***Unintended Consequences:***

***Why U.S. Alternative Fuel Vehicle Adoption Increases Gasoline Consumption and Greenhouse Gas Emissions***

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## Overview

Energy security, air quality, climate change, and economic factors motivate efforts to transition the U.S. vehicle fleet to alternative fuels. Life cycle studies find that many alternative fuel vehicles (AFVs) can reduce air emissions and oil consumption. But due to the implications of federal fuel economy policy, net U.S. vehicle fleet emissions and oil consumption instead increase as more AFVs are adopted, at least through 2025.

This effect is a result of how the federal Corporate Average Fuel Economy (CAFE) policy is currently specified. CAFE requires that each manufacturer’s vehicle fleet satisfy a sales-weighted average efficiency standard and greenhouse gas emissions standard. The policy was created in response to the oil crisis of 1973, and CAFE vehicle efficiency standards, which had been stagnant during the 1990s and 2000s for cars, have been tightened dramatically during the Obama administration. They are now sufficiently stringent as to become binding constraints for nearly all automakers. When low-emission vehicles are adopted, they create slack in the constraint, allowing automakers to adjust sales mix and vehicle efficiency in the remainder of the fleet. A strategic automaker’s resulting sales-weighted average gasoline consumption and greenhouse gas emission rates remain bound to the CAFE standard. The Congressional Budget Office noted this issue in a 2012 report, stating that “with CAFE standards in place ... putting more electric (or other high-fuel-economy) vehicles on the road will produce little or no net reduction in total gasoline consumption and greenhouse gas emissions”. Goulder et al. (2012) also note this “leakage” effect in relation to state Pavley limits on vehicle greenhouse gas emissions.

## But with recent changes to CAFE policy, this leakage effect is now amplified. Starting in 2012, the U.S. government added incentives to CAFE policy allowing automakers that sell AFVs (including flex-fuel vehicles (FFVs), compressed natural gas vehicles (CNGVs), battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell vehicles (FCVs)) to meet less-stringent fleet efficiency targets. So, when automakers treat the CAFE standard as binding constraint, every AFV sold results in a relaxed CAFE standard for the manufacturer, which increases fleet-wide emissions and oil consumption.

## Methods

Life cycle assessment

## Results

We derive a closed form expression for changes in fleet-wide gasoline consumption and greenhouse gas emissions as a function of alternative fuel vehicle adoption. We estimate that each time an AFV is sold in place of a conventional vehicle, cumulative U.S. emissions increase by up to 60 metric tons of CO2, and gasoline consumption increases by up to 6,700 gallons, depending on the AFV and the year of sale. Counterintuitively, increased sales of AFVs that use less gasoline result in greater fleet-wide gasoline consumption and emissions. Using projections for vehicles sold from 2012 to 2025 from the U.S. Energy Information Administration, we estimate the effect leads to a cumulative increase of 30 to 70 million metric tons of CO2 and 3 to 8 billion gallons of gasoline consumed by 2040. And these estimates may be 30-40% higher in practice due to differences between the optimistic laboratory vehicle efficiency tests used in CAFE compliance calculations versus vehicle efficiency in real-world conditions. Because of the effect of the CAFE AFV incentives, other policies that are encouraging or mandating AFV sales in order to achieve emissions reductions, such as California’s “Zero-Emission Vehicle” regulations, may be achieving the opposite – at least through 2025 while CAFE AFV incentives are in place. And vehicle purchasers hoping to do their part to reduce environmental impact may be instead opening the door for others to increase emissions and oil consumption exceeding what the AFV owner can save.

## Conclusions

We discuss pros, cons, and issues of policy options to address this effect: (1) Eliminating the CAFE AFV incentives would eliminate the amplification effect but not the leakage, and the resulting standards may be more difficult for automakers to achieve given low gas prices and consumer preferences for large performance vehicles. (2) Eliminating other policies that support AFV adoption would reduce short term emissions but do nothing to put the fleet on a path to transition that would take over a decade even if the ideal technology and infrastructure were available at competitive costs today. (3) Tolerating near term emissions and oil consumption increases in pursuit of long term reductions is an option, but future benefits attributed to these policies are only realized if the policies succeed in securing a transition to AFVs that would not have happened otherwise (or would have happened more slowly otherwise). (4) Improved coordination between federal and state policymakers could presumably reduce negative interactions among policies, but coordination is nontrivial: the new CAFE standards themselves were created as a federal compromise with California, which wanted more stringent state standards. (5) Pricing externalities at a value equal to the marginal damage caused to society is an efficient option, but public support is dismal even if tax revenues are returned to American households, and policies such as regulaing CO2 as a pollutant, subsidizing fuel-efficient vehicles, and requiring high fuel efficiency have more public support. Nevertheless, continued attempts to persuade the public of the benefits of an efficient externality pricing approach that addresses end goals directly, rather than favoring specific technologies, remains important. While higher prices on gasoline, electricity, and other fuels to reflect the damages they cause are not the only mechanisms needed to secure a transition to alternative-fuel vehicles or to manage climate change and air pollution, they would help to mitigate some of the unintended and often difficult-to-spot effects of interactions among well-intentioned policies.

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