Reducing Vehicle Pollution: The Role of Stock Turnover

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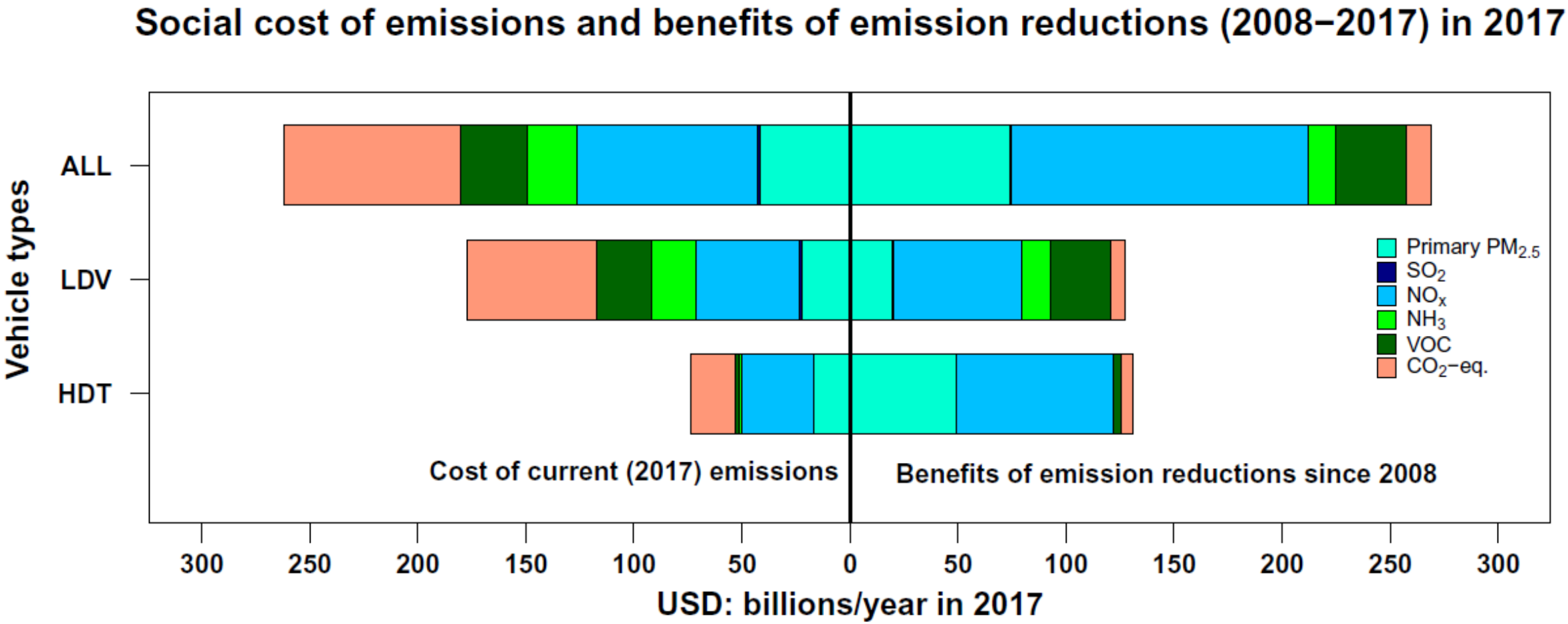
US transportation sector pollution



Source: Choma et al. (2021), *Proceedings of the National Academy of Sciences*

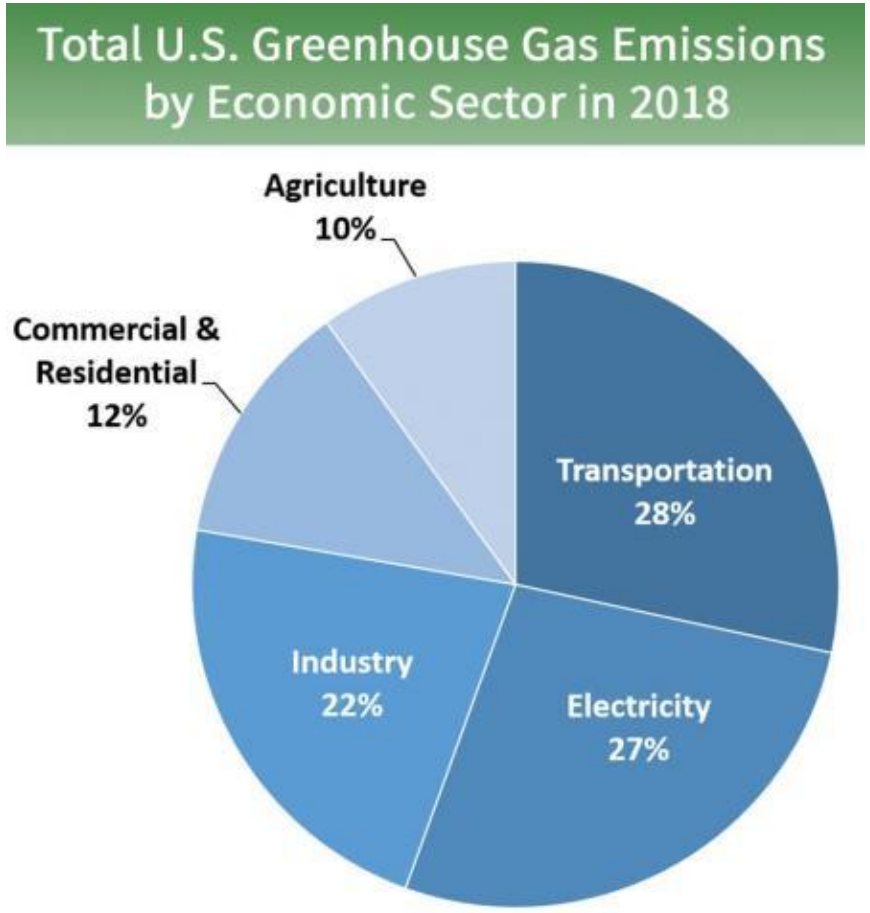
Biden Climate Goal

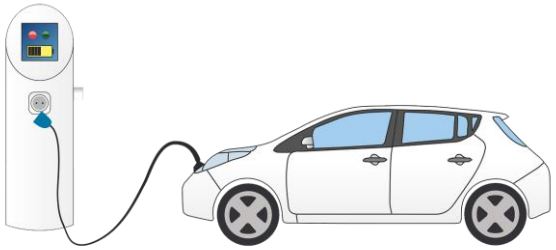
Reduce economy-wide net CO_2 emissions by 50-52% in 2030 relative to 2005 levels, which is equivalent to a 43% reduction relative to 1990 levels (White House 2021a)

A similar goal appears in the most recent Intergovernmental Panel on Climate Change (IPCC) report for limiting warming to 1.5 degrees C, which requires reducing global emissions by 40% below 1990 levels by 2030 and net-zero emissions by 2050 (White House 2021b).

Transportation is largest source of US GHG emissions.

Potential of Electric Vehicles (EVs) for reducing pollution





100% on road fleet of EVs

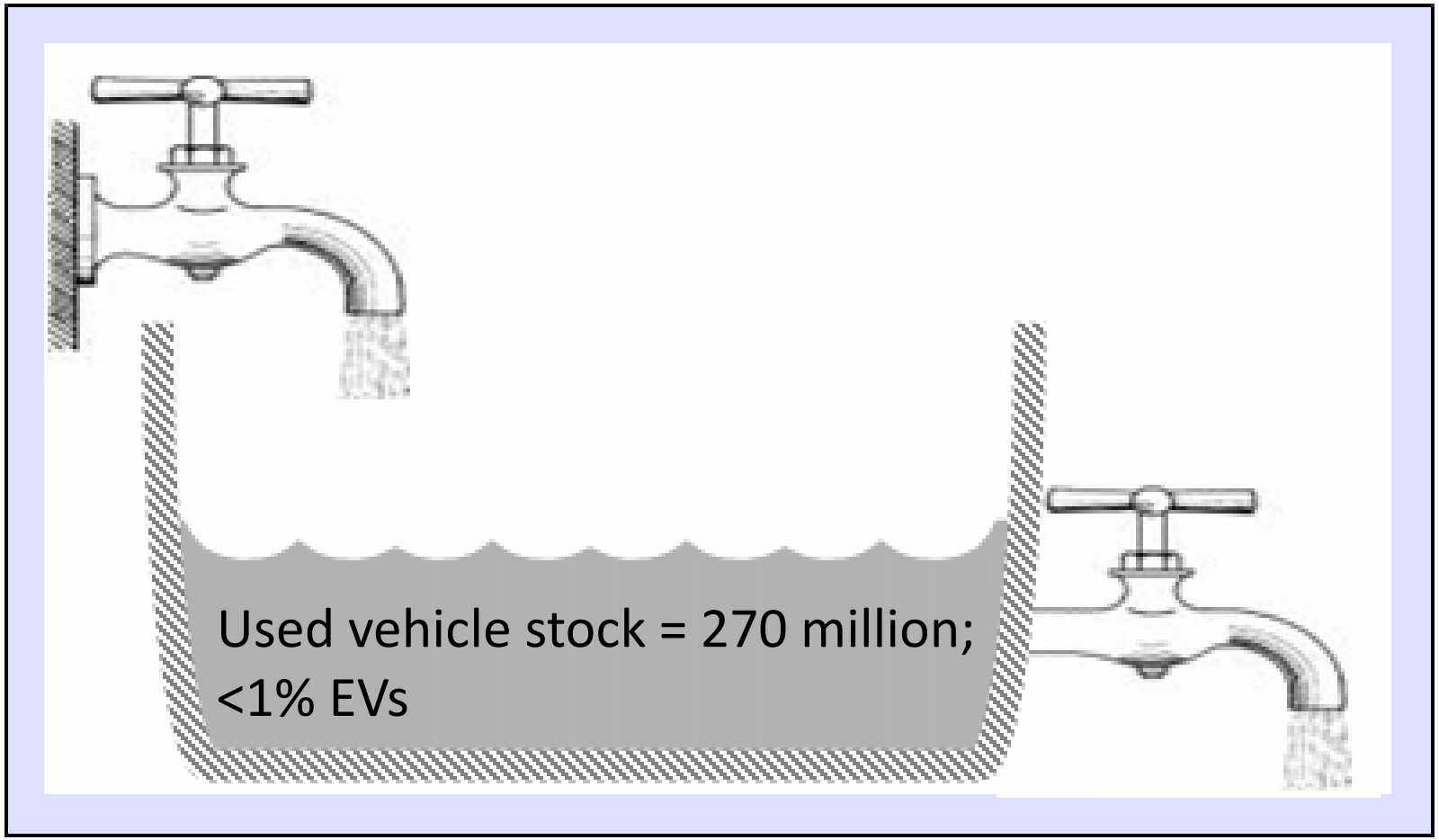
100% clean electricity

= Zero car, truck and electricity emissions

Stock turnover “bathtub” problem

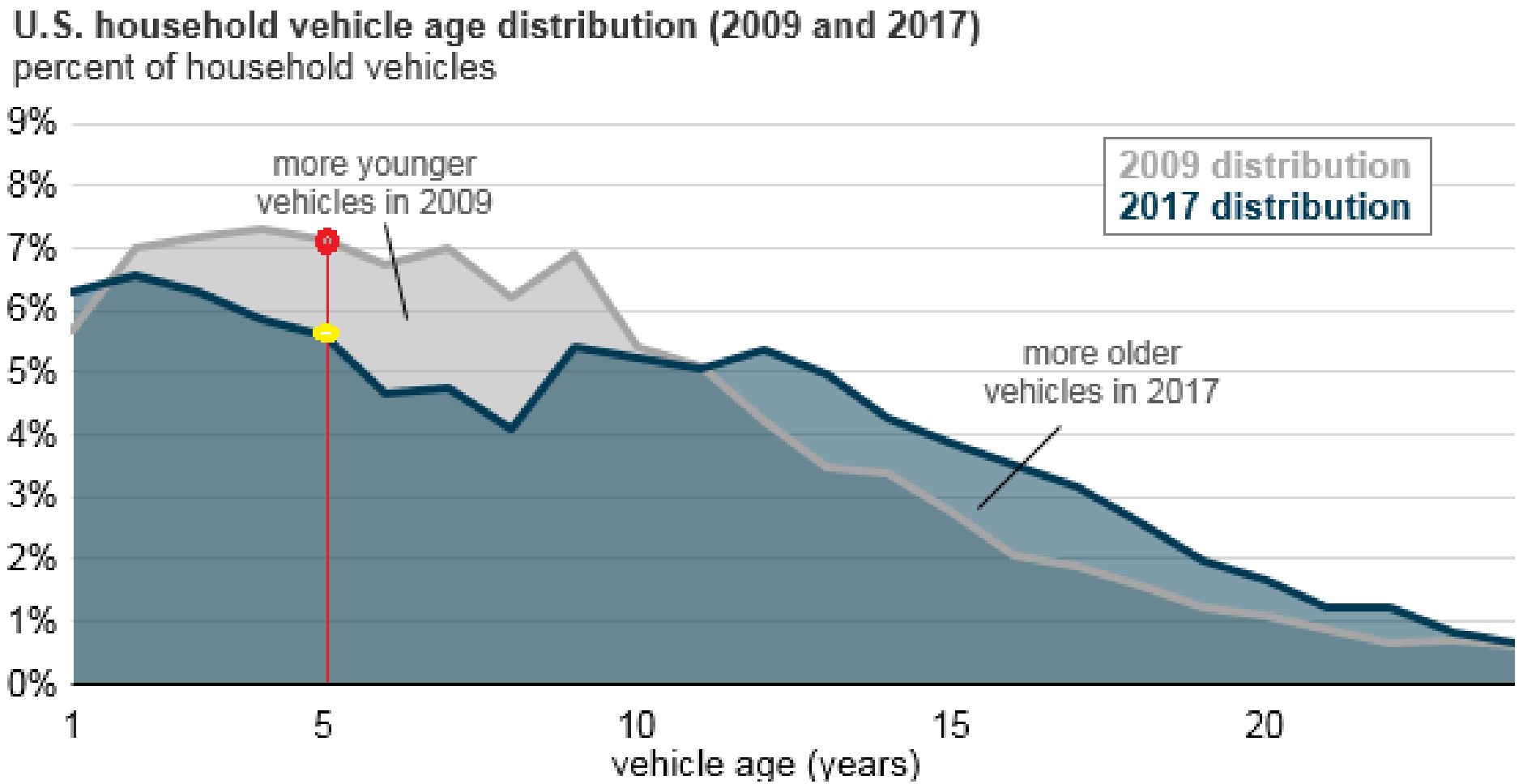
New vehicle sales = 15 million;

~5% were EVs in 2021



Vehicle retirement (scrappage)

Vehicles are lasting longer



Our analysis

How quickly can passenger vehicle fleet be replaced by EVs, given expected patterns of stock turnover, i.e., the rate at which new vehicles replace used vehicles?

How quickly can passenger vehicle pollution be reduced?

How does the rate of electricity grid decarbonization affect transportation sector emissions reductions?

Methodology

We build a stock turnover model based on historical sales, registrations, and scrappage data.

Each year, new vehicles are sold, used vehicles age by one year, and a fraction of used vehicles are removed from the stock via scrappage.

We project stock dynamics through 2075 and measure changes in vehicle type shares, vehicle miles traveled, and CO2 emissions.

Baseline data

Vehicle registrations and scrap rates as of January 2020: IHS Markit

Gasoline vehicle fuel economy: Wards Automotive and fuel economy.gov

Plug-in EV electricity per mile: fuel economy.gov

Annual vehicle miles traveled: NHTSA (derived from IHS Market data)

CO_2 emissions from one gallon of gasoline: Environmental Protection Agency

Projections input data – new vehicle sales shares

We model two scenarios for new vehicle sales:

California's goal: 100% new EV market share by 2035

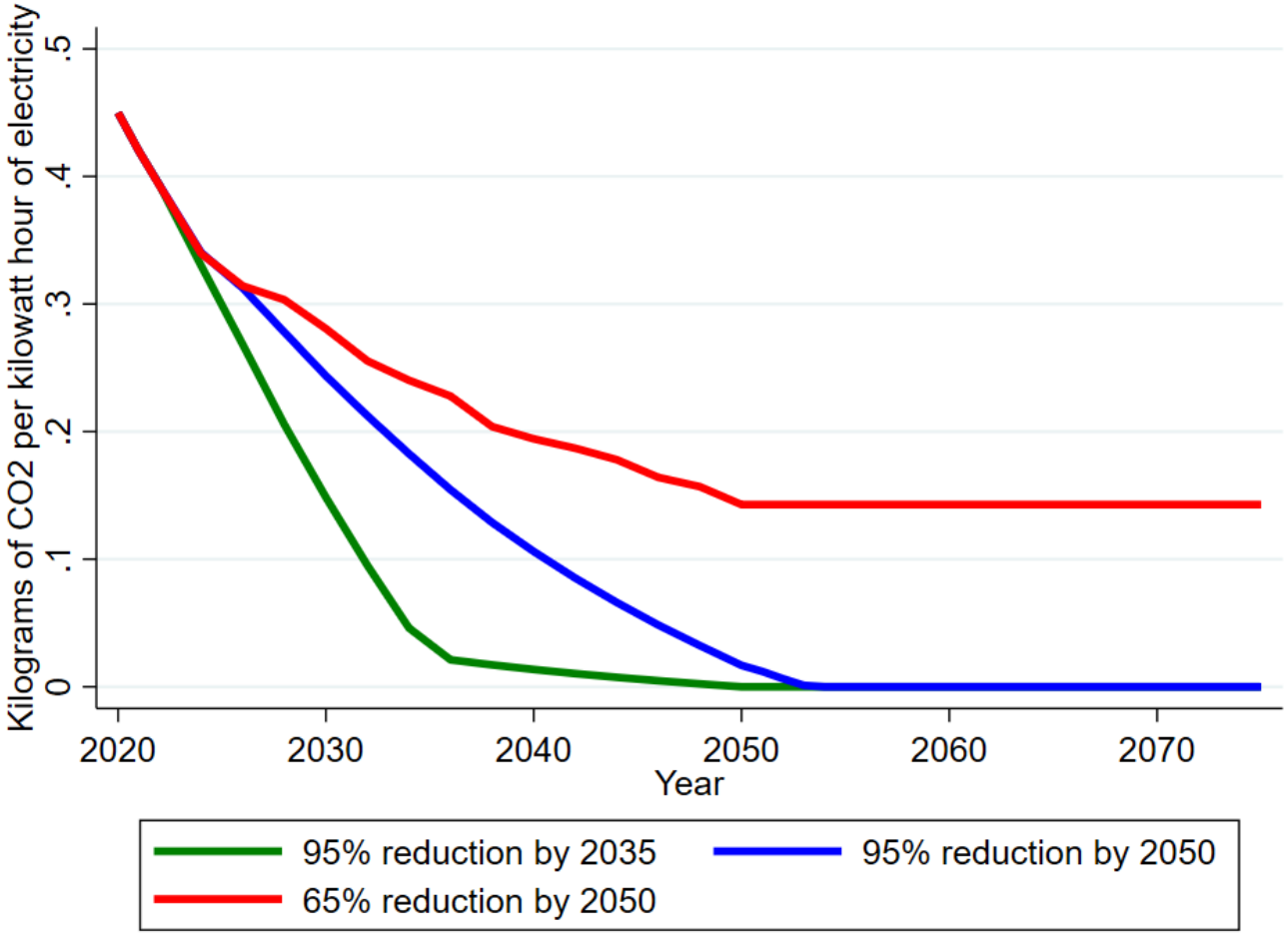
Industry projections: 100% new EV market share by 2045

In each scenario, we have hybrid sales initially increasing, then falling to zero.

Projections input data – CO2 rates

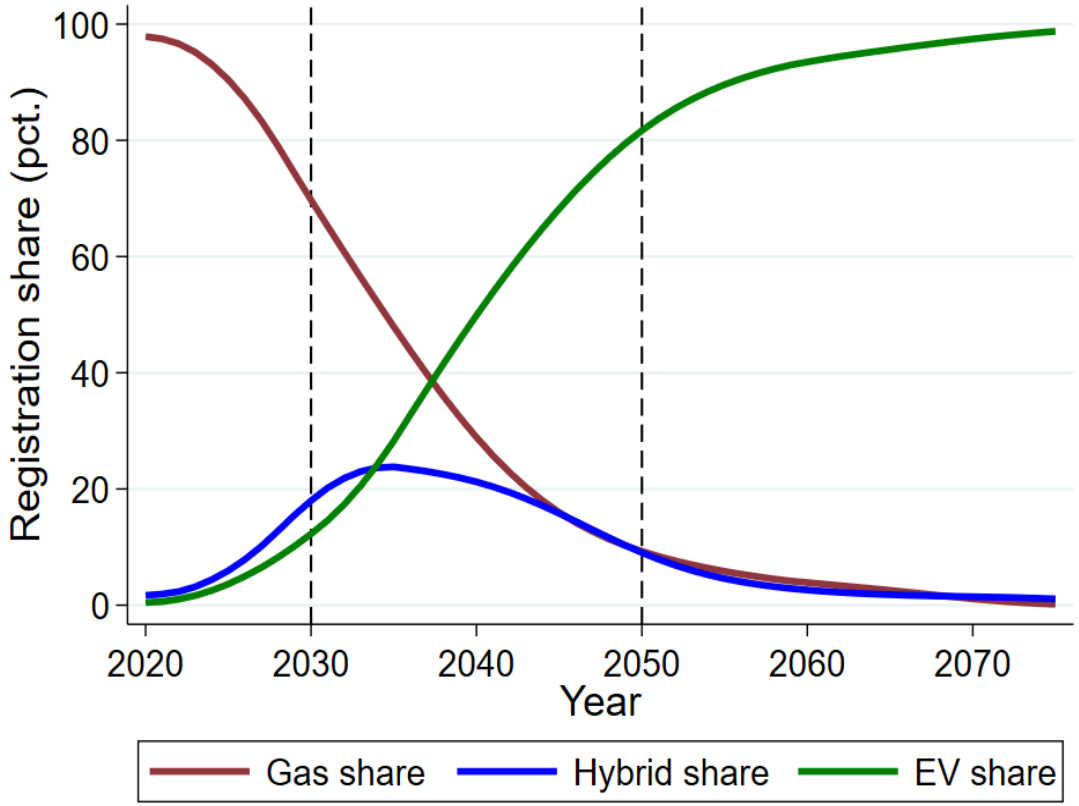
CO_2 emissions per kilowatt hour of electricity generated: National Renewable Energy Laboratory (NREL) 2021 Standard Scenarios Report

- Three scenarios:
  1. no new carbon policies
  2. 95% reduction by 2050
  3. 95% reduction by 2035

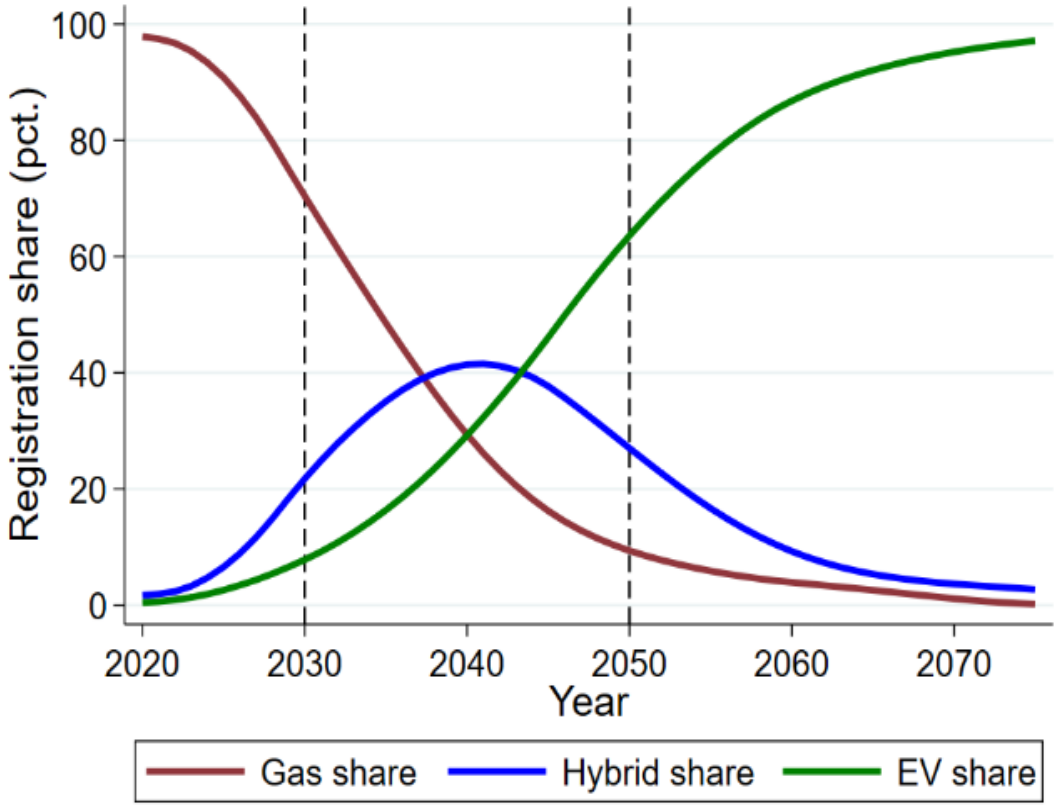


Results – on road vehicles

100% new EV market share by 2035

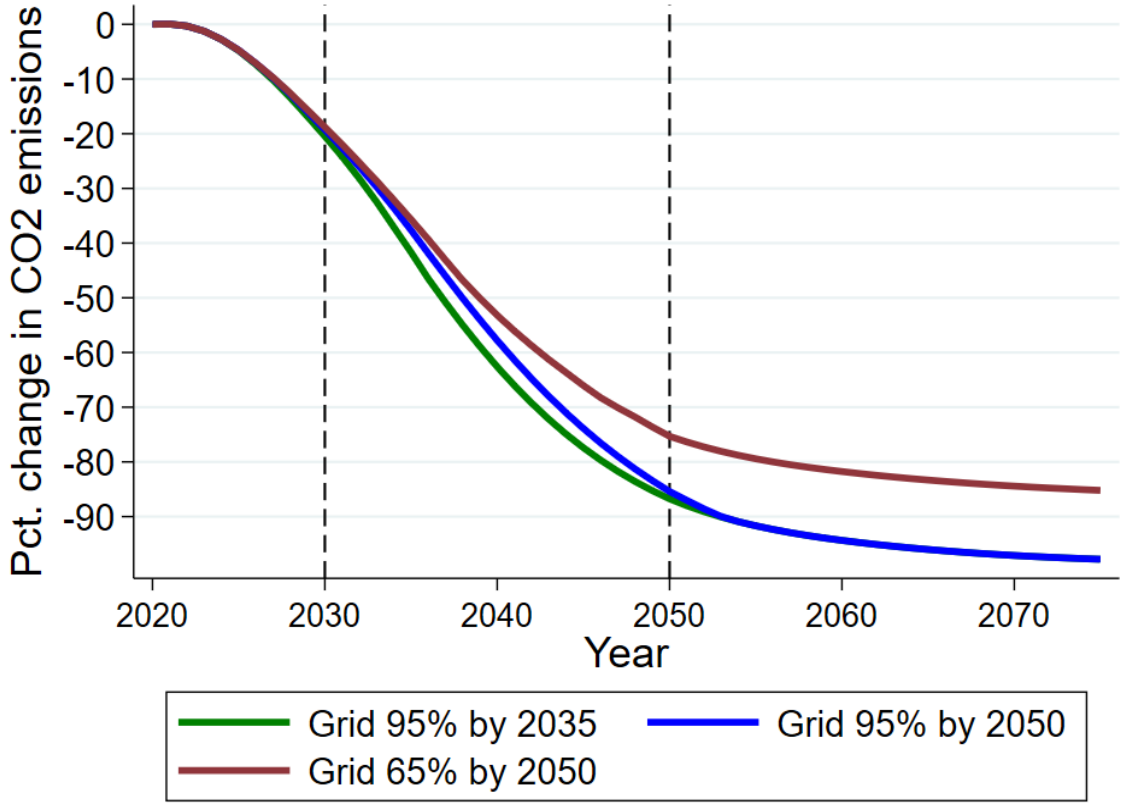


100% new EV market share by 2045

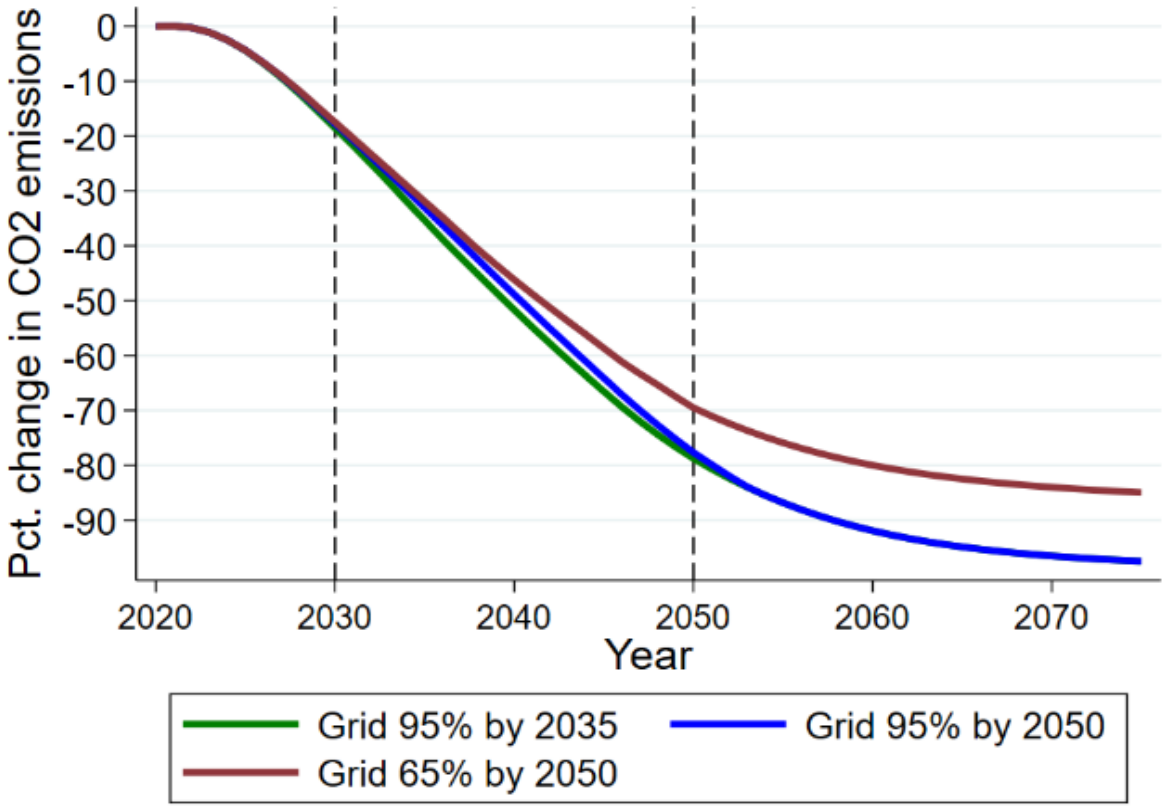


Results – CO2 emissions

100% new EV market share by 2035



100% new EV market share by 2045



Summary

Emissions reductions for passenger vehicles by 2030 are only ~20% and fall short of Biden economy-wide goals.

Emissions reductions by 2050 are ~70%-85%.

The rate of electricity grid decarbonization has little effect on passenger vehicle emissions reductions.

- This is due to **good timing**: the electricity grid will have cleaned up by the time the *on-road* EV share becomes large.
- Concerns about electricity grid emissions due to electric vehicle charging matter less over time.

Policy implications

To achieve the current administration's 2030 climate goals, accelerating the rate of stock turnover is necessary.

- Used gasoline vehicle retirement programs should be considered.

2050 goals can be met with aggressive near term increases in EV sales.

- Charging station and purchase subsidies should be expanded.

Future work: how will transition to electric vehicles affect low-income communities, and what role does policy have for making the transition more equitable?

Thank you!