Electric Vehicle Penetration: Should we subsidize the chicken or the egg?

Christopher Knittel

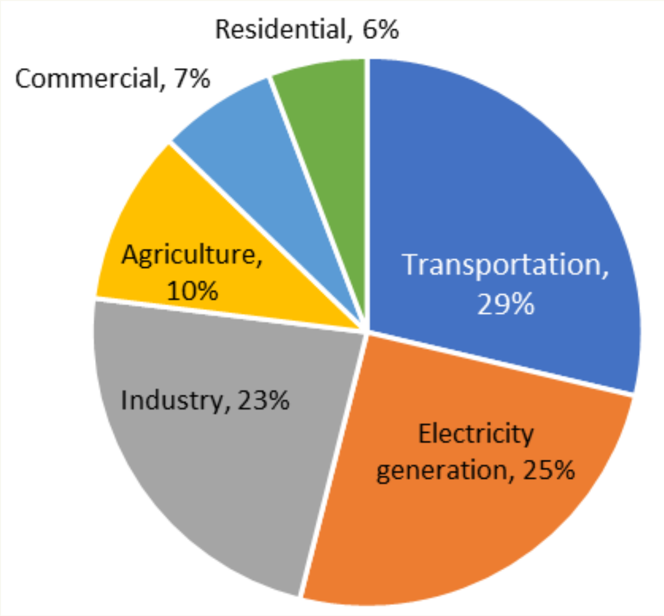
George P. Shultz Professor of Energy Economics, Sloan

Deputy Director for Policy, MITEI

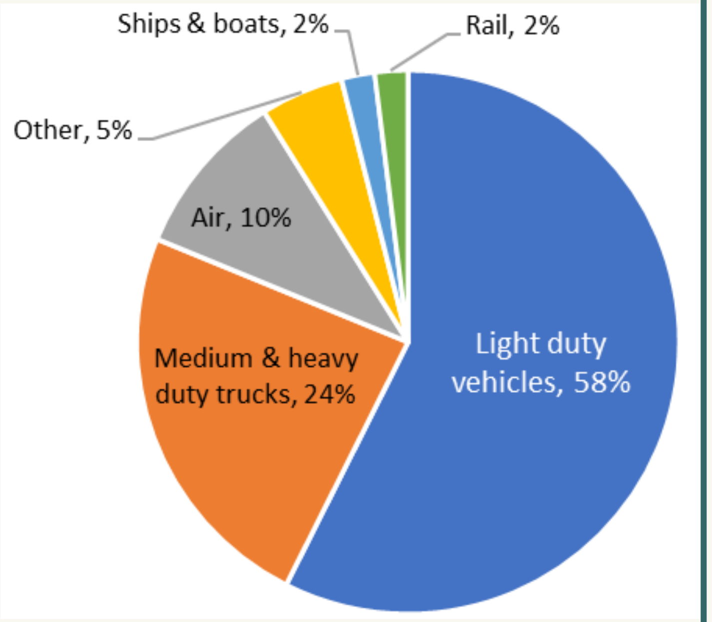
Director, MIT Center for Energy and Environmental Policy Research

Background

US GHG Emissions by Sector, 2019



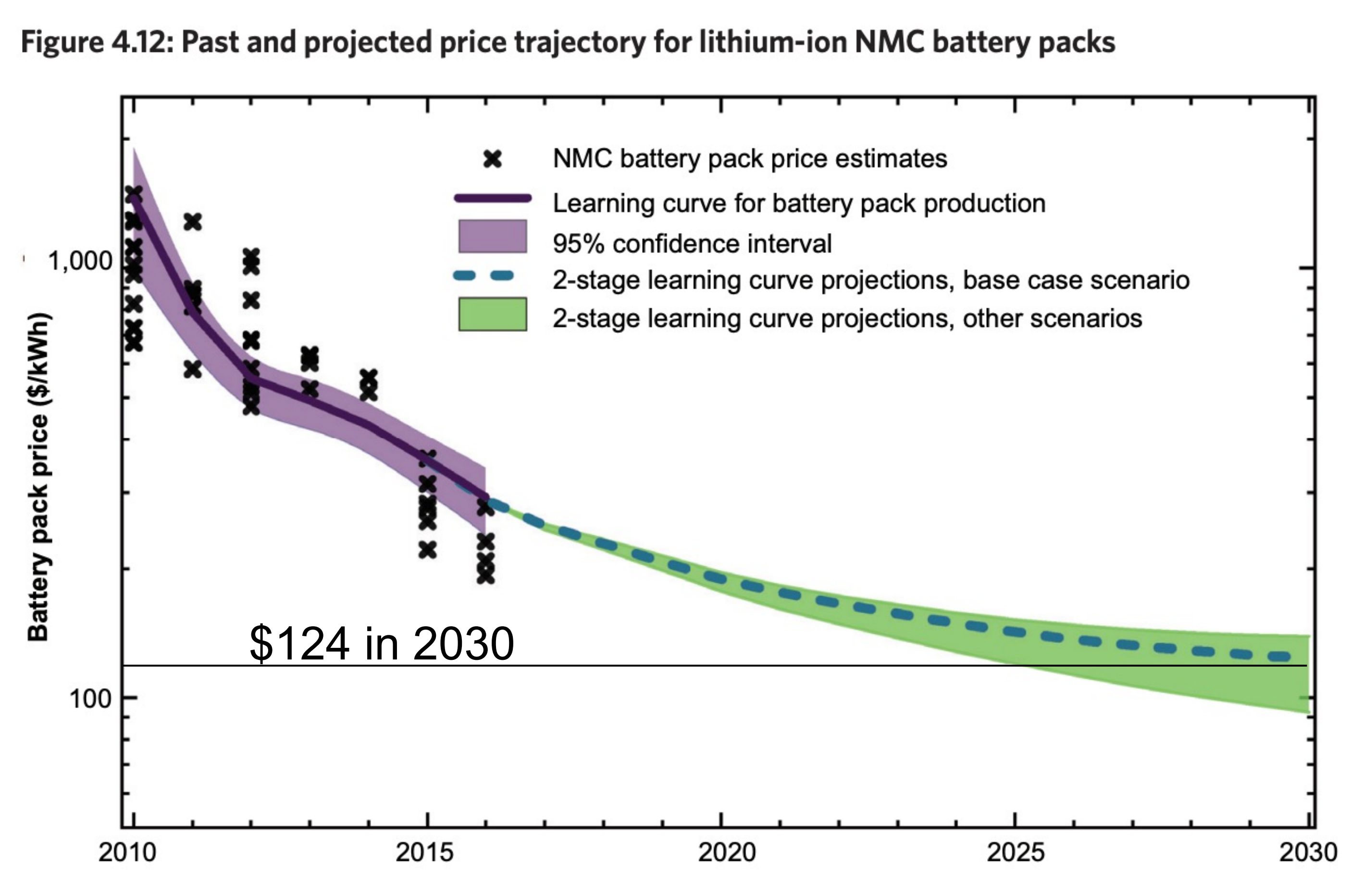
US Transport CO2 Emissions by Mode, 2019



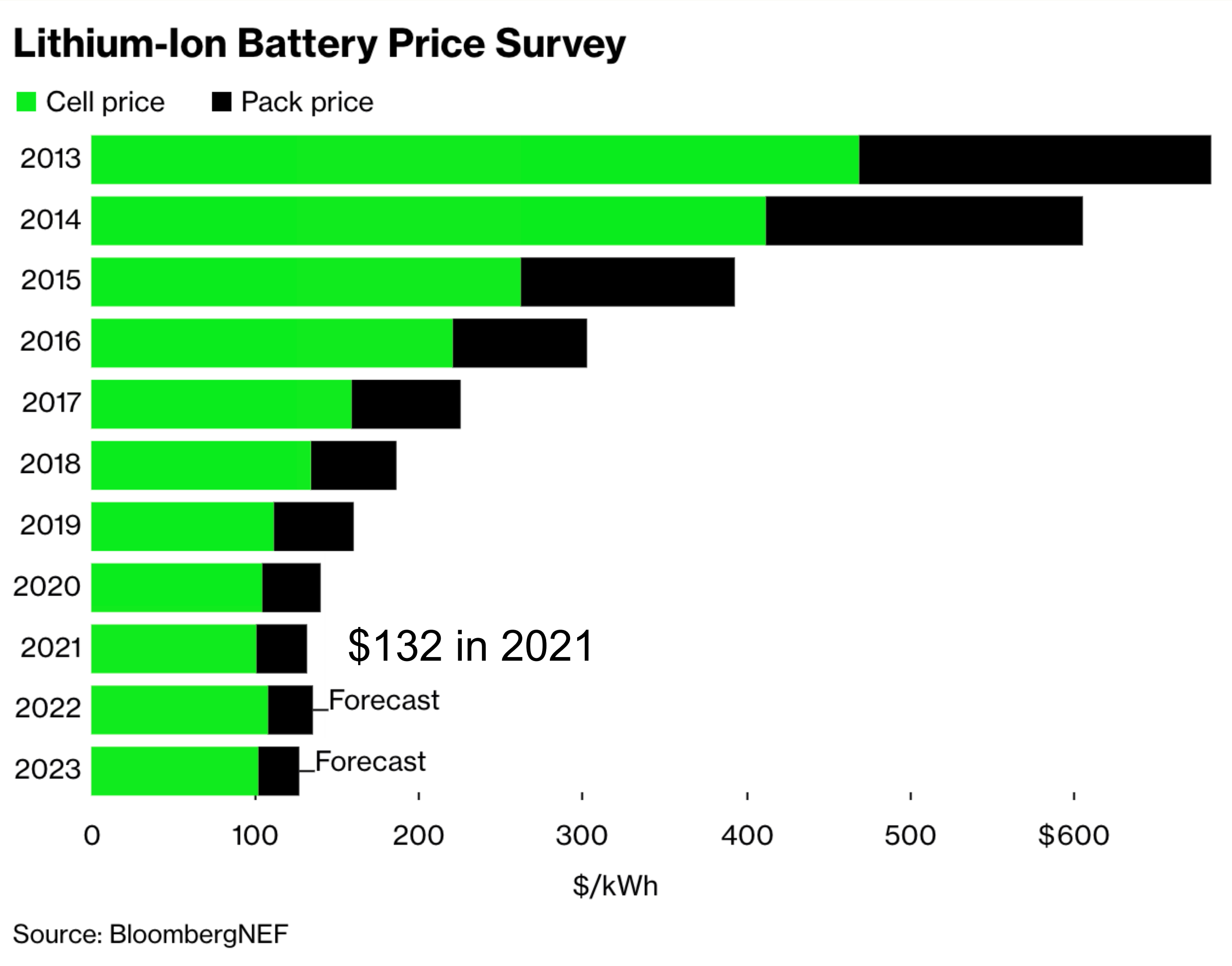
Sources: EPA Greenhouse Gas Inventory, EIA AEO 2021

Background

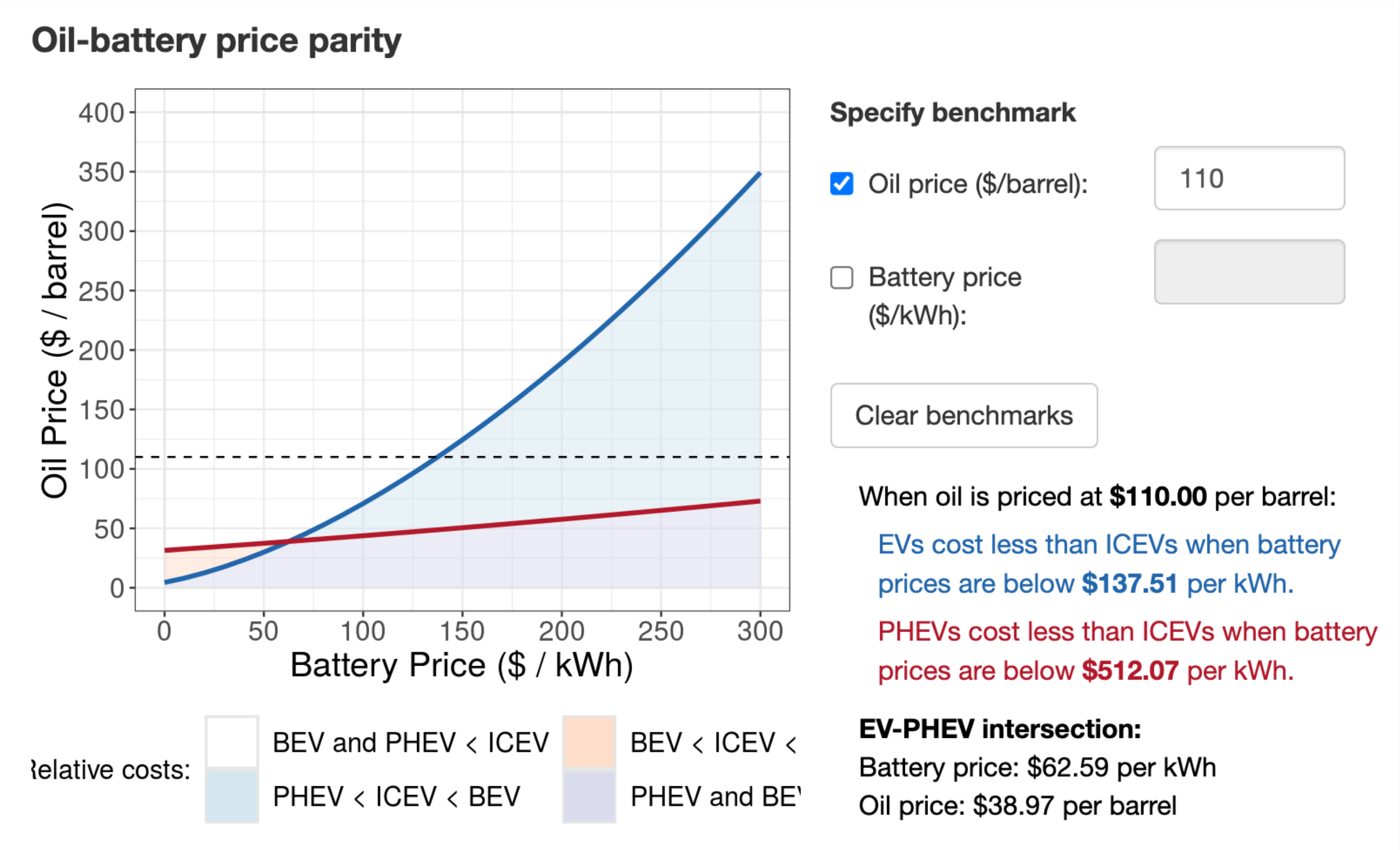
- Battery costs have fallen tremendously

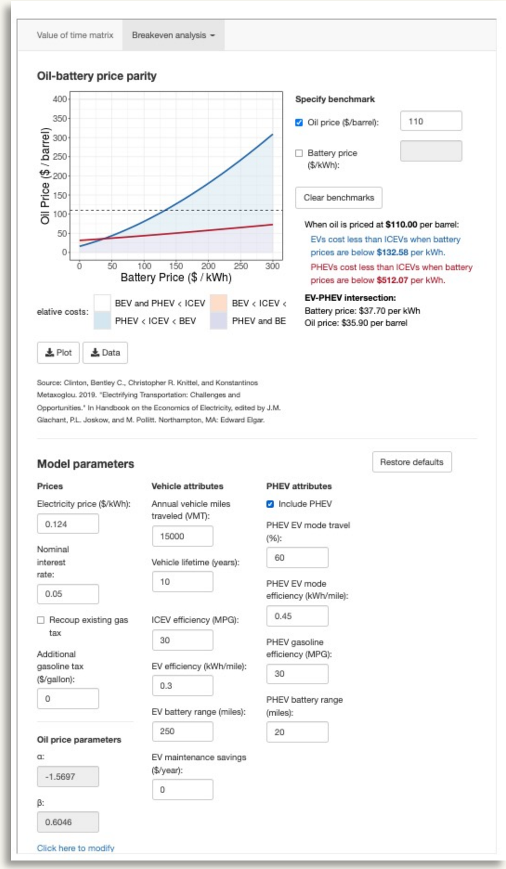


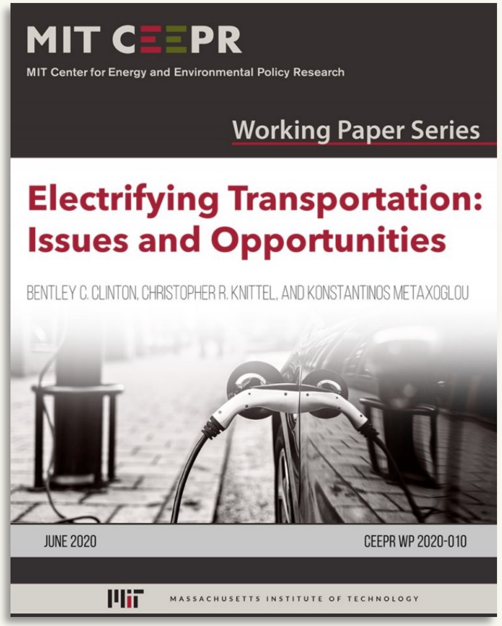
More recent data



Parity or close to parity







Specific example

	2021 Ford Transit	2022 Ford e-Transit
Ford transit cargo van, medium roof, regular length, 9500 GVWR payload package	3.73 limited slip axel, 10 spd auto transmission	67kWh battery, 108 mi range
MSRP	**$38,945**	**$48,280**
one-time L2 installation cost	$0	$2,000
Fuel efficiency	15 mpg	1.6 mi/kWh
Total annual energy	1,460 gal	13,550 kWh
Annual energy cost	$3,786	$1,355
Annual maintenance	$1,172	$600
Lifetime fuel & maintenance (NPV)	**$22,537**	**$8,887**
Full user cost (NPV)	**$61,482**	**$59,167**

Sources: Ford Build & Price Web tool; *Car and Driver*; Edmunds.com; Green Car Reports; Forbes; EIA accessed July 10-11, 2021. Assumes 70 mi/day, 312 days/year, 5 year lifetime, 5% interest rate; 2021 dollars.

The Chicken-and-Egg Problem

- EVs need charging stations and charging stations need EVs
  - Classic "Network Externality" Problem
  - Exists in lots of places: software/hardware, platforms, etc.
  - **Key results:** You can get "stuck" in a bad equilibrium

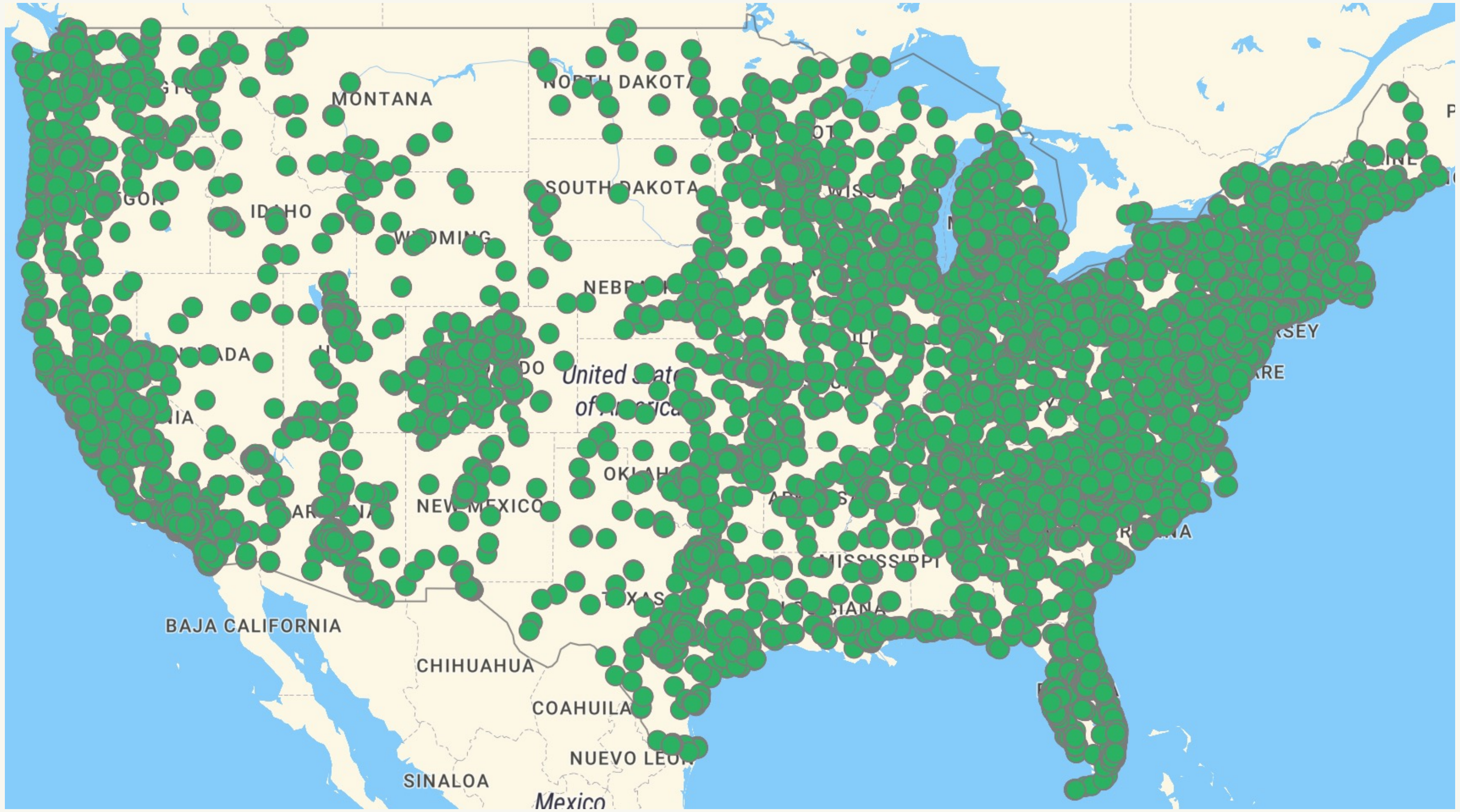
- Big question for policy makers:
  - The optimal policy is to subsidize the chicken, the egg, or both
  - The right mix depends on consumer behavior

You don't always get stuck

- Some have noted that we didn't subsidize gas stations back in the day (actually we did, and we do)
  - 1. Don't always get stuck
  - 2. Weren't worried about climate change back then

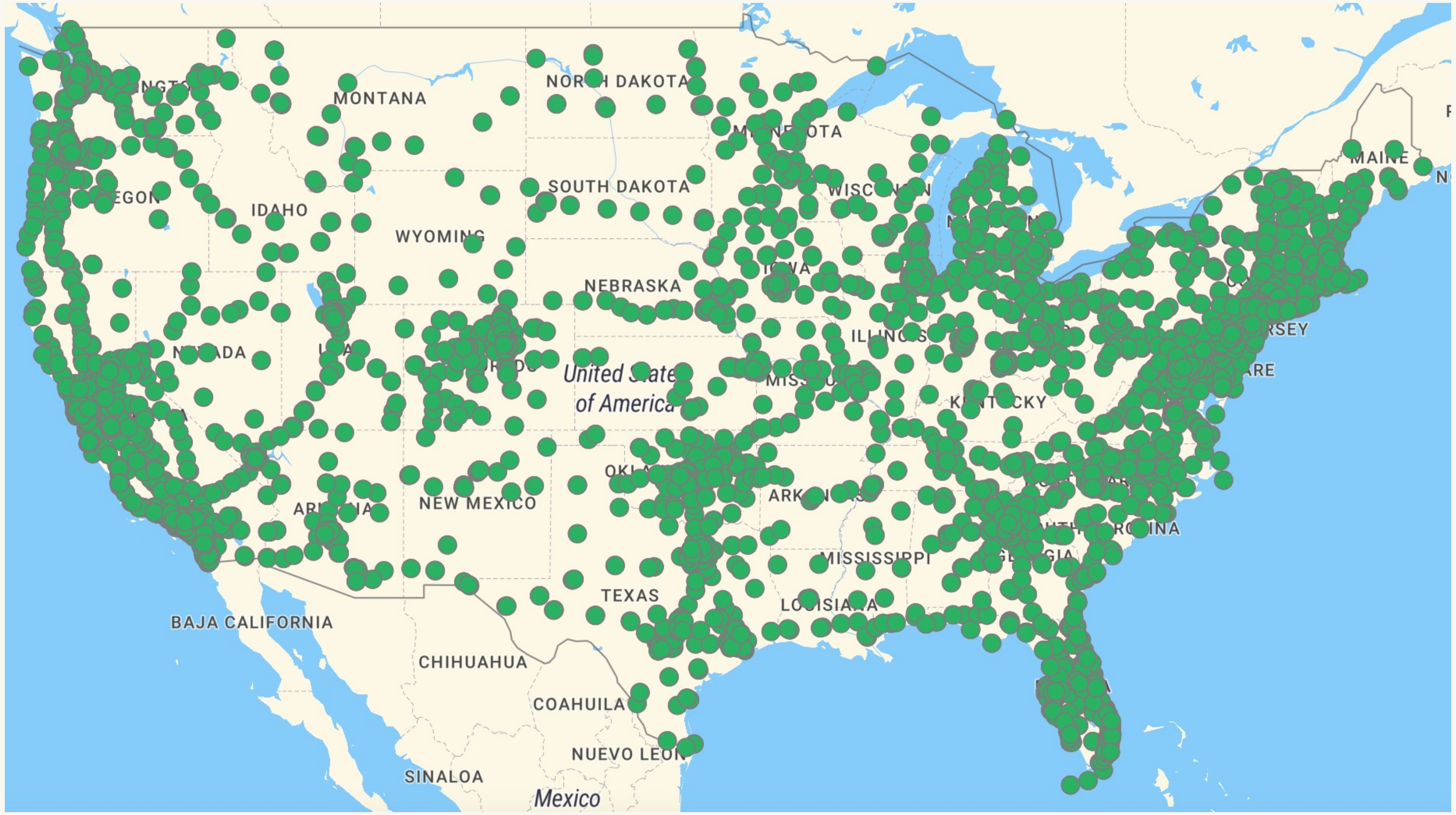
Existing charging stations

- Public Level 2: your dryer plug, 5-7 hours to fully charge
  - Lots! 42,000 plugs



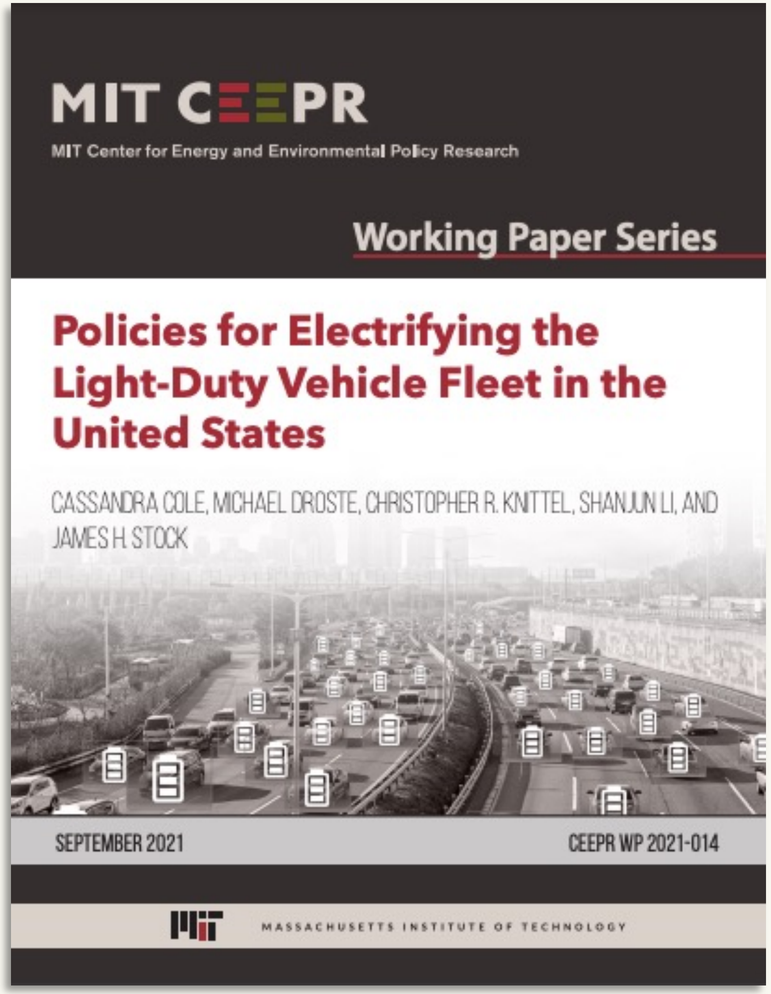
Existing charging stations

- Public Level 3: your dryer plug, 30 minutes to 80% charge
  - Lots! 6,100 plugs (MA has roughly 6,000 gas pumps)



Subsidize the chicken? Subsidize the egg?

- The Biden Administration has announced a goal of 50% EVs by 2030
  - Can we get there?
  - Are we thinking of the right mix of subsidies?
- We specify a consumer choice model and a cost of building charging stations to analyze what set of policies can get us there



https://ceepr.mit.edu/wp-content/uploads/2021/09/2021-014.pdf

Basic idea

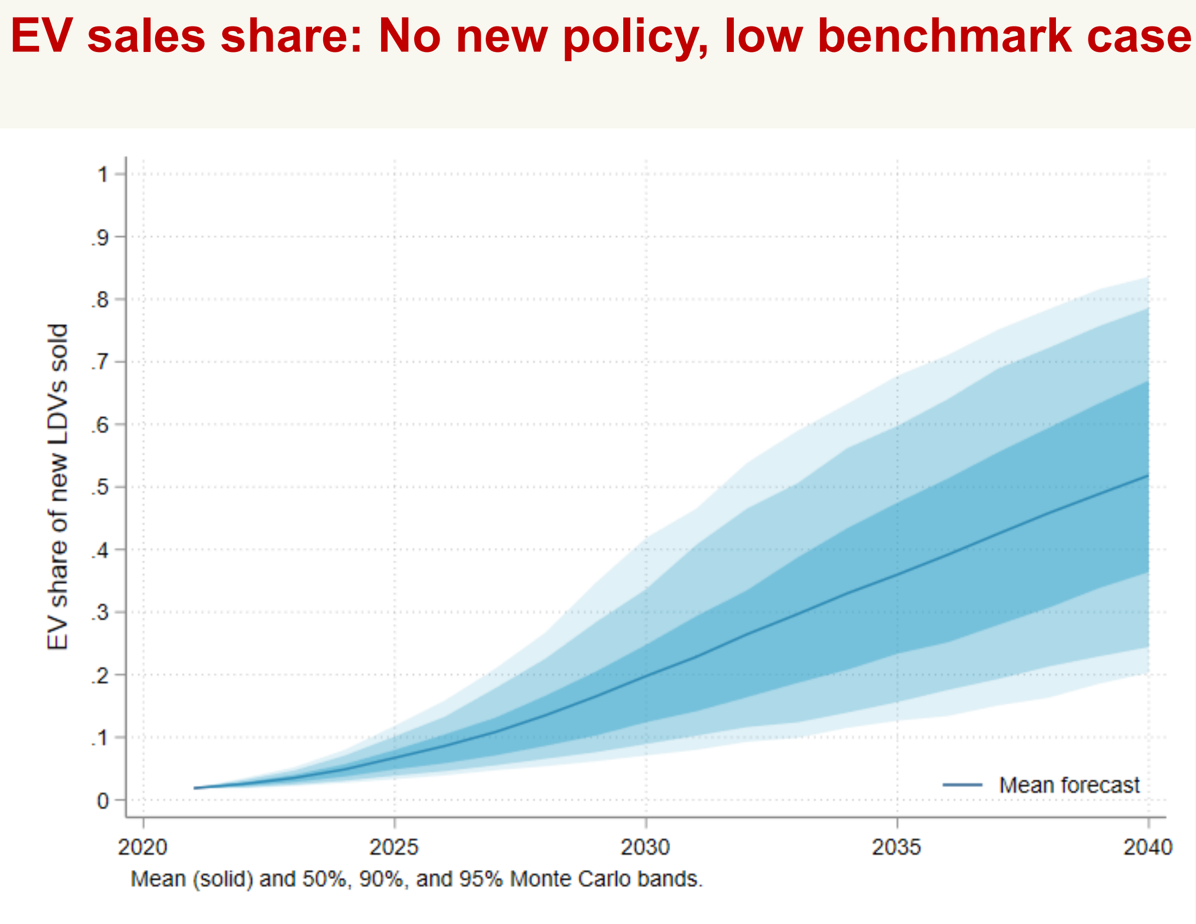
- Long literature in economics studying how consumers make vehicle choices
  - Key references: Zhou & Li (2017, 2018), Springel (2020), Archsmith, Muehlegger, & Rapson (2021); also see Holland, Mansur, Yates (AEJ-EP forthcoming)
- Shorter, but growing, literature on the importance of level 2 and level 3 charging stations on the decision to buy EV v. ICE
- We rely on these empirical

- Engineering estimates of cost of Level 2 and Level 3 stations

What we do not do

- We do not "optimize" charger deployment or subsidies
  - Implicitly we are assuming they are placed in the same way as existing stations
  - *On-going work:* identify those places that are just "out of the money"
    - To help policy makers target subsidies better
- No regional heterogeneity
- Exogenous technological change
- No expectations

What would happen absent policy?



Policies considered

- We vary how much we subsidize stations and vehicles
- Lots of numbers here!

- Vary how much we subsidize stations costs from 0% to 85%
  - Different budgets
- Vary how much we subsidize vehicles from $3,900 to $10,000
  - Reduce after 2026
- ZEV or not, but with a cap

	Policies				
	Station cost share		EV sales rebate		ZEV permit price cap ($)
	Percent	Budget ($B)	2022 - 2025	2026+	
0	-	-	-	-	-
A1	0.67	7.5	-	-	-
A2	-	-	10,000	11,000	-
A3	0.67	7.5	10,000	11,000	-
A4	0.67	7.5	-	-	10,000
E1	0.67	7.5	6,000	3,900	-
E2	0.67	15.0	5,500	3,500	-
E3	0.70	25.0	5,000	3,250	-
E4	0.75	28.0	5,000	2,750	-
E5	0.80	30.0	4,600	2,400	-
E6	0.85	40.0	3,900	2,100	-
F1	0.67	7.5	6,000	3,900	10,000
F2	0.67	15.0	5,500	3,500	10,000
F3	0.70	25.0	5,000	3,250	10,000
F4	0.75	28.0	5,000	2,750	10,000
F5	0.80	30.0	4,600	2,400	10,000
F6	0.85	40.0	3,900	2,100	10,000

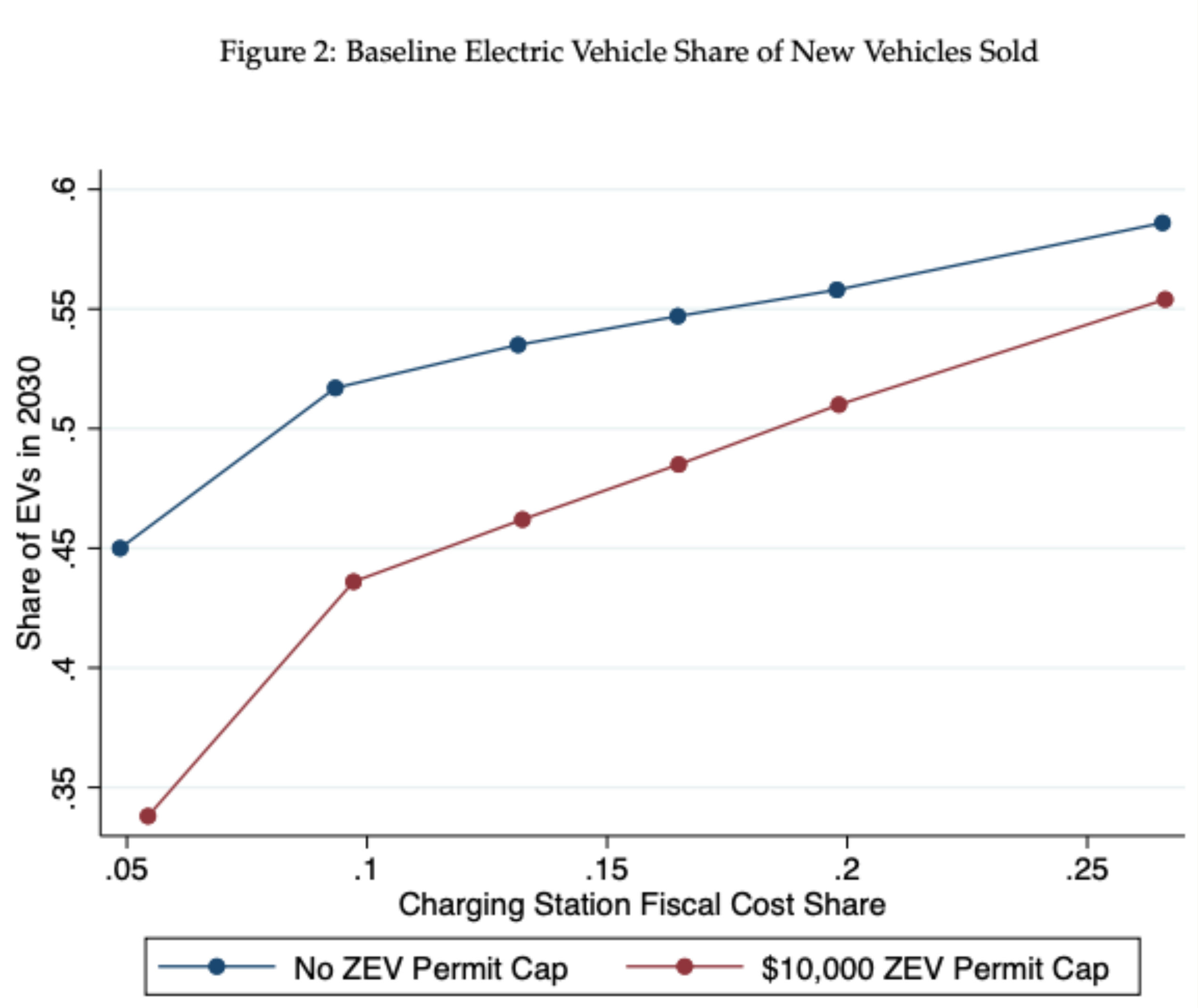
Can we get to 50%?

- Yes
- But infrastructure is key
- Notice that money is better spent on charging stations than on vehicles
  - (at least on the margin)

	Policies					EV share & Emissions	
	Station cost share		EV sales rebate		ZEV permit price cap ($)	EV Sales Share by 2030	ΔCO2 in 2030 (mmt)
	Percent	Budget ($B)	2022 - 2025	2026+			
0	-	-	-	-	-	0.199	-
A1	0.67	7.5	-	-	-	0.293	-28
A2	-	-	10,000	11,000	-	0.426	-46
A3	0.67	7.5	10,000	11,000	-	0.459	-75
A4	0.67	7.5	-	-	10,000	0.412	-44
E1	0.67	7.5	6,000	3,900	-	0.338	-44
E2	0.67	15.0	5,500	3,500	-	0.436	-55
E3	0.70	25.0	5,000	3,250	-	0.462	-59
E4	0.75	28.0	5,000	2,750	-	0.485	-66
E5	0.80	30.0	4,600	2,400	-	0.510	-74
E6	0.85	40.0	3,900	2,100	-	0.554	-87
F1	0.67	7.5	6,000	3,900	10,000	0.450	-57
F2	0.67	15.0	5,500	3,500	10,000	0.517	-64
F3	0.70	25.0	5,000	3,250	10,000	0.535	-67
F4	0.75	28.0	5,000	2,750	10,000	0.547	-73
F5	0.80	30.0	4,600	2,400	10,000	0.558	-79
F6	0.85	40.0	3,900	2,100	10,000	0.586	-90

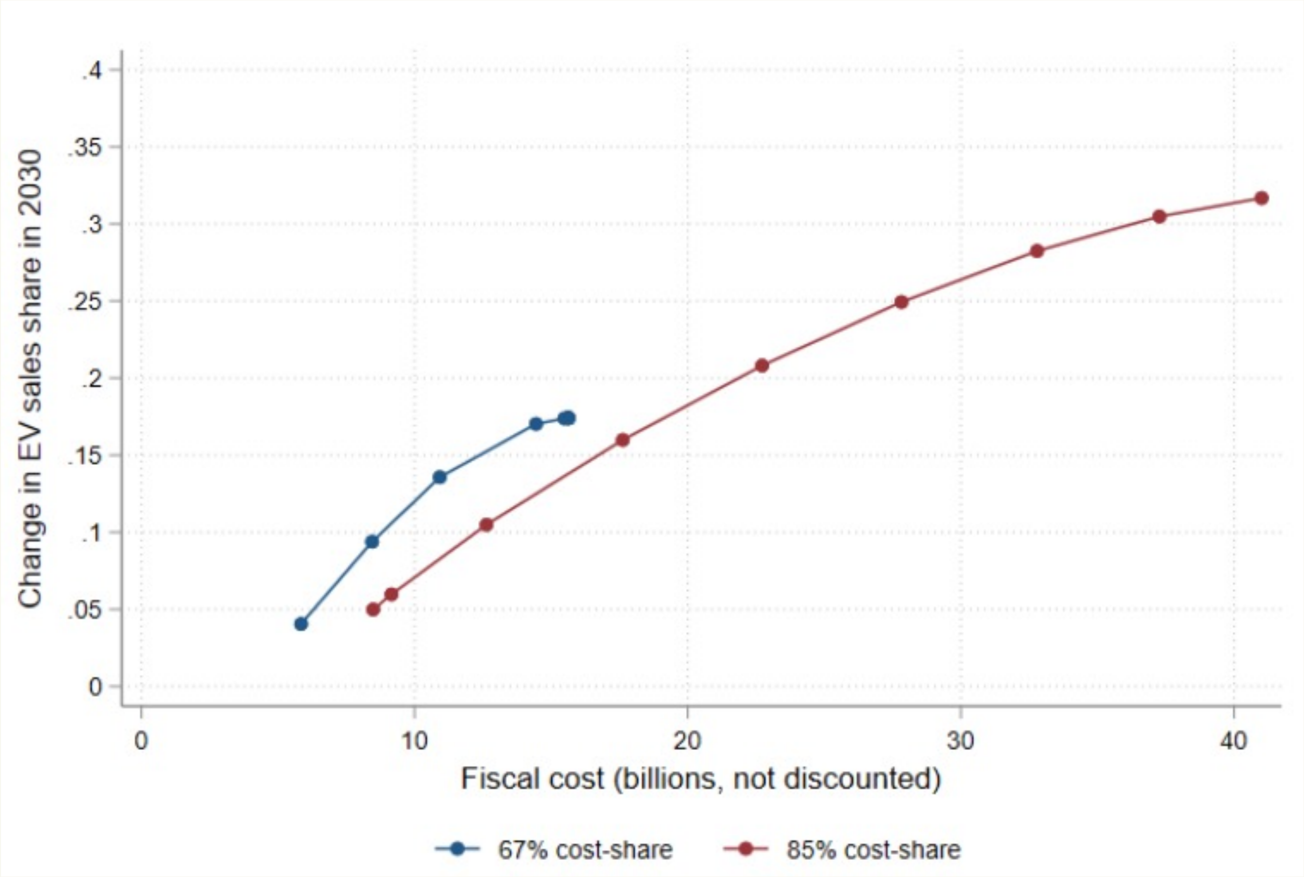
The biggest lesson

- Subsidize the egg!
- This graph holds fixed the amount of governmental expenditure
- But allocates a different share to charging stations
- =>Subsidizing charging stations is more effective



But, don’t go crazy

- Station subsidies are better spent spread out
- 67% subsidy is more effectives than 85% subsidy for a given budget
- 67% seems to be the sweet spot for budgets less than $20B (also topic of current work)



Lots more numbers

	Policies					EV share & Emissions		Fiscal costs ($B, not discounted)			
	Station cost share		EV sales rebate		ZEV permit price cap ($)	EV Sales Share by 2030	ΔCO2 in 2030 (mmt)	Total	Of which:		
	Percent	Budget ($B)	2022 - 2025	2026+					Chargers	Rebates	Inframarginal Rebates
0	-	-	-	-	-	0.199	-	-	-	-	-
A1	0.67	7.5	-	-	-	0.293	-28	8	8.4	-	-
A2	-	-	10,000	11,000	-	0.426	-46	347	-	347	154
A3	0.67	7.5	10,000	11,000	-	0.459	-75	457	8.9	448	144
A4	0.67	7.5	-	-	10,000	0.412	-44	9	8.7	-	-
E1	0.67	7.5	6,000	3,900	-	0.338	-44	158	8.6	149	63
E2	0.67	15.0	5,500	3,500	-	0.436	-55	160	15.6	145	56
E3	0.70	25.0	5,000	3,250	-	0.462	-59	158	20.9	137	51
E4	0.75	28.0	5,000	2,750	-	0.485	-66	158	26.0	132	45
E5	0.80	30.0	4,600	2,400	-	0.510	-74	156	31.0	125	39
E6	0.85	40.0	3,900	2,100	-	0.554	-87	158	42.2	116	32
F1	0.67	7.5	6,000	3,900	10,000	0.450	-57	178	8.6	169	63
F2	0.67	15.0	5,500	3,500	10,000	0.517	-64	174	16.2	157	56
F3	0.70	25.0	5,000	3,250	10,000	0.535	-67	170	22.4	148	51
F4	0.75	28.0	5,000	2,750	10,000	0.547	-73	167	27.4	139	45
F5	0.80	30.0	4,600	2,400	10,000	0.558	-79	162	32.1	130	39
F6	0.85	40.0	3,900	2,100	10,000	0.586	-90	162	43.0	119	32

Policy questions

- How best to spend the $7.5B in the BIL/IIJA?
  - ($5B specific to stations)
  - Goal is 500k **chargers** by 2030

- Several big issues:
  - Optimal placement of the chargers
    - Fill in local areas v. create corridors
  - Correct cost-sharing amount?
  - Need for up-time oversight?
  - Energy justice issues
  - Can utilities rate-base chargers?

Wrapping up

- Decarbonizing transportation is critical for climate goals
  - Light-duty sector likely the lowest hanging fruit

- Need to decide how much to focus on vehicles and stations

- Our results suggest focusing more on stations

- BIL provides $7.5B for stations ($5B earmarked), this likely isn't enough to hit 2030 targets, but target is feasible