Competitiveness of Soil Carbon as an Option: Is it a Bridge to the Future?

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GTSP
Global Energy Technology Strategy Program

Battelle

JGCRI
Joint Global Change Research Institute

University of Maryland

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

Overview

- Simulate a range of mitigation options in the United States
  - Terrestrial sequestration and biofuel offsets
  - Non-CO_2 greenhouse gases
  - CO_2 from energy system
  - CO_2 capture and storage from electric power
- No single model can simulate all activities and processes
- Develop strategy to determine relative contribution of mitigation options under hypothetical carbon policies
  - Multiple sources
  - Dynamics of capital stock turnover and saturation
  - Run a series of carbon price experiments

Mitigation Options

- Terrestrial Offsets
  - Soil sequestration, Afforestation, Biofuel Offsets
  - Agricultural Sector Model (McCarl, B.A. and Schneider, U.A. 2001. "Greenhouse Gas Mitigation in U.S. Agriculture and Forestry." *Science* **294**, 2481-2482.)
  - FASOM used for recent results on dynamics
- Non-CO_2 Greenhouse Gases
  - Methane, Nitrous Oxide, F-gases
  - Energy Modeling Forum (EMF-21) baselines and marginal abatement cost curves
- Energy System
  - CO_2 emissions from energy combustion; carbon capture and storage (CCS) from electricity generation
  - Battelle Second Generation Model

Carbon Price Experiments

Hotelling Rate	Carbon Price in First Time Step (2015) $50	$100	$150	$200	$300
0%					
1%					
2%					
3%					
4%					

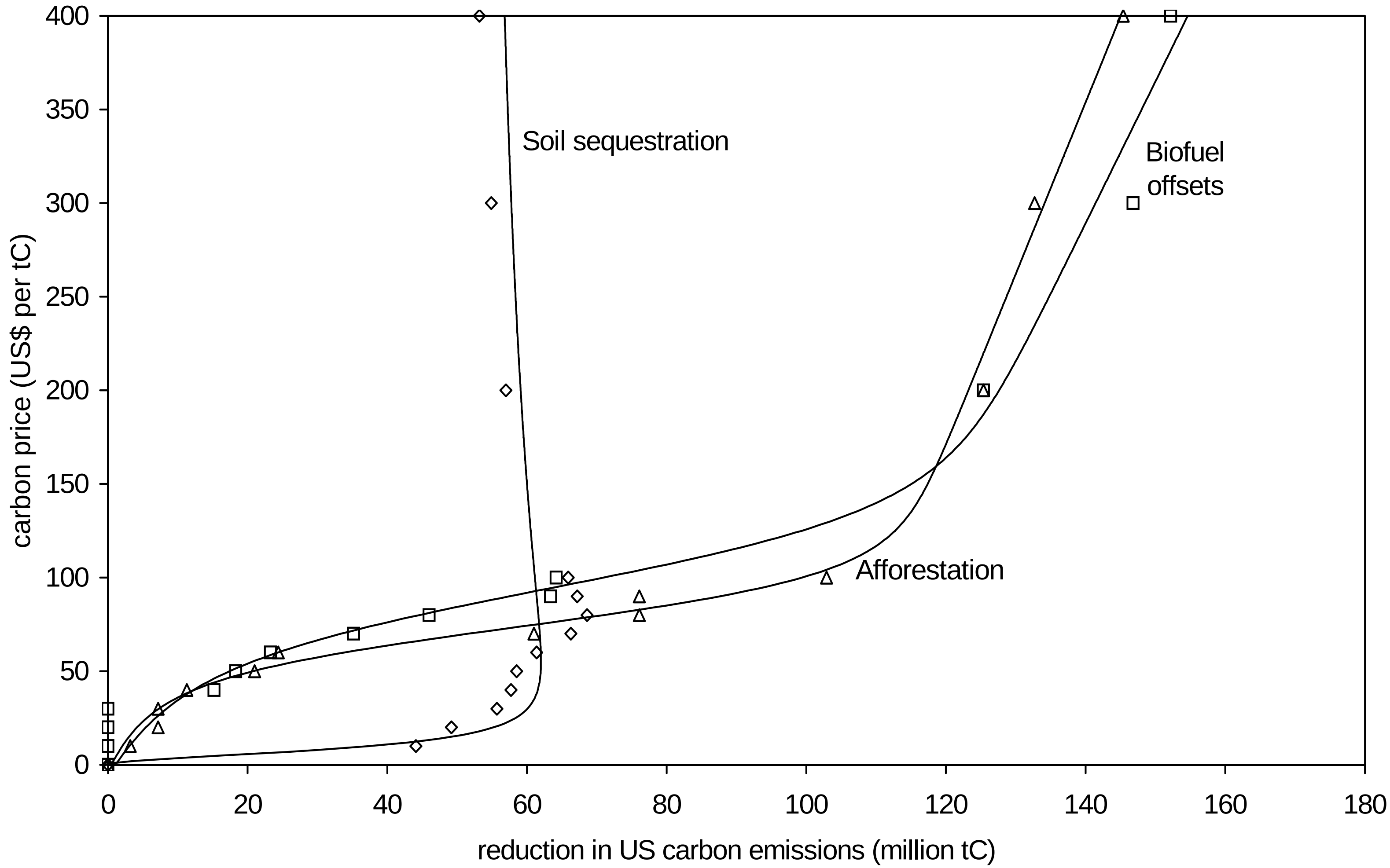
Mitigation Assessment in Agriculture

- Multi-period analysis of agriculture and forest response
- Examines overall and component response at varying carbon prices
- Simultaneous across all agricultural greenhouse gas mitigation strategies
- Simultaneous modeling of other agricultural environmental problems
- Based on life-cycle comparisons

GHG activities in FASOM

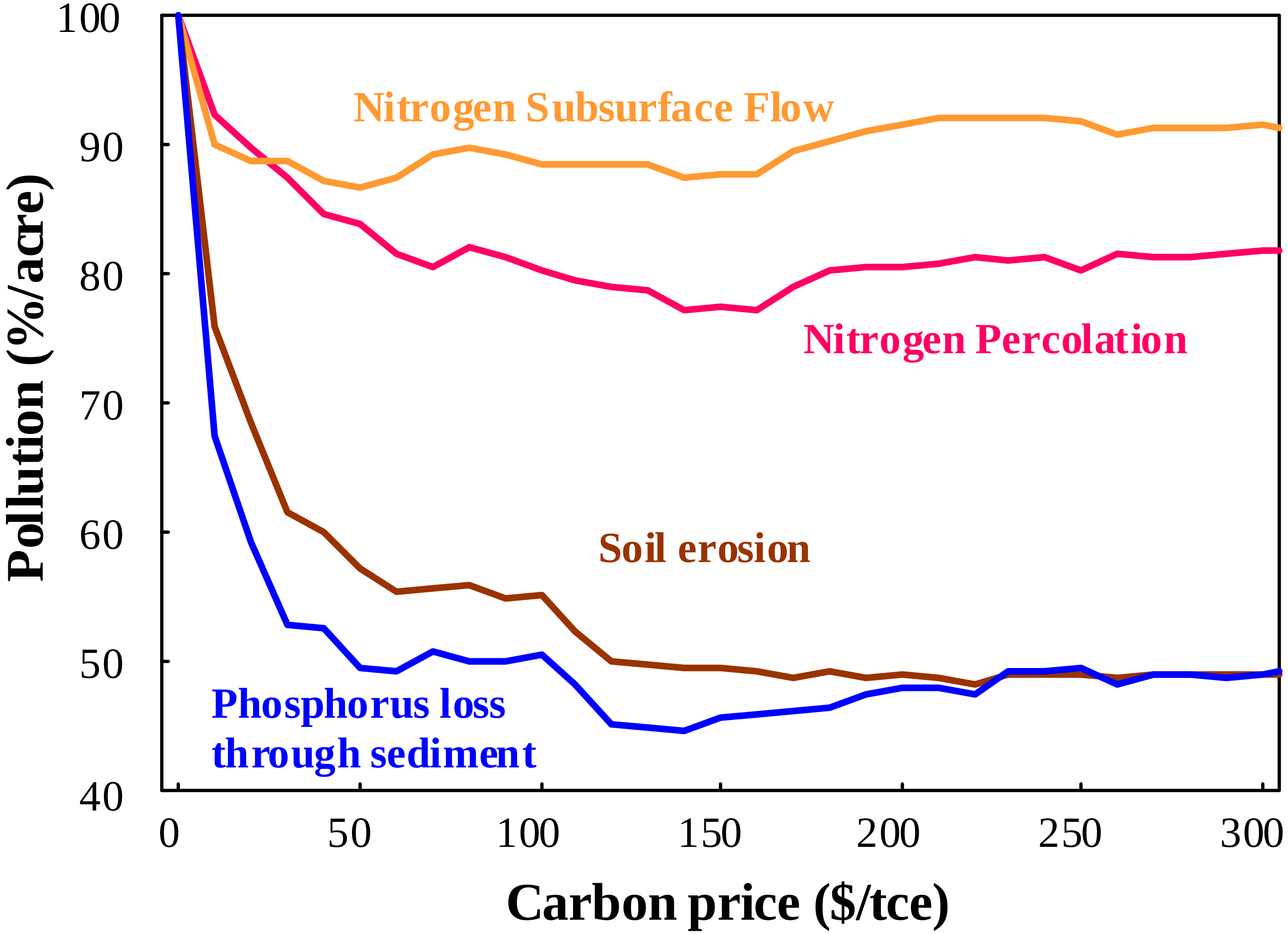
- Multiple GHG strategy setup
- Detailed GHG emission accounting
  - Forest carbon
  - Soil carbon
  - N_20
  - CH_4
  - Fuel use carbon emissions
- National GHG balance
- GWP weighted sum of all GHG accounts
- GHG policy implementation

Reduction in carbon emissions from three activities simulated in the Agricultural Sector Model



Source: McCarl and Schneider (2001)

Multi-environmental Impacts

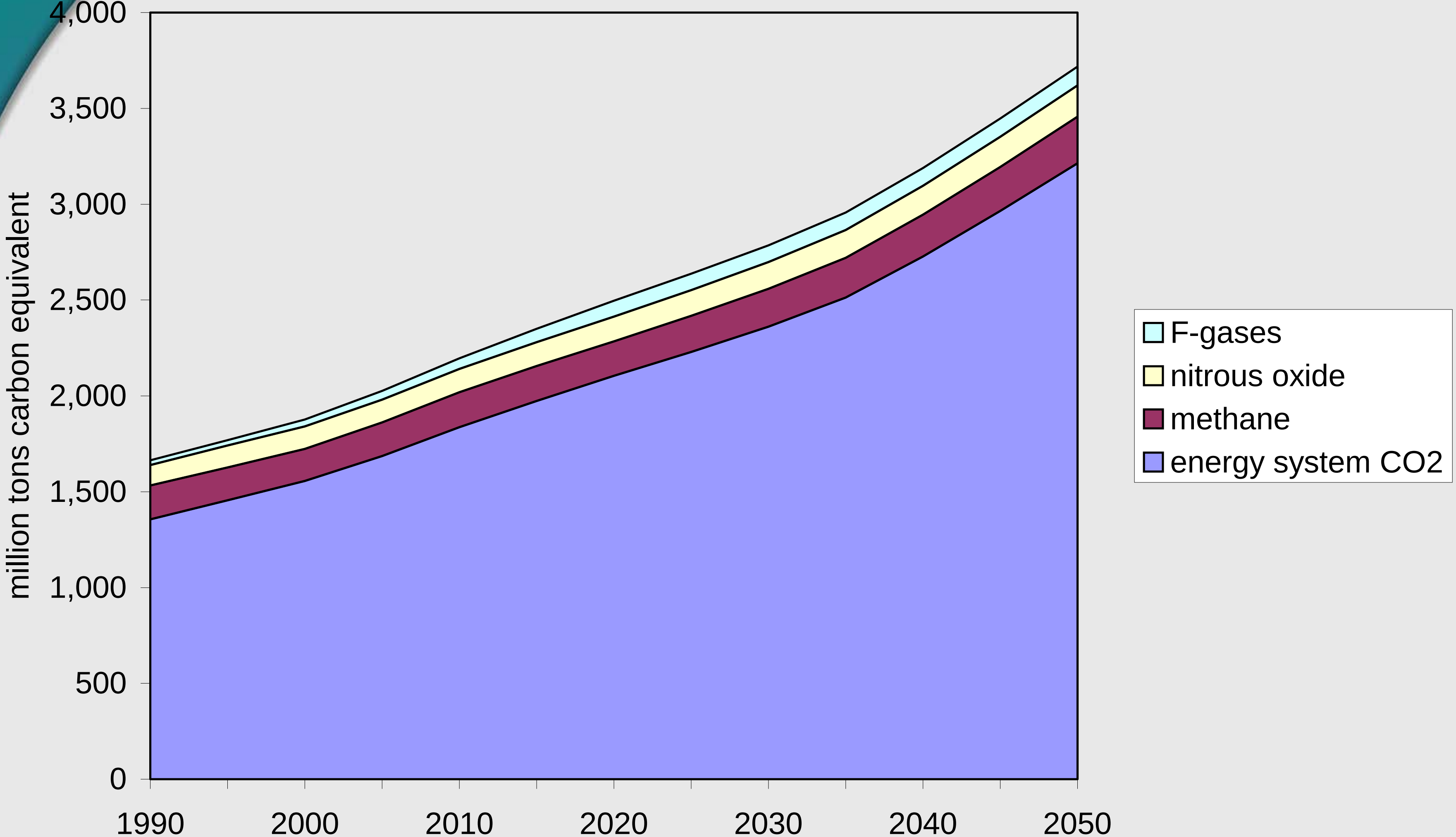


Source: Pattanayak, S.K., A.J. Sommer, B.C. Murray, T. Bondelid, B.A. McCarl, and D. Gillig, "Water Quality Co-Benefits of Greenhouse Gas Reduction Incentives in Agriculture and Forestry," Report to EPA, 2002.

Second Generation Model

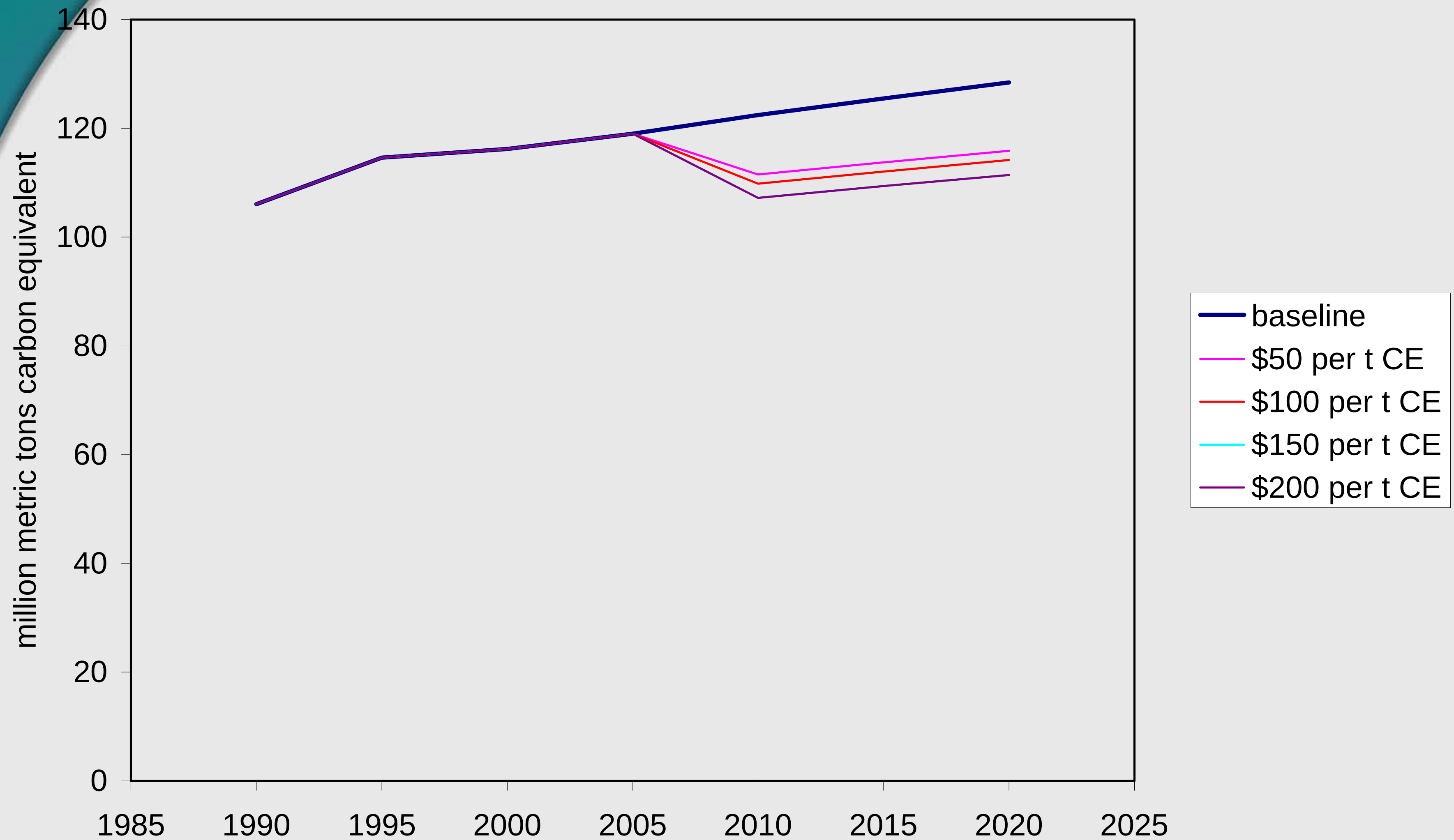
- SGM characteristics
  - Computable general equilibrium model of United States and other world regions
  - Five-year time steps from 1990 through 2050
  - Capital stocks are industry specific with a new vintage for each model time step
- Carbon capture and disposal from electric power
  - Engineering cost model for capture process from David and Herzog, 2000, “The Cost of Carbon Capture,” Proceedings of the Fifth International Conference on Greenhouse Gas Control Technologies
  - Constant cost of carbon disposal ($40 per tC)

U.S. Carbon Equivalent Emissions (baseline)



EMF-21 Baseline and Mitigation for USA: Methane

EMF-21 Baseline and Mitigation for USA: Nitrous Oxide



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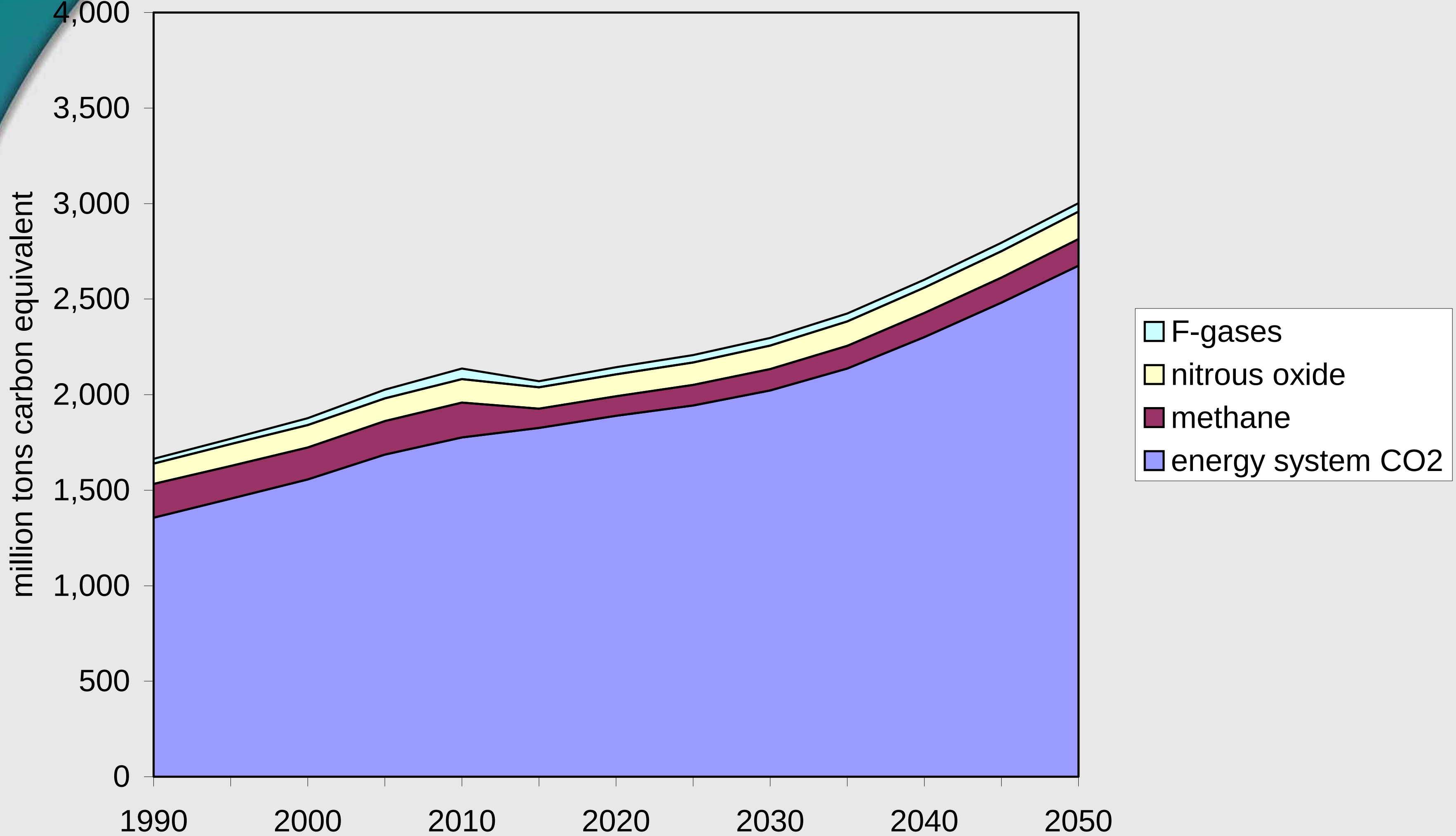
U.S. Carbon Equivalent Emissions ($100 constant)



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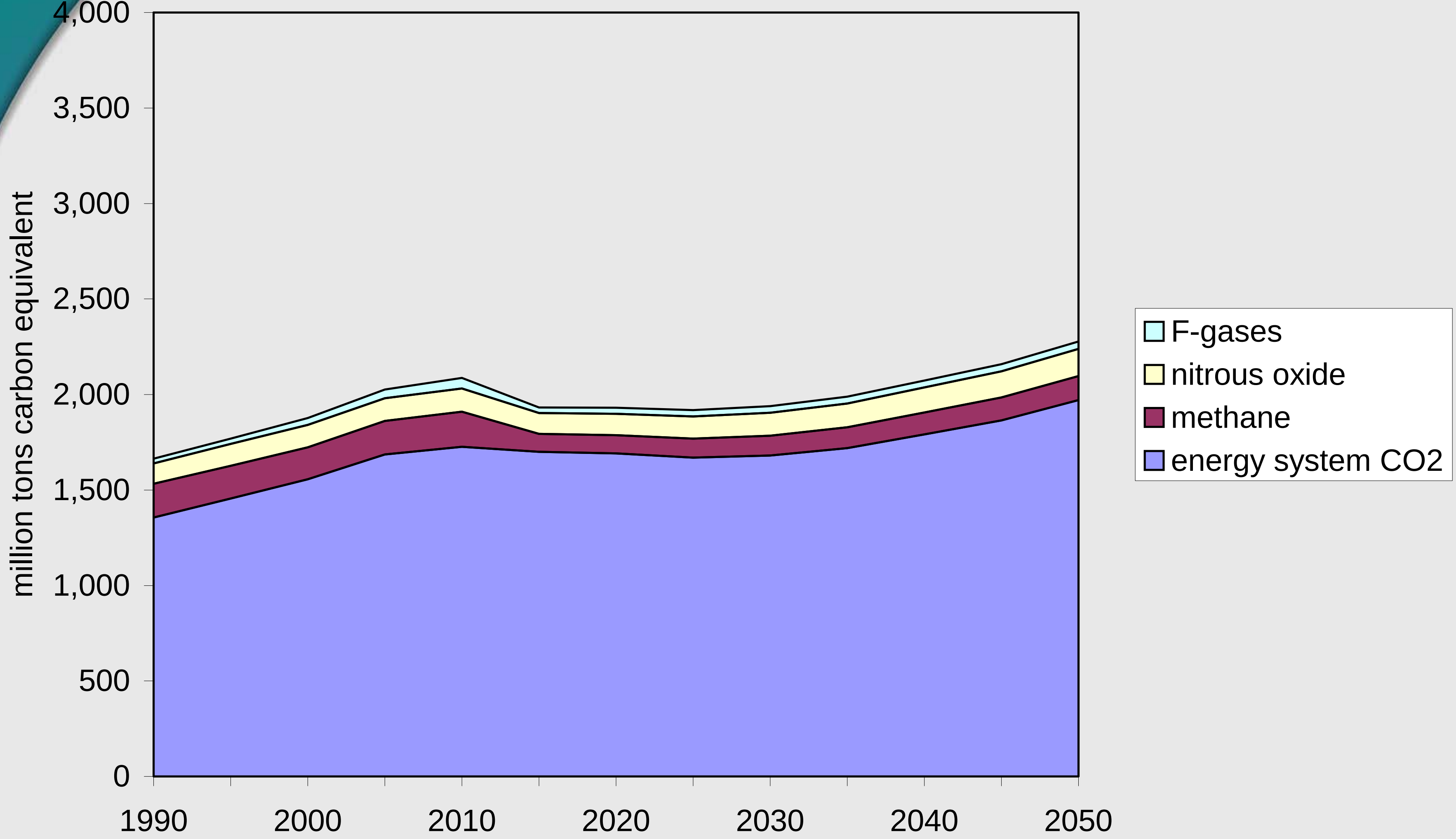
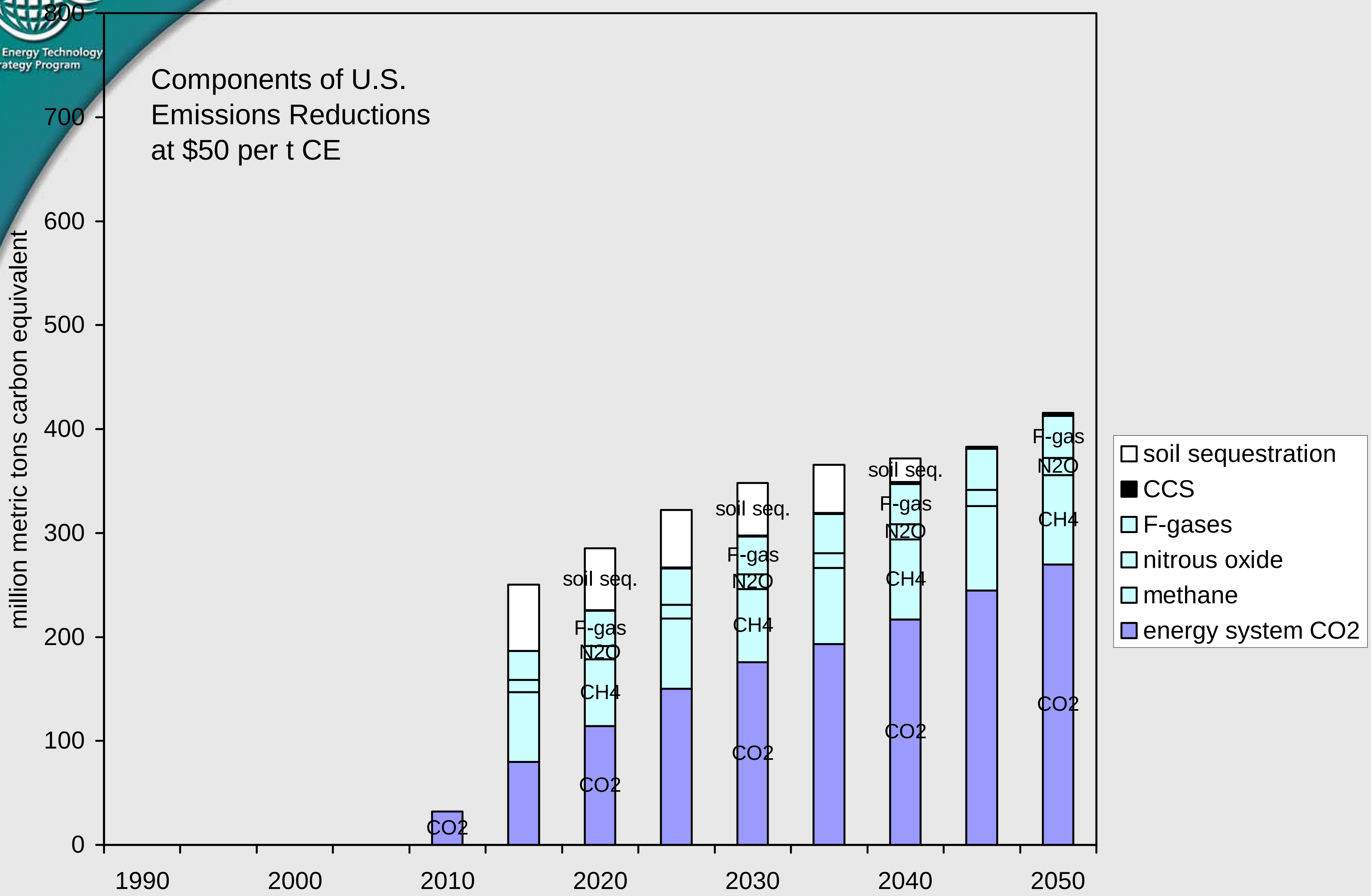
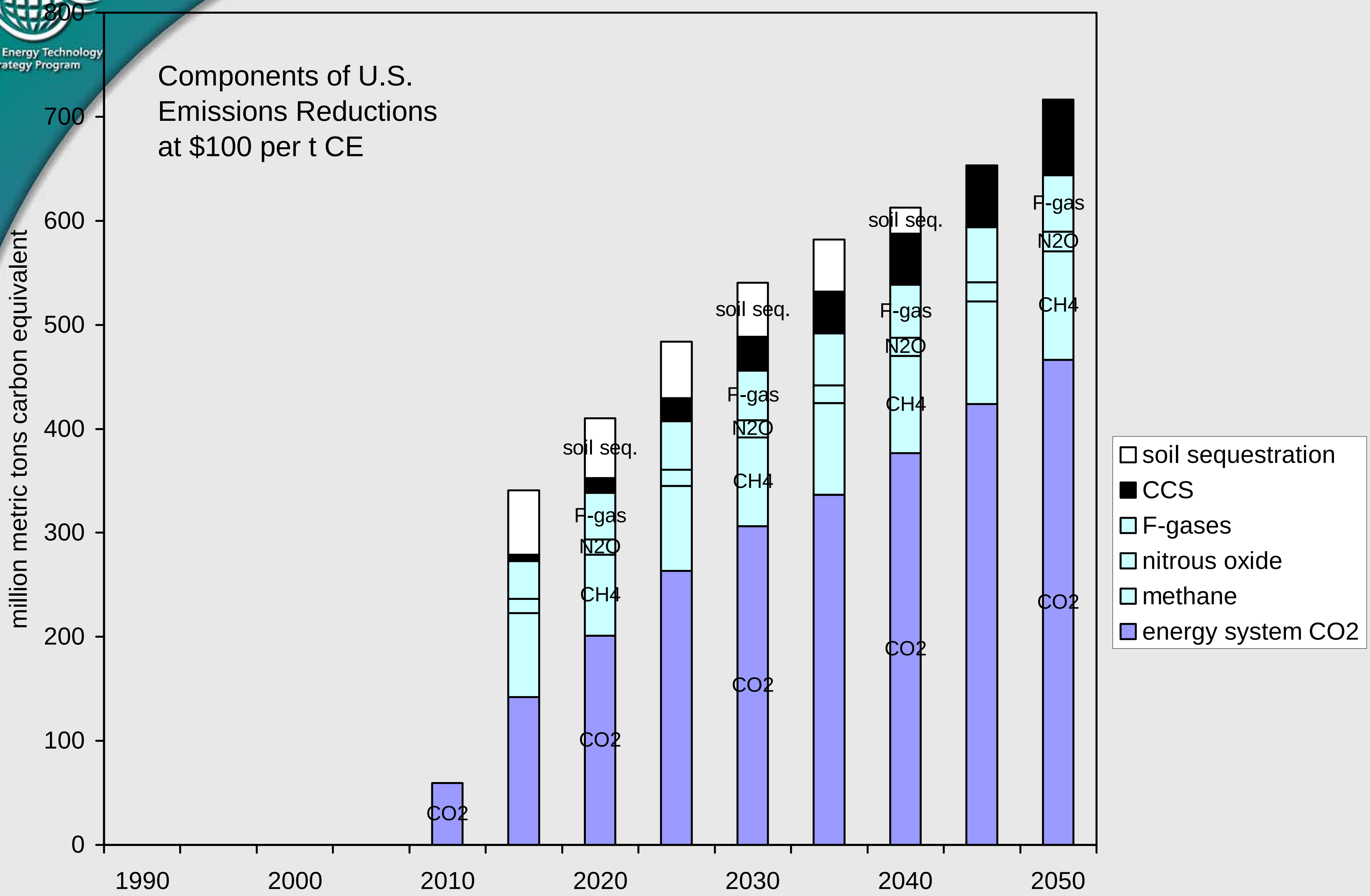
U.S. Carbon Equivalent Emissions ($200 constant)



Combining Results across Mitigation Options

- Soil carbon
  - Cost-effective in short term at low carbon prices
  - Saturates after 20 or 30 years
- CO_2 Capture and Storage
  - Cost-effective at higher carbon prices
  - Limited in short term by turnover of existing capital stock
  - Large future potential
- Non-CO_2 greenhouse gases
  - Cost-effective at low carbon prices in the short term
- Energy efficiency
  - Increases along with carbon price
  - Limited in short term by turnover of existing capital stock


Components of U.S.
Emissions Reductions
at $50 per t CE
million metric tons carbon equivalent
800
700
600
500
400
300
200
100
0
1990
2000
2010
2020
2030
2040
2050
CO2
CH4
N2O
F-gas
soil seq.
soil sequestration
CCS
F-gases
nitrous oxide
methane
energy system CO2



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Other Considerations

- Will terrestrial mitigation options operate at same carbon price margin as options from energy system? Real-world policy proposals place constraints on allowed offsets.
- Understanding what is in the baseline and what is not
- Dynamic considerations
  - Capital stock dynamics: How soon will you see emissions reductions?
  - Saturation
  - Permanence
  - Transactions costs
  - Interactions between mitigation options