Decarbonizing power and transportation at the urban scale

An analysis of the Austin, Texas Community Climate Plan

**Dr. Benjamin D. Leibowicz**
Assistant Professor, The University of Texas at Austin

**Coauthor:**
Max T. Brozynski (The University of Texas at Austin)
Summary

• We develop an energy system optimization model to identify least-cost decarbonization pathways for the power and transportation sectors at the urban scale.
• Apply it to study the Austin, Texas Community Climate Plan.
• We find that the policy raises net present power and transportation costs by 2.7% relative to a no policy case.
• The optimal decarbonization pathway has two stages: first decarbonize electricity, then electrify transportation.
• Battery storage and coordinated EV charging play key roles.
Cities and Climate Change

• Many cities around the world are enacting ambitious plans to reduce GHG emissions at the urban scale.

• The C40 Cities Climate Leadership Group committed to limiting global warming to 1.5°C has expanded its membership to 96 cities that encompass 25% of global GDP.
Cities and Climate Change

• In March 2018, the IPCC held a first Cities and Climate Change Science Conference to reflect the growing importance of cities for mitigating and adapting to climate change.

• Rigorous analysis and tools to inform city climate policies are largely lacking, and critical knowledge gaps remain.
OSeMOSYS

• For this study, we develop a customized formulation of the Open Source Energy Modeling System (OSeMOSYS) in GAMS.
• OSeMOSYS selects the least-cost pathway of capacity investments and operational variables over time, to meet exogenous demands while satisfying a host of constraints.
We introduce six notable structural modifications:

1. Make vehicles non-dispatchable
2. Detailed representation of vehicle-to-grid (V2G) storage
3. Endogenous capacity scale-up rate constraints
4. Ensure adequate generation capacity under extreme conditions
5. Multiple levels of demand response
6. Ability to purchase carbon offsets up to some maximum quantity
Austin, Texas

- The Austin metro area has a population of 2 million that is growing at four times the rate of the U.S. as a whole.
- It is a member of the C40 network, and in 2015 it enacted the ambitious Community Climate Plan to achieve net-zero citywide GHG emissions by 2050.
Austin, Texas

2010 GHG Inventory

Austin Community Climate Plan (ACCP)
Demand Profiles

(a) Electricity Demand Profile
(b) Transportation Demand Profile
Results: Policy Cost

- The climate plan (with a 10% offset allowance) results in a fairly moderate 2.7% increase in net present power and transportation costs relative to the no policy case.
- The policy cost increases as the offset allowance is reduced.
Results: Emissions

- Electricity will eventually start to decarbonize even without a policy stimulus, but this is not true of transportation.
- The optimal decarbonization pathway first shifts electricity to renewables, then electrifies transportation.
Results: Electricity Generation

- In the baseline, generation first shifts strongly toward natural gas, then toward solar PV based on favorable cost projections.
- Under the climate plan, wind mostly replaces gas as a complement to solar PV, and fossil fuel use decreases faster.
Results: Private Transportation

- Alternative fuel vehicles do not make inroads into the private vehicle mix without a policy stimulus.
- The climate plan induces gradual but persistent electrification, especially in the later years with a cleaner power sector.
Results: Public Transportation

- In contrast to private cars, the bus fleet is insensitive to the policy context, with biodiesel the technology of choice.
- Capital cost differentials are higher here, so limited carbon offset purchases are allocated to buses with high priority.
Results: Dispatch

- Solar-heavy generation requires a lot of battery storage, which charges during the day and discharges at night.
- Optimal EV charging occurs during the day to align with solar, suggesting that workplace charging infrastructure is crucial.
Results: Two Additional Scenarios

1. Significant modal shift from private to public transportation
   • There are no major changes in technology mixes, but the higher occupancy and efficiency of public transportation reduces system costs.

2. Higher EV capital costs due to charging infrastructure
   • This causes hybrid vehicles to comprise part of the private vehicle mix, though in small numbers relative to EVs. The policy cost increases.
Conclusions

• The climate plan (with a 10% offset allowance) results in a fairly moderate 2.7% increase in net present power and transportation costs relative to the no policy case.

• The policy cost increases as the offset allowance is reduced, but offsets continue to be purchased even at very high prices.

• The optimal decarbonization pathway first transitions electricity to renewables, then electrifies transportation.

• Battery storage will be critically important, and infrastructure should enable daytime EV charging using solar power.
Extension to Building Energy Services
The 35 MW Webberville solar farm sells power to Austin Energy through a PPA.