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Carbon Dioxide Capture and Storage: a Developing Option to Mitigate Climate Change Risk

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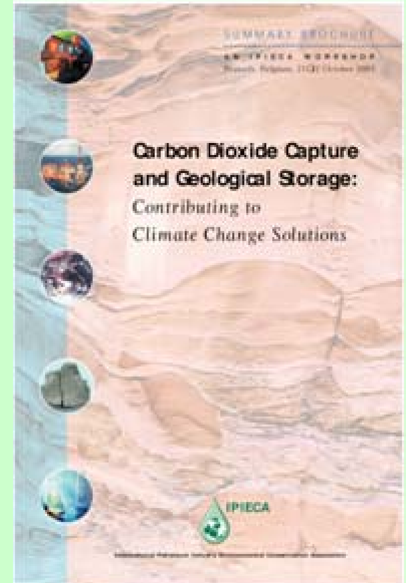
IPIECA Climate Change Working Group Reports

Carbon Dioxide Capture and Geological Storage: Contributing to Climate Change Solutions

- **Brussels, Belgium, 21-22 October 2003**

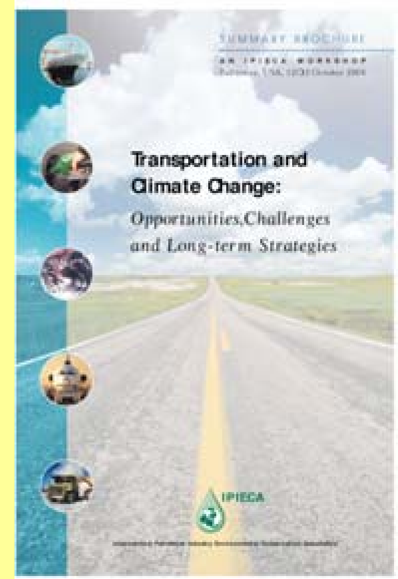
• **CCS of potentially large scope: electricity generation, fuel conversion**
•**"Technology improvement is an essential component in addressing the risk of climate change while providing affordable energy."**



Transportation and Climate Change: Opportunities, Challenges and Long-term Strategies

Baltimore, Maryland, 12-13 October 2004

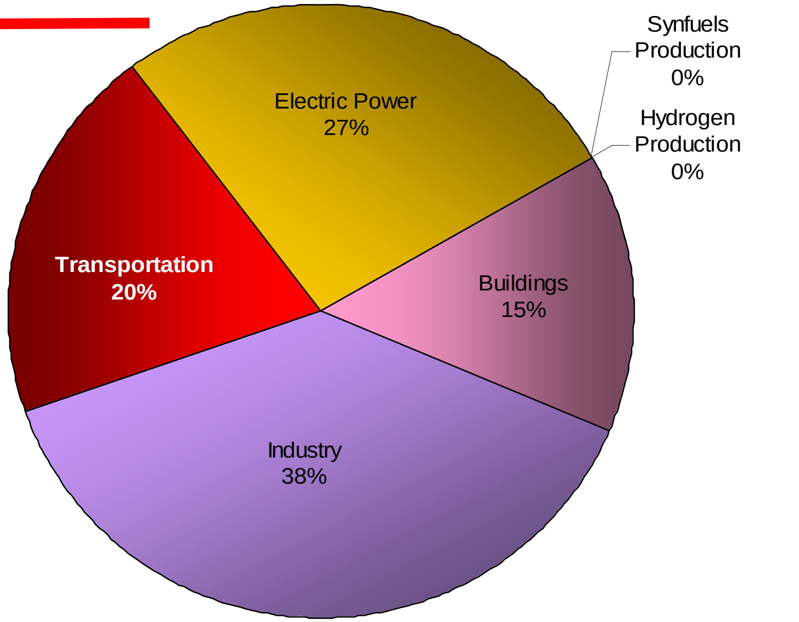
•**"indicates the importance of a portfolio of approaches considering the entire transportation system extending from the roles that transportation plays, to the infrastructures that enable it, to the technologies that carry it out."**



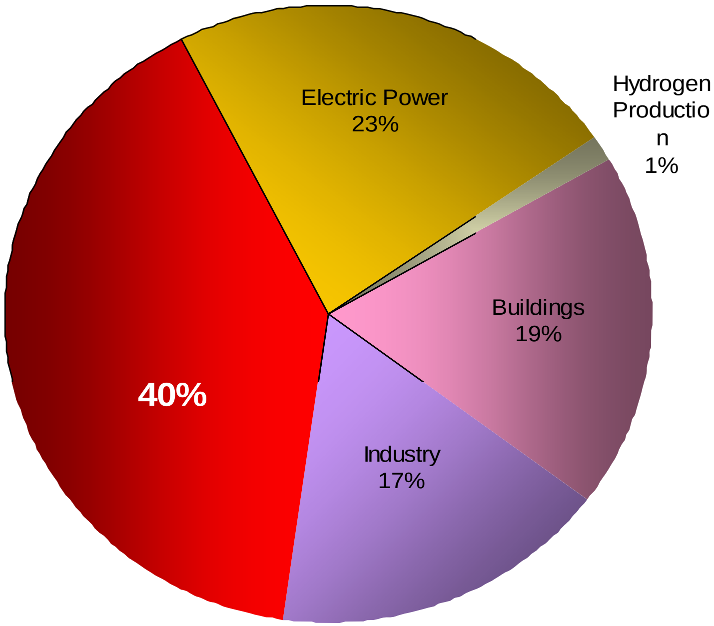
Workshop reports freely available online through IPIECA website
www.ipieca.org

Projecting Mitigation

Year 1990 CO_2 Emissions



- Development of illustrative scenarios provides some insights
- Assuming
  - Idealized, least-cost GHG mitigation worldwide
  - A GHG stabilization level
  - Technology, population, socioeconomic development
- Unless these assumptions prove to be substantially incorrect – as efforts to improve technology may accomplish -- then transportation will command a larger share of future CO2 emissions.



Year 2095, CO_2 Emissions, Reference Case, 550 ppm CO_2

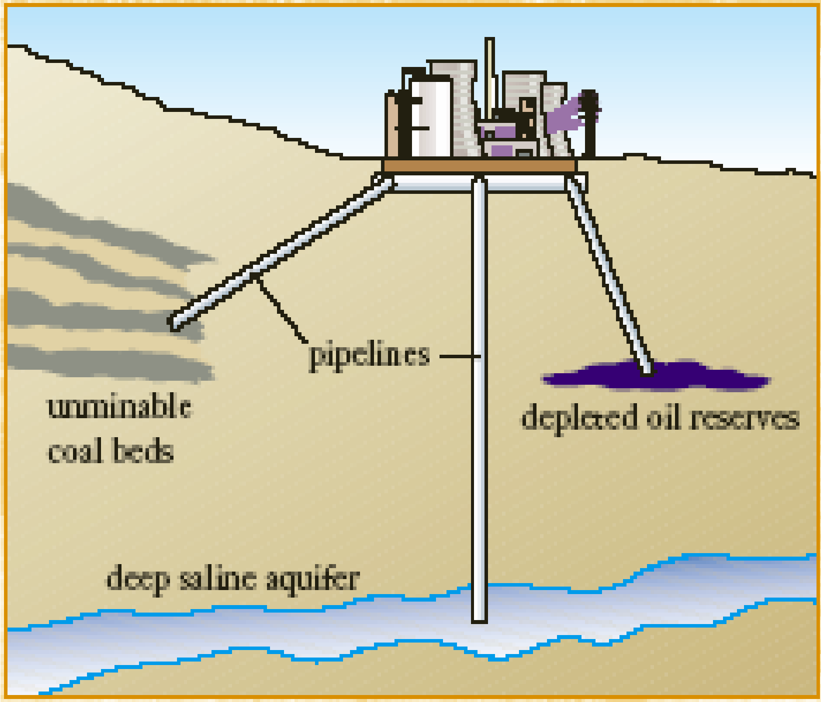
350 gallons gasoline ~ 1 tC emissions
1$/gal gasoline ⇒ $350/tC

Source: Edmonds, IPIECA workshop *2004*

What is
Carbon Dioxide Capture and Geological Storage (CCS)?

CCS is the capture of CO2 from large stationary sources, its transportation to an appropriate injection site where it is pumped into underground geological formations

- **Electricity production results in the largest set of large stationary sources of CO_2; ~40% of global CO_2 emissions**
- **Capture in power production can be carried out by separating CO_2 from flue-gas using an amine absorbent at a cost of roughly 40 US$/t$CO_2$**
- **Alternative methods include:**
  - **pre-combustion decarbonisation**
  - **combustion using oxygen instead of air or**
  - **separation using membranes, solid adsorbents cryogenics**
- **Captured CO_2 can be transported by high pressure pipelines or tankers to land-based or offshore geological sites**
- **At site CO_2 is injected for storage**
- **Geological storage sites include depleted natural gas and oil fields, deep saline aquifers, and coal seams.**



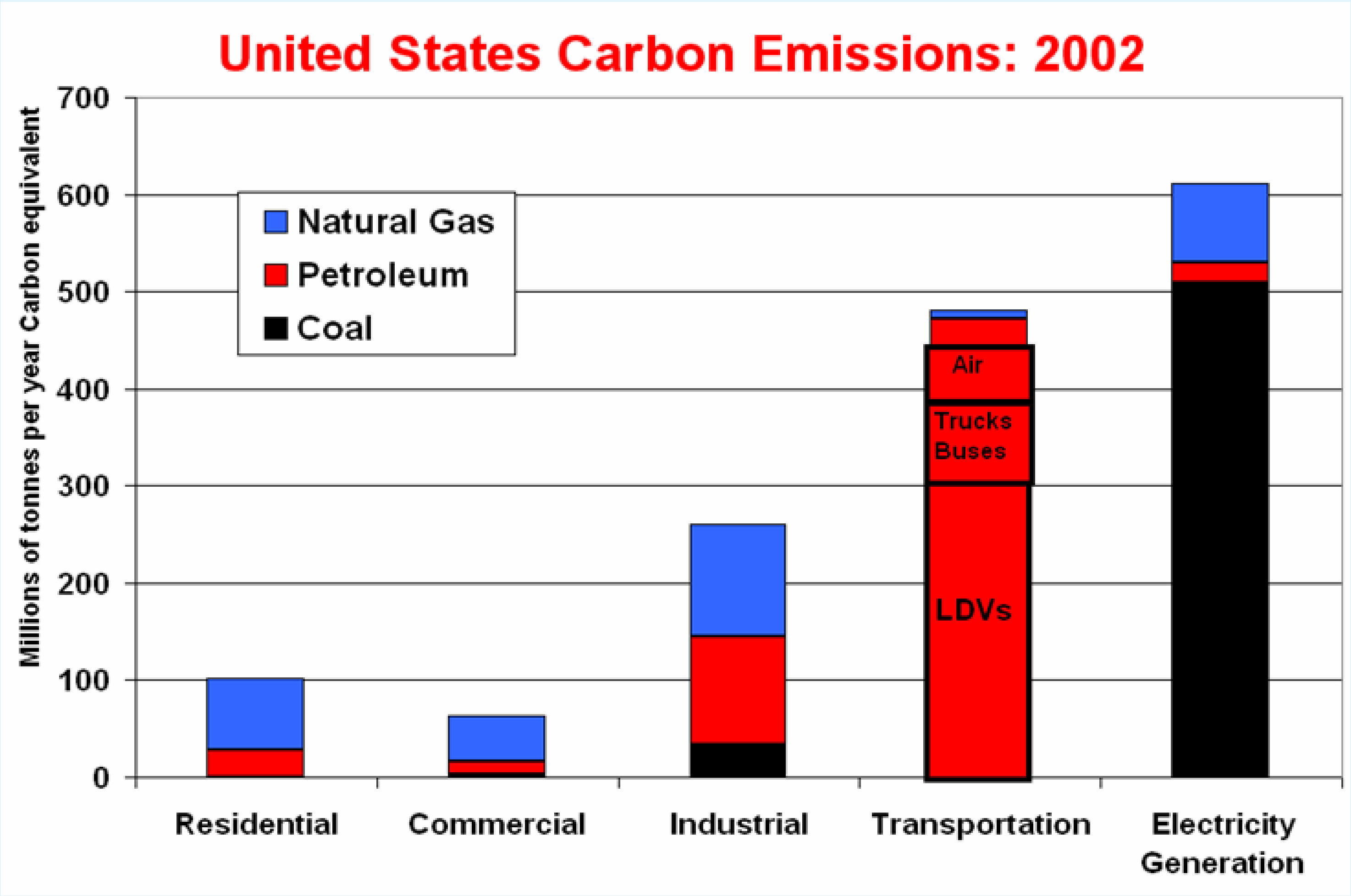
- **Ocean storage raises issues:**
  - **Cost of transport**
  - **Ecosystem effects**
  - **Public acceptance**

CO2 Capture and Storage Technology for a Greenhouse Gas Constrained Future

- Scope for CCS is large
  - Potential storage sites are widespread and have huge volume
  - Emissions from power production and industry = 63% of global CO_2 emissions
  - If shift to hydrogen or electricity for transportation's energy carrier, then scope could include another 25% of global CO_2 emissions

Importance of:

- Coal in CO2 emissions from power
- Oil in CO2 emissions from transportation



CO2 Capture and Storage Technology for a Greenhouse Gas Constrained Future

- **CCS adds costs and consumes energy leading to**
  - **increased cost of energy services**
  - **additional depletion of energy resources**

- **The current cost of CCS from power plants is roughly 40-60 US$/t$CO_2$**

- **In limited cases capture costs can be modest:**
  - **gas processing**
  - **production of some chemicals**

Case dependent

- **And in some limited cases CCS is economic:**
  - **enhanced oil recovery**
  - **acid gas disposal**

Opportunities for early experience

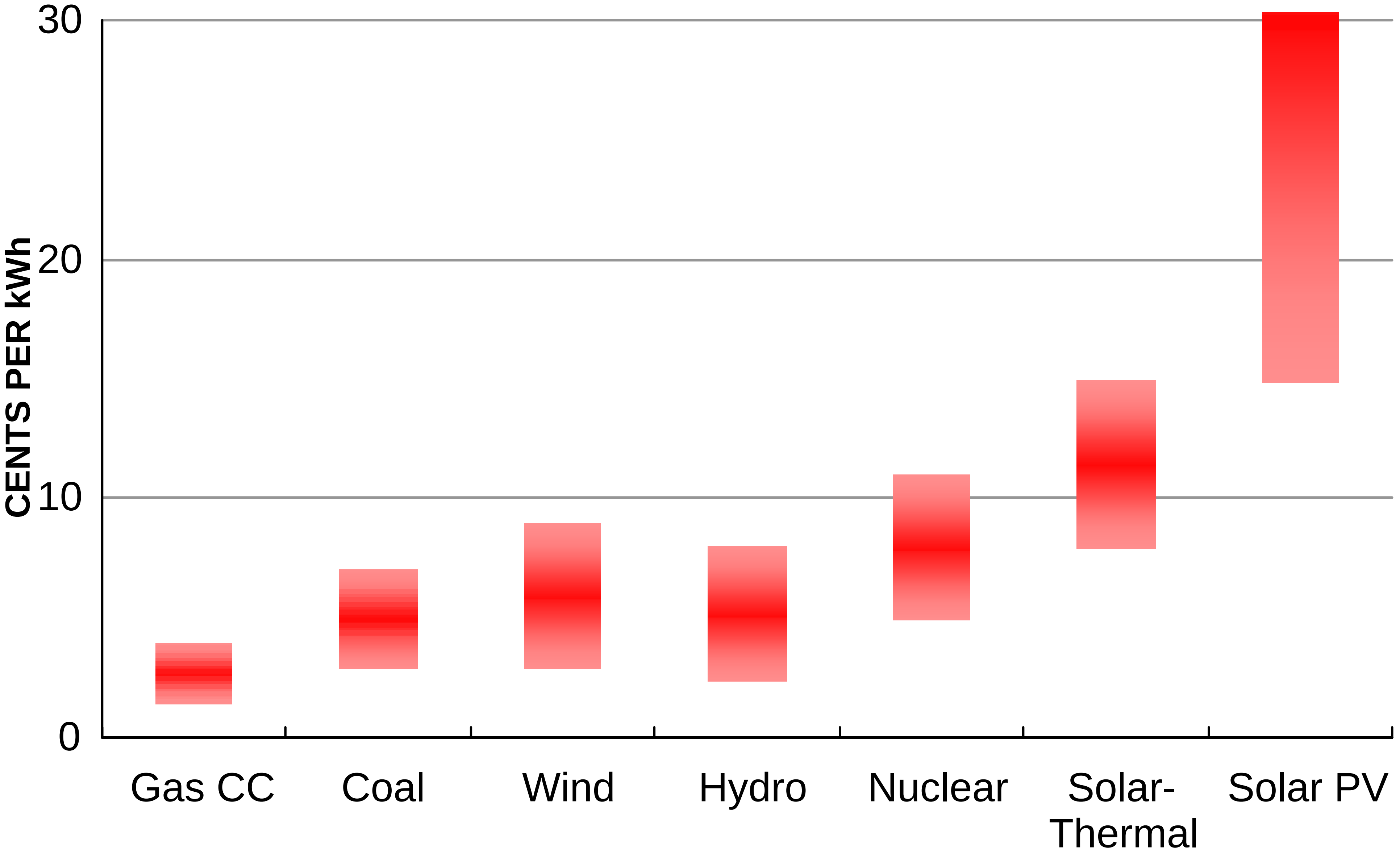
- **In scenarios where atmospheric concentration stabilizes over the next century CCS can play a primary role:**
  - **Assumes advances in technology**
  - **Assumes drivers from policy measures**
  - **Entails massive infrastructure addition rivalling that of current global energy system**

- **Because of the large scale and cost, deployment of CCS on a scale that affects global emissions would require many decades**

- **There are significant uncertainties in:**
  - **long-term technology development;**
  - **and policy measures to mitigate climate change**

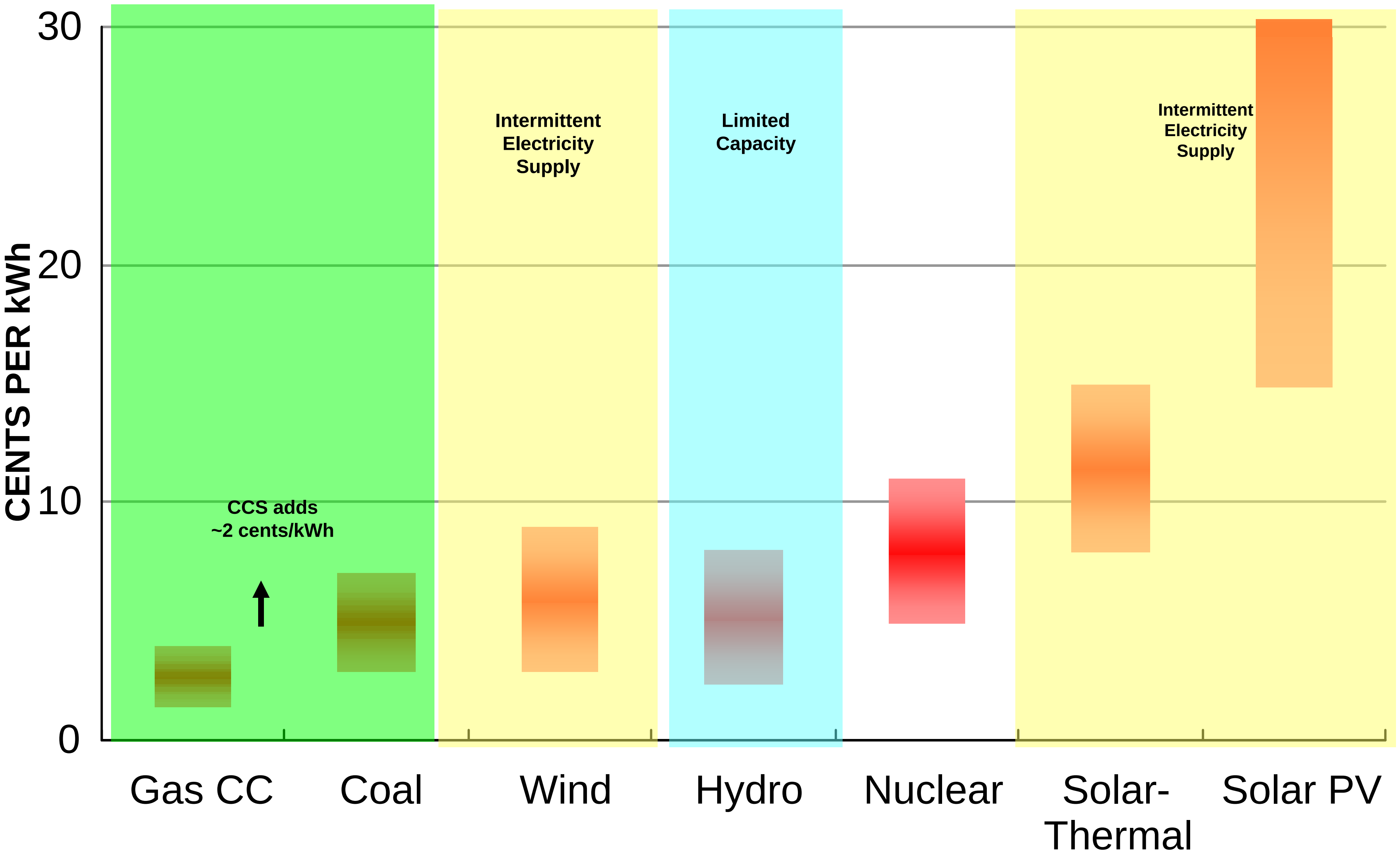
How CCS evolves in comparison to competitive and complementary technologies will influence its future prospects

Electricity Costs



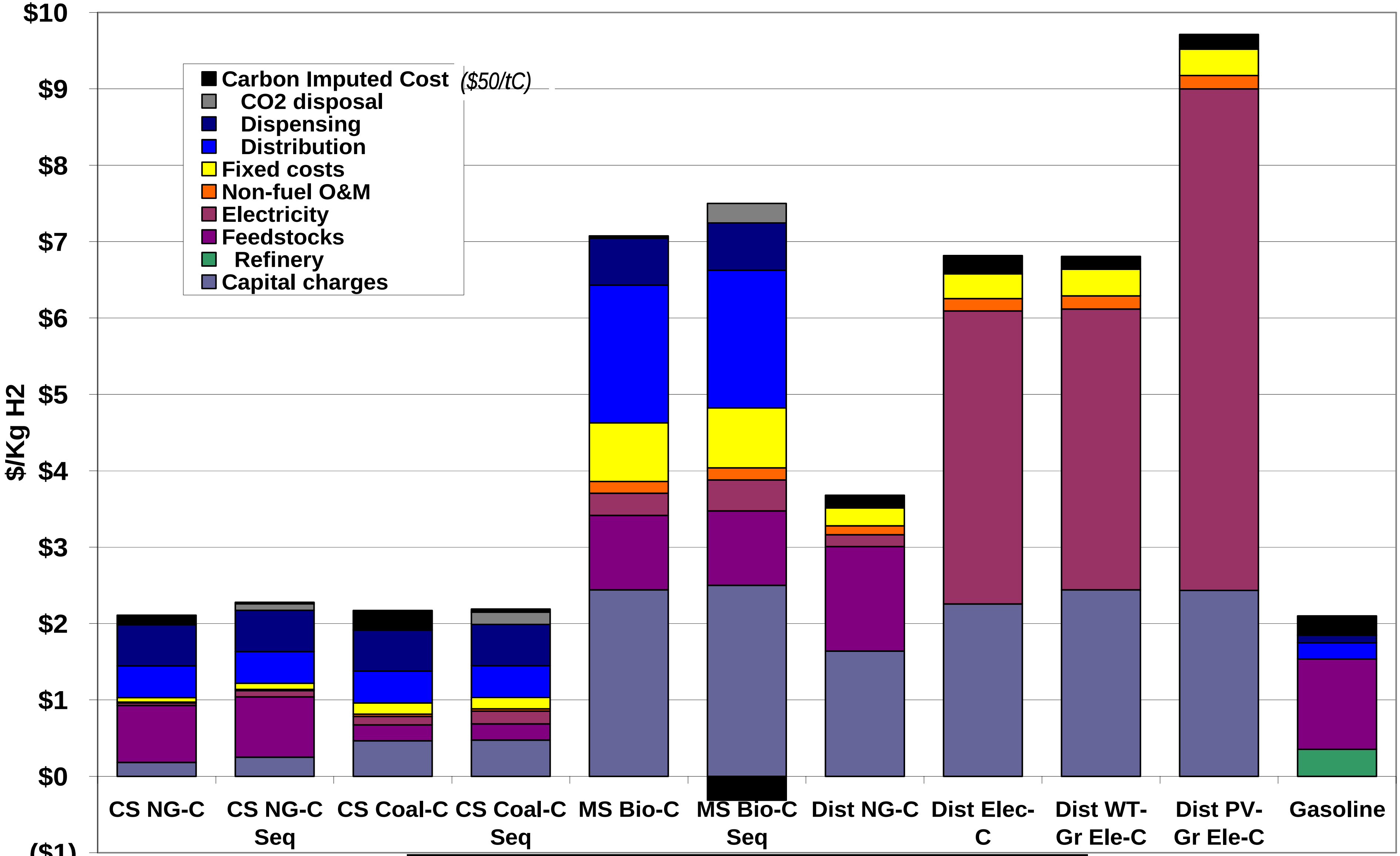
Exxon Mobil (2002)

Electricity Costs



Exxon Mobil (2002)

H2 Production with Current Technologies: Cost Estimates



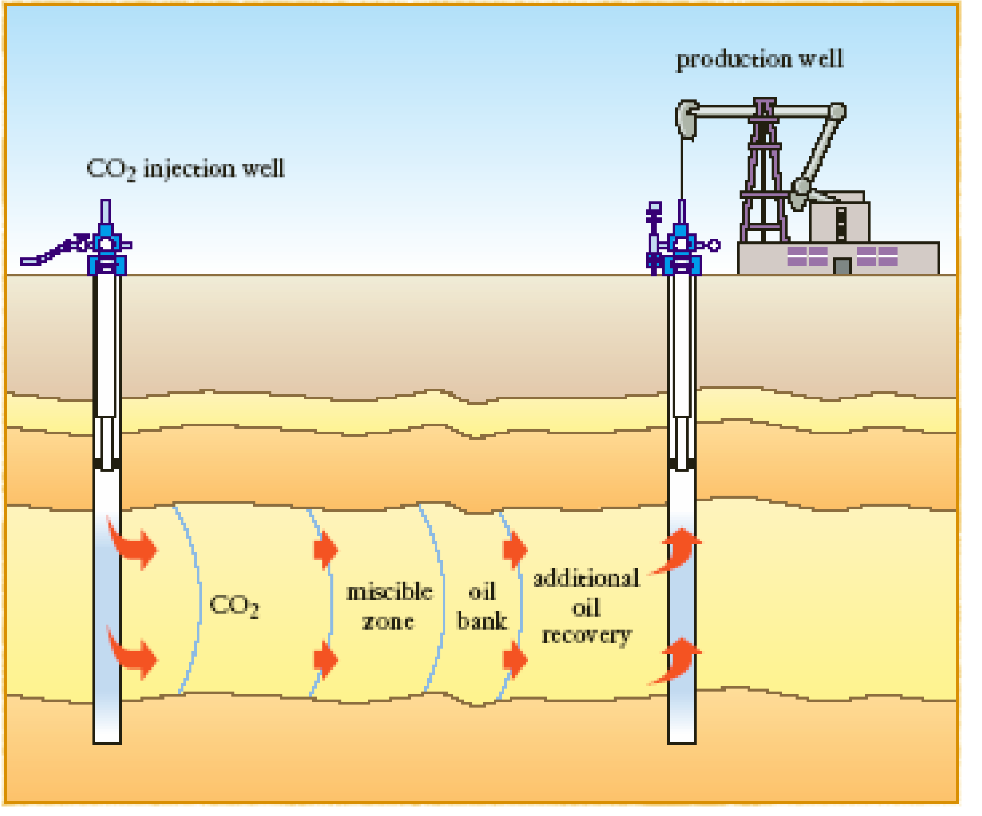
Does not include costs of vehicles

The Hydrogen Economy, NRC/NAE (2004)

Basis for Risk Management for an Expanded Role of Geological Storage of CO2

- **Science builds on over 30 years of industry experience**
  - **enhanced oil recovery (EOR)**
  - **acid gas injection and CO_2 storage**

- **Safety achieved by site selection and risk management systems that make use of information from:**
  - **Site characterisation;**
  - **Operational monitoring;**
  - **Scientific understanding;**
  - **Engineering experience**



➢ Experience provides valuable information on the management of geological storage

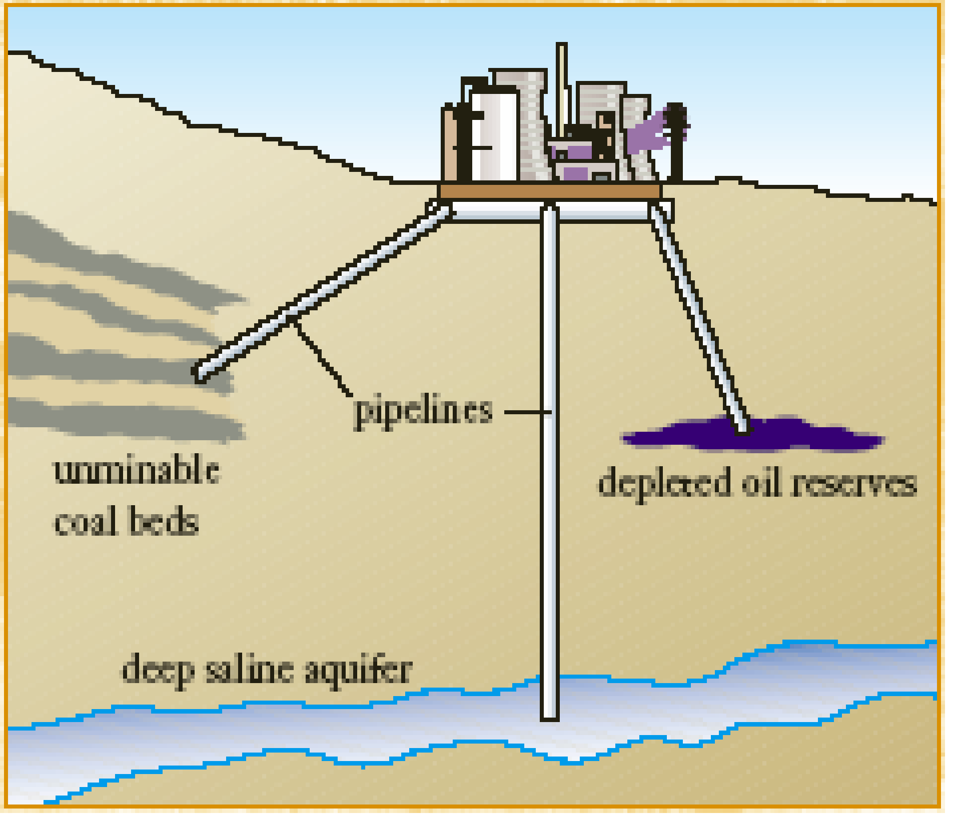
- Fossil fuel emissions are several orders of magnitude greater

To avoid a substantial portion of global emissions would require CCS on much larger scale than existing experience

Basis for Risk Management for an Expanded Role of Geological Storage of CO2

➢ Geologic storage will require consideration of a broader range of geological settings than have been considered for EOR

- **Volume of pore-space beneath land and offshore ample in comparison to emissions of CO_2 from fossil fuels**
  - **How much could effectively be used is an evolving question**
  - **Depleted oil and gas fields might accept 920,000 Mt CO_2 (45% of fossil fuel CO_2 emission to 2050)**
  - **Deep aquifers form a class of sites that have much greater capacity (perhaps up to 500% of emissions to 2050)**



Basis for Risk Management for an Expanded Role of Geological Storage of CO2

- **Site characterization has been used to choose formations suitable for acid gas injection**
- **Operational monitoring can be used to guide operations and detect deviations from project specifications.**
- **Monitoring can be used to expand understanding of the phenomena that underpin geological storage of CO_2**
- **Improved understanding of how to assess and operate in less familiar geological settings would be valuable**
- **Effective site selection criteria make use of improved:**
  - **risk assessment case studies,**
  - **site characterizations,**
  - **and the analysis of well integrity**

For CCS to expand to a substantial portion of fossil fuel emissions warrants full consideration of risks to form the basis for engineering, management, and regulatory systems to achieve acceptable and safe operation

Carbon Dioxide Capture and Storage: a Developing Option to Mitigate Climate Change Risk

- Technically feasible
- Availability of storage sites
- May apply to a significant fraction of CO_2 emissions, allowing coal to remain in a GHG constrained world
- Enables hydrogen with low emissions from fossil fuels and biomass (negative emissions)
- While not economic, appears to compete with other (currently not economic) large-scale mitigation options

- Leads to more rapid resource depletion
- Enormous infrastructure, decades of investment to implement
- Public acceptance (political vulnerability)
- Regulatory and legal frameworks unclear
- Large scale CCS not driven by market forces, but by policy intervention -> uncertainty -> investment risk which always increases cost

A portfolio of technology initiatives advancing not only CCS, but also other technology options is appropriate in this situation