



Trends in Carbon Emissions Economic Intensity: Economic Performance and Role of Public Policies and Programs

State & Local Capacity Building Branch
STAPPA/ALAPCO Global Warming Committee
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Roadmap

1. **Overview of the Carbon Emissions Economic Intensity Index (CEEI)**
 - ◆ **Objectives and Methodology**
2. **Key Findings**
 - ◆ **Insights from Corollary studies**
 - ✦ CEEI and State Economic Performance
 - ✦ Peer Group Analysis
 - ◆ **Insights from State Level Analysis of Carbon Emissions Economic Intensity (CEEI)**
3. **Value to State and Local Governments**
4. **Summary and Potential Next Steps**

Overall Objectives of the CEEI Framework

- Estimate and measure CO₂ emissions relative to economic activity
- Show trends in state-level CO₂ emissions and intensity over time
 - ◆ in aggregate
 - ◆ By energy-consuming sector
- Support understanding of change over time in emissions and emissions intensity in terms of key macro-factors
 - ◆ Energy efficiency
 - ◆ Fuel mix
 - ◆ Composition of economic activity across key sectors
 - ◆ Quantity of economic activity

Overall Objectives of the CEEI Framework

- **Provide a framework for comparing CO₂ intensity, and change in intensity**
 - ◆ across states
 - ◆ to the nation
 - ◆ as a whole
- **Support state and local government's programs and activities that affect CEEI by**
 - ◆ assessing effectiveness of state-level programs and policies
 - ◆ support “lessons learned” from one state to another

Summary of the CEEII Framework

- **CEEII reports, at the state level, carbon emissions in relation to the value of the activity that generates the emissions**
 - ◆ **Basic question of analysis: How productive are states in the use of carbon emissions as an input to production of economic value?**
- **CEEII is calculated over the period 1977-2000 for all states and the District of Columbia**
- **Analysis disaggregated into five key energy consuming sectors:**
 - ◆ **1. Electric power generation**
 - ◆ **2. Industry**
 - ◆ **3. Commercial/Institutional**
 - ◆ **4. Transportation**
 - ◆ **5. Residential**

Summary of the CEEII Framework - background

- **For economic value producing sectors, CEEII calculated using value added:**
 - ◆ **Electric power generation**
 - ◆ **Industry**
 - ◆ **Commercial/Institutional**
 - ◆ **Transportation – value added component only**
- **For other sectors, CEEII calculated using other appropriate value normalizing concepts**
 - ◆ **Residential – population, number of households**
 - ◆ **Non value added Transportation – non-truck vehicle miles; also registered vehicles and total vehicle miles traveled for all transportation**

Summary of the CEEI Framework - background

- Carbon emissions are estimated based on fuel consumption by sector, using fuel- and, where appropriate, state-specific carbon emission factors
 - ◆ DOE/EIA is source of fuel consumption and emission factor information
- We normalize emission estimates for year-to-year fluctuation in heating and cooling requirements
- Carbon emissions from electricity generation analyzed in two ways:
 - ◆ As generated by the electric power sector
 - ◆ Assigned to the end-use consumer sector
- CEEI reported by sector and aggregated over sectors:
 - ◆ All sectors
 - ◆ Value added sectors only

Summary of the CEEI Framework - background

Decomposition Analysis

- The CEEI framework uses index analyses (Divisia and Laspeyres) to decompose the change in carbon emissions intensity, at the aggregate and individual sectoral level, in terms of:
 - ◆ Economic structural change (across sectors)
 - ◆ Energy efficiency
 - ◆ Fuel mix
- The decomposition analysis is important in assessing the effect of government policies and programs on carbon emissions intensity

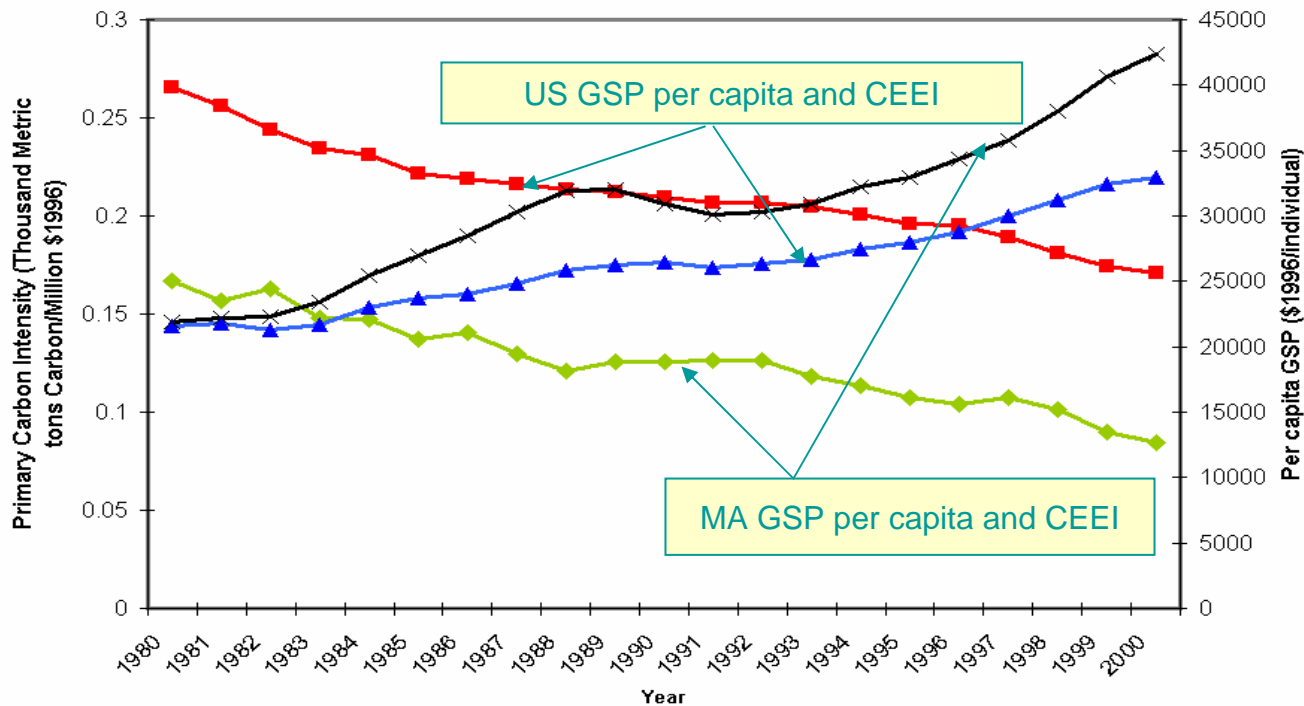
Insights from CEEI Corollary Analyses: CEEI and State Economic Performance

- Using historical data from the CEEI framework and controlling for factors that influence CEEI and/or economic performance (that is per capita GSP) such as:
 - ◆ Economic structure
 - ◆ Climate
 - ◆ Structure of energy supply
 - ◆ Social and demographic factors
 - ◆ Labor and capital use
 - ◆ Energy prices

- We analyze the relationship between CEEI and per capita GSP

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How Did Emissions Intensity and per Capita GSP Change for a State? Massachusetts and US



CEEI Change 1980 – 2000	
MA	-49%
US	-36%

Per capita GSP Change 1980 – 2000	
MA	93.5%
US	52.3%

■ United States All Sectors Primary Carbon Intensity
 ◆ State All Sectors Primary Carbon Emissions Intensity
▲ United States GSP per Capita (1996\$ per individual)
 ✕ State GSP per Capita (1996\$ per individual)

Insights from CEEI Corollary Analyses: CEEI and State Economic Performance

- **We econometrically analyzed four questions:**
 - ◆ **How do changes in aggregate and decomposed CEEI affect economic performance?**
 - ◆ **How do changes in economic performance affect CEEI?**
 - ◆ **How do changes in CEEI by sector affect economic performance?**
 - ◆ **How do changes in sector specific economic performance affect sector specific CEEI?**

Insights from CEEI Corollary Analyses: CEEI and State Economic Performance – Key Conclusions

- **Both aggregate and decomposed CEEI have a significant negative (favorable) causal relationship with per capita GSP**
 - ✦ A decline in CEEI is expected to result in an improvement in economic performance (an increase in per capita GSP)
- **Per capita GSP has a significant negative (favorable) causal relationship with aggregate and decomposed CEEI**
 - ✦ An improvement in economic performance (per capita GSP) is expected to result in a reduced CEEI
- **The significant bi-directional causality between CEEI and state economic performance indicates that states should be able to implement programs or policies that simultaneously reduce CEEI and improve state economic performance**

Insights from CEEI Corollary Analyses: CEEI and State Economic Performance – Key Conclusions

- **CEEI in the residential sector and per capita GSP has a positive bi-directional relationship**
 - ✦ This indicates that an increase in CEEI in the sector is expected to enhance per capita GSP, and an increase in per capita GSP is expected to enhance residential CEEI (increase carbon intensity)
- **CEEI in industrial, commercial and non-value added transportation has a negative (favorable) relationship to per capita GSP**
 - ✦ A reduction in CEEI in any of those three sectors is expected to result in an increase in per capita GSP
- **State governments should be able to target programs towards the commercial, industrial and non-value added transportation sectors to achieve simultaneously:**
 - ✦ Improvement in sector specific economic performance
 - ✦ Reduced sector specific CEEI (decrease carbon intensity)
- **The next question is: what are the programs that can achieve such simultaneous movement?**

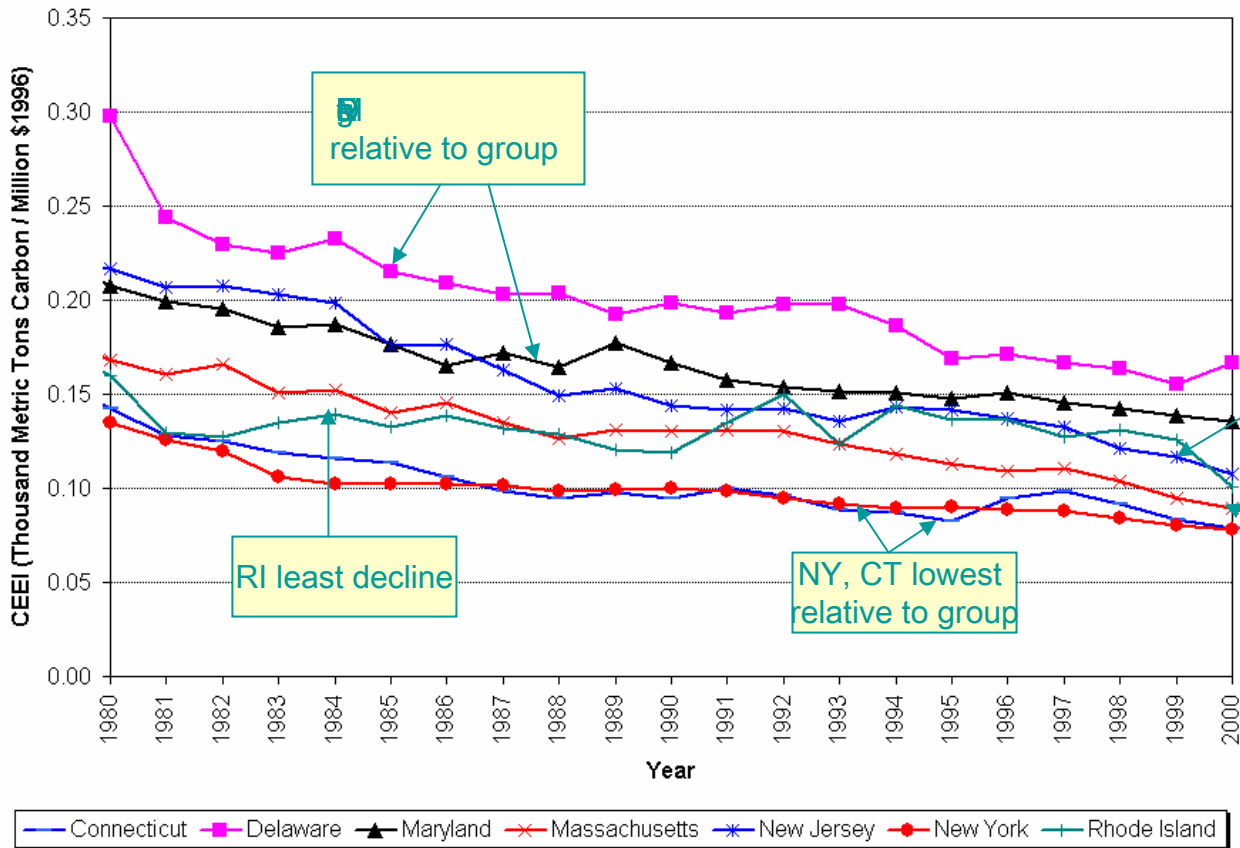
Insights from CEEI Corollary Analyses: Peer Group Analysis

- **Effort led to development of peer groups of states for use in analyzing effectiveness of state-level policies and programs, and in other comparative performance analyses**
 - ◆ **Accounted for baseline endowment factors that influence carbon emissions intensity and that aren't controllable by state policy in the near-term:**
 - ✦ Per capita income
 - ✦ Carbon intensive industry concentration
 - ✦ Climate
 - ✦ Share of energy from non carbon emitting sources
 - ✦ Population density
- **Enables comparison of states that have similar endowment characteristics - avoids “apples to oranges” comparison between states**
- **Enables more meaningful “lessons learned” support from one state to another**

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How do States compare?

Example of Benchmark Group E



Differences within peer groups contain important information regarding program performance and untapped state potential for change

NJ downward trend: large relative decline

MA downward trend: large relative decline

relative to group

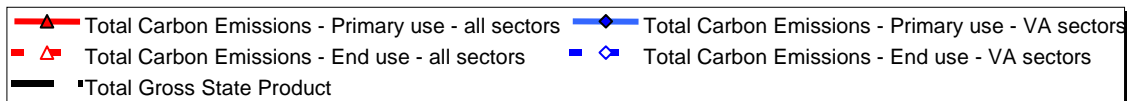
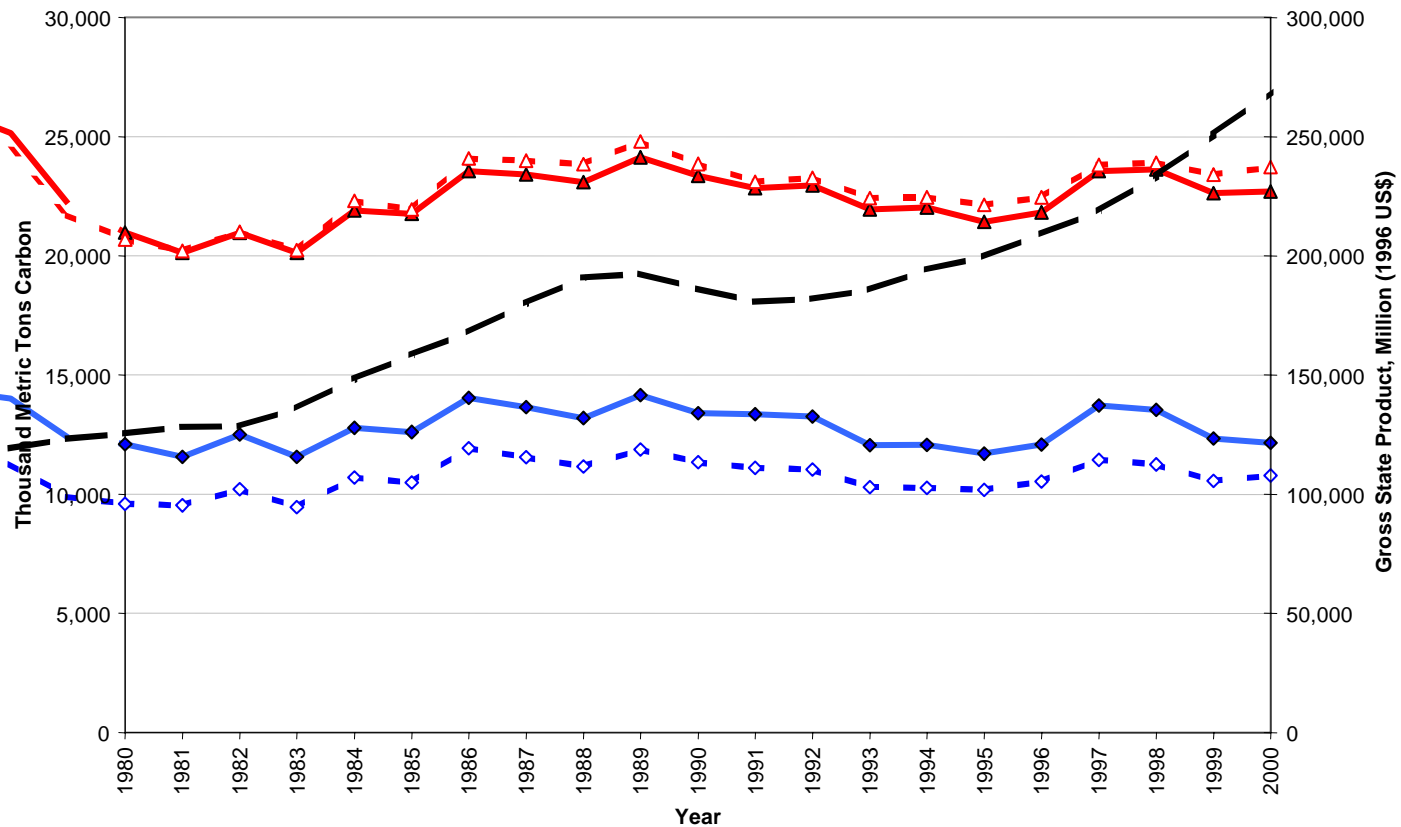
RI least decline

NY, CT lowest relative to group

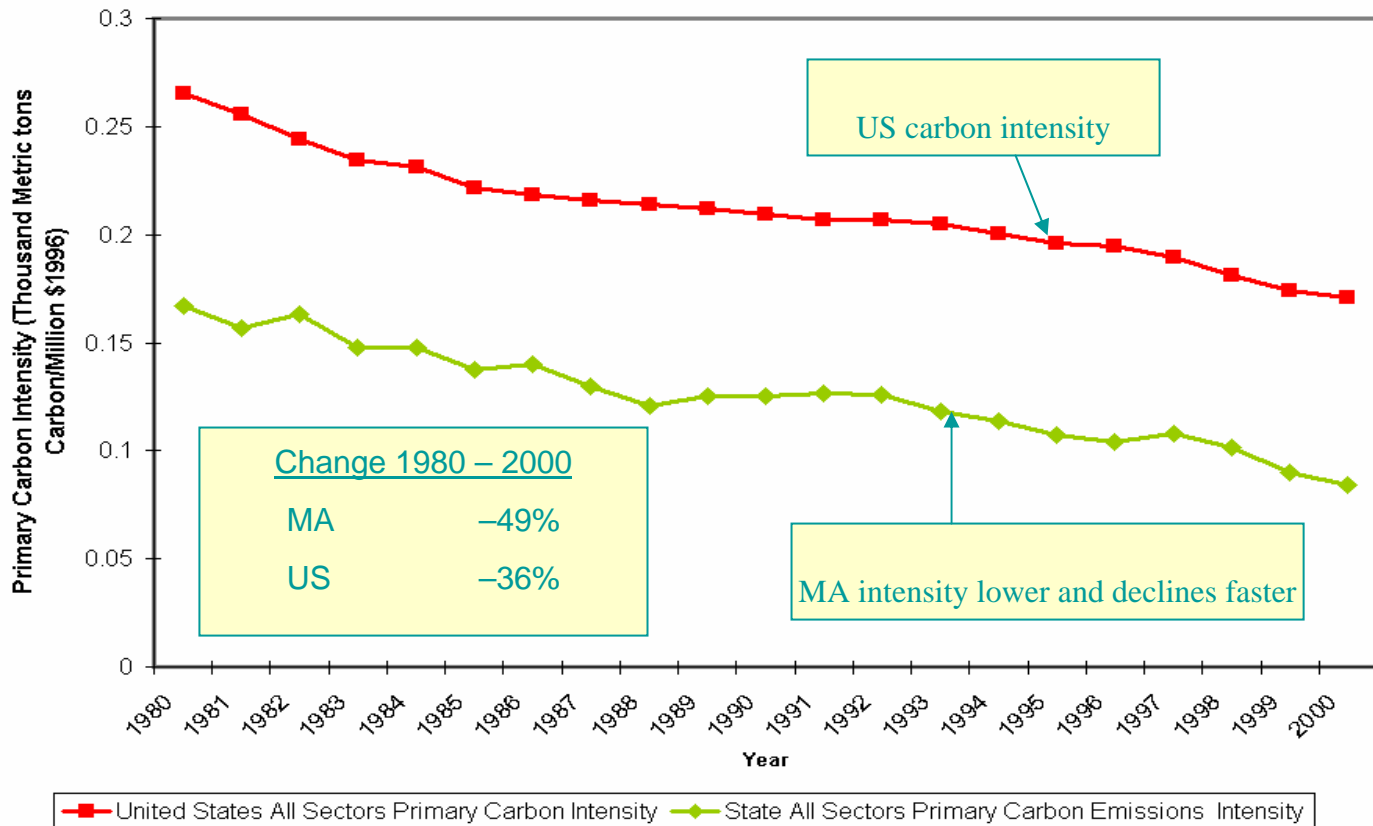
Insights from State Specific CEEI Analysis

- Preliminary analysis of selected states: Connecticut and Massachusetts so far, more to follow:
- Some key early conclusions:
 - ◆ Some states have achieved substantial reductions in carbon emissions intensity, partly as a result of external economic factors, but also as a result of policy interventions
 - ◆ Movement in economic activity and carbon emissions does not occur in lock-step
 - ◆ Beneficial lessons can be learned from the “leader” states – e.g., Massachusetts’ energy efficiency and renewable energy programs appear to have substantially reduced carbon emissions intensity performance in several sectors
 - ◆ Carbon emissions intensity and, *more importantly*, the change in carbon emissions intensity varies substantially across states

How Did Emissions Intensity Change for a State? Example of Massachusetts: Total Carbon Emissions and GSP

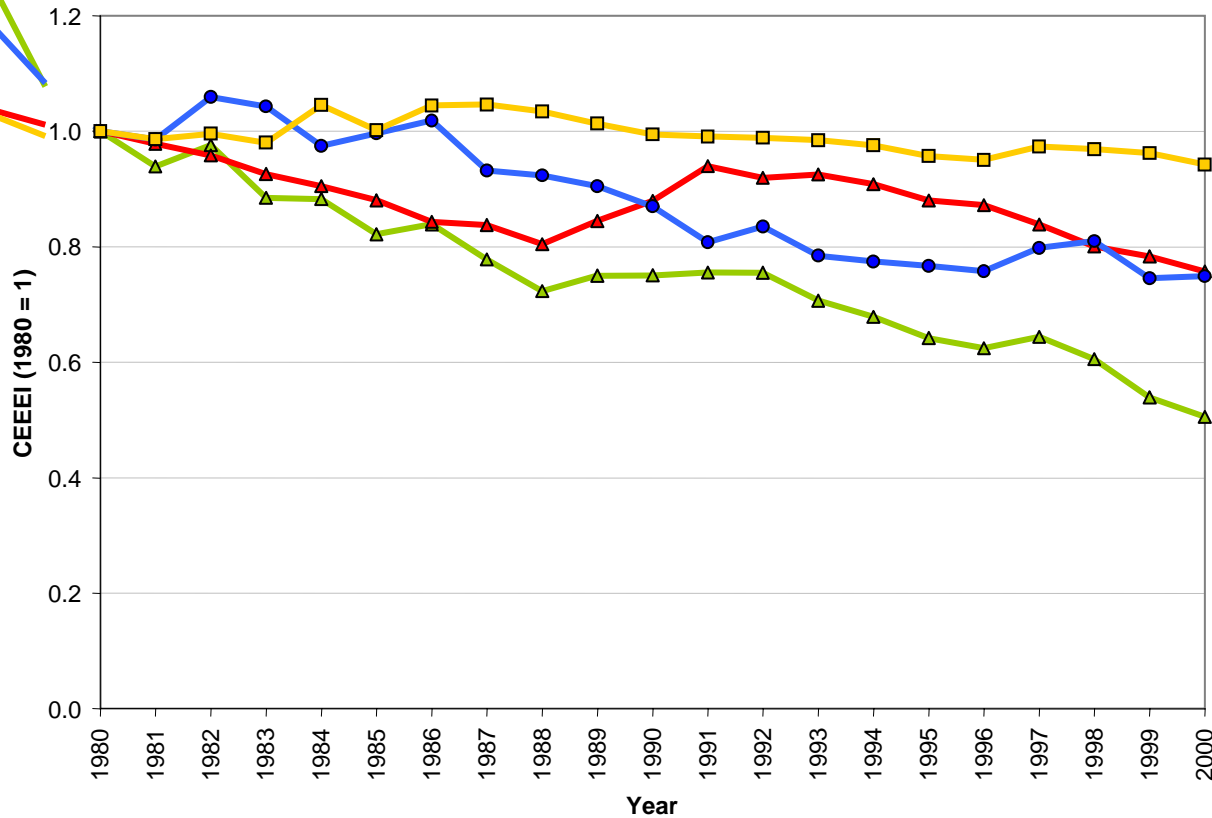


How Did Emissions Intensity Change for a State? Massachusetts and US Primary CEEI



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Index

How Did Emissions Intensity Change for a State? Massachusetts: A Closer Look at Primary CEEI



Change 1980 – 2000

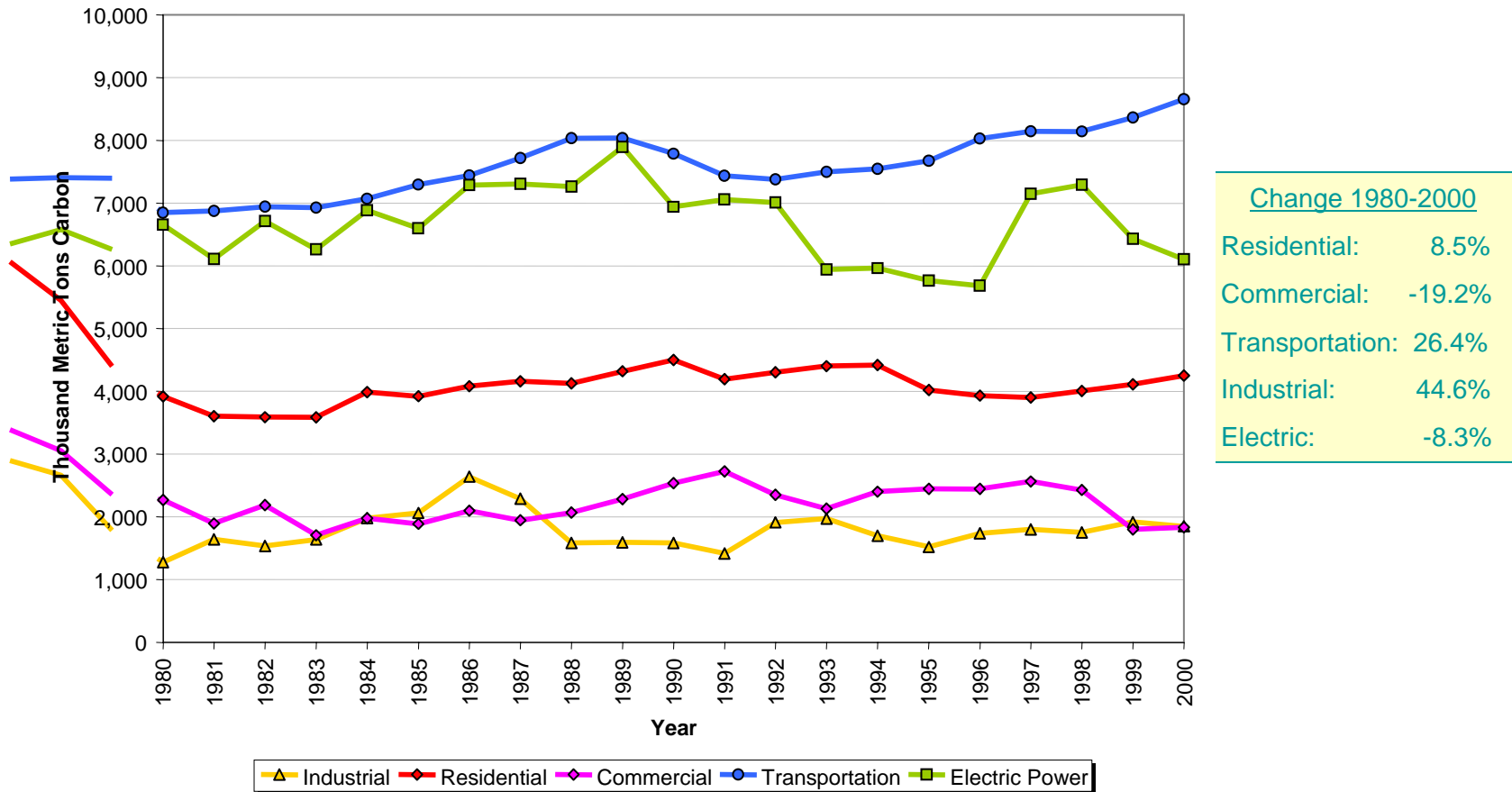
Primary CEEI	-49.5%
Due to (% share):	
Structure	44.5%
Efficiency	45.5%
Fuel Mix	10.0%

Shift towards
natural gas drives mix
impact

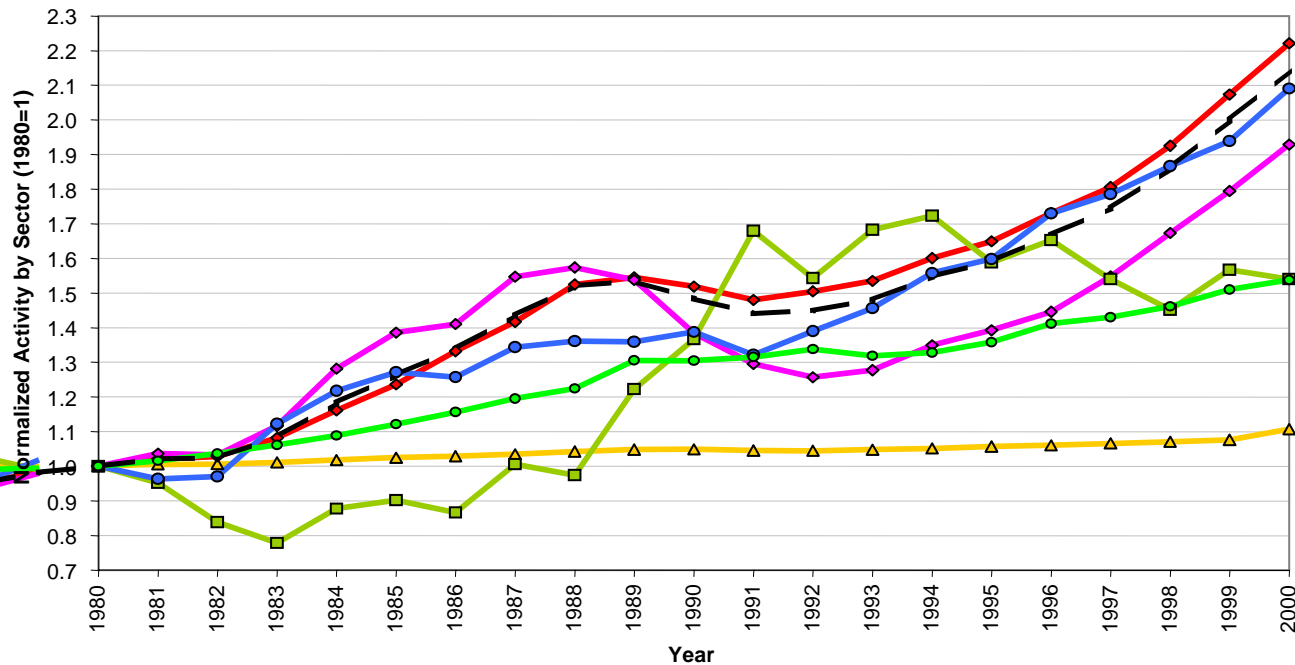
Increase in growth of
commercial sector
drives structure
impact

▲ Vary All ▲ Vary Structure only ● Vary Efficiency only ■ Vary Fuel Mix only

How Did Emissions Intensity Change for a State? Massachusetts Primary Carbon Emissions by Sector



How Did Emissions Intensity Change for a State? Massachusetts Change in Activity by Sector



Commercial grows fastest, accounts for 77% of GSP

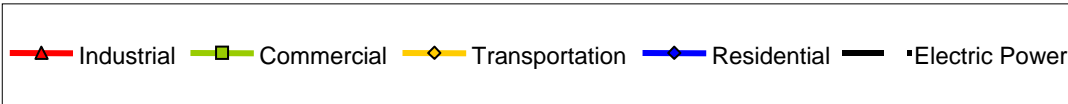
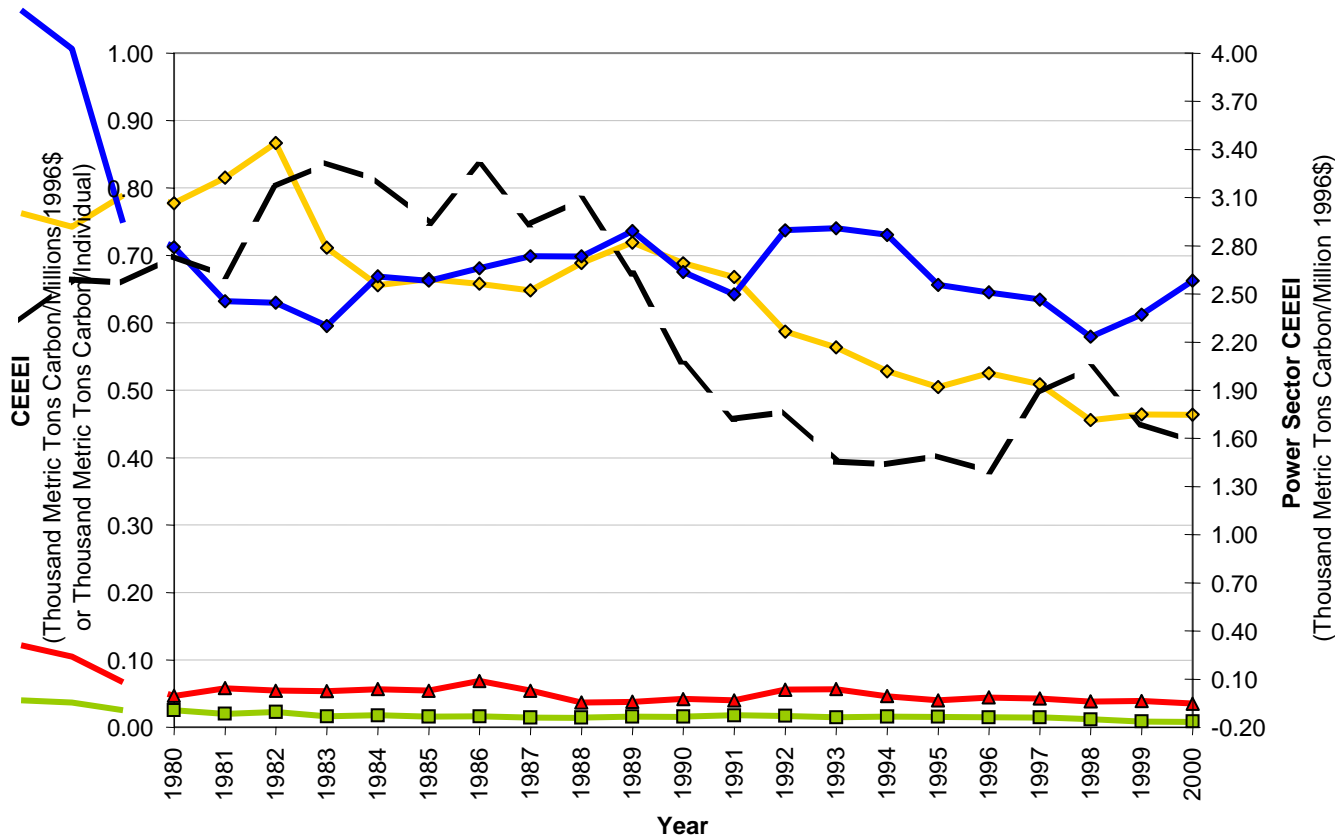
Industrial; large decline in early 1990s

Residential growing most slowly

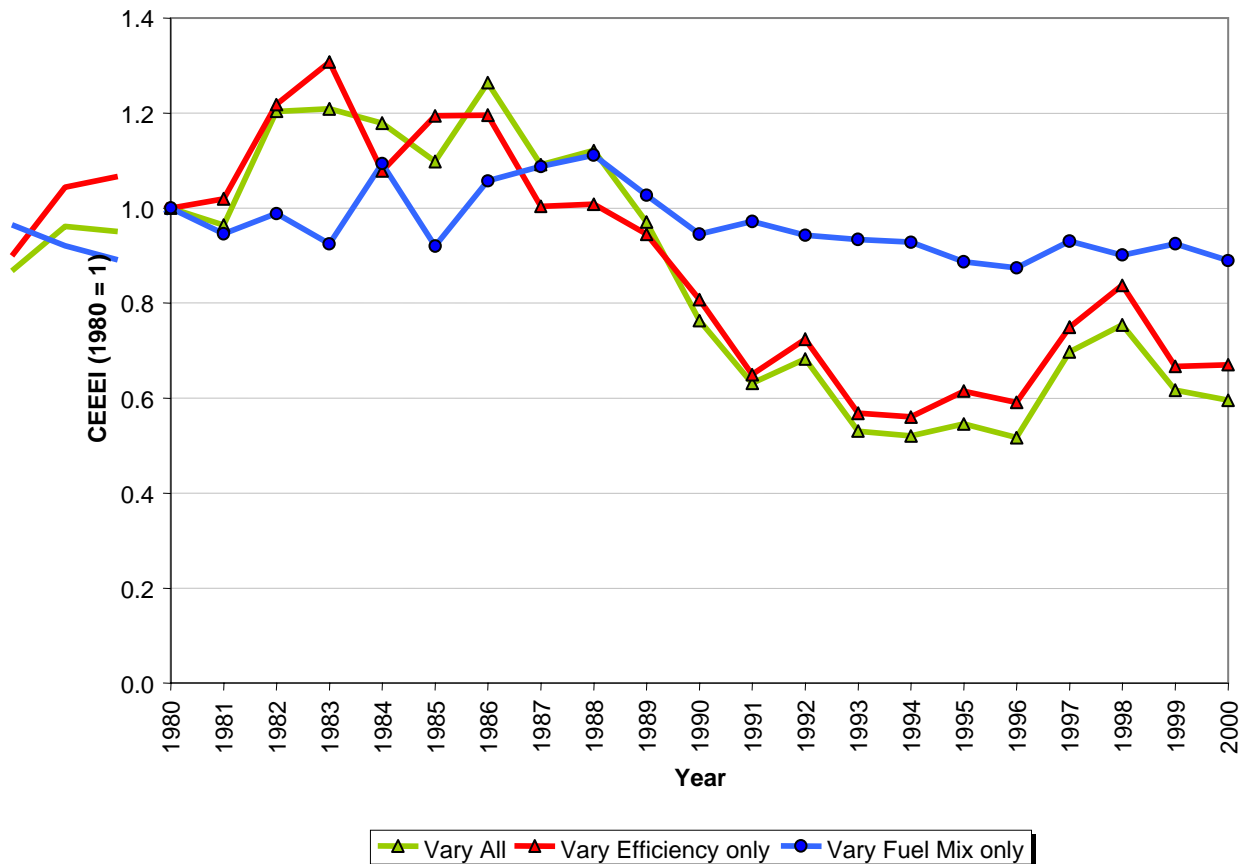


All sectors but residential and NVA transportation based on real value added. Residential based on population, NVA transportation on vehicle miles traveled.

How Did Emissions Intensity Change for a State? Massachusetts Primary CEEI by Sector



How Did Emissions Intensity Change for a State? Massachusetts: A Closer Look at Electricity Generation



Change 1980 – 2000

All: -40.4%

Due to (% share):

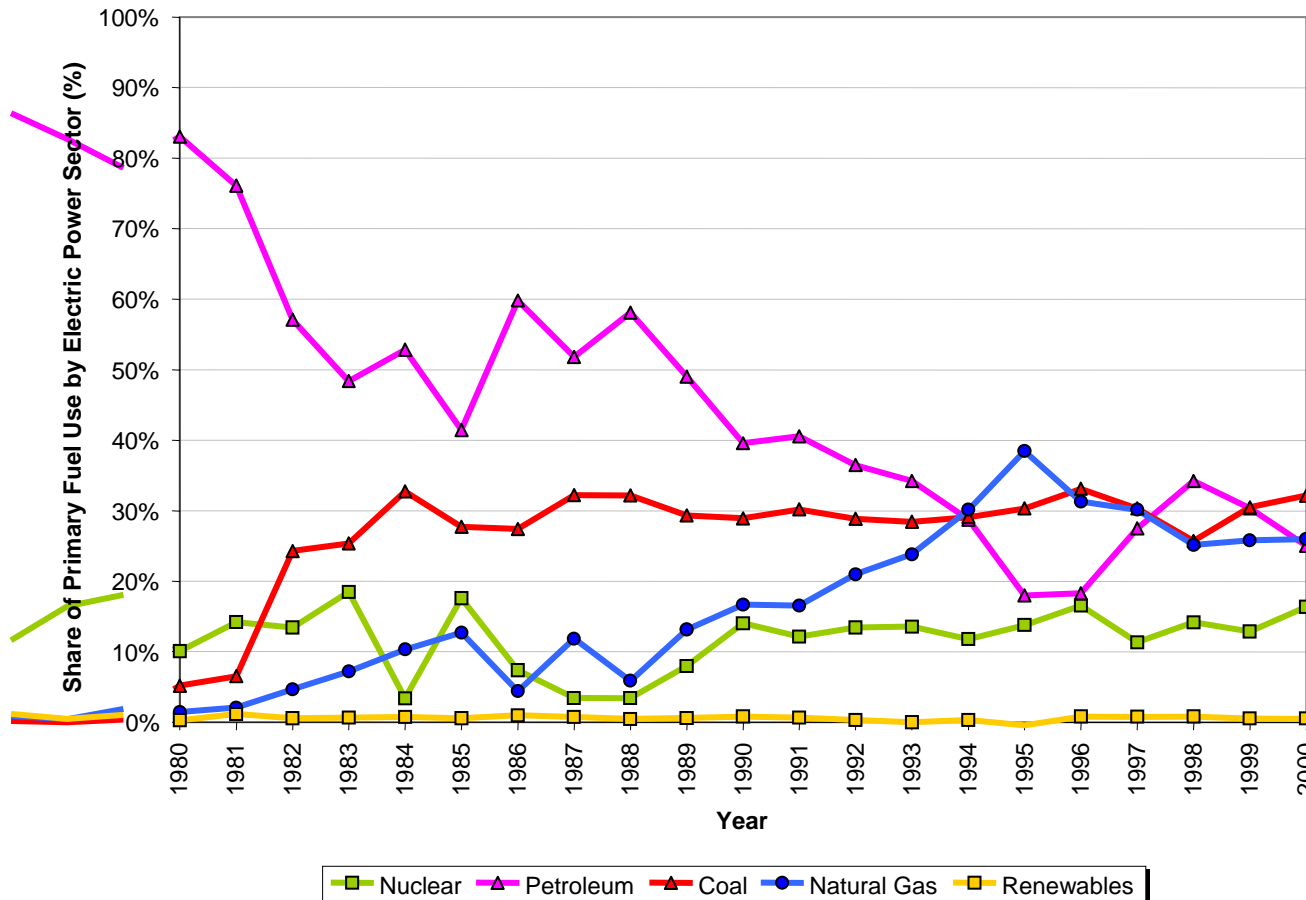
Efficiency 75.0%

Fuel Mix 25.0%

Can we link those shifts to specific policy or economic events?

Can we draw any lessons of MA's experience for its peer states?

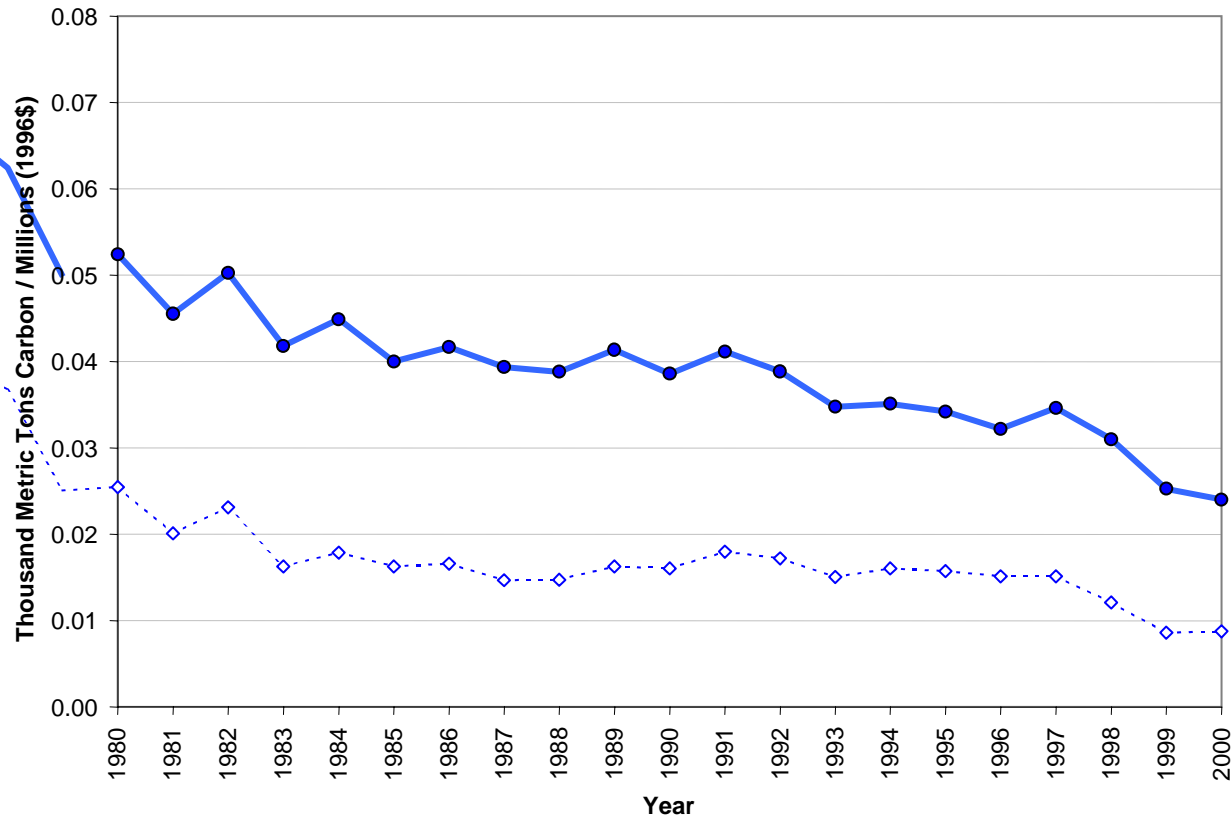
How Did Emissions Intensity Change for a State? Massachusetts: Fuel Switching in Electric Generation



Coal: 1981-1984
negotiated
increase

Natural gas: 1988
onwards,
increase due to
deregulation of
natural gas
markets

How Did Emissions Intensity Change for a State? Massachusetts: Commercial Primary and End-Use CEEI



Change 1980 – 2000

Primary: -63.6%

End-Use: -51.5%

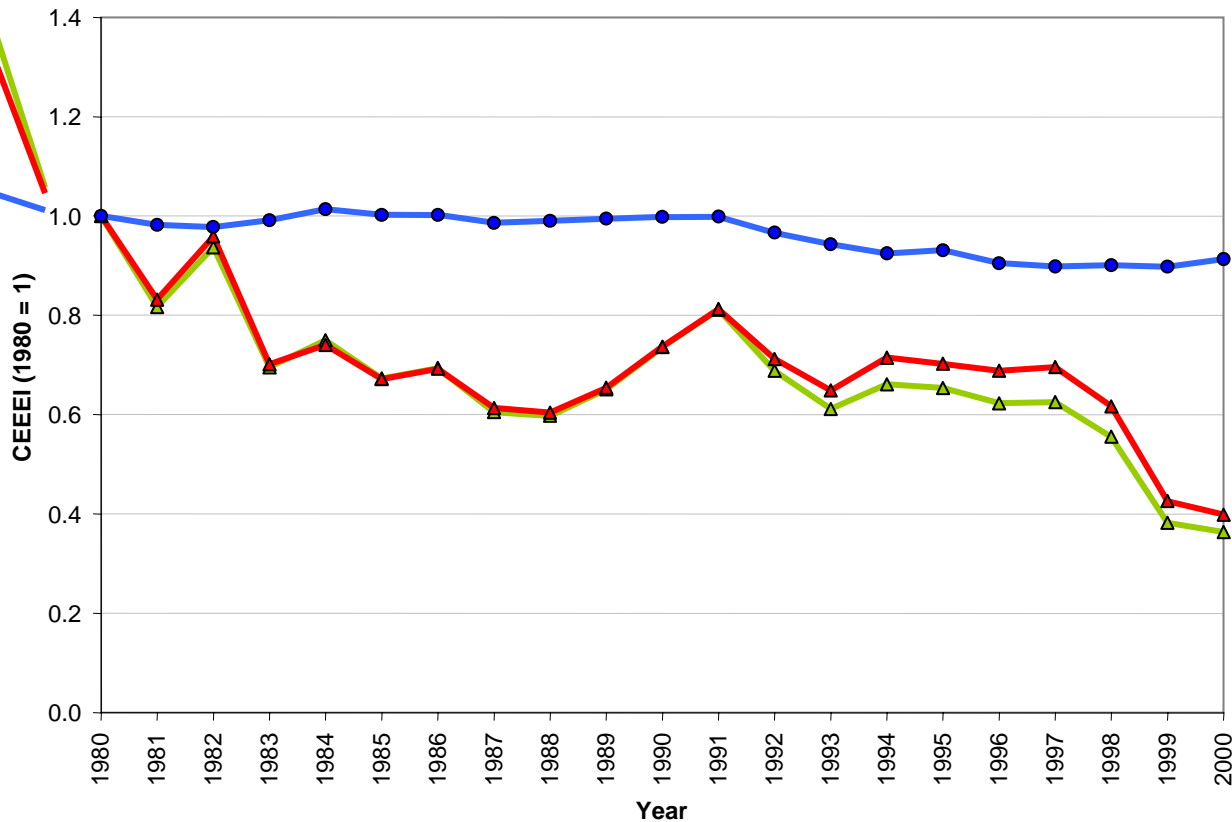
Reason for change?

● Commercial - End Use

◇ Commercial - Primary Use

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Economic
Intensity
Index

How Did Emissions Intensity Change for a State? Massachusetts: A Closer Look at Commercial Sector



Change 1980 – 2000

All -63.6%

Due to (% share):

Efficiency 87.4%

Fuel Mix 12.6%

Efficiency Impact

Strong building codes
and appliance
standards

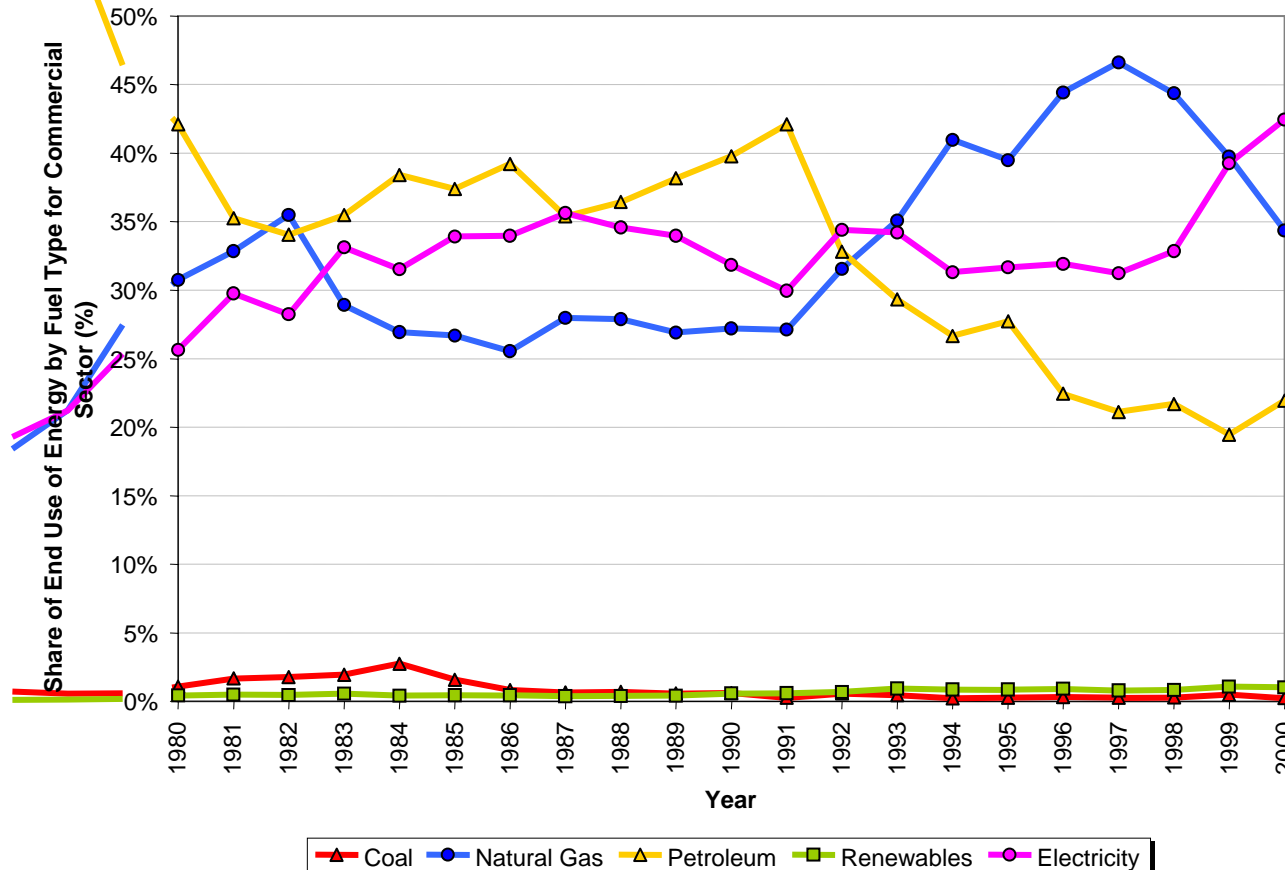
Structural shifts

Can we draw any
lessons of MA's
experience for its
peer states?

▲ Vary All ▲ Vary Efficiency only ● Vary Fuel Mix only

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Economic
Intensity
Index

How Did Emissions Intensity Change for a State? Massachusetts: Fuel Switching in Commercial Sector



Natural Gas: increasing
early 1990s – replacing
petroleum

Electricity: increasing
late 1990s – replacing
Natural Gas

Main Findings for Massachusetts

- **MA on average achieved significant reduction in CEEI between 1980-2000**
- **Decomposed results indicate that the change is due to:**
 - ◆ **Structural changes (45% primary use, 44% end-use)**
 - ◆ **Efficiency change (45% primary use, 42% end-use)**
 - ◆ **Fuel mix change (10% primary use, 14% end-use)**
- **Substantial number of programs seem to have contributed to reduced CEEI**
 - ◆ **Energy Conservation Services Program**
 - ◆ **Building codes**
 - ◆ **Deregulation and facilitated fuel switching**
- **Impact of programs is visible in sector specific CEEII metric**
- **Results indicate differing relative importance of sectors in achieving state-level reductions in CEEII and total carbon emissions – and differing reasons for change within sectors**

Summary

- **The CEEI captures changes in carbon intensity at the state and sector level**
 - ✦ Change in carbon emissions intensity varies substantially across states
 - ✦ Some states show significant reduction in CEEI due to external economic factors and as a result of state policy interventions
- **Peer groups enable comparison of states that have similar endowment characteristics**
 - ✦ Avoids “apples to oranges” comparisons
- **Reduction in CEEI correlate with economic performance**
 - ◆ State governments should be able to target programs towards the commercial, industrial and non-value added transportation sectors to achieve *simultaneously*:
 - ✦ Improvement in sector specific economic performance
 - ✦ Reduced sector specific CEEI
- **Seek to understand effects of state-specific *policies and programs* on CEEI**

Potential Value to State and Local Governments

- **Use the State-level CEEI framework to better understand trends and changes in CEEI as it relates to state specific programs and policies**
- **State level analyses used as “lessons learned” and applied to:**
 - ◆ **Assess effectiveness of already implemented programs and policies**
 - ◆ **Assess alternative trajectories for change in CEEI drawing on past experience within a state**
 - ◆ **Assess alternative trajectories for change in CEEI drawing on experience within peer groups**
 - ◆ **Assess related co-benefits such as health effects, energy security and enhanced economic performance, of alternative trajectories of change in CEEI**

Potential Value to State and Local Governments

- **Use econometric findings to support efforts that reduce CEEI, in particular focus on the potential favorable relationship between programs that reduce CEEI and enhanced economic performance**
- ***Other potential interesting areas of use or alternative next steps?***

Potential Next Steps

- **Continue to develop the framework and distribute to interested states**
- **Add additional years of data as they become available from EIA**
- **Analyze state-specific policies and programs**
 - ◆ *High priority for near-term work*
- **Add a “forward looking” scenario analysis component and analyze policy alternatives**
- **Econometrically assess the relationship between state economic performance and specific policies and programs that affect the CEEI**