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Global Energy Technology Strategy Program

The Global Energy Technology Strategy Program, PHASE 3

From Local Circumstance to Global Context and Back

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May 24, 2007

PNNL-SA-51961

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Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

Strategic Frame

Overall Goal: Understanding the role of technology in addressing climate change.

- In GTSP Phase 2, we tried to understand the details of technology and how that affected the role of technology in addressing climate change.
- In GTSP Phase 3 we will explore, how the details of technology *and* the time and place of their development and deployment affect the role of technology in addressing climate change.

GTSP Phase 3 Program Elements

Technology Analysis

Regional Analysis

Core Modeling
(serves all program elements)

Scenarios

Technology & Institutions

Core Modeling

- Goal: To develop the computational capacity to support the technology, regional, scenarios, and I&I research areas.

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IA Modeling

Core Modeling

Early 1980s	Early 1990s	Late 1990s	Present Day	Future
				Closed system
				Hydrology
				Ecosystem impacts
			Ag-land-use	Ag-land-use
			Terr. carbon cycle	Terr. carbon cycle
			Non-sulfur aerosol	Non-sulfur aerosol
		Sulfur aerosol	Sulfur aerosol	Sulfur aerosol
		Energy technology	Energy technology	Energy technology
	Atmos. Chem.	Atmos. Chem.	Atmos. Chem.	Atmos. Chem.
	Climate model	Climate model	Climate model	Climate model
	Ocean carbon cycle	Ocean carbon cycle	Ocean carbon cycle	Ocean carbon cycle
Energy-economy	Energy-economy	Energy-economy	Energy-economy	Energy-economy

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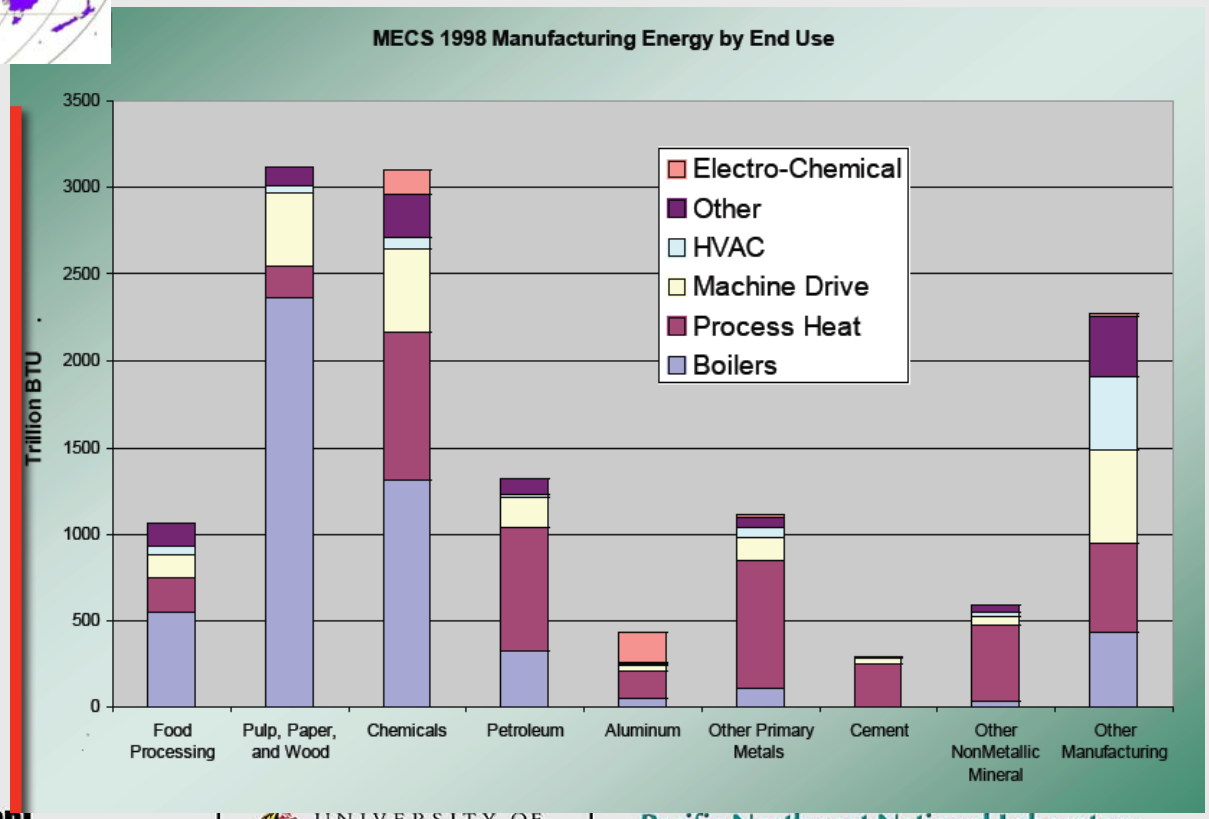
Data—The Final Frontier

Core Modeling

The MiniCAM is a 14-region global IAM, but representations of energy use varies tremendously.



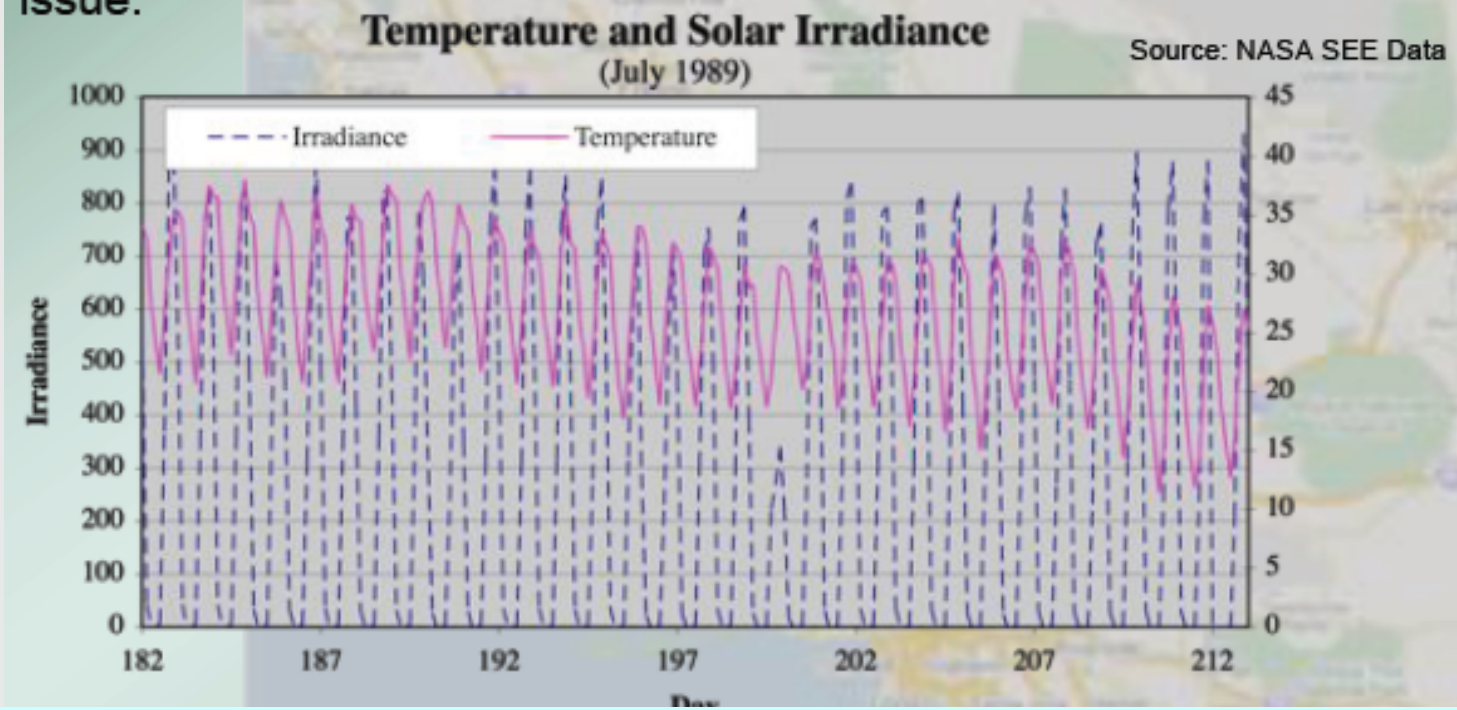
Our goal—raise the quality of buildings, industry, and transportation to at least the level of the present U.S. region.

Developing a PV Supply Schedule Requires Increasing Geographic Specificity

Core Modeling

On a cost of energy basis, PV systems will become increasingly competitive. PV systems have significant advantages over CSP in terms of modularity and performance in partially cloudy regions.

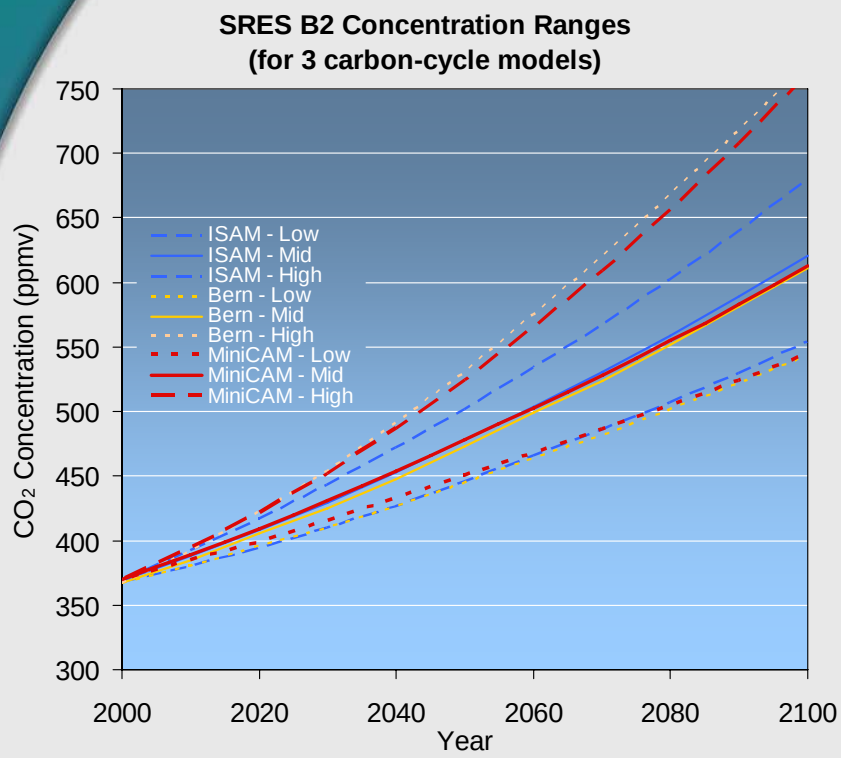
Reliability at high PV penetration levels is, however, a significant issue:



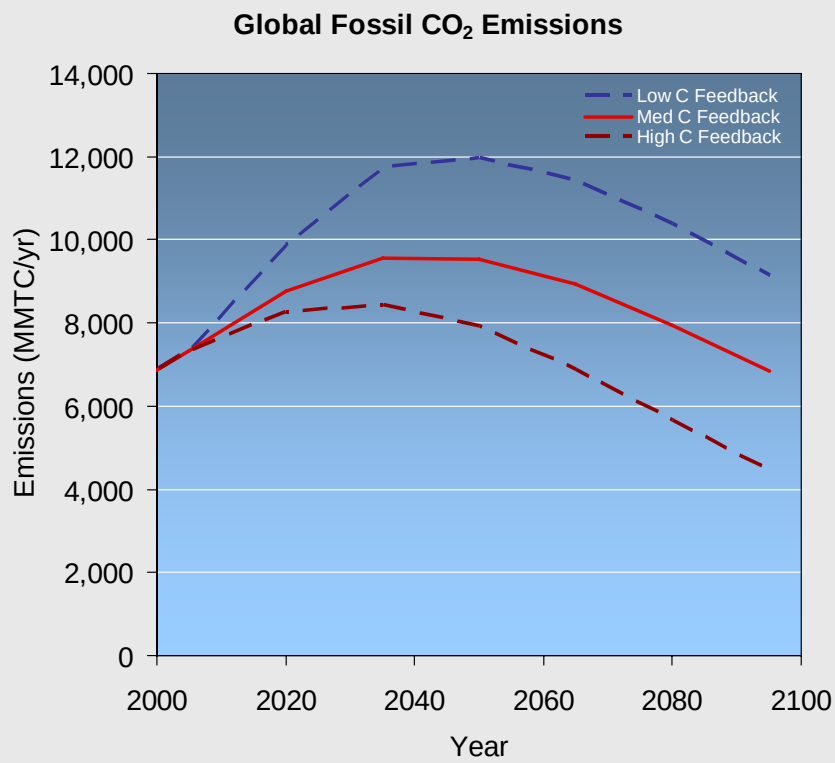
Even very sunny regions will have cloudy periods. Temperatures, and cooling demands, will not necessarily drop by the same amount.

Better Representation of Science and scientific uncertainty, e.g. Carbon Cycle

Core Modeling



Comparison of carbon cycle model results for the high, medium and low cases used for the MiniCAM results presented here (red lines) with results presented in the IPCC WG1 TAR for the Bern and ISAM carbon cycle models.



Emissions pathways for three alternative realizations of carbon cycle uncertainties.

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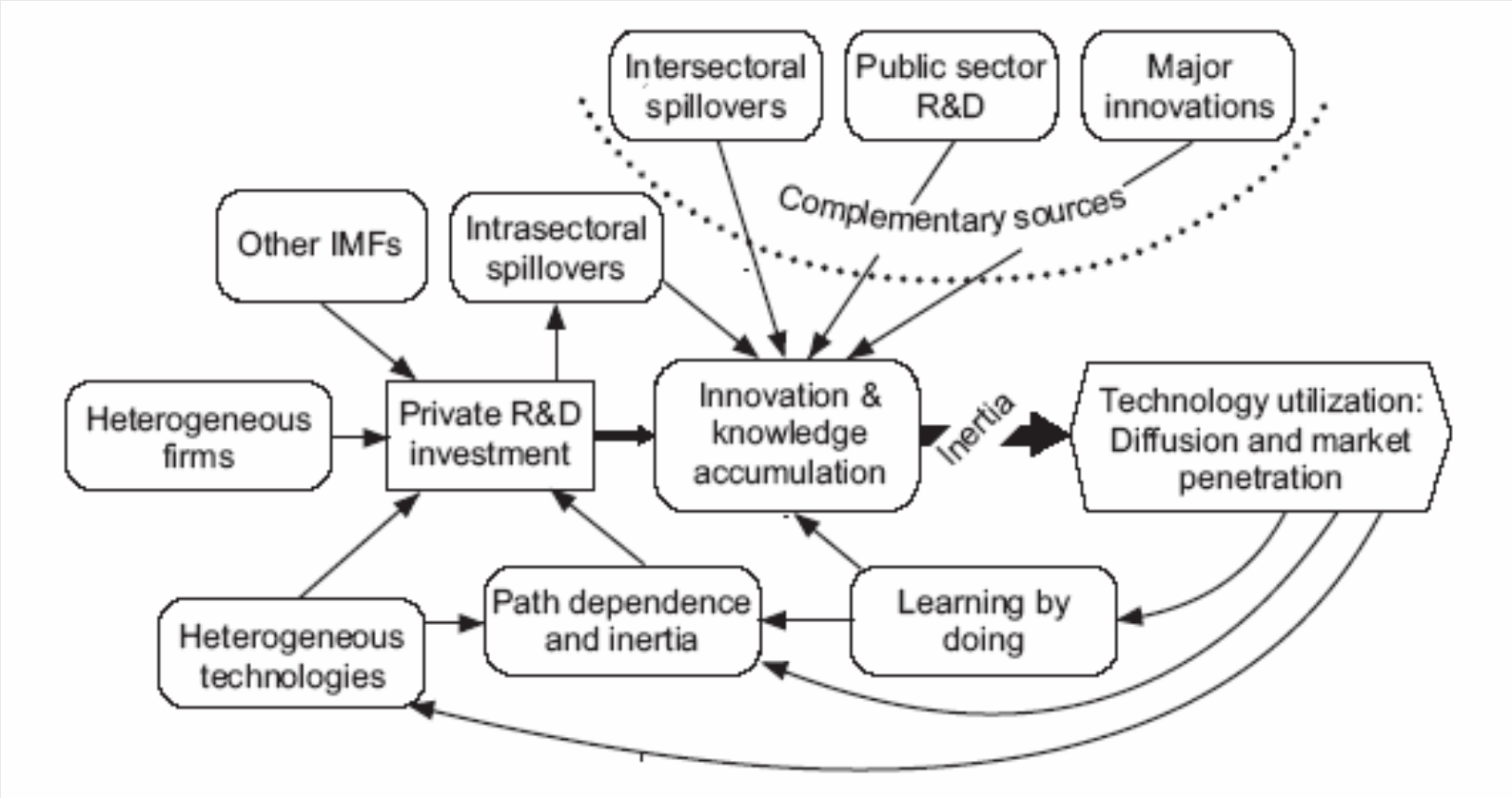
Model Development

Core Modeling

- Endogenous R&D and Technological Change?



Technology Analysis

- Goal: Understand the implications of specific technologies and technology systems for addressing climate change.
  - What is the technology?
  - What is the current state of development? What is on the shelf today?
  - How could the technology evolve or be improved? What could be on the shelf in the future and when?
  - What would have to happen to bring about these improvements? What are the R&D challenges?
  - What factors will affect deployment of the technology at large scale?
  - What role could this technology play in the short-, medium-, and long-term in addressing climate change?
  - What is the potential value of this technology in addressing climate change?

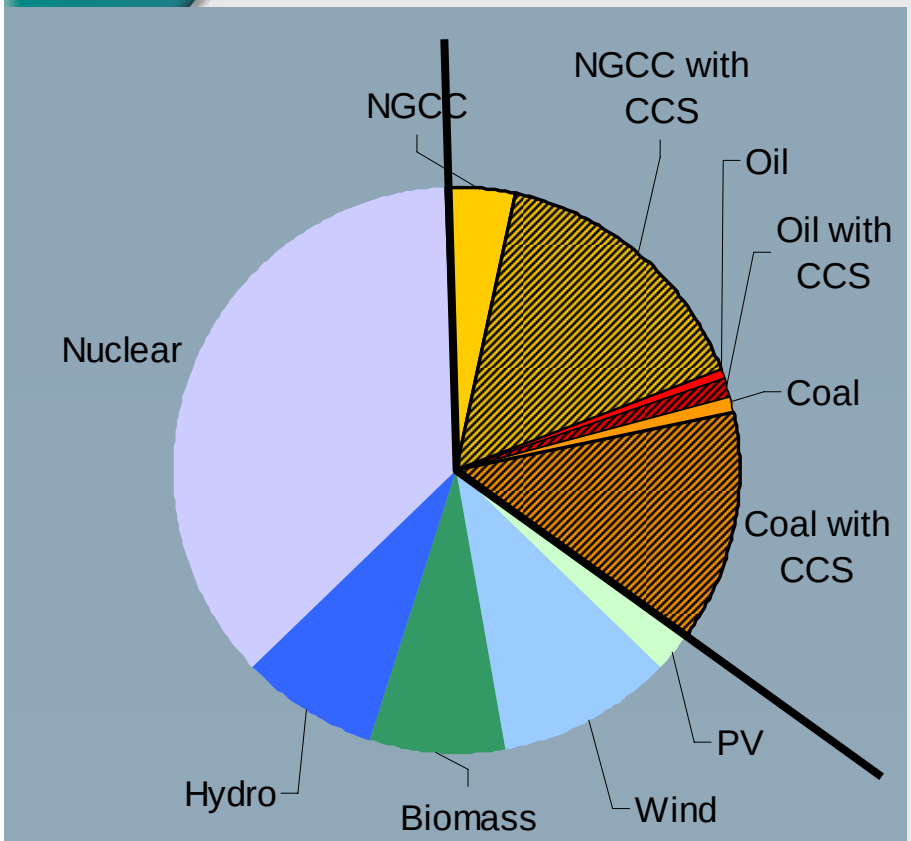
Candidate Technology Areas

- CO_2 Capture and Storage
- Biotechnology
- Nuclear Energy
- Wind and Solar
- Storage Systems
- Buildings
- Industry
- Transportation
- Hydrogen

Regional Analysis

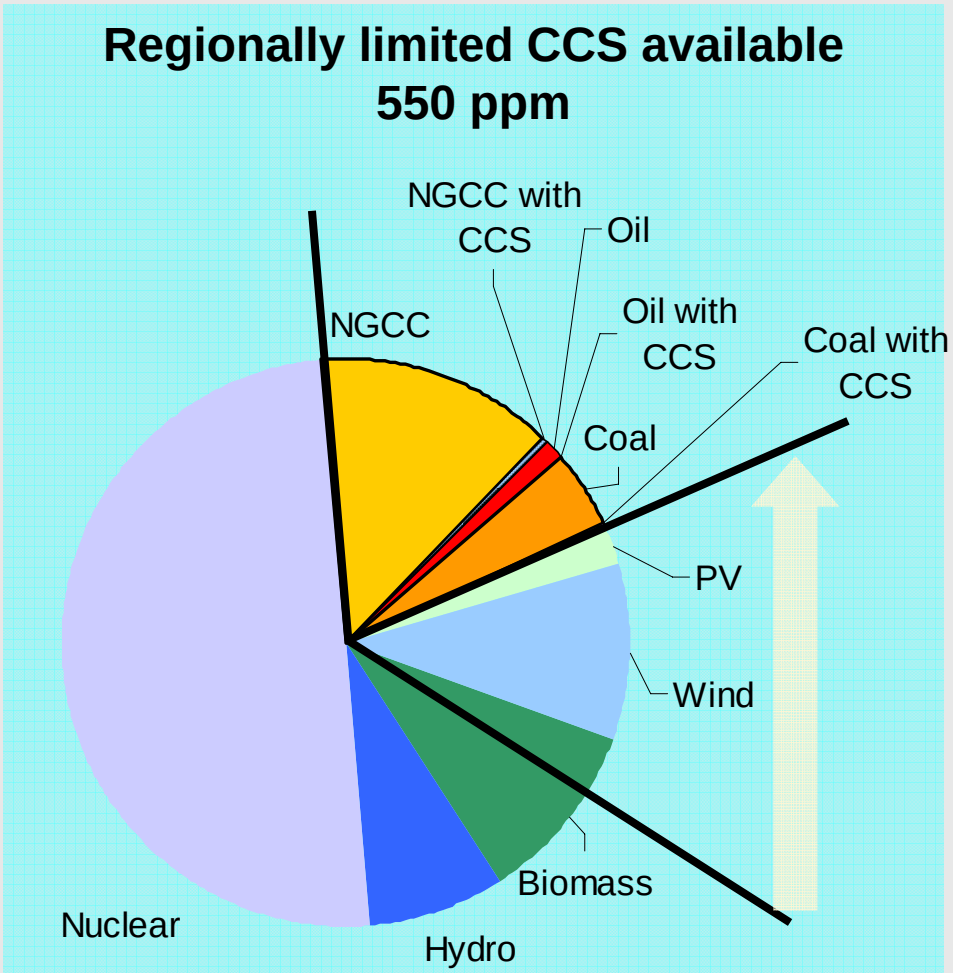
- Goal: Understand the implications of regional heterogeneity for technologies and technology systems in addressing climate change.
  - What is the Region and what are its characteristics?
    - What are the demographics, institutions, economics, and regional resource base
    - How might they evolve over near-, mid-, and long-term?
    - How important is the region in shaping climate change? What difference does it make when the region takes on an explicit limit on emissions?
  - What is the current state of technology deployment in the region? What is the average technology? What is the marginal technology?
  - What technologies and technology systems might be deployed in this region and at what scale in the short-, mid-, and long-term, and what factors might affect this deployment?

Composition of Power Generation in Japan, 2095



Regionally unlimited CCS assumed available, 550 ppm

Regionally limited CCS available 550 ppm



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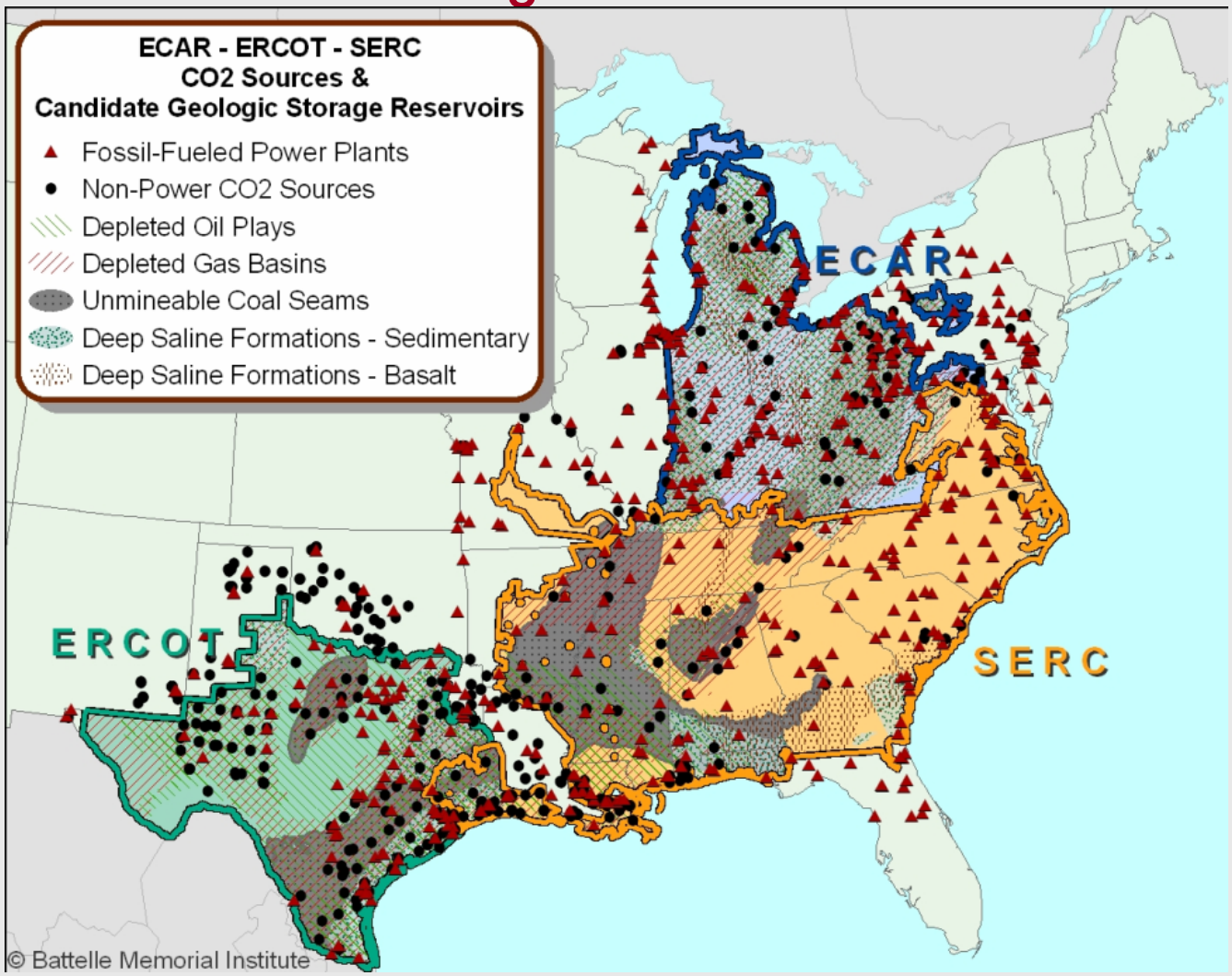
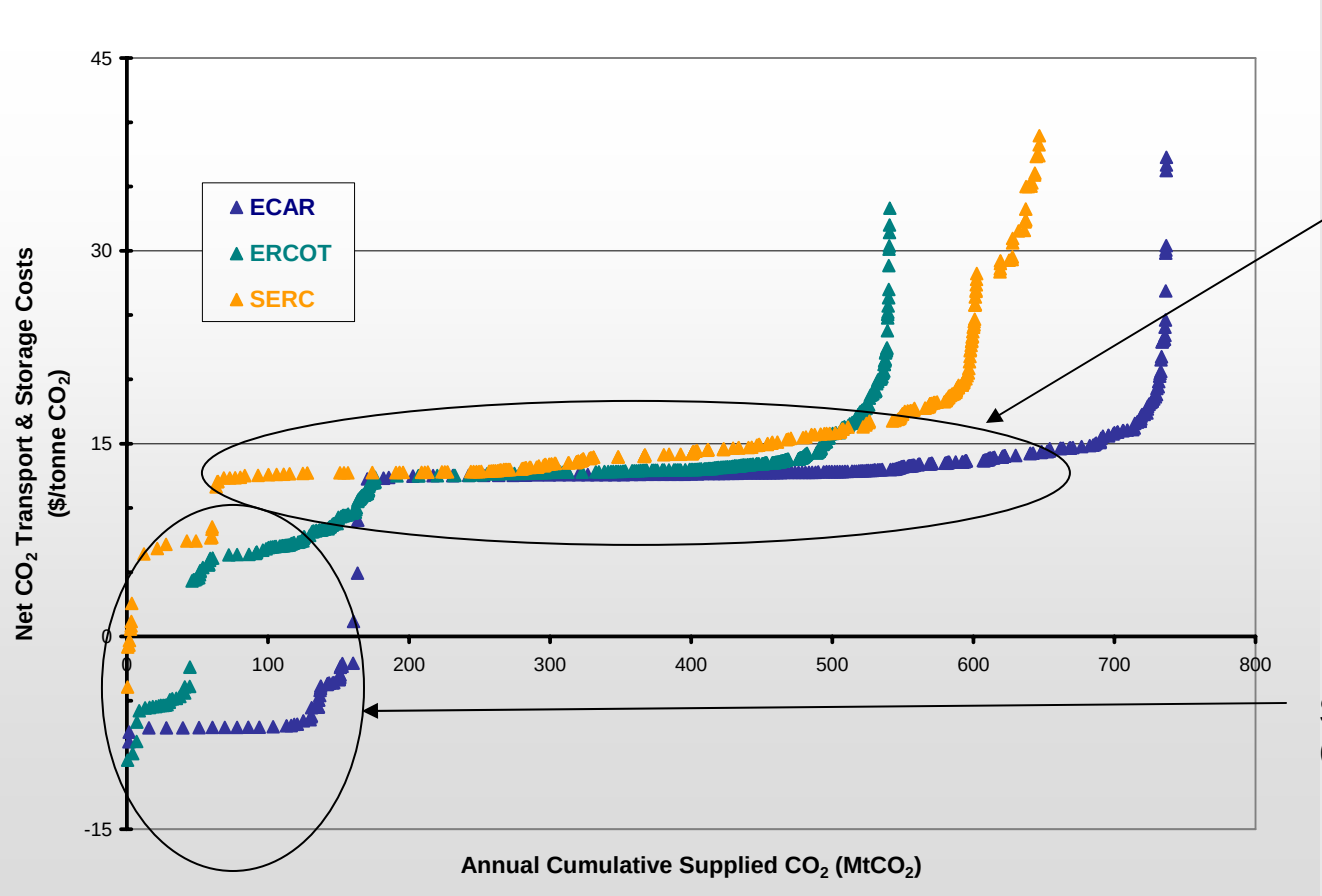
CO_2 Sources and Potential Storage Reservoirs in the Three Regions

Regional Analysis



CCS Transport and Storage Annual Cost Curves from CO_2-GIS Model

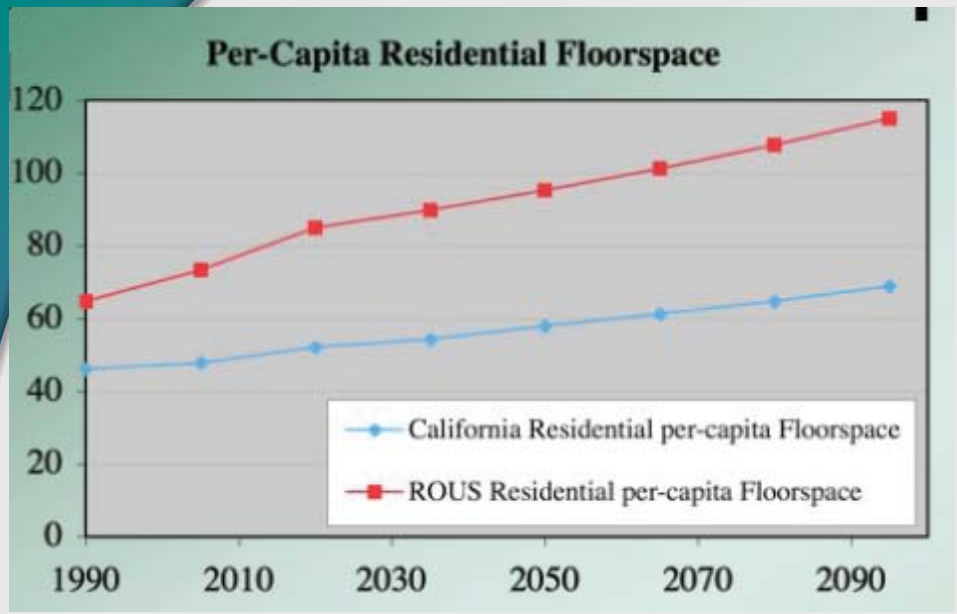


Deep saline formations and depleted gas fields supply majority of storage capacity in these regions.

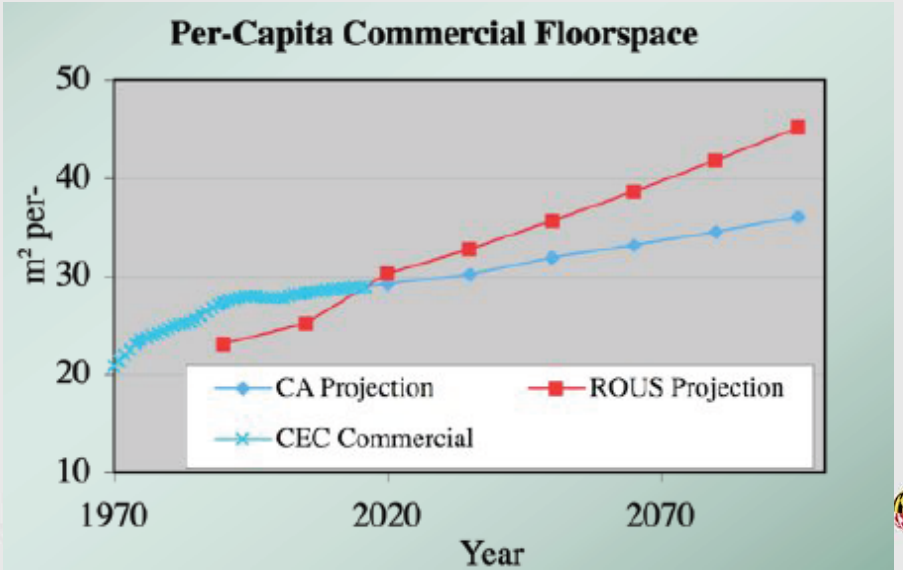
EOR and ECBM based storage opportunities

California Buildings Floor Space

Regional Analysis



California has much smaller residential floor space per capita than the United States average, apparently, with a slower growth rate.



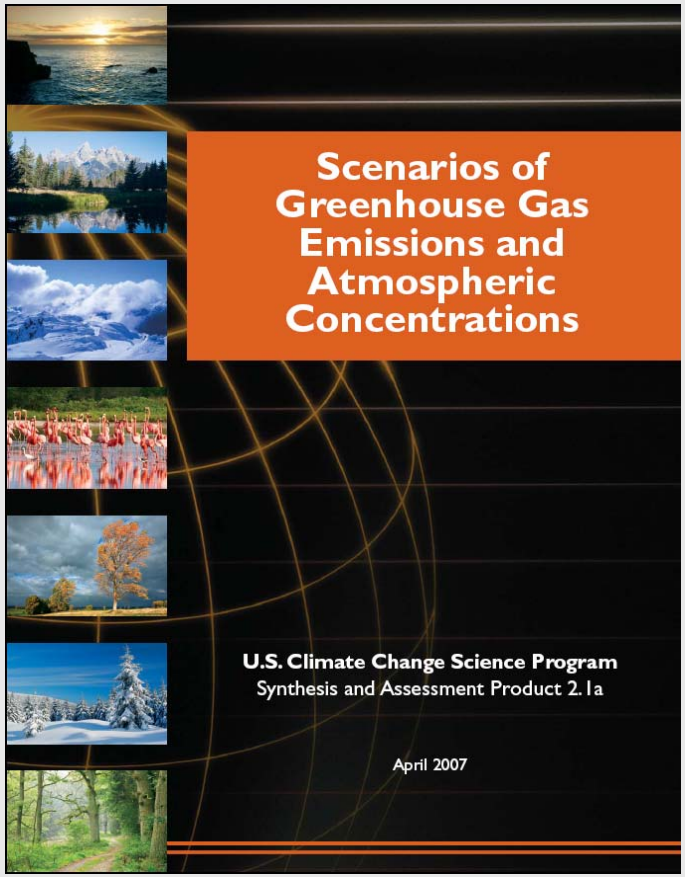
While commercial building comparisons are particularly prone to uncertainty due to definitional issues, it appears that California is comparable to the rest of the United States in per-capital commercial floor space, although the growth rate may be much lower.

Scenarios

- Goal: Develop scenarios of long-term global developments
  - What emissions trajectories are consistent with stabilization at alternative levels?
  - Bring in more regional detail.
  - Explore multiple paths of economic, social and governance development.
  - What difference does it make if a policy regime is inefficient, and to what regions and technologies does it make a difference, and what are these differences?
  - How might market inefficiencies affect technology choice.
  - How might differences in timing and development of technologies affect the evolution of technology systems, i.e. path dependence.
  - What is the role of electrification?

The SAP 2.1a

- It is finally out!
- An AR5?
  - The nature of scenarios to drive the new Earth System Models will be different.



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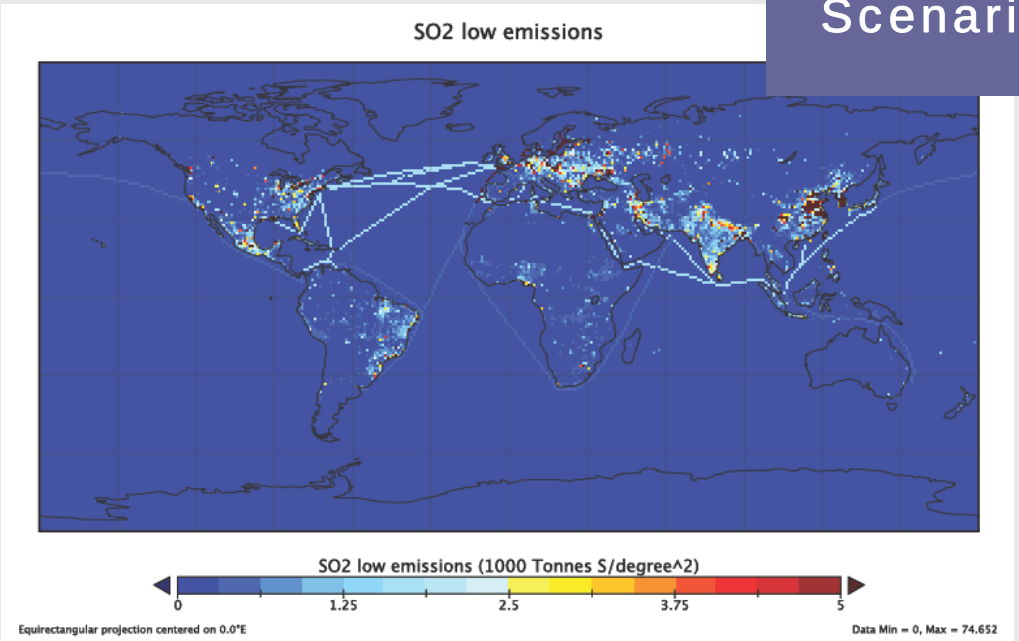
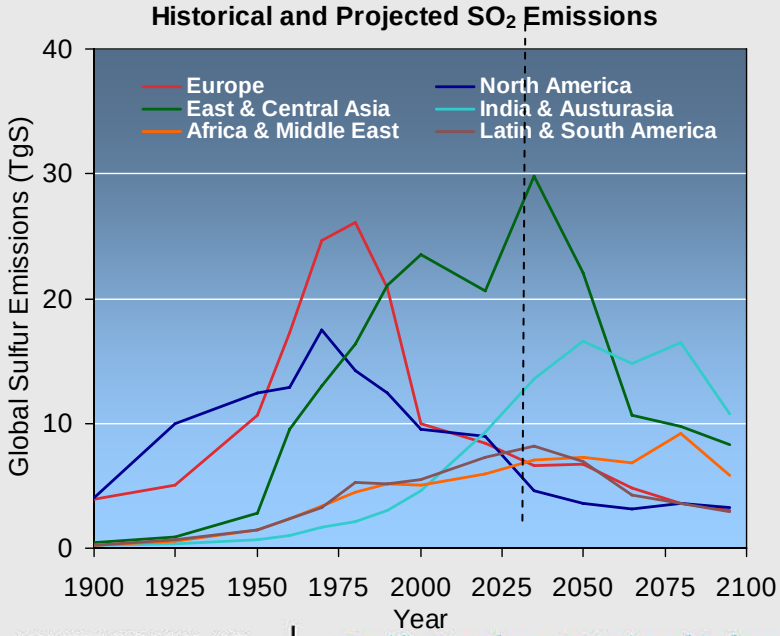
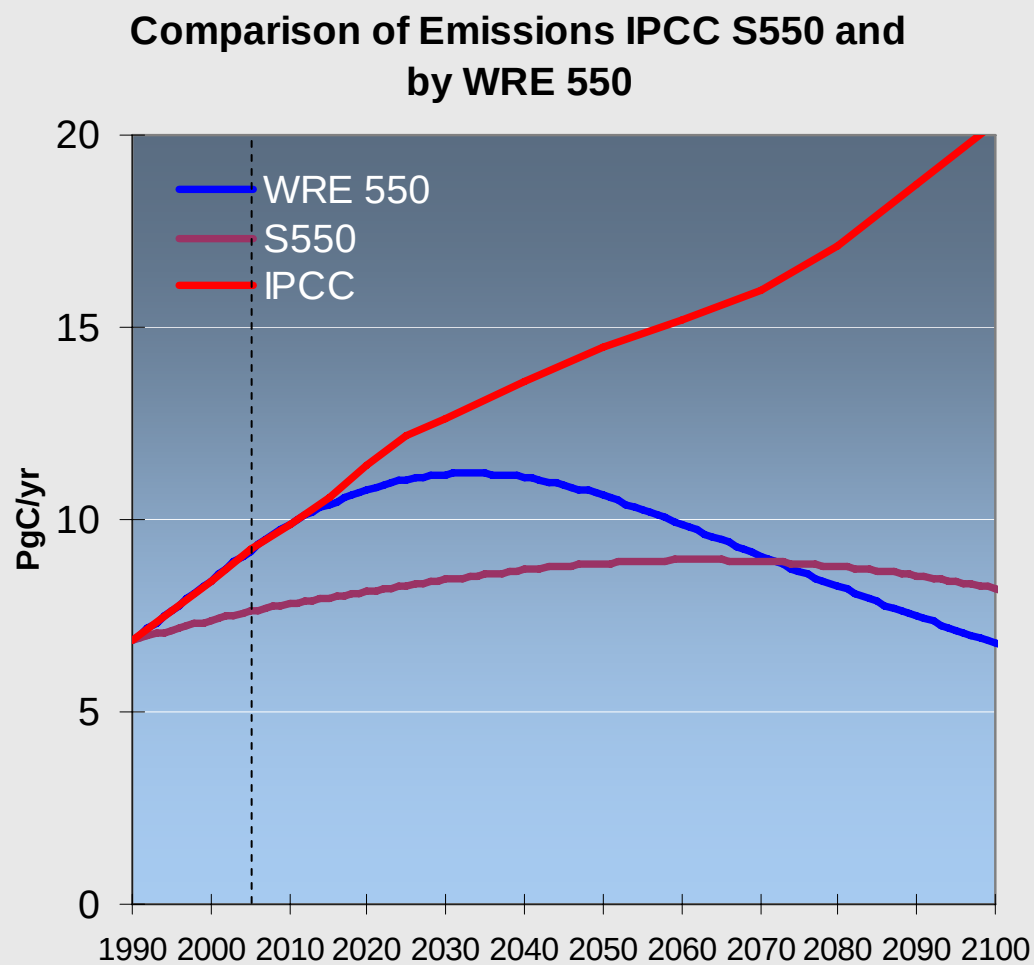
Scenarios for ESMs will be more sophisticated

We have provided geographically gridded emissions trajectories of reactive gases (CH_4, CO, NO_x, VOC's) and aerosol precursors (SO_2) to the ESM community and can provide updated scenarios including BC and OC. In the future we will need to provide land use and land cover.



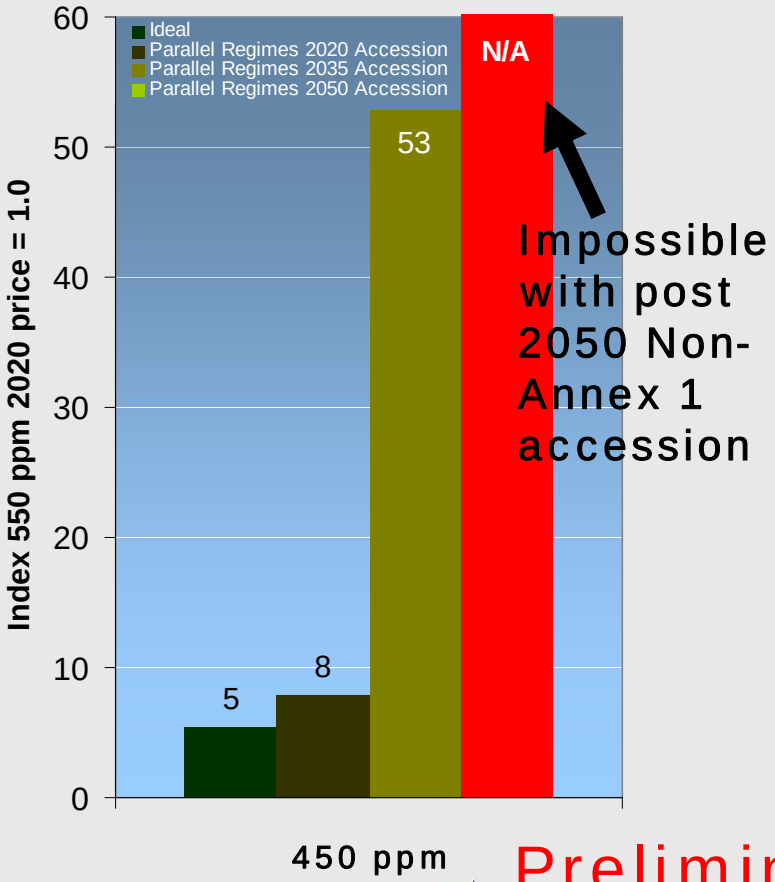


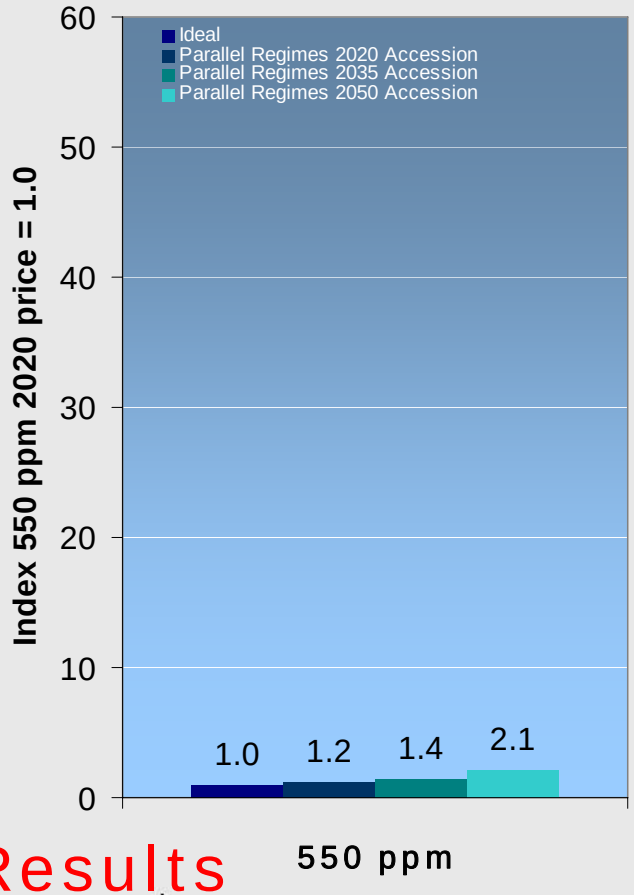
We have long known that costs depend on the context of stabilization.



Year 2020 USA carbon prices for different international regimes: 450 and 550 ppm

Near-term carbon prices depend on both the concentration at which CO_2 is stabilized and the degree and timing of accession.



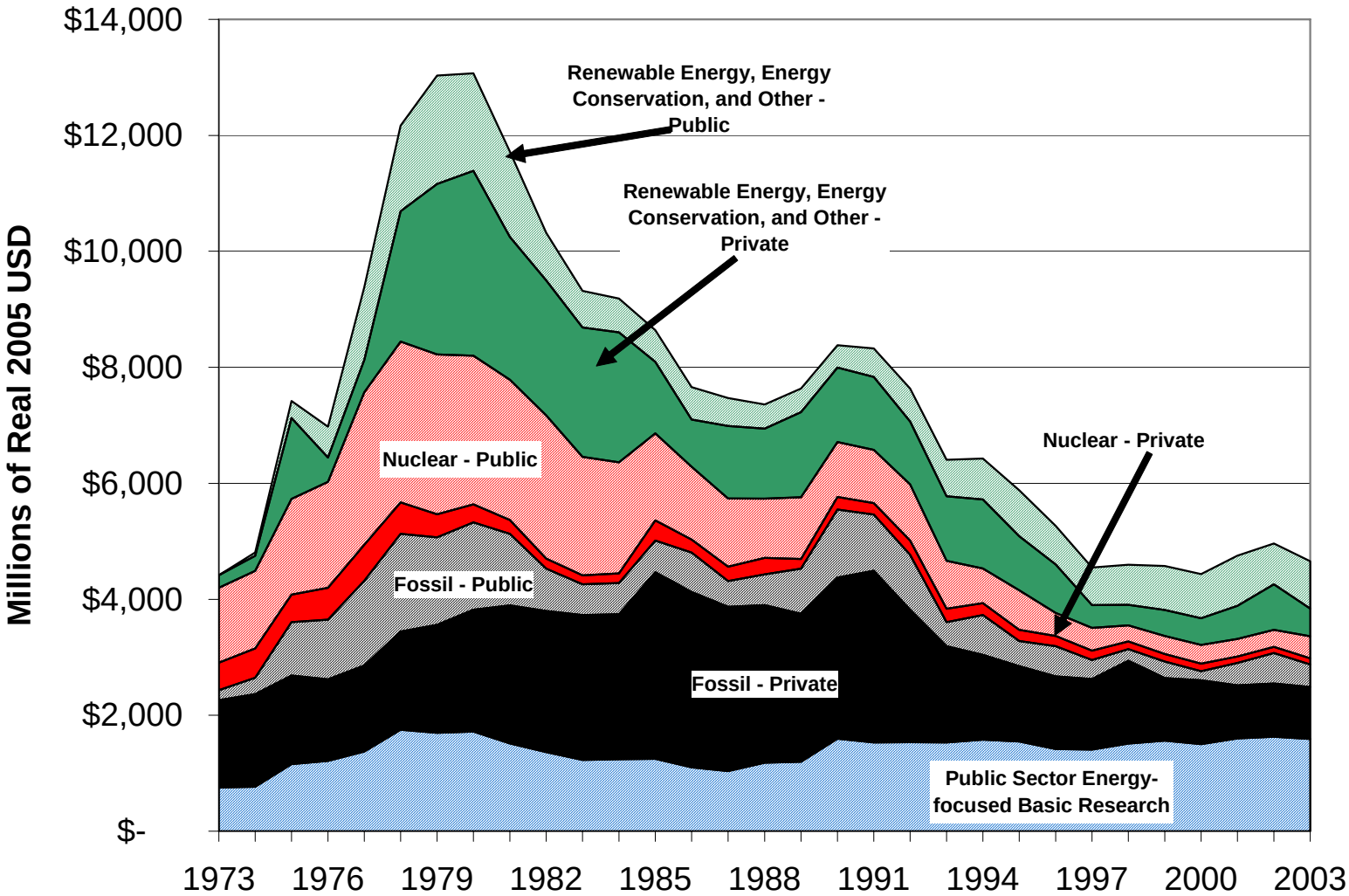


Preliminary Results

Technology & Institutions

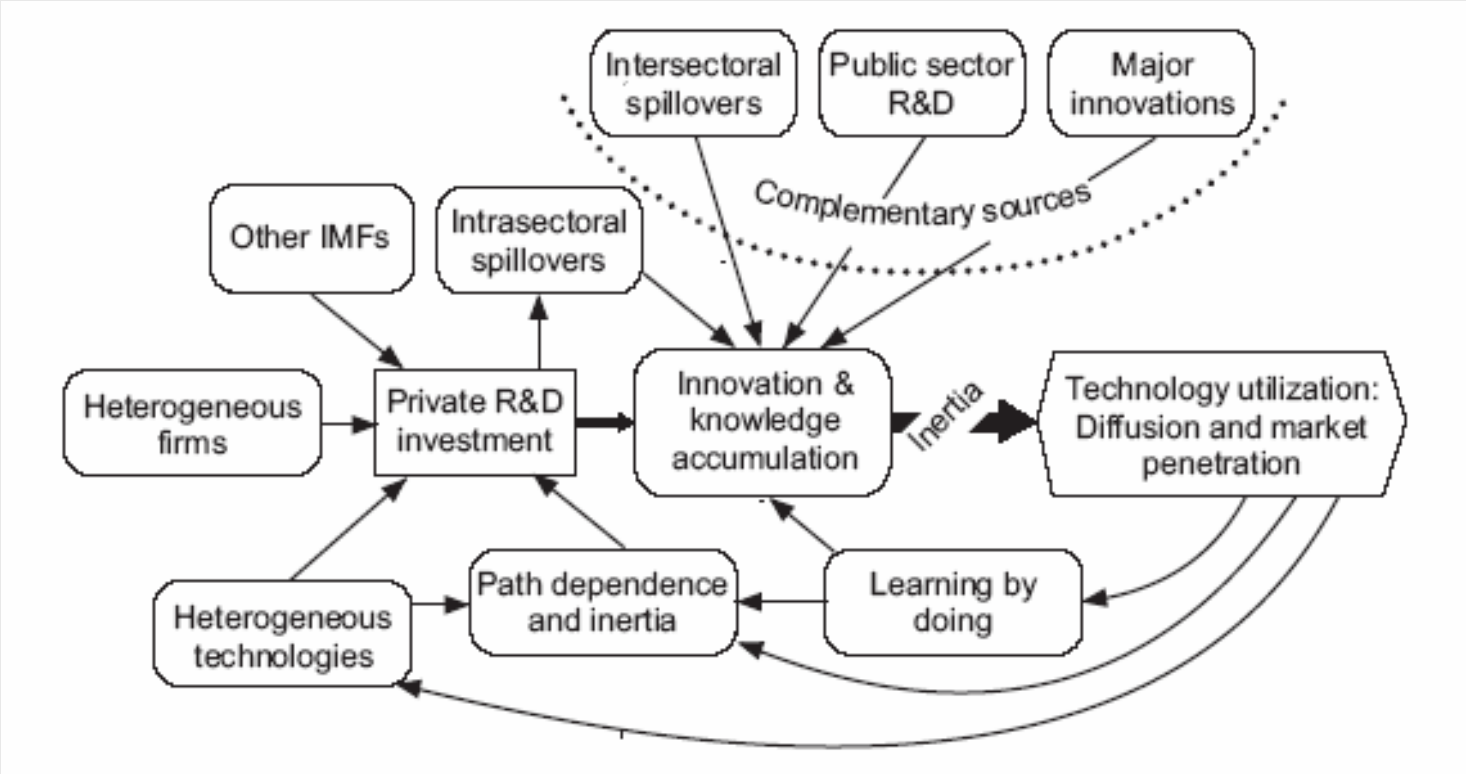
- Goal: Understand the implications of institutions and implementation for technologies and technology systems in addressing climate change.
  - Social Capacity: How formal are markets? How much of economy is outside of formal markets?
  - Continued work to monitor Energy R&D trends
  - Can we say anything about the link between R&D investments and technology development?
  - What is the optimal amount of R&D?
  - What is the optimal mix of R&D to deliver improved energy technology in the mid- and long-term?
  - Does society need differential policies for different technologies, based on learning-by-doing or other special circumstances?

U.S. Public and Private Energy R&D Since 1974



Technology

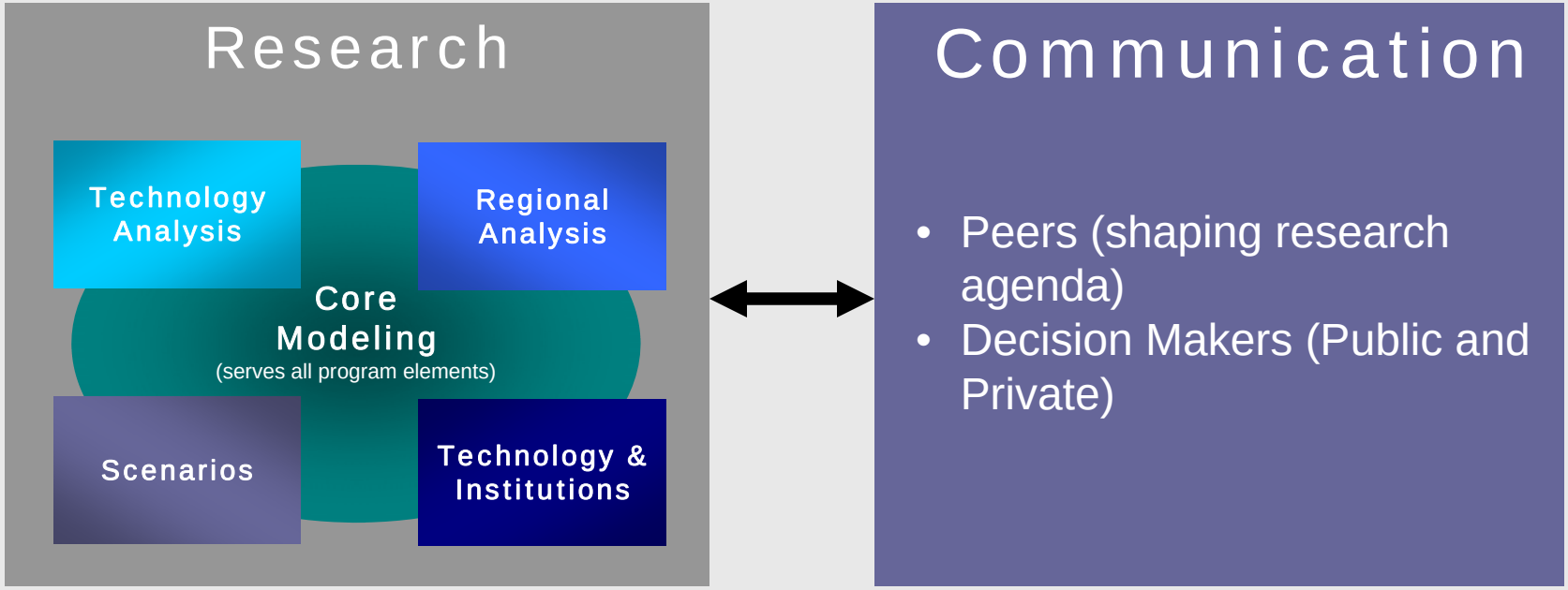
- Where does new technology come from?
- Is technological change predictable?
- How much more global R&D is needed in a climate-constrained world?
- Portfolio composition?



Institutions

- We assume that all institutions in all of our regions work efficiently.
- But some regions have more pervasive market systems than others.

Communication



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