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The Impact of Carbon Dioxide Geological Sequestration

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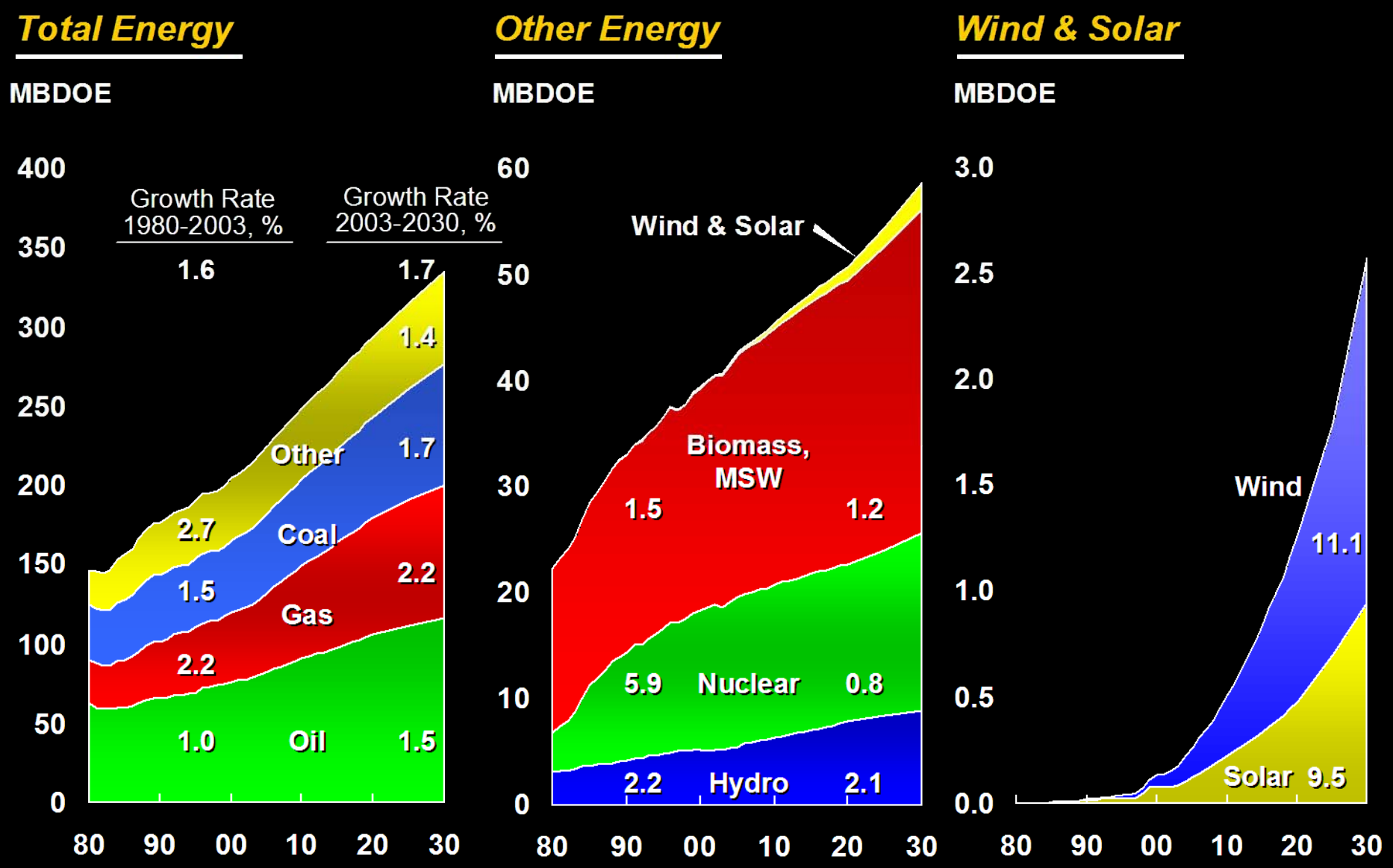
ExxonMobil

Carbon Geological Sequestration

- The most popular carbon storage method promoted and pilot tested
- Almost all estimates use sketchy empirical data or flawed steady state injection history (for EOR)
- The effect of burying all the extra CO_2 as per Kyoto Protocol on temperature change has never been evaluated

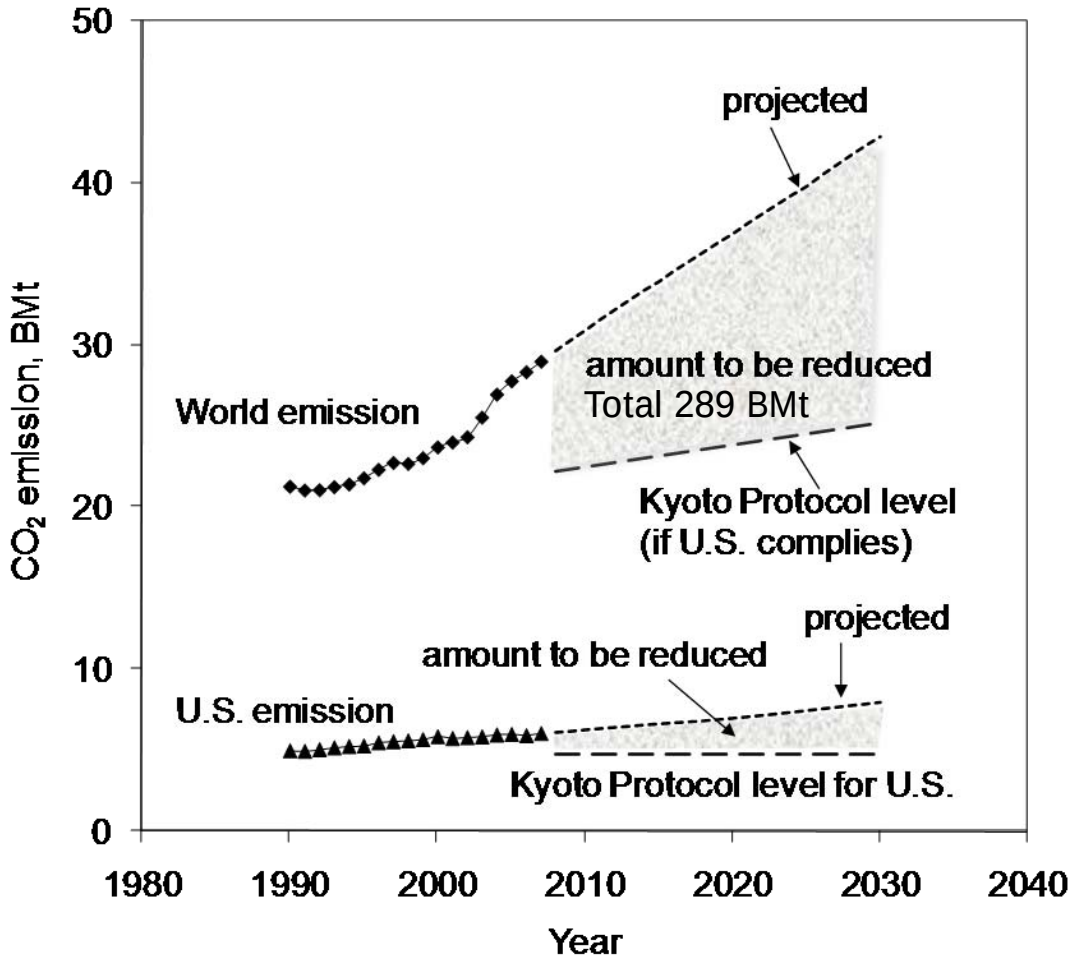
Oil & Gas Remain as Primary Energy Sources



Carbon Geological Sequestration – Scale and Cost

- Uncertainties and Risks
  - Oil and gas reservoirs, Deep saline formations
  - Coalbeds
- Policies and Regulations
  - Classification of CO_2
  - Ownership of injected CO_2
  - Perspective
- The Effect on Global Temperature Change

Amount of CO_2 to be reduced to comply with the Kyoto Protocol



Wells needed to inject the extra CO_2

Year	Extra CO_2 in U.S., BMt	Wells needed in U.S.	Extra CO_2 in the world, BMt	Wells needed in the world
2008	1.32	6875-66382	7.35	38282-369626
2010	1.48	7710-74428	8.33	43386-418910
2015	1.85	9636-93035	10.69	55678-537592
2020	2.21	11511-111140	13	67709-653760
2025	2.69	14011-135278	15.29	79636-768922
2030	3.21	16720-161430	17.7	92188-890120

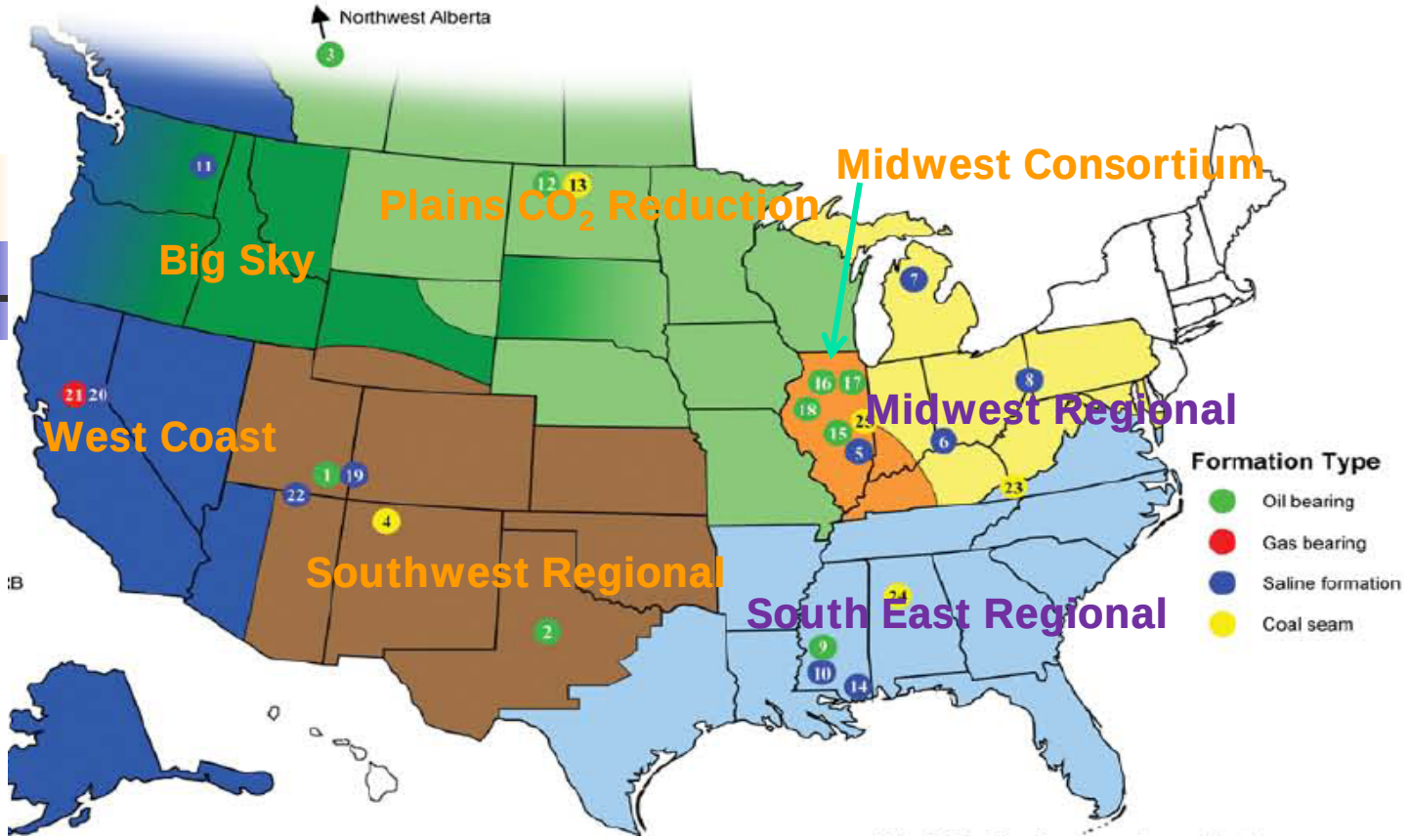
Very optimistically unrealistic estimates

Pseudosteady state injection would require 5 to 20 times the number of wells

Cost of Capturing and Compressing CO_2

Year	Extra CO_2 in U.S., BMt	Cost @ $167/Mt, $B	Extra CO_2 in the world, BMt	Cost @ $167/Mt, $B
2008	1.32	220.44	7.35	1227.45
2010	1.48	247.16	8.33	1391.11
2015	1.85	308.95	10.69	1785.23
2020	2.21	369.07	13	2171
2025	2.69	449.23	15.29	2553.43
2030	3.21	536.07	17.7	2955.9

- **Transportation cost (2007):**
  $2 million/mile pipeline, $1 million/mile power line
- **Electricity cost increase : at least 30%**



Seven Carbon Capture Partnerships in U.S.A.

Phase I – Characterization Phase (2003-2005): ~$2 to 3 million each
Phase II – Validation Phase (2005-2009): ~$18 million each
Phase III – Deployment Phase (2008-2017): ~ $100 million each

How Much Can Be Done by the Partnerships?

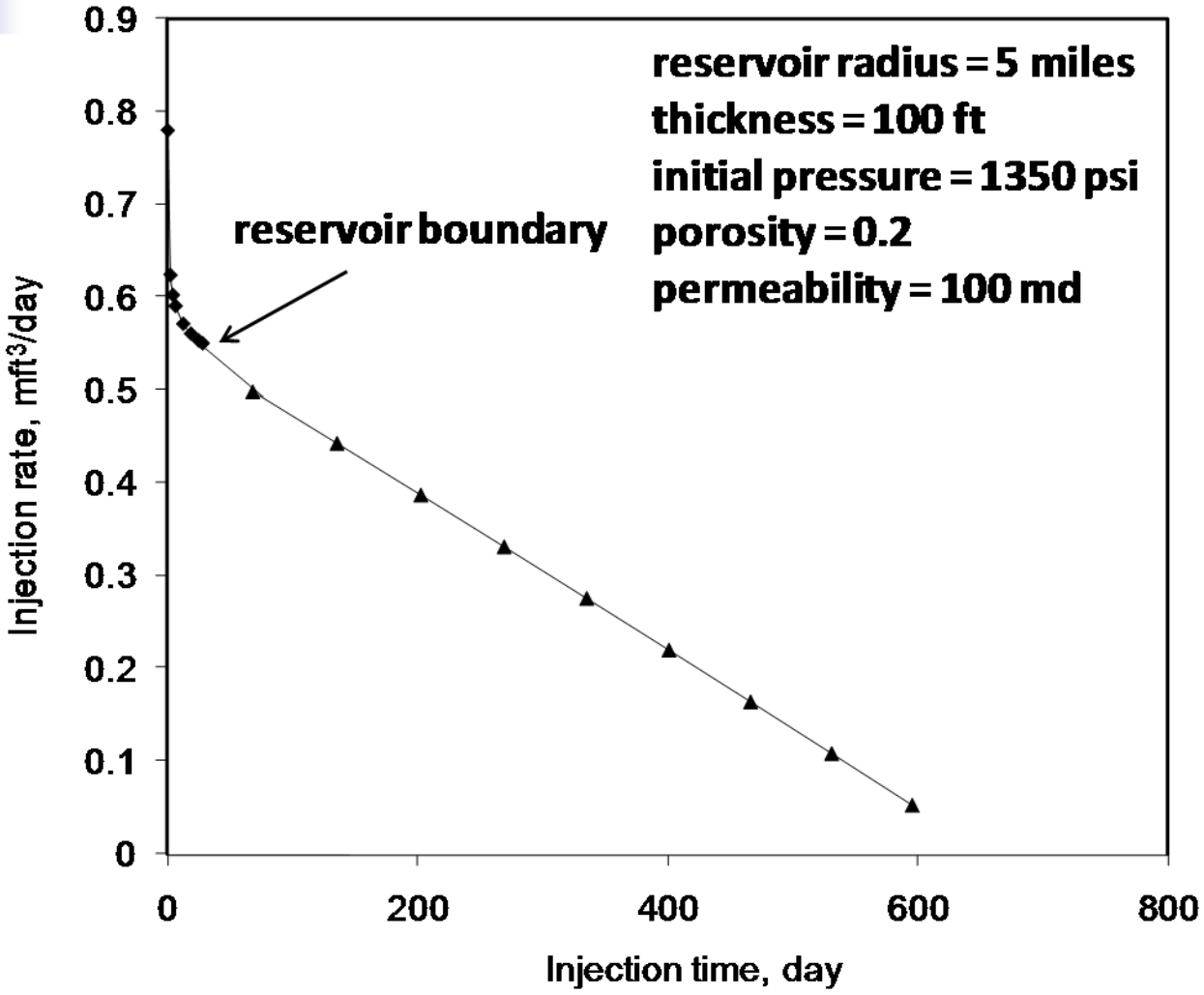
The Cancellation of FutureGen

World's first coal-fired power plant with zero CO_2 emissions original plan cost $0.9 billion, grew to $1.8 billion before cancellation

Geological Sequestration

- Closed Reservoir
  - Pore volume is crucial
- EOR injection rates are inappropriate analogs
- Injection rate will decline
- Maximum CO_2 volume dictated by capacity and fracturing pressure limitation

Injectivity reduction



Other problems

- Injectivity reduction because of scales and bacteria growth
- Polycyclic aromatic hydrocarbons and water contamination
- Sudden leakage
  - All coalbeds leak
  - Unknown saline formation geological conditions

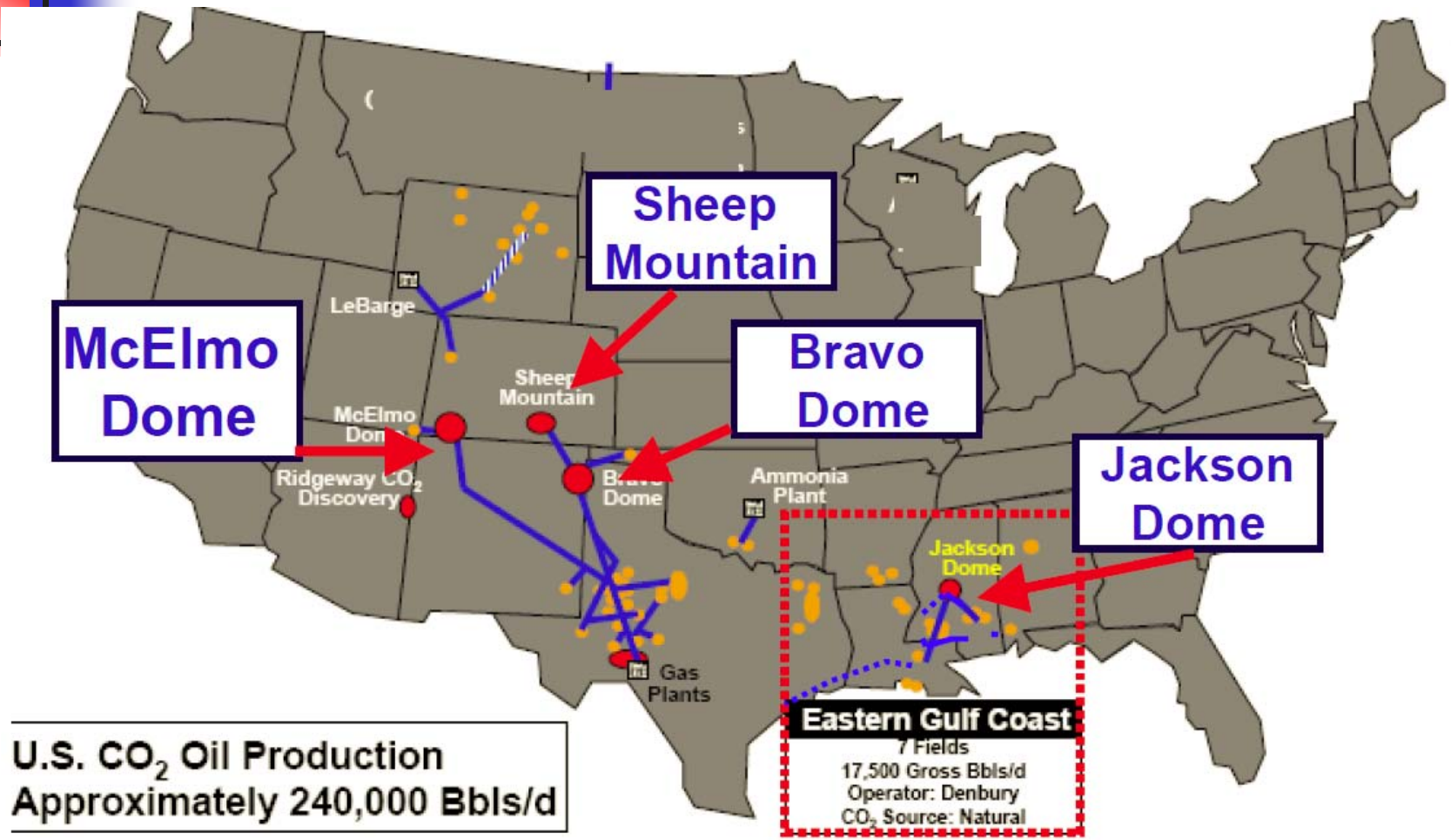
Sequestration management

- Classification of CO_2
- Ownership of injected CO_2
- Global policies or regulations
  - Who makes the rules?
  - Population distribution
  - Industrial development
  - Financial burden

Sequestration management

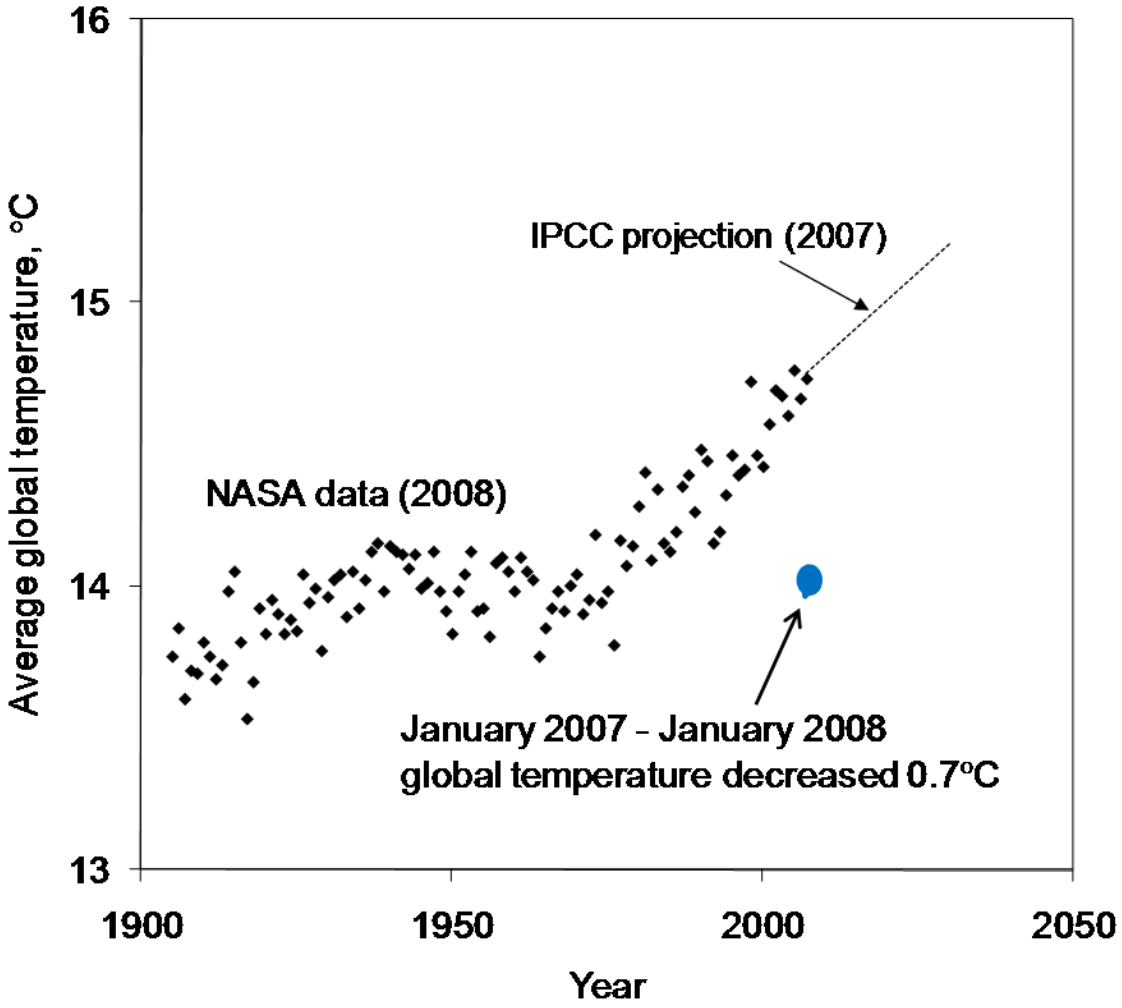
- Who pays for the management costs?
  - Routine maintenance
  - Leakage remediation
  - Lawsuits

No CO_2 for sequestration!!

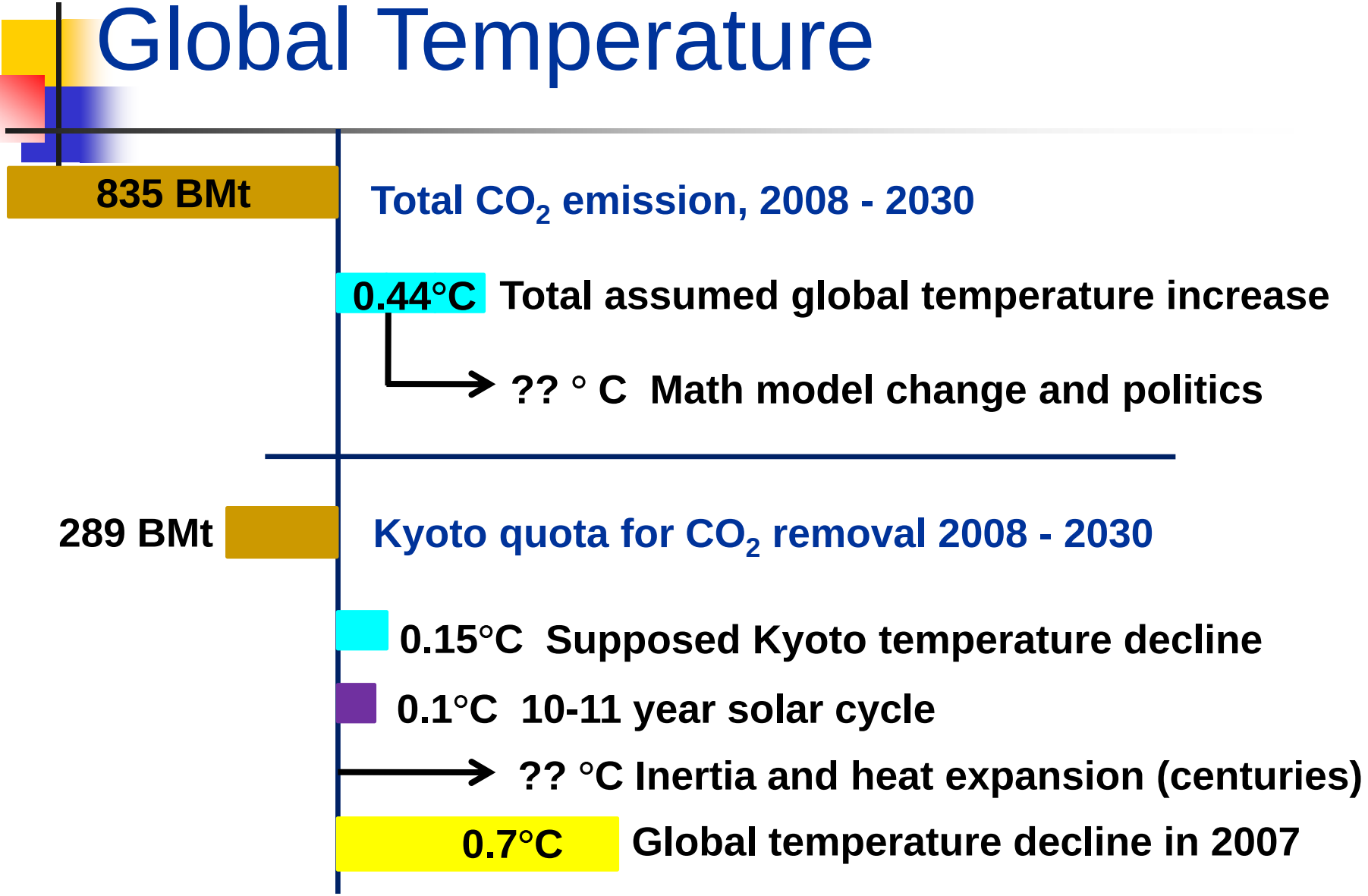


Denbury Resources, Inc. (Sept. 2007)

Global temperature change



Kyoto Protocol Program on Global Temperature



Conclusions

- CO_2 sequestration is likely to be many orders of magnitude more difficult than people think;
- Costs will be in the trillion dollars even if the physical issues are solved;
- Meeting the Kyoto Protocol is either economic impossible or self destructive;
- Management of sequestered CO_2 will be a nightmare.