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Optimal pathways to net-zero emissions

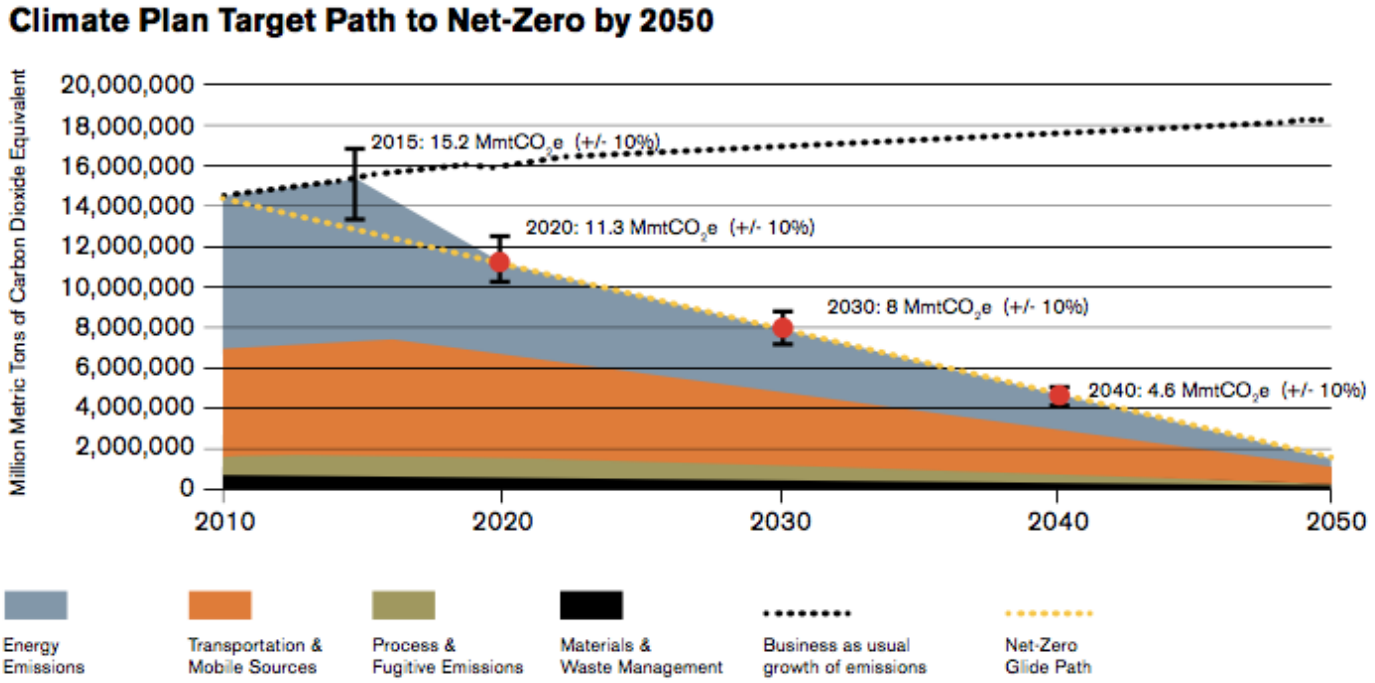
A study of Austin, Texas

Max Brozynski
Ph.D. Student
Graduate Program in Operations Research and Industrial Engineering
Department of Mechanical Engineering
The University of Texas at Austin

Austin, Texas

Austin Community Climate Plan

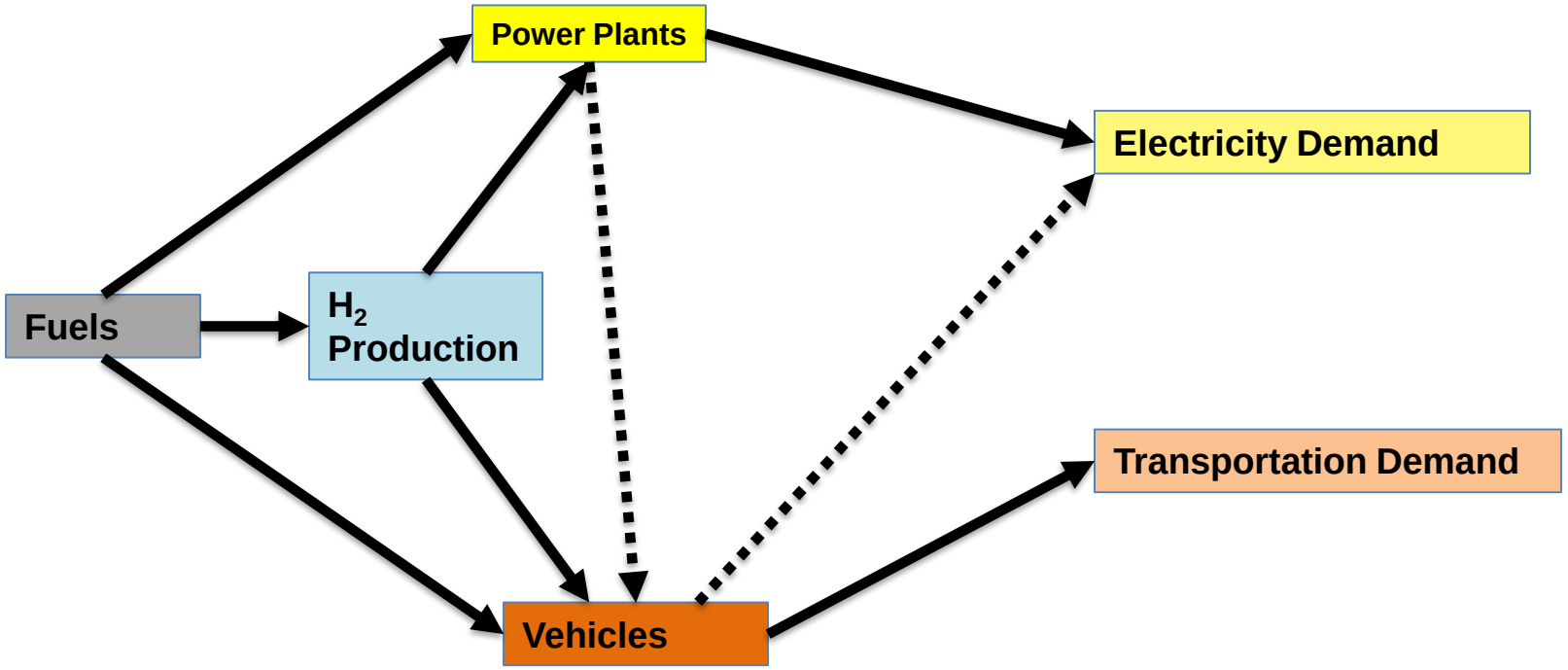
- In 2014, Austin City Council adopted Resolution No. 20150604-048, the **Austin Community Climate Plan** setting a goal of net-zero community-wide greenhouse gas emissions by 2050.



The questions we hope to answer

- How should we be generating electricity?
- What should our vehicle fleet mix look like?
- How expensive will this policy be?
- What synergies exist between the electricity demand and the transportation demand sectors?
- Will hydrogen play a role?
- How should this energy system be modeled?
- Optimal pathways

Techno-economic modeling framework



- Different technologies produce different outputs
- Links exist between sectors

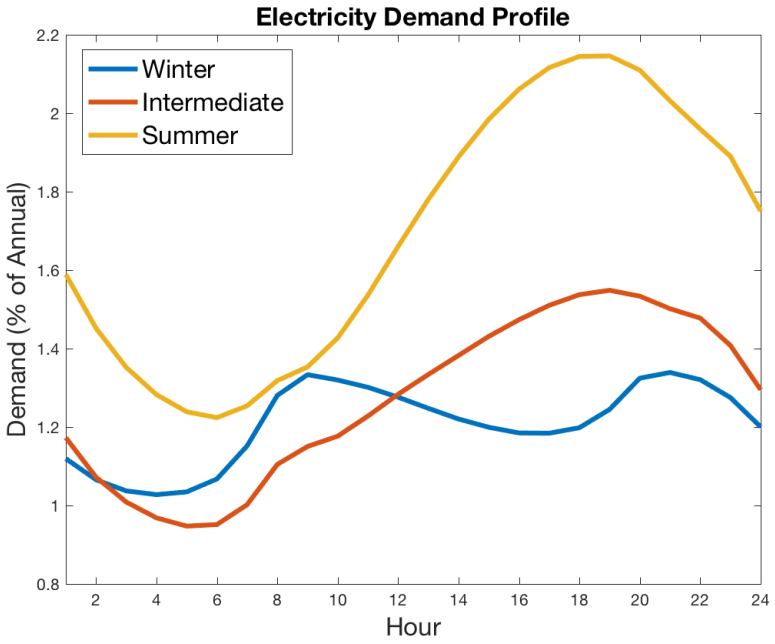
OSeMOSYS (Open Source Energy Modeling System)

- Minimize NPV of Total Costs
  - Subject to:
    - Capacity adequacy
    - Energy balance
    - Lower and upper bound constraints
    - Emissions activity
- Implemented as a linear program (LP) in GAMS
- Solved by CPLEX

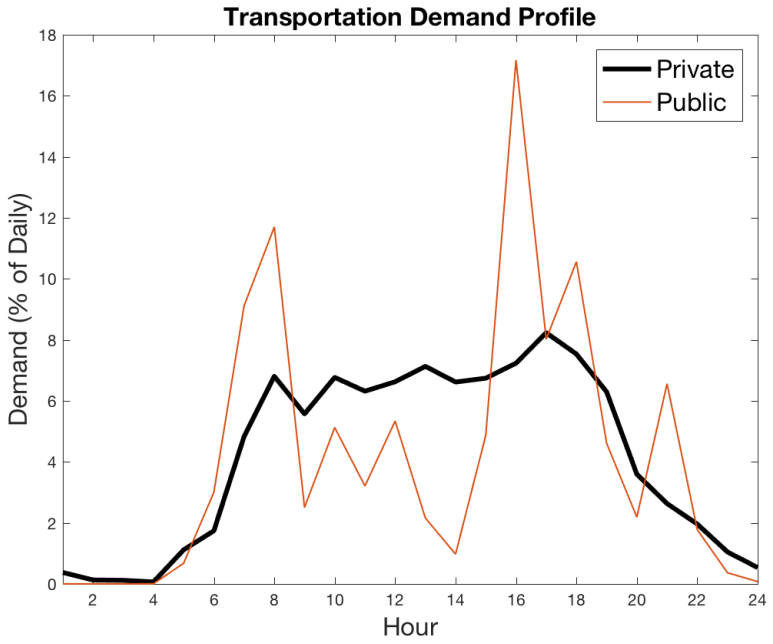
Customization

- Our implementation includes:
  - Increased resolution by hourly timeslices for three representative seasons for both transportation and electricity
  - Transportation treated as non-dispatchable demand with hourly demand profile
  - Demand response
  - Storage technologies to mitigate the duck curve
  - V2G

Demand Profiles for Electricity & Transportation



Source: ERCOT Hourly Load

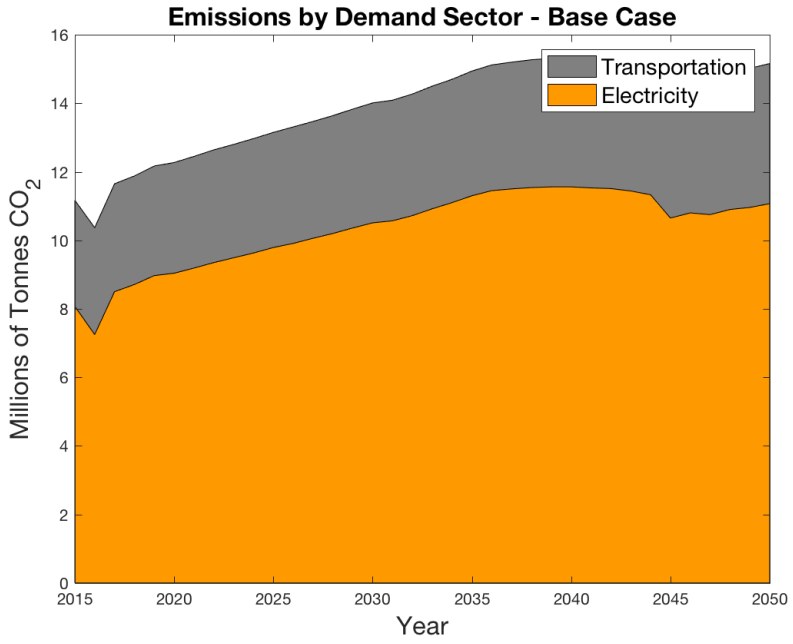


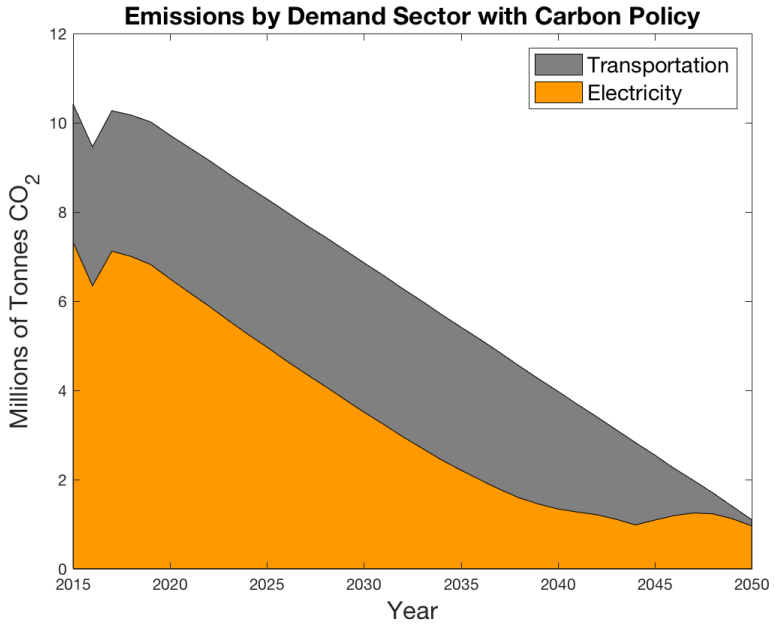
Source: NHTS Data

Model Results

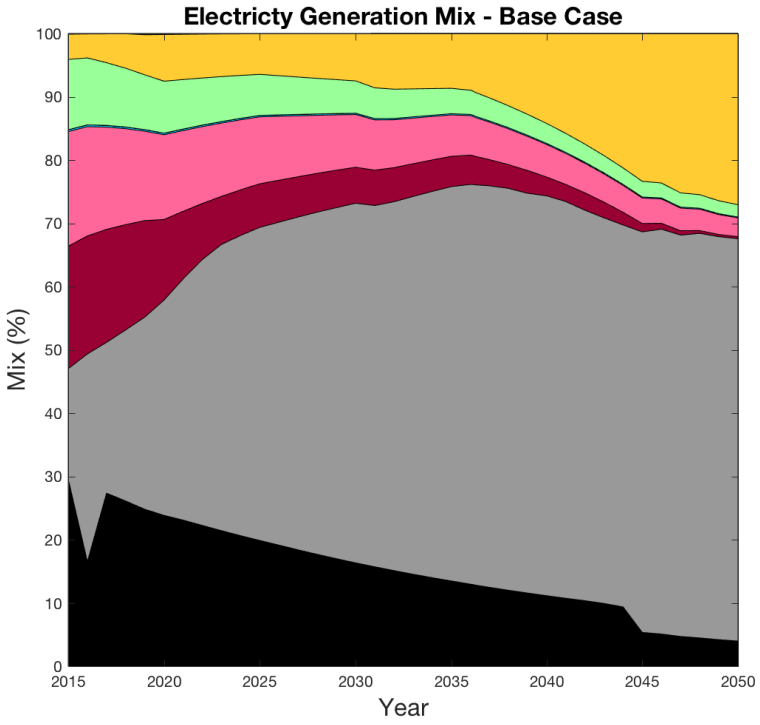
- Base Case: no carbon policy
- CO_2 Policy Cases: achieve **10% (**8%, 6%, 4%, 2%) of 2015 base case emissions by year 2050
- We compare the following for the Base Case and 10% Policy case:
  1. Emissions by sector to year 2050
  2. Electricity generation by technology to year 2050
  3. Vehicle fleet mix to year 2050
- Finally, how sensitive are costs to these small variations in the 2050 target?

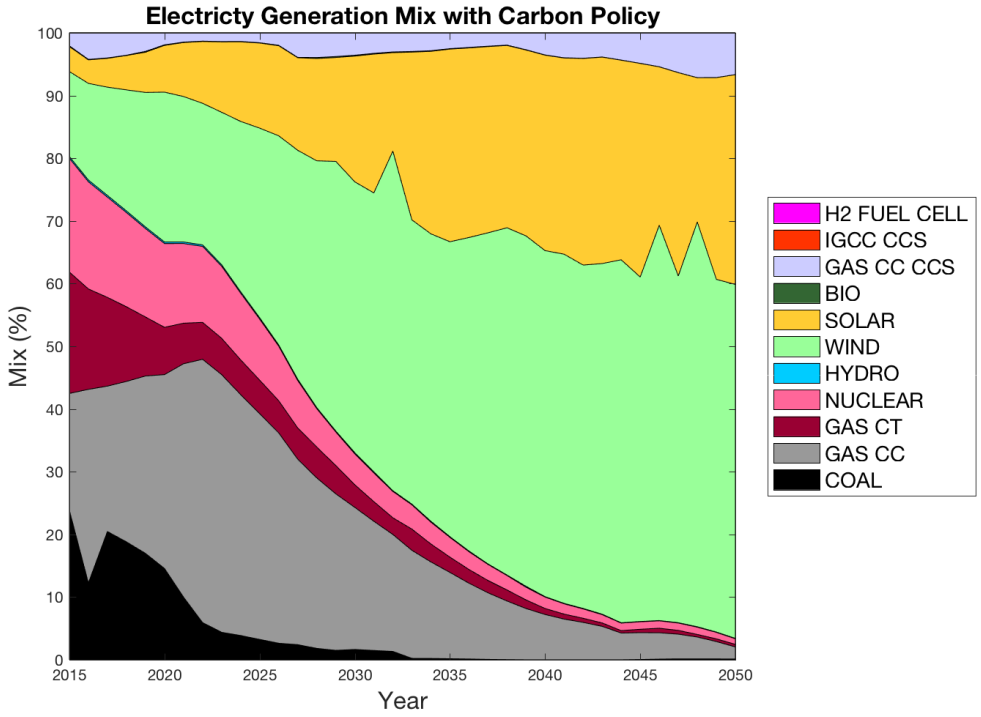
Emissions


Emissions by Demand Sector - Base Case
Transportation
Electricity
Millions of Tonnes CO_2
Year
0
2
4
6
8
10
12
14
16
2015
2020
2025
2030
2035
2040
2045
2050

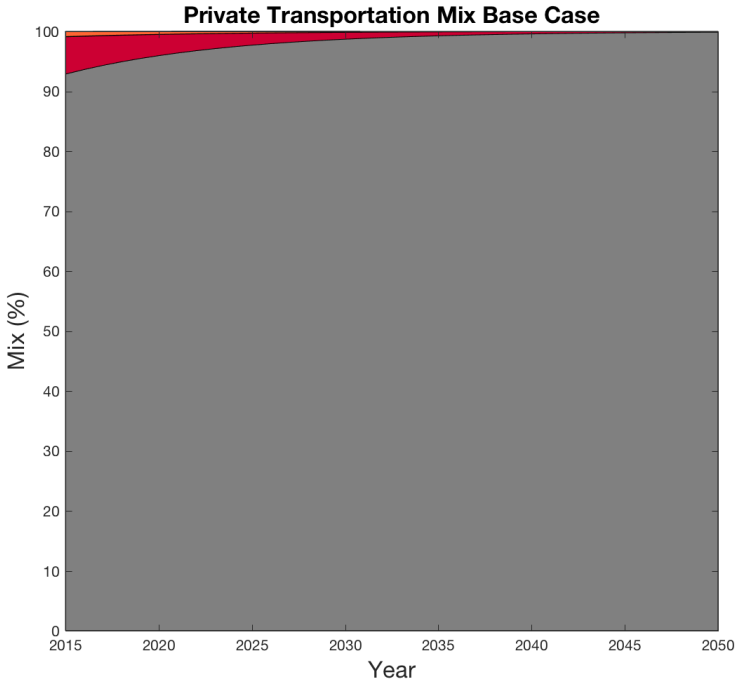

Emissions by Demand Sector with Carbon Policy
Transportation
Electricity
Millions of Tonnes CO_2
Year
0
2
4
6
8
10
12
2015
2020
2025
2030
2035
2040
2045
2050

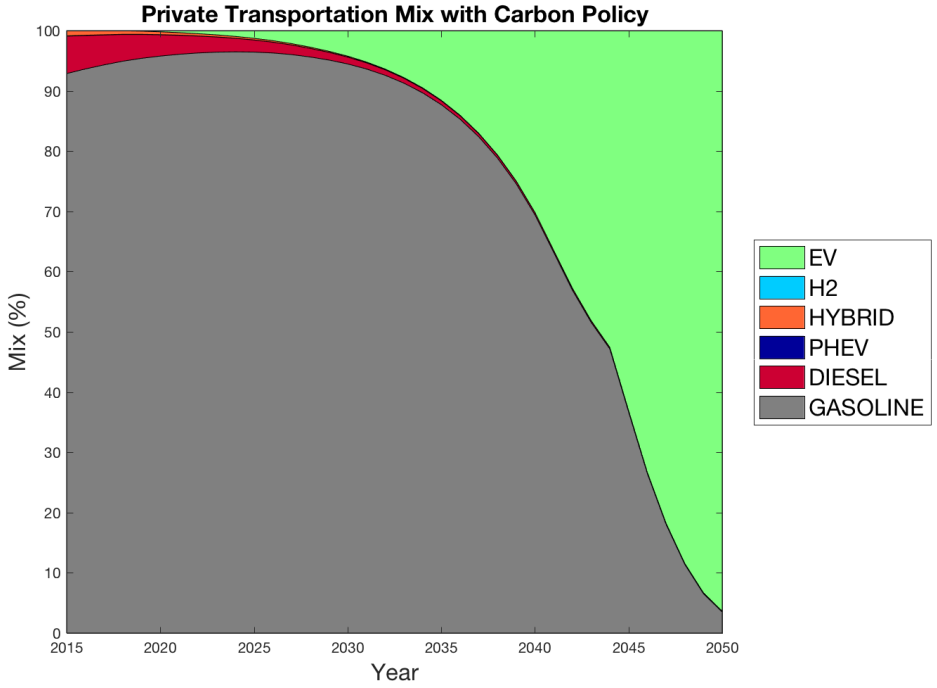
Electricity Generation





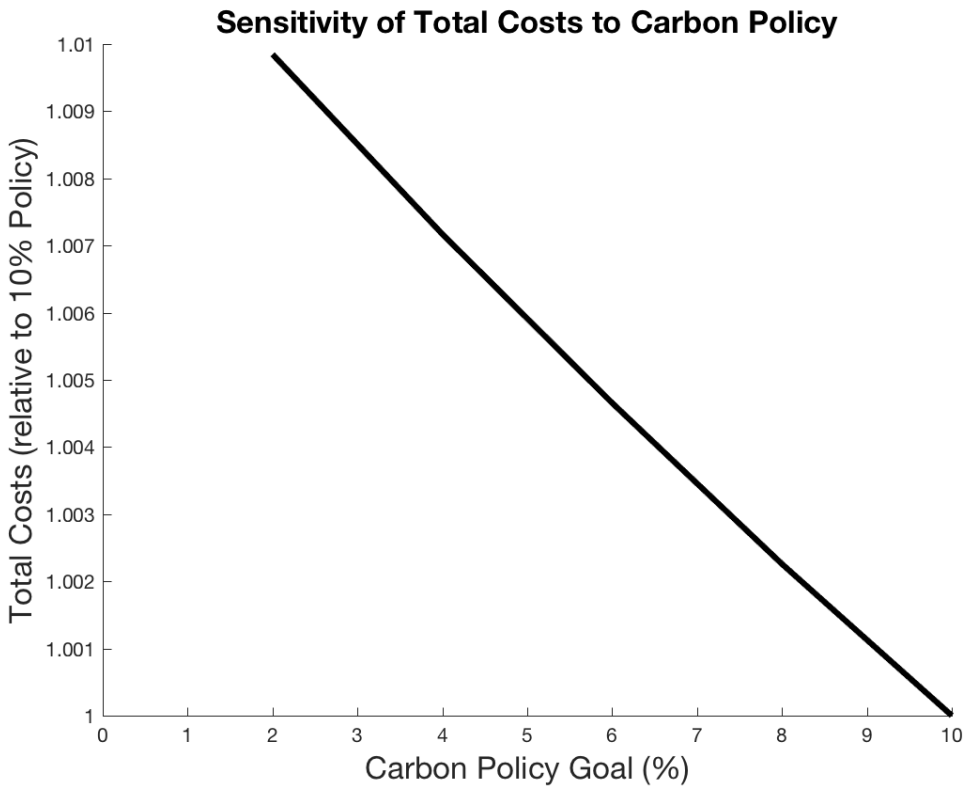
Transportation Mix





Cost sensitivity to CO_2 Policies

Policy	Cost (Rel. to Base)
None	1
10%	1.056
8%	1.059
6%	1.061
4%	1.064
2%	1.067



Takeaways

- As predicted by the literature, we see that power is the first sector to decarbonize
- In the last ten years of the model, however, the decrbonization strategy switches to transportation
- Solar and wind dominate in the policy case with some activity by CCS technologies
- Electric vehicles are brought into the fleet mix after the initial stock of ICEs depreciates

Future work

- Model demand for individual services & end-use technologies that enable us to capture the effects of efficiency improvements and fuel switching
- Explore shared and autonomous vehicle fleets that *can* be dispatched by a central planner
- Consider a full inventory of emissions
- Introduce a detailed analysis of the physical layout of the city, to include individual buildings, evolving urban form

The End

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The University of Texas at Austin
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