National Center for Sustainable Transportation

POLICY BRIEF

# Life Cycle-Based Policies Are Required to Achieve Emissions Goals from Light-Duty Vehicles

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## Issue

In the United States, vehicle emissions are responsible for 29% of total greenhouse gas (GHG) emissions with the majority of these coming from light-duty vehicles. To reduce GHG emissions, the U.S. has adopted policies to support the development and deployment of low-carbon fuels and zero emission vehicles (ZEVs—e.g., plug-in hybrid electric vehicles [PHEVs] and battery electric vehicles [EVs]).

Most current policies focus on emissions from vehicle operation only, omitting significant contributions from vehicle production and other parts of the vehicle and energy life cycle.

GHG emissions from vehicle operation and even from operation plus production are almost always lower for EVs than for conventional internal combustion engine vehicles (see **Figure**). However, as EVs become more efficient, low-carbon electricity becomes more common, and the size of the global EV fleet increases, emissions from production and other non-operation parts of the life cycle become increasingly important.

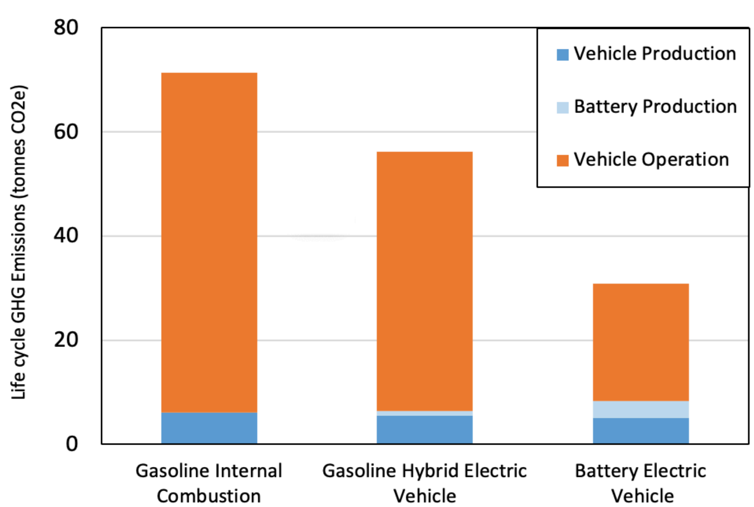


*Figure. Life cycle greenhouse gas emissions from vehicle production and operation for gasoline and battery electric vehicles (Ambrose et al. Under Review; assumes light duty passenger vehicle operating in average U.S. conditions).*

Researchers at UC Davis studied: (i) the effect of different factors on life cycle emissions; (ii) the impact of excluding life cycle emissions from policies; and (iii) potential strategies that might be used to effectively incorporate life cycle emissions in light-duty vehicle GHG policy.

## Key Findings & Policy Implications

**Multiple factors, especially those determined by the location of EV production and operation, affect life cycle GHG emissions** (see **Table**). Electricity fuel mix and ambient temperatures have major effects on emissions during vehicle operation. Lower temperatures affect both energy demand for cabin heating and the performance of battery charging and discharging. Extreme temperatures—for example, those below freezing—can have as much of an effect on per mile GHG emissions as can electricity fuel mix. In production, key determinants of emissions include: the sources of power used in manufacturing; the types of materials used to construct the vehicle, such as the materials used for vehicle light-weighting; and the manufacture of the battery system.

**Omitting life cycle emissions can lead to paradoxical policy outcomes, where vehicles with higher life cycle emissions but lower tailpipe emissions are preferred over vehicles with lower total emissions.** Studies have illustrated the risk of these policy outcomes with hybrid electric vehicles and EVs. Even if such outcomes are currently rare, their frequency and significance remain unknown in terms of national or global vehicle fleets.

*Table. The impact of various factors on GHG emissions during vehicle operation and production.*

| Factor | EV Operation Emissions | EV Production Emissions |
|---|---|---|
| Higher-emission source of electricity | ↑ | ↑ |
| Extreme cold or hot temperatures | ↑↑ | ↑ |
| Battery design and cell production | ↑ or ↓* | ↑ or ↓* |
| Lighter vehicle materials | ↓ | ↑ |
| Higher-emission power source for manufacturing | – | ↑ |

*Whether there is an increase or decrease depends on the materials used and design choices.

**Existing U.S. policies on fuel efficiency gains and zero-emission vehicle (ZEV) credits could undermine GHG reductions.** The harmonized US Corporate Average Fuel Economy (CAFE) and EPA GHG standards are based on vehicle size (footprint). As a result, the current shift in the EV mix towards larger vehicles could reduce the potential improvement. Credits for manufacturing ZEVs and alternative fuel vehicles are intended to encourage development of new technologies. However, these ZEV credits could lower emissions improvements from non-ZEV vehicle sales. To avoid this, the emissions benefits of ZEVs, over relevant timescales, must be greater than the increase in non-ZEV emissions allowed by ZEV credits.

**Policies and regulations around the world that implement life cycle approaches provide some insights for new policies for light-duty vehicles.** No existing policies provide a template for a successful life cycle-based policy on light-duty vehicles. However, a number of life cycle-based policies targeting transportation fuels, and biofuels in particular—most notably California's Low Carbon Fuel Standard—can serve as examples.

**Another life-cycle approach would rely more on independent analysis of the vehicle supply chain, namely by using the environmental product declaration (EPD) process.** The European Commission pioneered the EPD system, and the experience provides examples of implementation for a system where actors in the global automotive supply chain (e.g., suppliers and original equipment manufacturers) provide verified EPDs for components and final assembly. At least one sector in the U.S.—i.e., building materials—has seen a rise in EPD production and use due to the US Green Building Council's inclusion of EPDs in their Leadership in Energy and Environmental Design (LEED) certification system.

One potential problem is the increasing complexity of modern vehicles. Is individual part- and material-tracking feasible? Europe's End-of-life Vehicle Directive may provide some guidance. This policy forces vehicle manufacturers to be responsible for vehicle disposal and mandates recyclability and other waste-oriented restrictions that must be considered by producers. As part of this process, standardized part-labeling has been implemented that identifies constituent materials. Labeling could in theory be expanded to include a full EPD.

## More Information

This policy brief is drawn from "Program for Vehicle Regulatory Reform: Assessing Life Cycle-Based Greenhouse Gas Standards," a research report from the National Center for Sustainable Transportation, authored by Alissa Kendall, Hanjiro Ambrose, Erik Maroney, and Huijing Deng of the University of California, Davis. The full report can be found on the NCST website at https://ncst.ucdavis.edu/project/program-vehicle-regulatory-reform-assessing-life-cycle-based-greenhouse-gas-standards.

For more information about the findings presented in this brief, please contact Alissa Kendall at amkendall@ucdavis.edu.




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