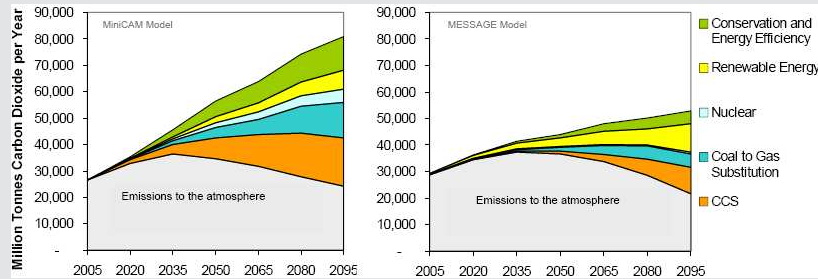


## Future warming





## Economic Potential of CCS

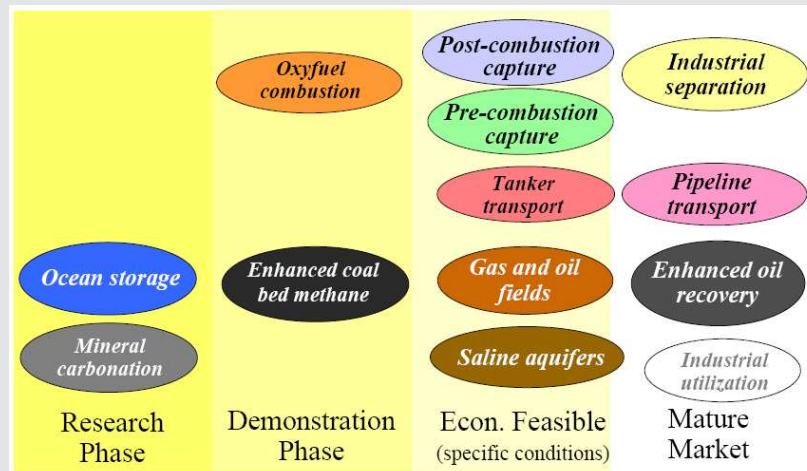


- Across a range of stabilization and baseline scenarios, models estimate cumulative storage of 220–2200 GtCO<sub>2</sub> via CCS to the year 2100.
- This is 15–55% of the cumulative worldwide mitigation required to achieve stabilization.
- Cost is reduced by 30% or more with CCS in the portfolio

Source: E.S. Rubin, Carnegie Mellon



## Maturity of CCS Technologies Research



Source: E.S. Rubin, Carnegie Mellon



## Status of Capture Technology

- CO<sub>2</sub> capture technologies are in commercial use today, mainly in the petroleum and petrochemical industries
- Capture also applied to several gas-fired and coal-fired boilers, but at scales small compared to a power plant
- Net capture efficiencies typically 80-90%
- Integration of capture, transport and storage has been demonstrated in several industrial applications, but not yet at an electric power plant
- R&D programs are underway worldwide to develop improved, lower-cost technologies for CO<sub>2</sub> capture; potential to reduce costs by ~20-30% over near term, and significantly more in longer term

Source: E.S. Rubin, Carnegie Mellon



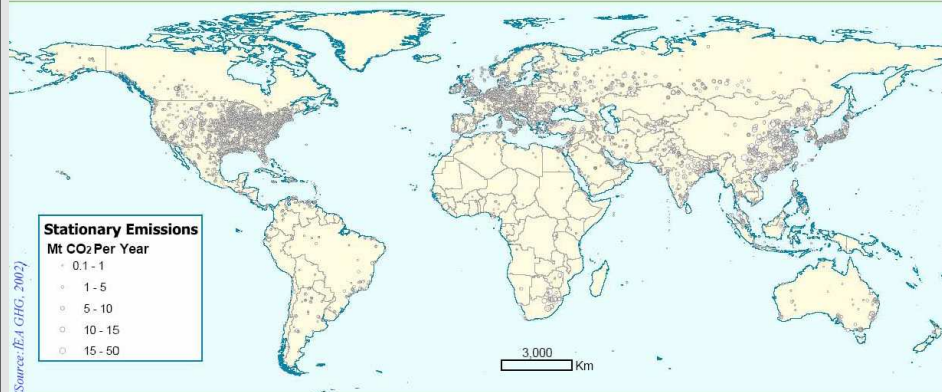
## Existing/Proposed CO<sub>2</sub> Storage Sites:



Source: E.S. Rubin, Carnegie Mellon



## Global Distribution of Large CO<sub>2</sub> Sources

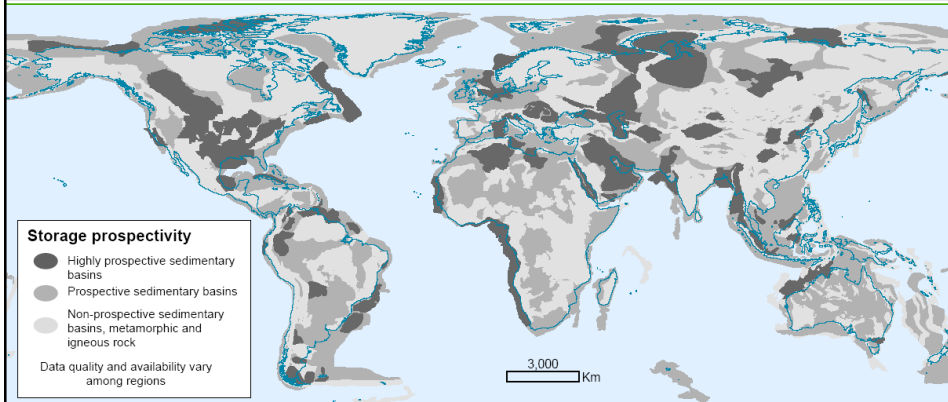


Large sources clustered in four geographical regions.  
Fossil fuel power plants account for 78% of emissions;  
industrial processes (including biomass) emit 22%.

Source: E.S.Rubin, Carnegie Mellon



## Potential Geological Storage Areas



- Good correlation between major sources and areas with potential for geological storage. More detailed regional analyses required to confirm or assess actual suitability for storage.

Source: E.S.Rubin, Carnegie Mellon



## Estimated CCS Cost for New Power Plants Using Current Technology

(Levelized cost of electricity production in 2002 US\$/kWh)

Power Plant System	Natural Gas Combined Cycle Plant	Pulverized Coal Plant	Integrated Gasification Combined Cycle Plant
<i>Reference Plant Cost (without capture) (\$/kWh)</i>	0.03–0.05	0.04–0.05	0.04–0.06
<b>Added cost of CCS with geological storage</b>	<b>0.01–0.03</b>	<b>0.02–0.05</b>	<b>0.01–0.03</b>
<b>Added cost of CCS with EOR storage</b>	<b>0.01–0.02</b>	<b>0.01–0.03</b>	<b>0.00–0.01</b>

- Variability is due mainly to differences in site-specific factors. Added cost to consumers will depend on extent of CCS plants in the overall power generation mix

Source: E.S.Rubin, Carnegie Mellon



## Cost of CO<sub>2</sub> Avoided

(2002 US\$ per tonne CO<sub>2</sub> avoided)

Power Plant System	Natural Gas Combined Cycle Plant	Pulverized Coal Plant	Integrated Gasification Combined Cycle Plant
Same plant with CCS (geological storage)	40–90	30–70	15–55
Same plant with CCS (EOR storage)	20–70	10–45	(-5)–30

Other industrial processes have roughly similar costs

Different combinations of reference plant and CCS plant types have avoidance costs ranging from \$0–270/tCO<sub>2</sub> avoided; site-specific context is important

Source: E.S.Rubin, Carnegie Mellon



## Would Leakage Compromise CCS as a Climate Change Mitigation Option?

- Studies have addressed non-permanent storage from a variety of perspectives
- Results vary with methods and assumptions made
- Outcomes suggest that a fraction retained on the order of 90–99% for 100 yrs, or 60–95% for 500 yrs, could still make non-permanent storage valuable for mitigating climate change
- All studies imply an upper limit on amount of leakage that can take place

Source: E.S.Rubin, Carnegie Mellon