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Barriers to Widespread Deployment of CO_2 Sequestration

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Outline

- Why is CO_2 sequestration important?
- What are the barriers to widespread deployment?

- Questions?

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Why is CO_2 sequestration important?

- It is now widely accepted that in order to prevent potentially large disturbances to the climate system, we need to stabilize atmospheric concentrations of CO_2 (at a yet to be specified level)
  - Note that the goal is stabilization of **concentrations**, not emissions
- Because of its longevity in the atmosphere, in order to stabilize concentrations of CO_2, total CO_2 emissions need to peak, and ultimately **decline**
  - This needs to be done while simultaneously satisfying the world's growing demand for energy
  - One implication is that the carbon content of energy supply needs to decrease
- Finding a solution for fossil fuels is essential if society truly wants to address climate change
  - Enduring use of fossil fuels essentially revolves around successful, **widespread** deployment of CO_2 Capture and Storage **(**CCS**)** technologies

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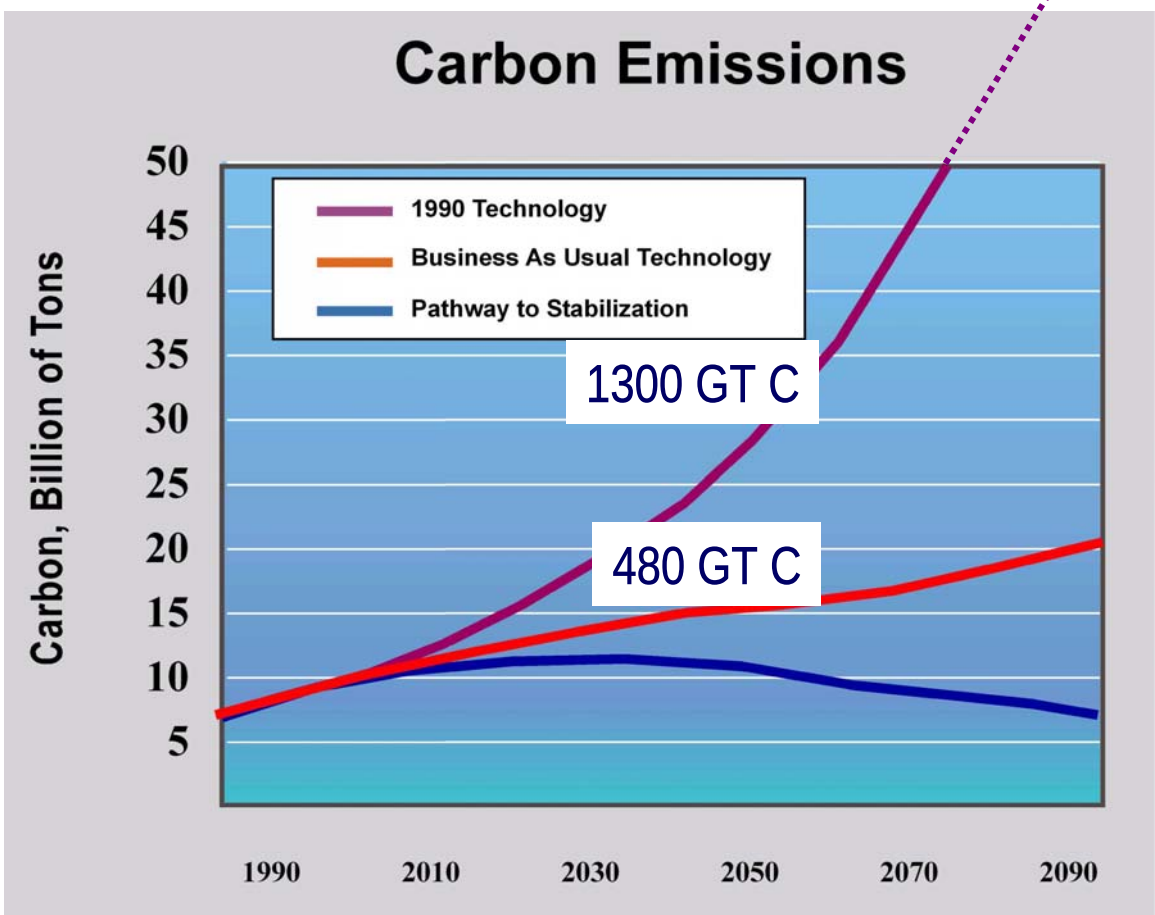
Commitment to Stabilization Requires Closing Two "Gaps"



"Business-As-Usual" Technology Gap

"Stabilization" Technology Gap

Source: Battelle Global Technology Strategy Project (GTSP)

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Meeting Energy Demands While Reducing CO_2 Emissions

- It is going to take significant contributions from diverse technologies, from renewables to energy efficiency to clean fossil fuels to make this happen.
- **No one technology can do this alone (No silver bullets)**
- Coal **has** to be part of an economically sustainable solution
  - Abundant, relatively cheap energy resource
  - Infrastructure in place
  - The U.S. is the “Saudi Arabia” of coal
    - Energy security- most estimates place our reserves at 200+ years
    - Allows climate policy without compromising economic growth
- CO_2 sequestration (at scale) is a critical piece of the puzzle

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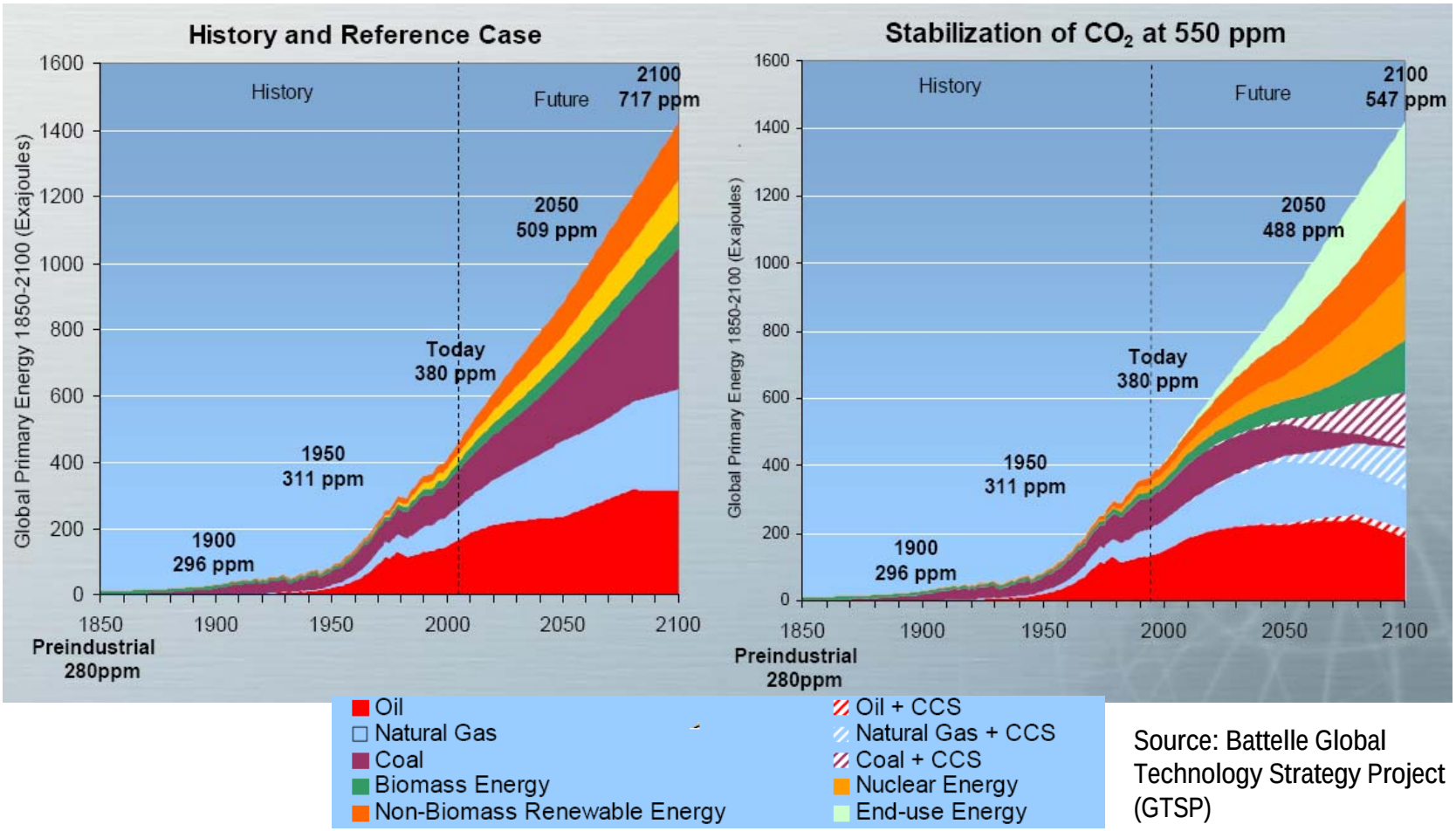
The Energy System will look very different over the next century…



Source: Battelle Global Technology Strategy Project (GTSP)

…and CO_2 sequestration is a key technology for the energy system.

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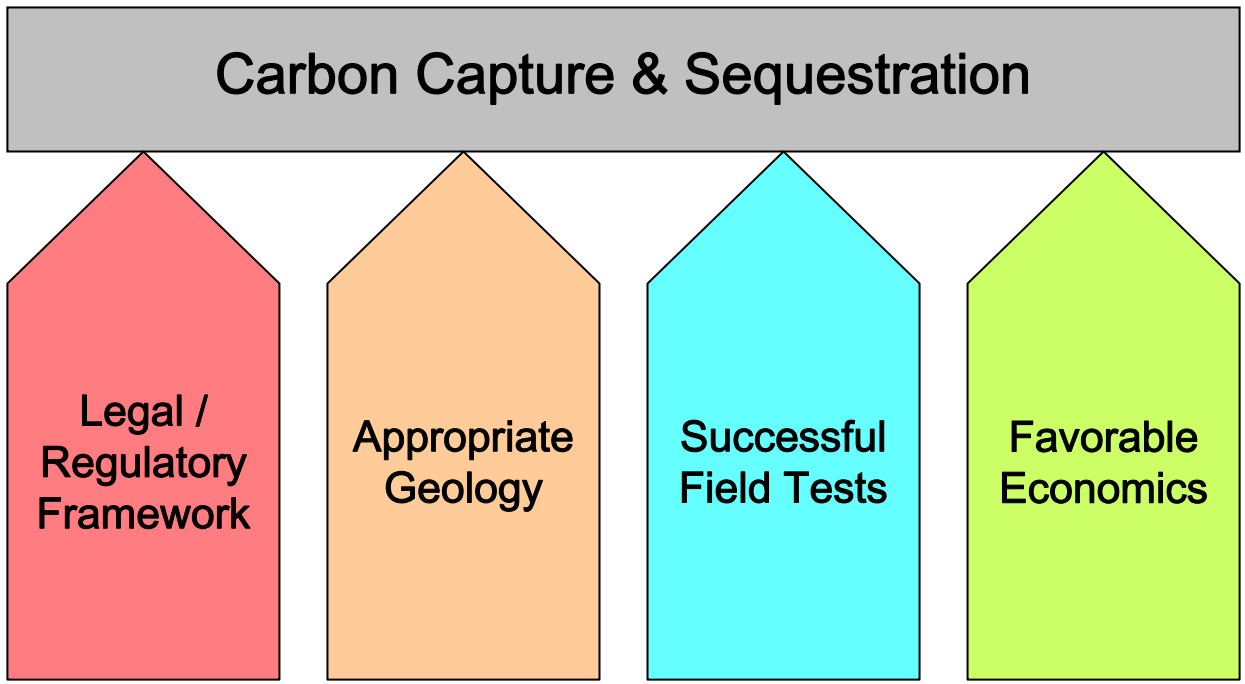
Let us put a positive spin on “barriers”- what are the pre-requisites for widespread deployment?



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Legal / Regulatory Framework

- Carbon capture and storage will not be deployed until all legal and regulatory issues have been addressed.
- In particular issues around long term liability and subsurface rights must be resolved
- Liability protection is a necessary pre-requisite for securing financing (and commercial deployment)
  - Timeframe mismatch necessitates statutory protection
- Subsurface rights need to be secured
  - How much is enough?
- Consistent regulatory requirements for injection, monitoring and closure
  - Federal guidelines would be preferable

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Appropriate Geology

- What is appropriate geology?
  - Contained, receptive target formation topped by one or more layers of impermeable caprock
- Formation needs to be well-characterized
  - Verified capacity, not estimated potential!
    - Role for SER?
  - Geologic properties (porosity, permeability, etc.,)
  - Caprock extent and properties
  - Knowledge of any prior incursions
- First sites may warrant additional requirements
  - Increased safety margin

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Successful Field Tests

- Learning-by-doing is a necessary and critical component of technology deployment.
- Field-testing improves confidence of industry, regulators, stakeholders and the financial community.
- Field-testing can take several forms:
  - Pilot scale
    - Necessary first step
    - Early test bed for technologies
    - Regional partnerships are a good example
  - Commercial scale
    - FutureGen: research platform for integration of state-of-the-art gasification, cleanup and CO_2 capture and sequestration
  - Need more!

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Favorable Economics (1)

- CO_2 capture and sequestration is a cost, and will require an external signal to be deployed
- Economics has two parts:
  - Capture costs
  - Sequestration costs

Capture Costs:

- Additional costs of capture from coal-fired power plants range from $30-$60/ton of CO_2
- Capex requirements can be 40-80% higher compared to baseline plants, depending on technology and whether retrofit
  - IGCC plants promise lower costs
  - Flue gas (post combustion) capture may not only be widely deployed - on both coal and gas fired plants - but should eventually be cost competitive

Favorable Economics (2)

Sequestration Costs:

- Cost estimates for transport and injection vary from $5-$12 per ton of CO_2 in the literature
- While EOR has the potential for economic returns, it is a niche opportunity
  - May help some early projects
  - Long-term returns uncertain
  - Deep saline formations have orders of magnitude greater storage potential

Bottom Line:

- Early deployments will require significant cost sharing and/or financial assistance to proceed

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A Few Final Thoughts

- While different components of CO_2 capture and sequestration have been tested or demonstrated at varying scales, it is important to recognize that substantive and necessary R&D is still on-going
- There is still a very significant integration challenge at commercial scale
- While technologies are evolving rapidly, they need an appropriate framework in order to be deployed successfully

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Questions?