General Equilibrium Assessment of Regional Climate Change Policy

Robert H. Beach

Martin T. Ross

RTI Environmental and Natural Resource Economics Program

Presented at the 2004 National IMPLAN User's Conference

Shepherdstown, WV; October 7, 2004

RTI INTERNATIONAL

P.O. Box 12194 · 3040 Cornwallis Road · Research Triangle Park, NC 27709
Phone: 919-485-5579 · Fax: 919-541-6683 ·rbeach@rti.org · www.rti.org

Introduction

- Analyses of options to mitigate global climate change generally concentrate on national policies
- Growing interest in climate policy at state and regional levels in U.S., especially Northeast
- Environmental benefits of state and regional policies, but
  - Limited scope
  - Possible lack of integration

Introduction (2)

- Analysis uses a dynamic CGE model (ADAGE) to examine impacts of regional climate action
  - Inefficiencies
  - Distributional effects
    - Regional
    - Households

Subnational Climate Policy

- Steps taken starting in late 1980s, but mostly symbolic
- Since January 2000, about 1/3 of states have instituted legislation or executive orders expressly intended to reduce GHG emissions
- Primarily focused on energy or transportation sectors, not comprehensive
- Other states have taken steps to limit their own involvement in climate change mitigation

Subnational Climate Policy (2)

- States typically point to benefits such as:
  - Environmental improvements (climate and non-climate related)
  - Economic benefits of renewable energy production
- However, there is a great deal of interest in forcing the federal government to act
  - Several lawsuits by groups of states

Northeast Climate Change Action Plan

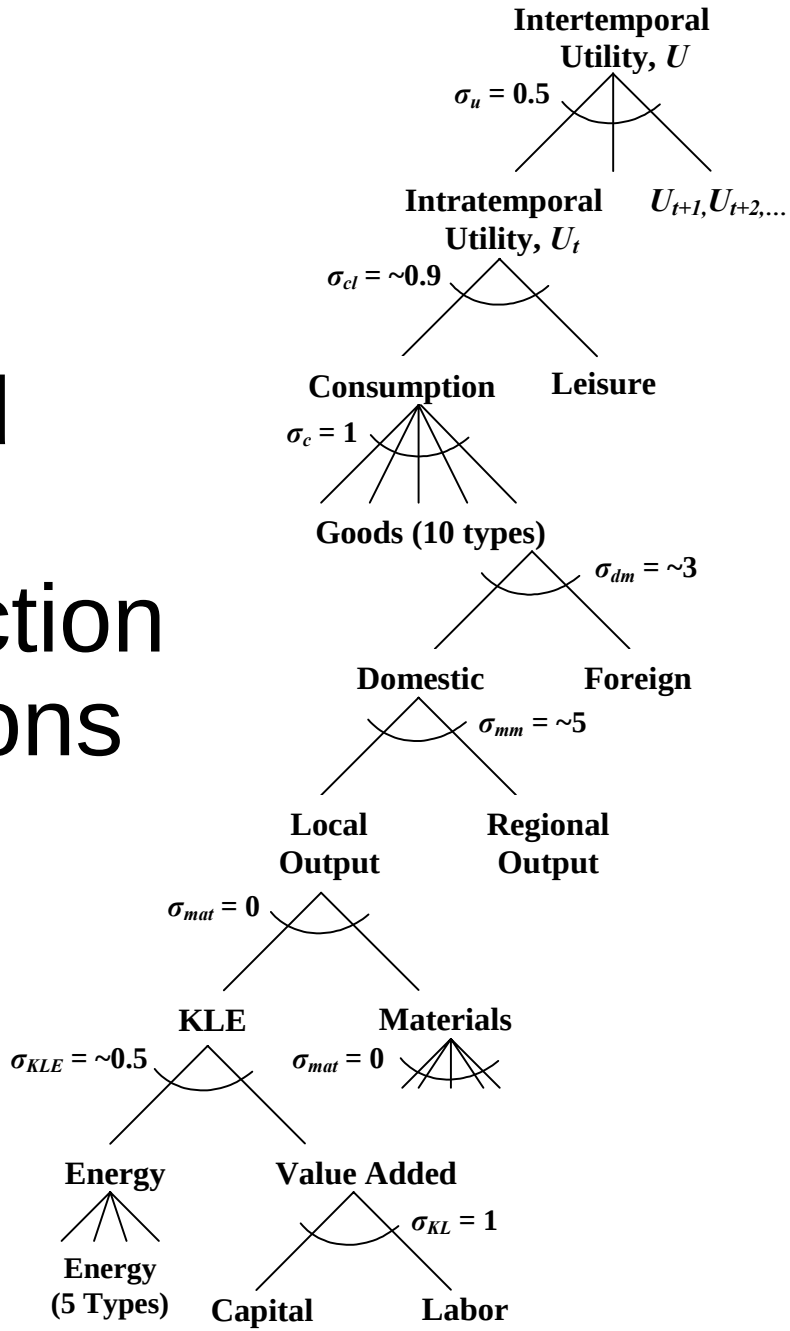
- Coalition of NE governors proposed a plan to reduce their states' GHG emissions to 1990 levels by 2010 and a further 10% by 2020
- Ten NE state governors developing a plan to have a regional market-based trading program for CO2 permits
- We examine regional policies for the NE based on these plans

ADAGE Model Structure

(Applied Dynamic Analysis of the Global Economy)

- Arrow-Debreu General Equilibrium
  - 4 representative households in each region (defined by income level) with foresight who maximize utility from consumption and leisure
  - Perfectly-competitive firms maximize profits subject to technology constraints
  - Supply = Demand; prices adjust so all markets clear simultaneously
- Equations
  - Production/Utility Functions – how inputs are currently used to produce output and available substitution possibilities
  - Nested CES Equations - allow input substitutions and energy-efficiency improvements

Nested CES Production Functions



ADAGE Model Structure (2)

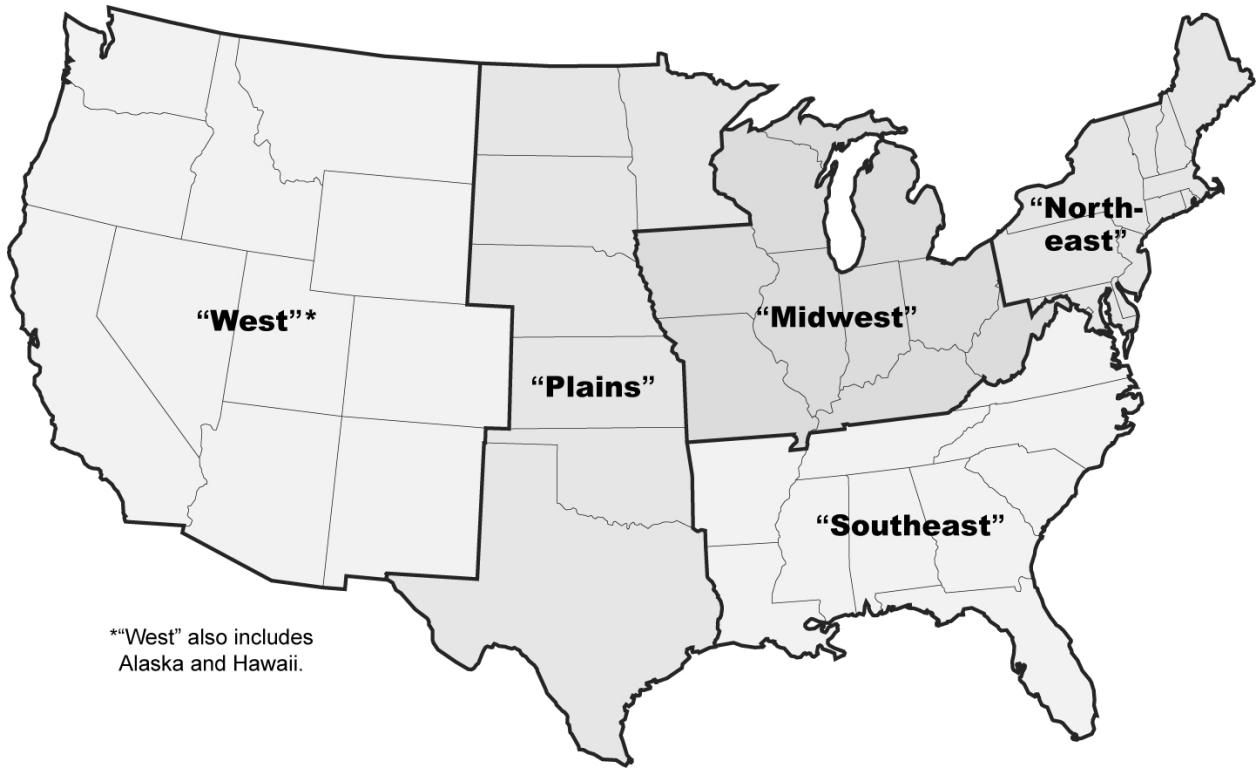
- Dynamic, Intertemporally-Optimizing CGE Model
  - Rational consumers with foresight who maximize utility
  - Typically run with 5 regions and 10 industries
  - Solves in 5-year intervals (2005-2050)
- Baseline Uses EIA's AEO & IEO Energy Forecasts
- Carbon Dioxide Emissions Tied to Fuel Use in Btus
- Non-CO_2 Emissions (CH_4, N_2O, HFC, PFC, SF_6)
  - MIT approach (endogenous modeling)
  - EPA forecasts by gas and sector
- Transition Path to New Equilibrium After Policy Shock
  - Controlled by capital adjustment costs (Goulder, McKibbin/Wilcoxen)
  - Quadratic costs control how fast economy responds to a policy elasticities

Key U.S. Model Data

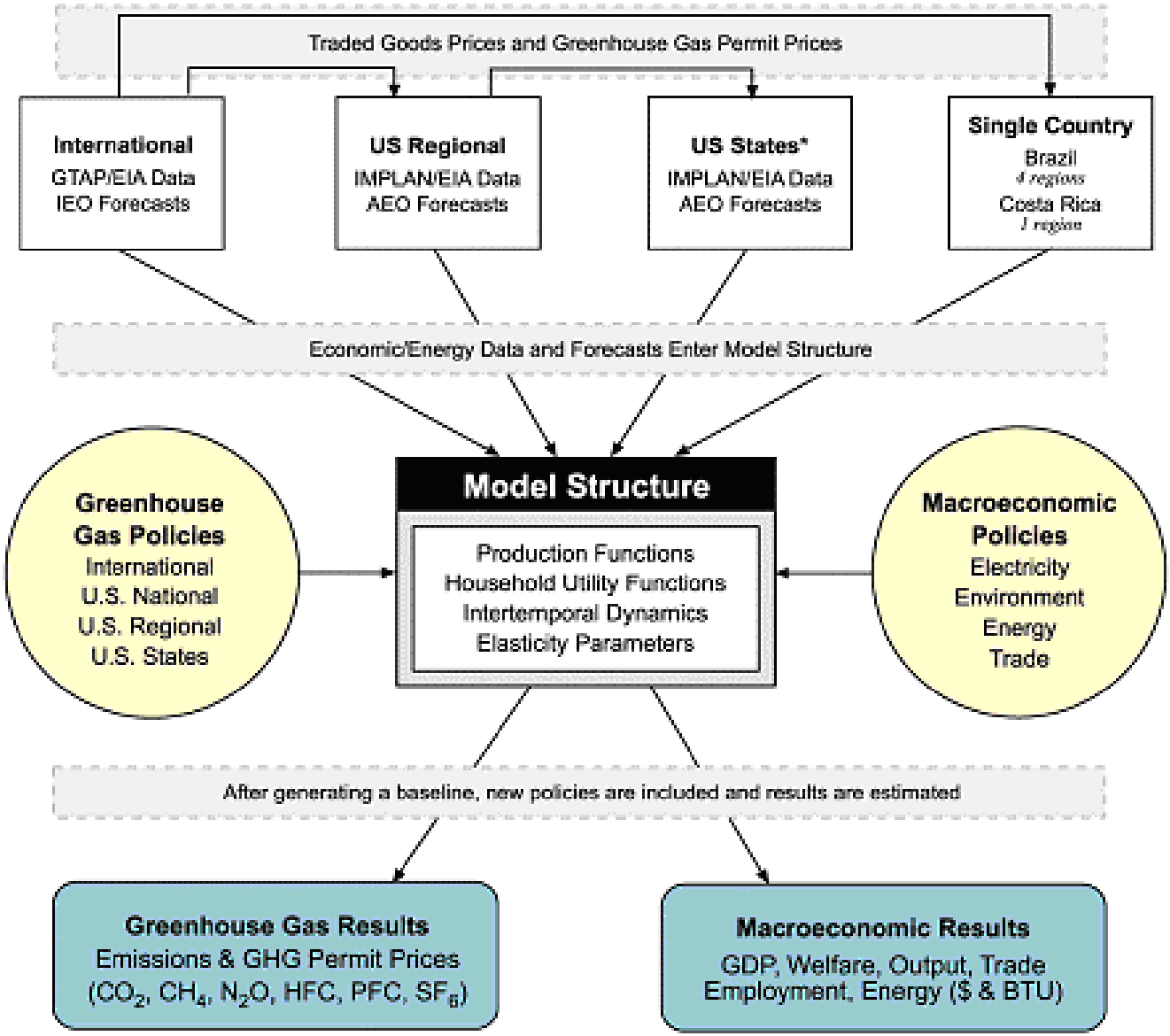
- Economic
  - IMPLAN (528 industries, 50 states & DC) and GTAP (world)
  - Output, production inputs, consumption by households, trade, etc.
- Energy
  - Energy Information Agency (AEO, IEO, MECS, Industry Annuals)
  - AEO & MECS => energy consumption for 39 U.S. industries
  - Forecasts of energy production and consumption (AEO & IEO)
- 10 “Core” Industries
  - **Coal**
  - **Crude Oil**
  - **Electricity**
  - **Natural Gas**
  - **Petroleum**
  - **Agriculture**
  - **Energy-Intensive Manufacturing**
  - **Other Manufacturing**
  - **Services**
  - **Transportation**

RTI INTERNATIONAL

U.S. Regional Model (Core Regions)



ADAGE: Integrated Framework

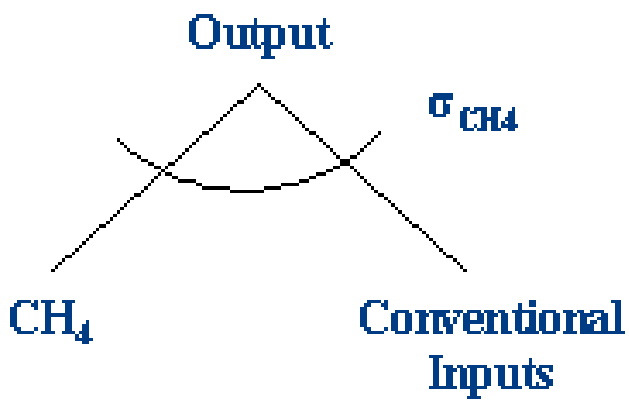


Model Baseline

- AEO/IEO Energy Production & Consumption Forecasts
  - Iterative solves to estimate baseline energy efficiency improvements
- Natural resources (coal, crude oil, natural gas)
  - Match resource prices to AEO forecast (to the extent feasible)
  - Set supply elasticity around resulting price path
- Sources of Growth:
  - Technology change
  - Increases in natural resources
  - Capital accumulation
  - Labor supply and productivity (AEO & IEO GDP forecasts)
- Non-fossil electricity generation is fixed at AEO/IEO forecast (future model improvement)

GHG Emissions

- Carbon Dioxide
  - Emissions tied to fossil-fuel use (tracked in Btus)
  - Options: improve efficiency, switch fuels, lower consumption
- Non-CO_2 Gases (CH_4, N_2O, HFC, PFC, SF_6)
  - Emissions not tied directly to fuel use
  - Marginal abatement cost curves
  - Accounts for interactions among gases and resource costs



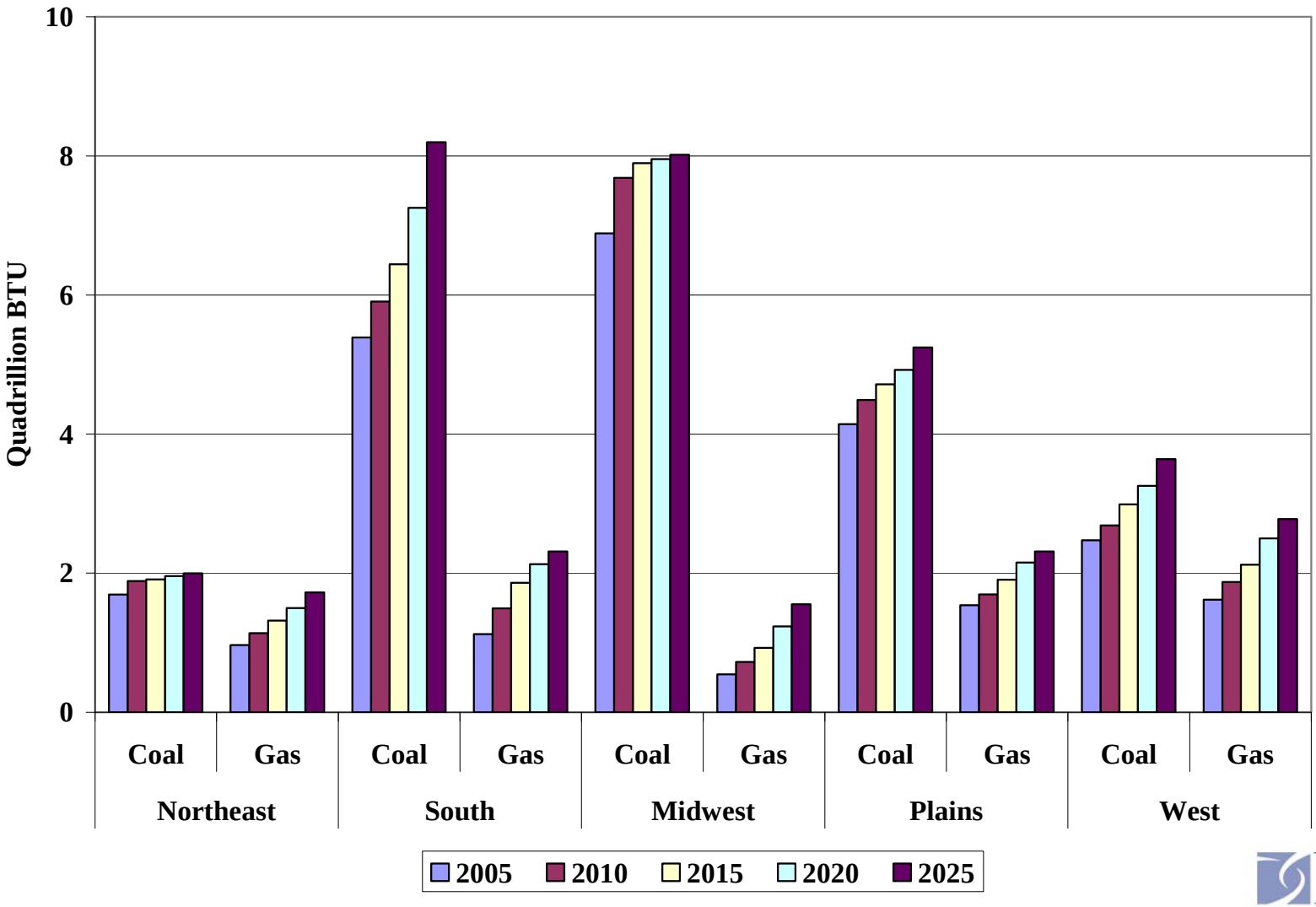
RTI INTERNATIONAL

Climate Change Policies Simulated

- All scenarios assume GHG emissions are capped at 1990 levels of CO2 emissions, beginning in 2010 and permit trading programs among all covered emissions sources

Scenario	Description
NE	NE cap on all GHG emissions (unilateral)
NE_nonRES	NE cap on GHG emissions, except residential emissions
NE_Carbon	NE cap on CO2 emissions alone
NE_MW	NE and Midwest cap on all GHG emissions
US_Match	U.S. cap on emissions achieving same level of emission reduction as NE_MW

Baseline Fuel Use in Electricity



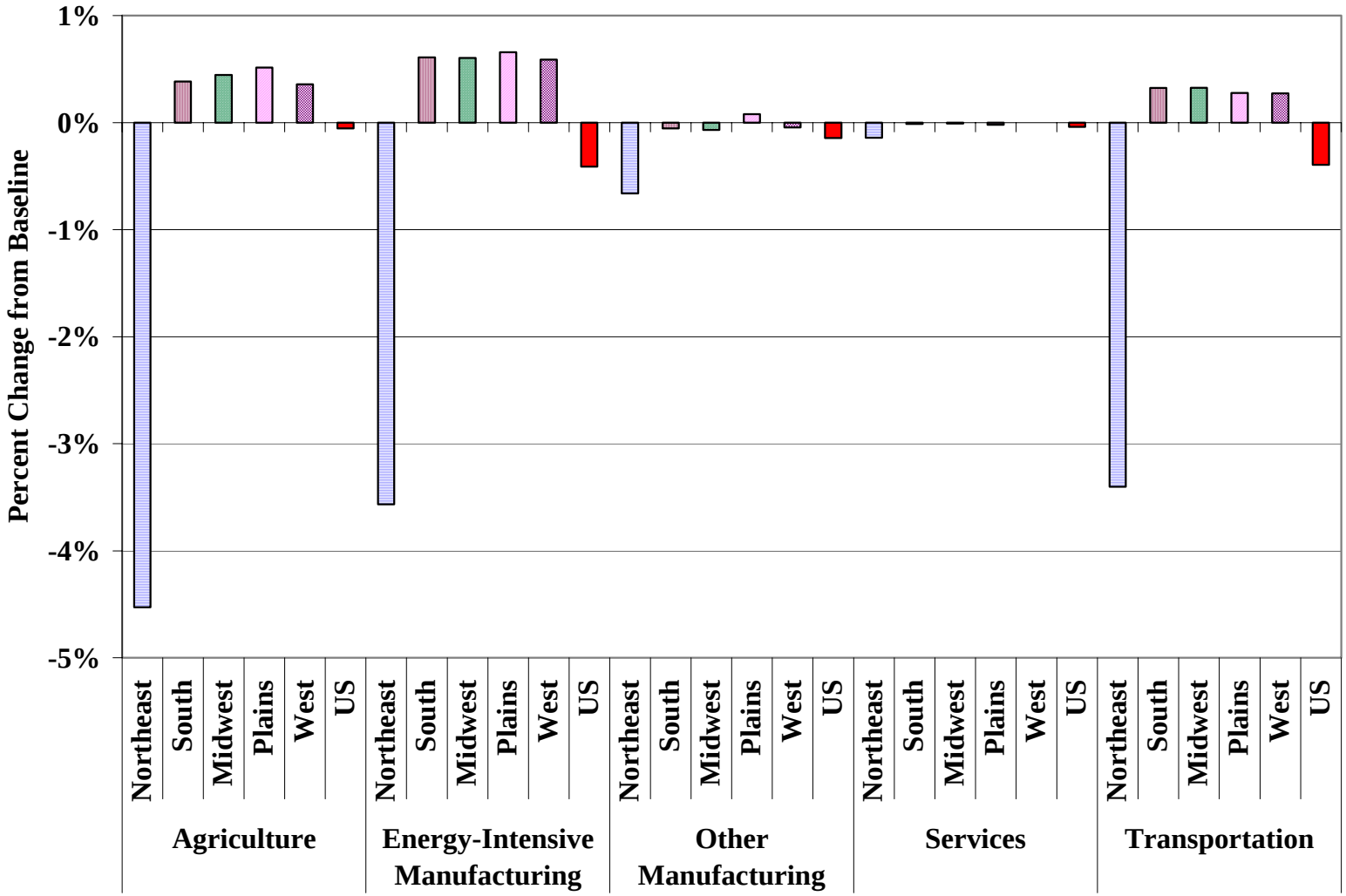
Summary Results: NE GHG Cap

(Cap emissions at 1990 levels, starting in 2010)

Variable	Northeast		U.S.	
	2010	2020	2010	2020
Permit Price ($/MTCE)	$34	$82		
GDP ($ million)	-$10,358	-$30,282	-$9,747	-$29,063
GDP (%)	-0.35%	-0.81%	-0.08%	-0.17%
Consumption (%)	-0.31%	-0.49%	-0.06%	-0.11%
Leisure Time (%)	0.15%	0.46%	0.04%	0.09%
Investment (%)	-1.40%	-1.94%	-0.21%	-0.28%
Employment - Jobs (%)	-0.09%	-0.28%	-0.02%	-0.06%
Wage Rate (%)	-0.53%	-1.07%	-0.11%	-0.23%

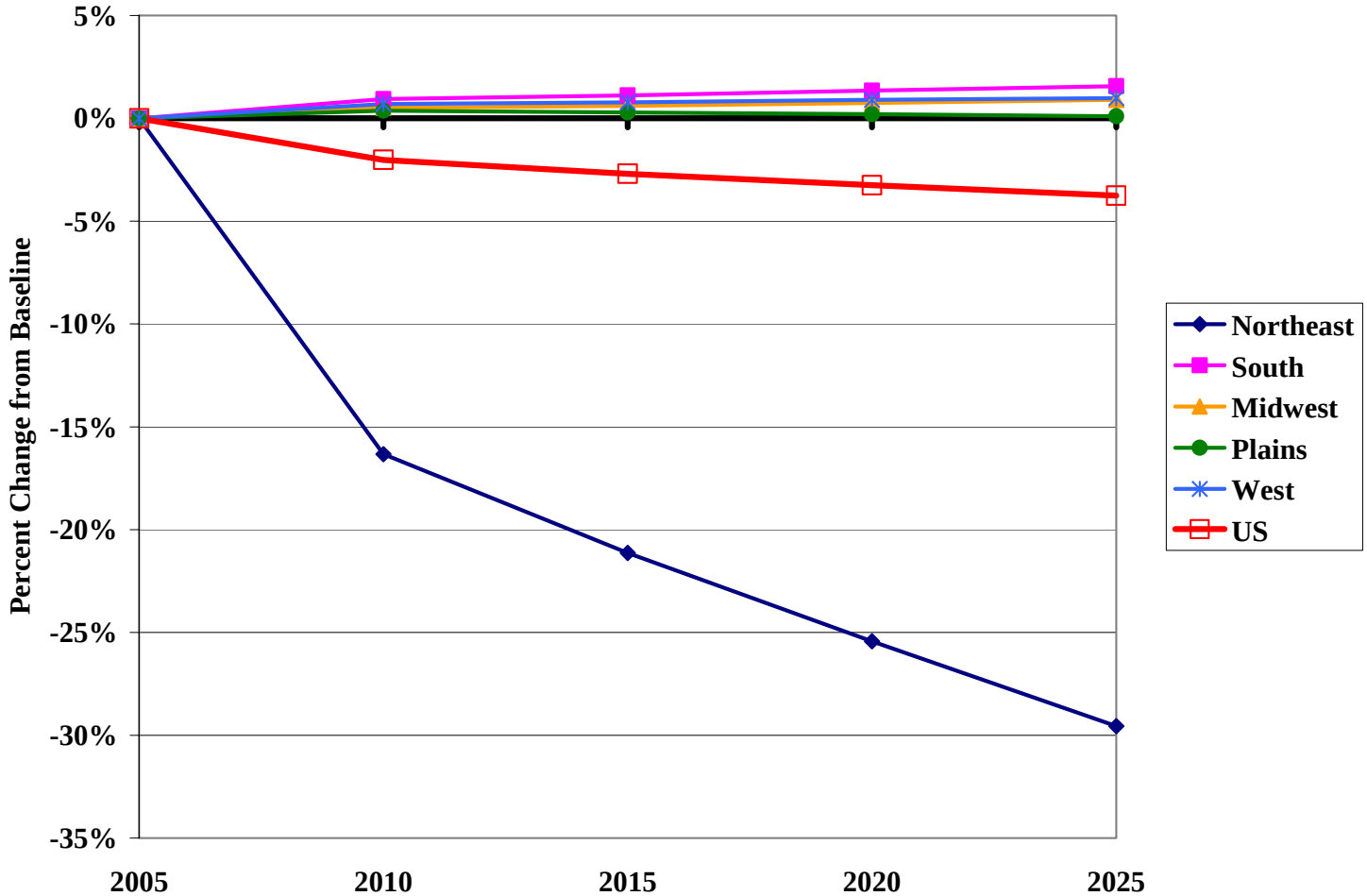
Output under NE GHG Cap

(Cap emissions at 1990 levels, starting in 2010)



Emissions under NE GHG Cap

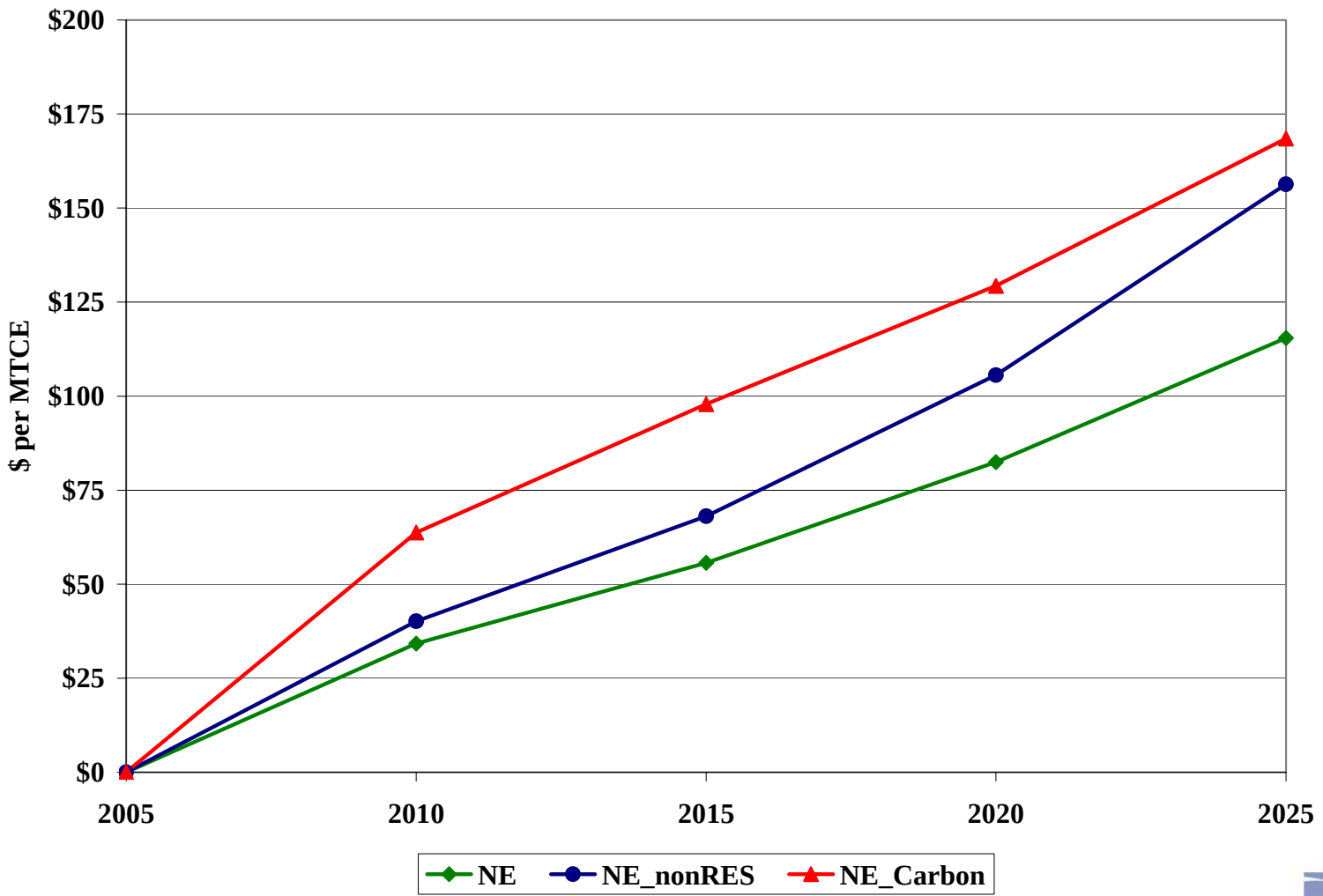
(Cap emissions at 1990 levels, starting in 2010)



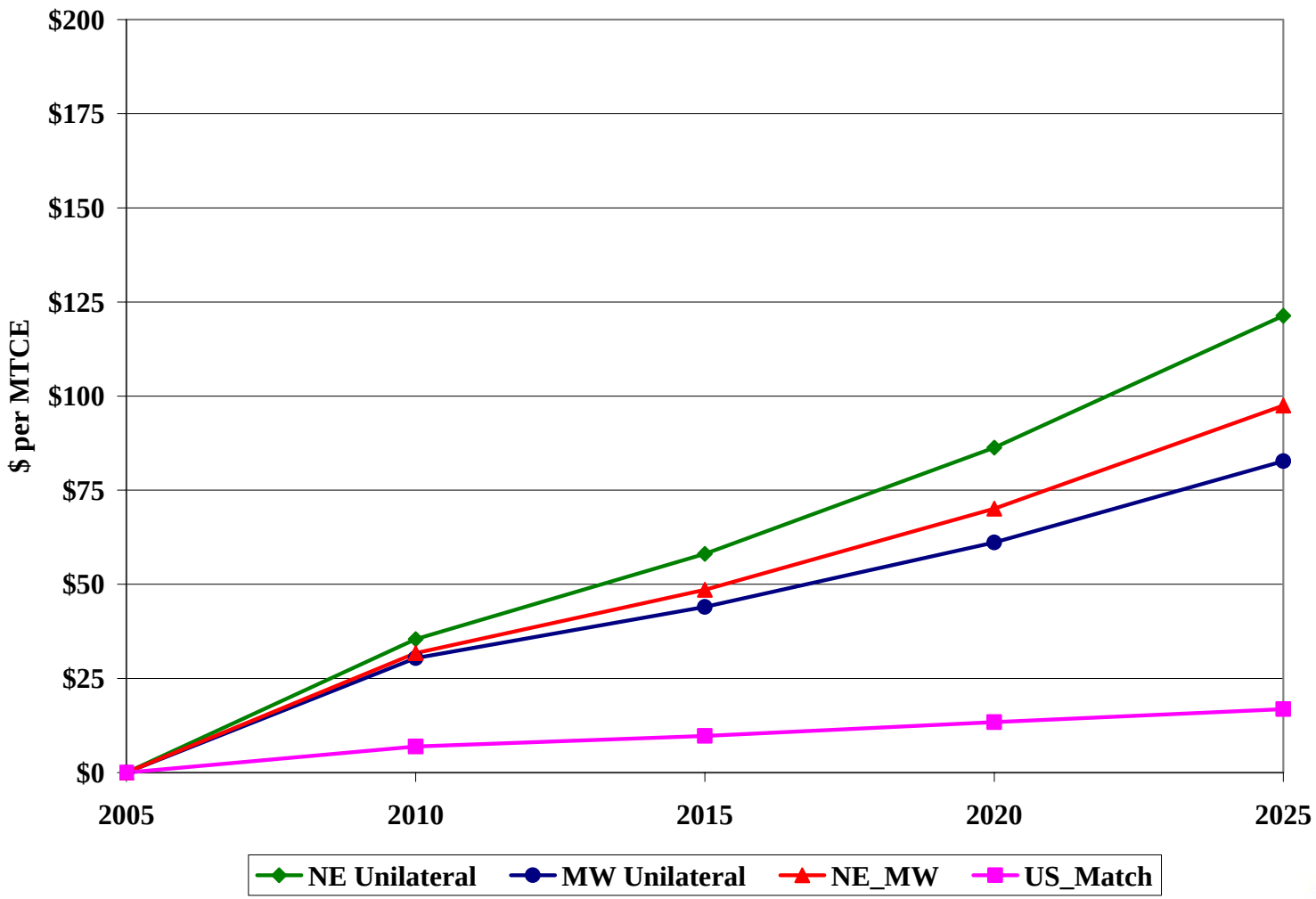
Leakage of Emissions Between Regions (NE GHG Cap)

Emissions Changes (MMTCE)	2005	2010	2015	2020	2025
Northeast	0.0	-54.5	-75.1	-94.1	-114.5
South	0.0	4.5	5.8	7.5	9.4
Midwest	0.0	2.8	3.4	4.3	5.4
Plains	0.0	1.4	1.1	0.8	0.4
West	0.0	2.8	3.4	4.1	4.7
US	-0.1	-43.1	-61.4	-77.3	-94.5
Leakage (%)		27%	22%	22%	21%

Permit Prices for Alternative Policies Within Northeast Region



Permit Prices for Policy Variants Across Regions



Household Expenditure Patterns
(Baseline)

	All House-holds	Income 0-15K	Income 15-29K	Income 29-50K	Income 50K+
Electricity	1.00	1.39	1.08	0.89	0.86
Natural Gas	1.00	1.20	1.02	0.94	0.95
Petroleum	1.00	1.01	1.08	0.98	0.96
Agricultural Produce	1.00	1.17	1.10	0.95	0.89
Energy-Intensive Goods	1.00	1.31	1.11	0.92	0.83
Other Manufactured Goods	1.00	0.87	0.98	1.02	1.06
Services	1.00	0.99	0.99	1.01	1.01
Transportation	1.00	0.91	0.88	1.02	1.14

Distributional Results - NE GHG Cap

(Household welfare changes – Hicksian EV)

	Income 0-15K	Income 15-29K	Income 29-50K	Income 50K+
Northeast	-0.37%	-0.35%	-0.32%	-0.17%
South	-0.02%	-0.01%	0.00%	-0.01%
Midwest	0.00%	0.02%	0.04%	0.03%
Plains	-0.04%	-0.06%	-0.09%	-0.15%
West	-0.03%	-0.02%	-0.01%	-0.02%
US	-0.09%	-0.08%	-0.08%	-0.06%

Conclusions

- As expected, more comprehensive GHG emission reductions policies are more cost-effective
  - Excluding residential emissions from NE restrictions raises permit prices 20-35%
  - Excluding non-CO2 gases from NE restrictions raises permit prices by 45-85%
  - Permit prices are 15-20% lower under the joint trading scenario between the NE and MW
  - Achieving the same reductions as at the NE level at the US level results in permit prices that are about 80-90% lower

Conclusions (2)

- Expanded coverage of a GHG policy also reduces leakage of emissions into other regions
  - Including the Midwest in a trading scheme with the NE reduces leakage from 20-30% down to ~6%
- Important distributional effects across regions and households