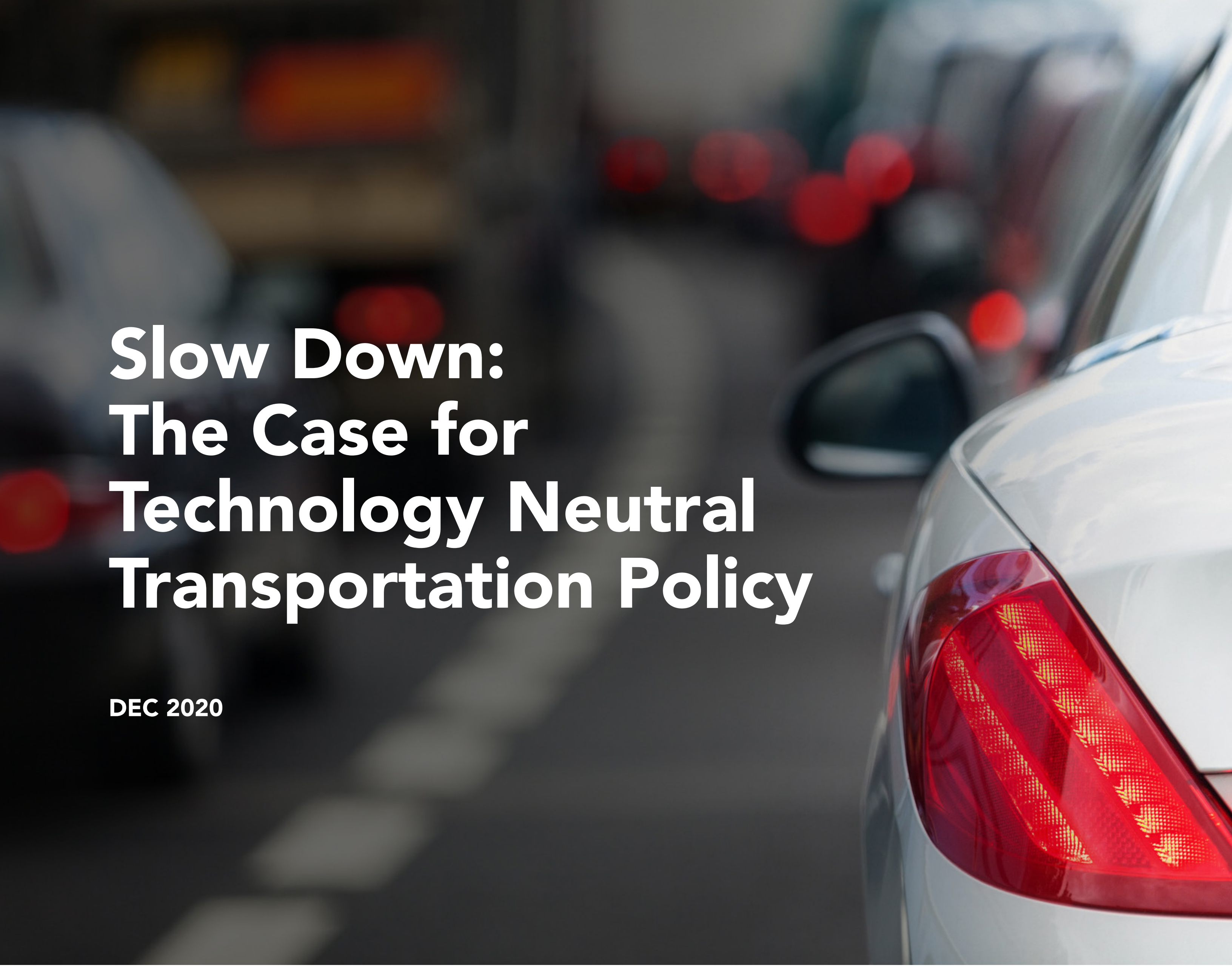


Slow Down: The Case for Technology Neutral Transportation Policy

DEC 2020

CONSERVAMERICA
Conservation *is* Conservative

www.conservamerica.org

Prepared by Todd Johnston, Vice President

TABLE OF CONTENTS

1. OVERVIEW:

There is growing support among policymakers for electric vehicles (EV) as the preferred technology for achieving deep reductions in carbon dioxide emissions from the transportation sector, including through policies that include mandates, bans on traditional internal combustion engines (ICEs), and consumer subsidies for EV purchases. The push to decarbonize the transportation sector, though, should not come at the cost of discouraging the development of other technologies. To ensure that the most efficient technology reaches the market and to be good stewards of taxpayer resources, policymakers should focus on competition and innovation.

There's no question that fully electric vehicles will play an important role in reducing emissions and fighting climate change. But at the same time, before policymakers rush to enact mandates or other subsidies that favor a particular type of vehicle, it's essential that the full picture is fully understood.

If our shared goal is to reduce total emissions to the atmosphere from the transportation sector, then one cannot simply focus on one part of the equation, such as miles per gallon or tailpipe emissions. Because different energy sources and drivetrains are used in different vehicles, the most crucial metric is overall lifecycle emissions – this includes emissions generated from mining to salvage.

This whitepaper is designed to highlight that metric. We are fortunate in that there is no shortage of studies that provide information about greenhouse gas emissions (GHG) from different vehicle propulsion technologies over their entire lifecycle. Unfortunately, much of this research — from government agencies, academic institutions, and other peer-reviewed sources — is often overlooked in policy discussions.

The studies that we summarize in this paper demonstrate that a variety of automotive technologies and powertrains deliver comparable GHG emission reductions. They show that the situation is not as simple as many make it out to be. No single technology is superior; thus, policymakers should not arbitrarily and unfairly advantage one over another. A one-size-fits-all approach that has the government picking winners and losers is the wrong way to go.

Key Takeaways:

- Based on the studies reviewed in this analysis, when examining the entire lifecycle of vehicles and their energy sources — which accounts for GHG emissions during fuel production, manufacturing, operation, and disposal stages — advanced internal combustion engine vehicles (ICEVs) and hybrid electric vehicles (HEVs) can produce comparable reductions in GHG emissions as similarly equipped, full battery electric vehicles (BEVs).
- The term *Zero Emission Vehicle* is a misnomer. All vehicle types are responsible for producing emissions throughout their lifecycles. Policies that only examine a vehicle's tailpipe emissions significantly distort the fact that BEVs emit GHGs, which are swayed heavily by the mix of energy sources used for electricity generation.
- Focusing on a single technology like BEVs discourages competition from other technologies that could significantly impact GHG emissions reductions in the nearer term and at a lower cost to consumers.
- If the ultimate goal is to decrease carbon emissions, mandating vehicle electrification and subsidizing electric vehicles may end up being among the most expensive and inefficient policies to adopt.

2. CURRENT POLICY ENVIRONMENT

U.S. policymakers, regulators, and industry are working to identify meaningful ways to reduce GHG emissions to address global climate change. One area identified as a priority is the transportation sector, driven by the fact that transportation currently accounts for 28 percent of U.S. GHG emissions, roughly the same as power generation (electricity), which contributes 27 percent of total GHG emissions, according to the U.S. EPA.[1]

Much of the policy focus has centered around reducing emissions from *passenger* transport — and specifically a move toward full vehicle electrification (BEVs). However, vehicles powered by various energy sources can play a meaningful role in reducing GHG emissions, including electric, natural gas, hydrogen, hybrid electric, gasoline, and diesel. It is important to take stock of the progress made in reducing emissions, including in transportation.[2] For example, by 2025, research indicates ICEV efficiency could improve by 30%,[3] and by 2050, "the fuel economy of some of ICEVs could double…"[4]

Policy decisions, especially any that seek to advance one automotive technology or powertrain over another, or focus on only one sector of the economy, must be based on sound research and credible data.

Government policies intended to exclusively spur the adoption of vehicles with zero *tailpipe* emissions — while ignoring other associated emissions during the full manufacturing, usage, and disposal cycle — are among the most expensive and least efficient solutions to reduce GHGs. According to the analyses below, promoting EVs over ICEVs is significantly more costly (per avoided ton of carbon dioxide emissions) than switching power generation plants from coal to natural gas.

The Rhodium Group estimates that even under the best circumstances, EV adoption is not enough to reduce emissions significantly.[5] Their analysis shows that even with a decade of record EV sales through 2030 under an expanded tax credit program, "about a 1 [percent] reduction in sectoral emissions below current policy."[6] Further, focusing on a single technology like BEVs discourages competition from other technologies that could significantly impact GHG emissions reduction in the nearer term and at a lower cost to consumers.

---

1 United States Environmental Protection Agency. "Sources of Greenhouse Gas Emissions," https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

2 US Environmental Protection Agency, "National Air Quality: Status and Trends of Key Air Pollutants" https://www.epa.gov/air-trends

3 Elgowainy, A., Han, J., Ward, J., Joseck, F., Gohlke, A., Linauer, T., Ramsden, M., Biddy, M., Alexander, S. Barnhart, I., Sutherland, L., Verduzco, T.J., Wallington (2016). Cradle-to-Grave Lifecycle Analysis of U.S. Light-Duty Vehicle-Fuel Pathways: A Greenhouse Gas Emissions and Economic Assessment of Current (2015) and Future (2025-2030) Technologies. Argonne National Laboratory. https://greet.es.anl.gov/publication-c2g-2016-report

4 Heywood, J., MacKenzie, D. (2015). "On the Road Toward 2050: Potential for Substantial Reduction in Light-Duty Vehicle Energy Use and Greenhouse Gas Emissions," Massachusetts Institute of Technology. http://web.mit.edu/sloan-auto-lab/research/beforeh2/files/On-the-Road-toward-2050.pdf

5 Larsen, J., King, B., Kolus, H., & Herndon, W. (2019). An Assessment of the GREEN Act: Implications for Emissions and Clean Energy Deployment. Rhodium Group, US Energy & Climate. https://rhg.com/wp-content/uploads/2019/12/An-Assessment-of-the-GREEN-Act.pdf

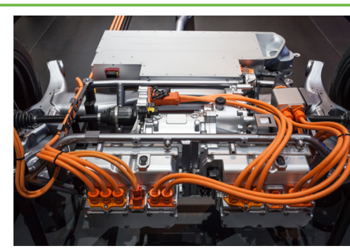
6 In this case, "current policy" is a reference to the Corporate Average Fuel Economy (CAFE) standards, which were amended in March 2020 by The Safer Affordable Fuel-Efficient (SAFE) vehicle rule.

3. VEHICLE AND ENERGY SYSTEMS

Vehicles encompass a spectrum of technology applications and powertrain platforms. They range from sophisticated electronic sensing, control, and propulsion systems, advanced ICEVs, HEVs, plug-in hybrid electric vehicles (PHEV) to BEVs, and fuel cell electric vehicles (FCEV) fueled with hydrogen. Each phase of a vehicle's lifecycle (i.e., manufacturing, use, and disposal), including components (e.g., batteries, tires, engines), requires an energy source that, when accounted for as a complete system, produces emissions — referred to as the "cradle-to-grave" or "lifecycle" emissions of that system. Because of the different energy sources and drivetrains used in these vehicles, it is important to consider their emissions as a system. Comparing miles per gallon or tailpipe emissions is not sufficient to properly analyze their total environmental performance.

Below is a table that differentiates each vehicle type by drivetrain, battery type, and battery size. The acronyms used to describe each vehicle type are used throughout this brief.

Table 1: Drivetrains and Battery Specifications for Each Vehicle Type

Vehicle Type	Acronym	Drivetrain	Battery	Battery Size Comparison
Internal combustion engine vehicle	ICEV	Powered by liquid fuel	Lead-acid; <1kWh	
Hybrid electric vehicle	HEV	Powered by liquid fuel and small electric motor	Nickel metal hydride or lithium-ion battery; 1-2 kWh	
Plug-in hybrid electric vehicle	PHEV	Powered by liquid fuel and electric grid charged battery	Lithium-ion battery; 4-20 kWh	
Battery electric vehicle	BEV	Powered by electric grid charged battery	Lithium-ion battery; 20-100 kWh	

4. DEFINING "ZERO EMISSION" VEHICLES

There is no such thing as a true zero-emission vehicle. As the lifecycle analysis studies below demonstrate, all vehicles produce emissions.

ICEVs generate emissions during manufacturing and, subsequently, during their full operating life and disposal. Most emissions in the ICEV lifecycle occur from operating the vehicle — combustion of gasoline and diesel produces tailpipe emissions.

Like ICEVs, BEVs also generate emissions during their operating lifetimes, but how they do so is significantly different. The electricity generated by power plants to recharge BEVs is a major source of emissions, rather than the tailpipe. The quantity of emissions depends on the mix of energy sources used to generate electricity and supply power to the charger. For example, a coal-burning power plant produces more emissions than one using natural gas. Increasing use of renewables (e.g., solar, wind) can reduce the carbon intensity of electricity generation since no or little GHGs are emitted. However, there are GHG emissions associated with manufacturing, transporting, and installing solar panels and wind turbines (as well as significant EV charging infrastructure), meaning that the electricity they generate still contributes GHG emissions to BEV lifecycles. Even in studies that considered less GHG-intensive electricity generation, where BEV emissions were lower than ICEVs and HEVs, BEV technology still produces about 35-65 percent of the emissions generated by HEVs over their lifecycle.[7]

There is no such thing as a true zero-emission vehicle. As the lifecycle analysis studies below demonstrate, all vehicles produce emissions.

Unlike ICEVs, batteries are a major individual component of BEVs, and the *manufacturing* of batteries for use in BEVs contributes 10-30% of their lifecycle emissions due to the significant amount of energy required for materials extraction and processing. BEVs are a relatively new technology with typical battery life warranties of 8-10 years. BEV batteries degrade over time, resulting in reduced vehicle driving range and power, as well as battery efficiency. One study noted that battery capacity loss not only reduces battery life but it also changes battery resistance and increases energy losses during charging and discharging, increasing CO_{2e} emissions by up to 16 percent compared to a new battery.[8] For some BEVs, battery degradation leads to replacement to extend the vehicle's operating life. However, the full impact of battery degradation and replacement on GHG emissions will not be understood until BEVs become more mature, and their battery lifetimes and failure rates are well documented.

The bottom line is that the term "zero-emission vehicle" is a misnomer, and this vernacular is misleading the public. No vehicle, no matter the energy source or powertrain technology, can be produced or operated free of emissions.

7 Heywood, J., MacKenzie, D. (2015). "On the Road Toward 2050: Potential for Substantial Reduction in Light-Duty Vehicle Energy Use and Greenhouse Gas Emissions," Massachusetts Institute of Technology. http://web.mit.edu/sloan-auto-lab/research/beforeh2/files/On-the-Road-toward-2050.pdf

8 Yang, F., Xie, Y., Deng, Y. & Yuan, C. (2018). Predictive modeling of battery degradation and greenhouse gas emissions. Nature Communications. https://www.nature.com/articles/s41467-018-04826-0.pdf?origin=ppub

5. RESEARCH REVIEW

The studies included in this brief represent a cross-section of independent data analysis that is often overlooked in policymaking. Each study is unique, offering different viewpoints on GHG emissions from a variety of powertrain technologies. The studies' underlying assumptions matter – different assumptions, such as vehicle size and performance, battery size and lifetime, the carbon intensity of electricity generation and fuel production, and the state of technology advancements, cause results to vary. These analysis methods can have large variability and uncertainties that are dependent on the assumptions made in the lifecycle analysis (LCA). However, taken together, multiple studies paint a picture of the range of possible outcomes under different scenarios and support the need for technology-neutral transportation policies that will result in the most efficient reductions in GHG emissions.

According to a number of cradle-to-grave lifecycle analyses, vehicles powered partially or fully by gasoline internal combustion engines emit about the same or lower levels of carbon dioxide than EVs, while other analyses give a slight advantage to EVs. Hybrid vehicles — those that use both an internal combustion engine and battery propulsion systems — often match or outperform all other vehicle types' lifecycle emissions based on the GHG intensity of *today's electric grid*. Some studies also consider future vehicle technology advances as well as improvements in the GHG intensity of electricity generation.[9]

> **Even in studies that considered less GHG-intensive electricity generation, where BEV emissions were lower than ICEVs and HEVs, BEV technology still produces about 35-65 percent of the emissions generated by HEVs over their lifecycle.[7]**

Additionally, all of the studies may have significantly undercounted GHG emissions from EVs when factoring in global carbon intensity from electricity. For example, in 2019, China was home to 47 percent of the world's EVs.[10] China also has about a 37 – 40 percent higher than global average carbon intensity for electricity generation.[11] China continues to build coal power plants for electricity generation. E&E News reported, for example, that China approved more coal-fired power plants in March 2020 than it did in all of 2019.[12]

9 These studies do not consider the potential for centralized carbon capture at power plants that may not be possible to the same extent within the ICEV and HEV lifecycles and could favor PHEV and BEV technologies for CO_{2e} reductions over the longer term.

10 IEA (2020), Global EV Outlook 2019, IEA, Paris. https://www.iea.org/reports/global-ev-outlook-2020

11 Li, X., Chalvatzis, K. & Pappas, D. (2017). China's electricity emission intensity in 2020 – an analysis at provincial level. *Energy Procedia*. 142, 2779-2785. https://doi.org/10.1016/j.egypro.2017.12.421

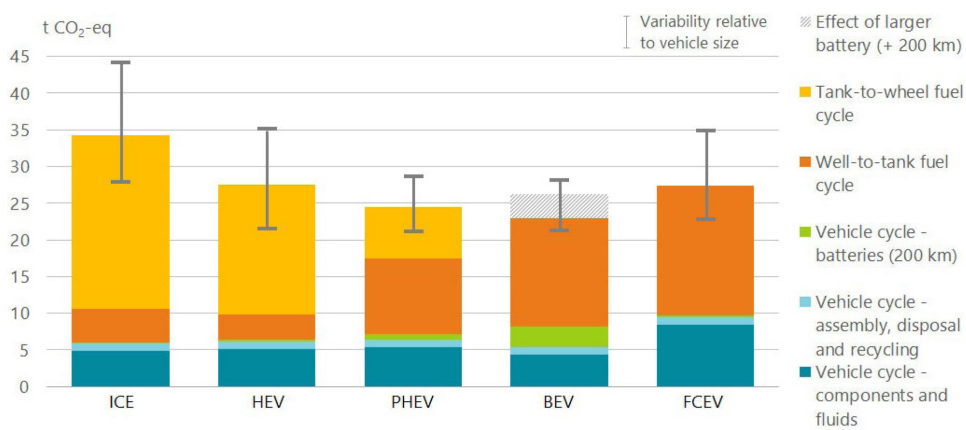
12 "Surging coal use in China threatens global CO2 goals," Benjamin Storrow, E&E News, https://www.eenews.net/stories/1063354565

Further, many of the studies[13] cited in this paper did not consider temperature and HVAC impacts on battery performance and range in the LCA. A study[14] from the American Automobile Association found that compared to 75°F, HVAC use at 20°F in a BEV results in an average reduction of combined driving range and combined MPGe by 41 percent and 39 percent, respectively; while HVAC use at 95°F in a BEV results in an average reduction of both combined driving range and combined MPGe by 17 percent.

In order to present results on a uniform basis in this policy brief, studies showing final carbon dioxide emissions data in grams per mile (or grams per kilometer) are converted to metric tons emitted over the vehicle's life, which is assumed to be 150,000 miles (or 240,000 km) driven.

IEA 2019

The International Energy Agency's 2019 study found relative parity among vehicle types (HEVs, PHEVs, and BEVs) in its lifecycle emissions assessment, based on IEA's global average carbon intensity for electricity generation (518g CO2/kWh), as referenced in its Global EV Outlook 2019.[15] Two BEV types provided the range of emissions used in this study. The lower bound is represented by a smaller BEV with a 200 km (124 mi.) driving range between charges, while the higher bound (cross-hatched) represents a larger BEV with a 400 km (249 mi.) range.



Source: IEA 2019. All rights reserved. Notes: This figure portrays mid-size vehicles having similar performance with the exception of driving range. The BEV refers to a vehicle with 200 km range; the addition of the shaded area refers to a vehicle with 400 km range. The ranges suggested by the sensitivity bars represent the case of small cars (lower bound) and of large cars (upper bound) – for BEVs, the lower bound of the sensitivity bar represents a small car with a 200 km range, and the upper bound represents a large car with a 400 km range. The carbon intensity of the electricity mix is assumed equal to the global average (518 g CO2/kWh). FCEVs are assumed to rely entirely on hydrogen produced from steam methane reforming. Other assumptions used to develop this figure are outlined in the Chapter 4 of the Global EV Outlook 2019, focused on lifecycle GHG emissions.

BEV: 23-27 metric tons CO_{2e} depending on battery size/driving range
ICEV: 34 metric tons CO_{2e}
HEV: 27 metric tons CO_{2e}
PHEV: 24 metric tons CO_{2e}

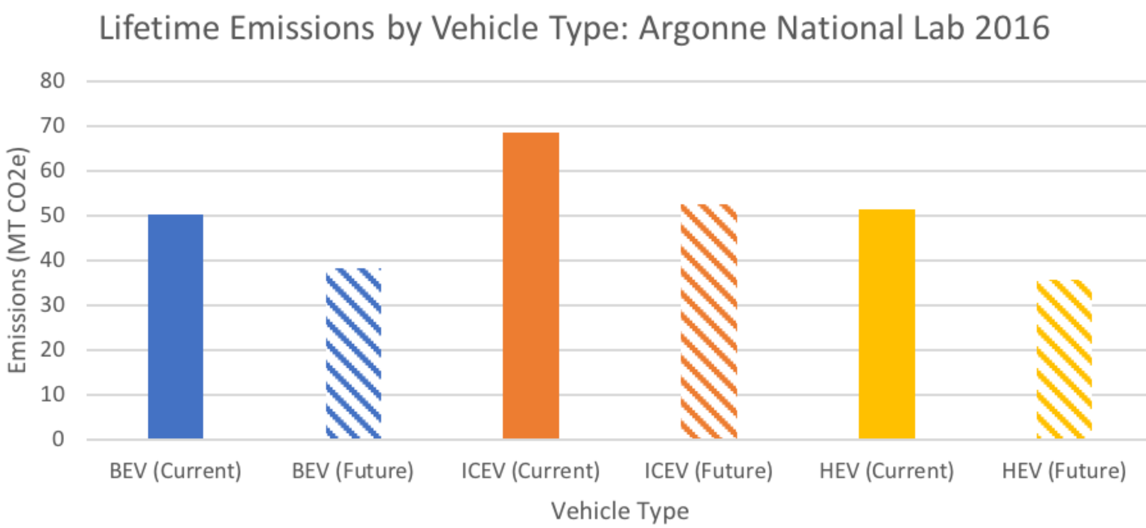
13 IEA 2019, Argonne National Laboratories 2016, 2019 MIT Insights into Future Mobility, and EU 2014

14 American Automobile Association, "Icy Temperatures Cut Electric Vehicle Range Nearly in Half," 2019. https://newsroom.aaa.com/2019/02/cold-weather-reduces-electric-vehicle-range/

15 IEA (2019), Global EV Outlook 2019, IEA, Paris. https://www.iea.org/reports/global-ev-outlook-2019

Argonne National Lab 2016

The Argonne National Laboratory study from 2016[16] showed both current and projected future lifecycle GHG emissions for each vehicle type. Future emissions are estimates “based on adoption of advanced vehicle and powertrain technologies in the 2025–2030 timeframe.” BEV estimates are based on 210-mile-range vehicles using the EIA 2015 Annual Energy Outlook; future vehicle emissions are based on projected technology gains from that same outlook.[17] This study is another example that hybrid vehicles equipped with internal combustion engines (HEVs) are nearly the same as BEVs when it comes to lifecycle GHG emissions. This was the conclusion of the study, even though the GREET model used in the study did not consider temperature and HVAC impacts.



BEV current: 336 g CO_{2e} /mi = 50.4 metric tons CO_{2e} /lifetime*
BEV future: 256 g CO_{2e} /mi = 38.4 metric tons CO_{2e} /lifetime*

ICEV current: 457 g CO_{2e} /mi = 68.55 metric tons CO_{2e} /lifetime*
ICEV future: 352 g CO_{2e} /mi = 52.8 metric tons CO_{2e} /lifetime*

HEV current: 343 g CO_{2e} /mi = 51.45 metric tons CO_{2e} /lifetime*
HEV future: 238 g CO_{2e} /mi = 35.7 metric tons CO_{2e} /lifetime*

16 Elgowainy, A., Han, J., Ward, J., Joseck, F., Gohlke, A., Linauer, T., Ramsden, M., Biddy, M., Alexander, S. Barnhart, I., Sutherland, L., Verduzco, T.J., Wallington (2016). Cradle-to-Grave Lifecycle Analysis of U.S. Light-Duty Vehicle-Fuel Pathways: A Greenhouse Gas Emissions and Economic Assessment of Current (2015) and Future (2025-2030) Technologies. Argonne National Laboratory. https://greet.es.anl.gov/publication-c2g-2016-report

17 The Current Technology case assumes the EIA AEO 2015 average electricity grid mix for all pathways. For the Future Technology case, production of electricity for electric vehicles and hydrogen for FCEVs is based on EIA’s 2015 estimates of the levelized cost of electricity from new generation resources. This includes estimates for solar electricity, wind electricity, and electricity from ACC generation. Electricity for the other Future Technology case pathways is based on the AEO 2015 projected average grid mix for 2030.

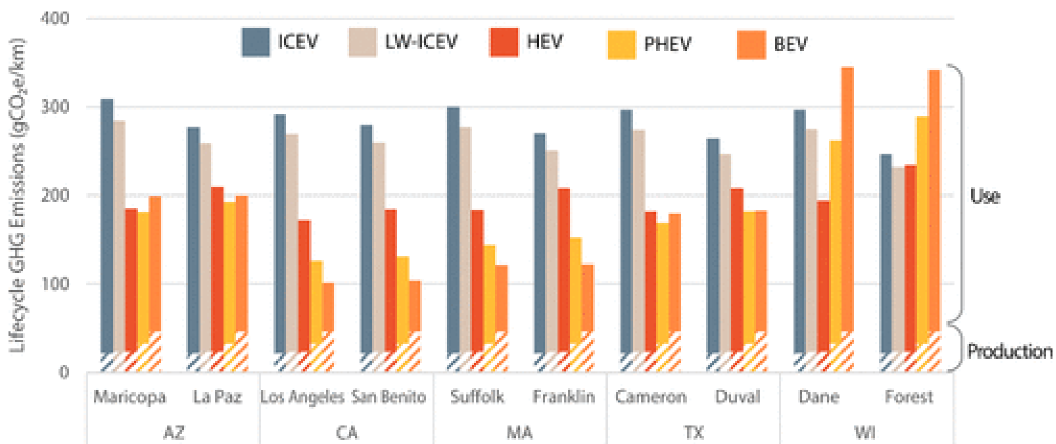
MIT/Ford Motor Co. 2019

The MIT/Ford 2019 study[18] examines local driving conditions (urban vs. rural) and ambient temperatures, and the effects of these externalities on fuel/electricity consumption rates for each vehicle type. This study disaggregates the data from 10 selected counties in 5 U.S. states to show differences in lifecycle GHG emissions over the life of the vehicle.

The study finds that among the assessed technologies, ICEV emissions (vehicle efficiency) are impacted least by ambient temperature changes, whereas BEVs are impacted the most. However, ICEV emissions are most affected by local driving conditions (urban vs. rural) when propulsion and idling are the primary considerations. BEVS for this study assumes a 200-mile driving range.

In the graph below, the bars shown for ICEVs and HEVs reflect the high and low lifecycle GHG emissions levels factoring in driving conditions and ambient temperature effects.

However, in addition to local driving conditions and ambient temperature impacts, BEVs' lifecycle GHG emissions have a wide range, depending on the electricity grid mix[19] where an EV recharges. Thus, variability in energy sources supplying the electricity grid has the largest impact on resultant GHG emissions in the BEV lifecycle, as reflected in the graph below.



Average BEV, mostly clean grid[20] and mostly coal-fired grid[21]: 100-350 gCO_{2e}/km = 21.14 – 84.49 metric tons CO_{2e} /lifetime*

Average ICEV: ~250-305 gCO_{2e}/km = 60.35 – 73.63 metric tons CO_{2e} /lifetime*
Average HEV: ~170-210 gCO_{2e}/km = 41.04 – 50.69 metric tons CO_{2e} /lifetime*

18 "Regional Heterogeneity in the Emissions Benefits of Electrified and Lightweighted Light-Duty Vehicles" by Di Wu, Fengdi Guo, Frank R. Field III, Robert D. De Kleine, Hyung Chul Kim, Timothy J. Wallington, and Randolph E. Kirchain* https://pubs.acs.org/doi/10.1021/acs.est.9b00648.

19 The grid mix is defined as by the energy sources used by power plants to generate electricity that supplies the grid, which can include coal, natural gas, nuclear, renewables, etc.

20 It should be noted that California imports much of its power, including fossil fuel generated power from out of state, and does not include these sources in its estimation of its carbon-intensity

21 The study used data from power generation emissions in Los Angeles County, Calif. to represent BEV charging using a mostly clean grid. The study used data from power generation emissions in Dane County, Wis. to represent BEV charging using a mostly coal-fired grid. It should be noted that Dane County power plants are transitioning to renewable energy for the grid.

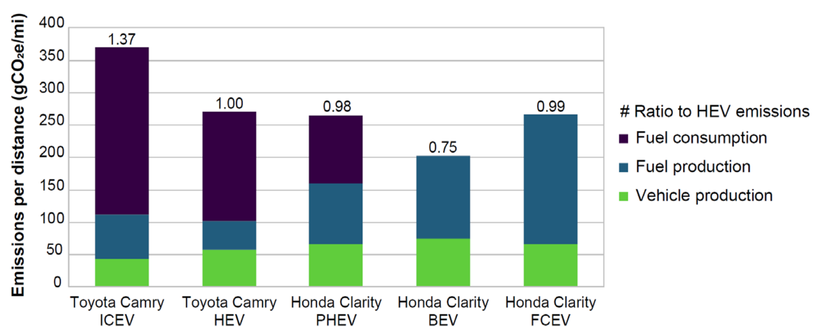
2019 MIT Insights into Future Mobility

The 2019 MIT report[22] "Insights into Future Mobility," combined the results of many disparate peer-reviewed studies into a holistic view of the future of the transportation system. This view extended well beyond vehicle lifecycle GHG emissions into the roles of economics, autonomous vehicles, traffic congestion, and other major impacts on the transportation system. Vehicle lifecycle emissions of different vehicle powertrain options were one aspect of the report.

The report considered best-in-class powertrain technology available in 2018 for similar vehicles. ICEVs emitted 37% more GHGs over their lifetime than HEVs, PHEVs, and FCEVs, which all had approximate parity in emissions. However, BEVs with electricity from the U.S. grid, using a 2018 U.S. grid carbon intensity average of 436g CO_{2e}/kWh, were estimated to emit approximately 25% less than HEVs over the vehicle lifetime. BEVs in this study is based on a 265-mile driving range. The study acknowledges ambient temperature's impact on BEV battery range but does not account for it in its calculations.

When considering future scenarios in which the grid would become cleaner, the report concluded that grid improvements would not materially change the relative emissions of the five technologies because as the grid becomes cleaner, so will ICEVs and HEVs become more efficient and consume less fuel. For example, the study did not consider expected future reductions in the carbon intensity of liquid fuels (petroleum and renewable fuels) consumed by ICEVs, HEVs, and PHEVs.

Figure 4.6: Greenhouse gas emissions per mile for cars with different powertrains, U.S. 2018



Note: Based on 180,000-mile life for all powertrains; U.S. 2018 average grid carbon intensity of 436 gCO_2e/kWh; gasoline production emissions of 19 gCO_2e/MJ; MPG values are 34 for ICEV, 52 for HEV, 42 gasoline and 110 electric for PHEV, 114 for BEV, 68 for FCEV (U.S. EPA 2018); 50/50 split of miles by gasoline and electric modes for PHEV; hydrogen production based on steam methane reforming with 13.6 gCO_2e/gH_2.

ICEV: 370 g CO_{2e} /mi = 55.5 metric tons CO_{2e} /lifetime*
HEV: 270 g CO_{2e} /mi = 40.5 metric tons CO_{2e} /lifetime*
PHEV: 265 g CO_{2e} /mi = 39.7 metric tons CO_{2e} /lifetime*
BEV: 203 g CO_{2e} /mi = 30.4 metric tons CO_{2e} /lifetime*
FCEV: 267 g CO_{2e} /mi = 40.1 metric tons CO_{2e} /lifetime*

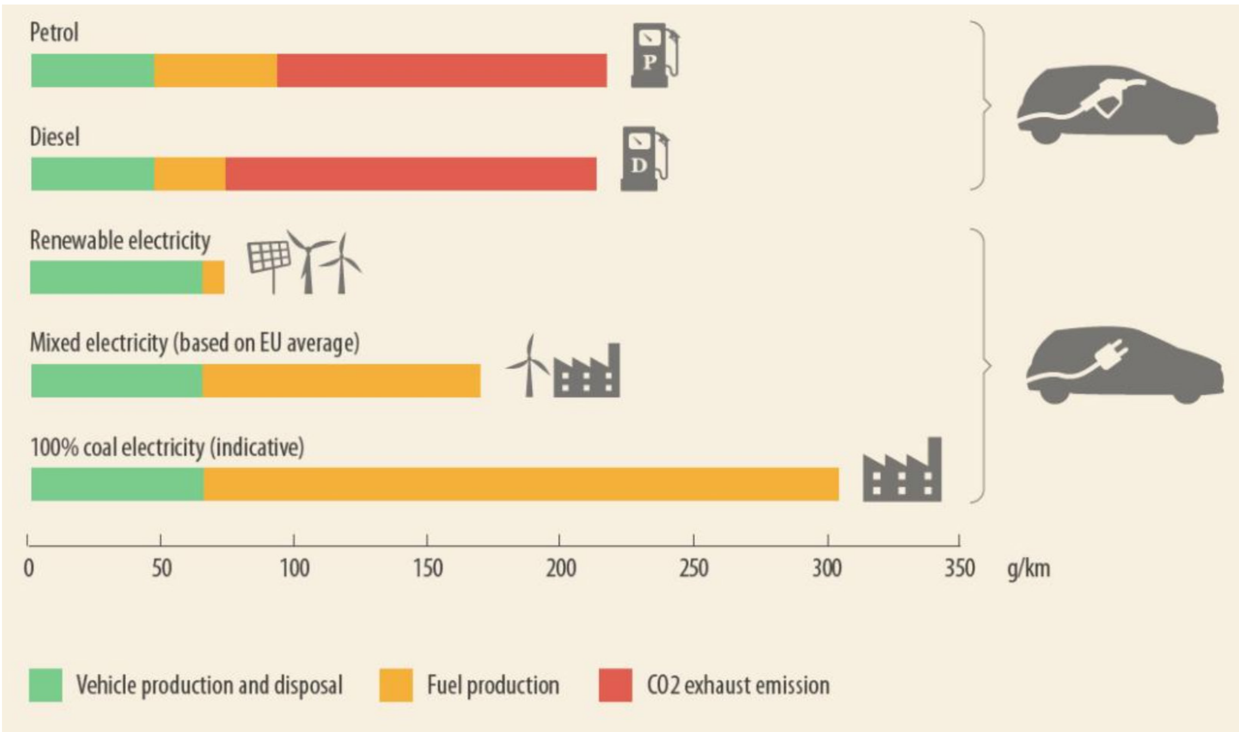
Note: The MIT Insights into Future Mobility study assumes a 180,000-mile life for all vehicle powertrains. However, to compare the lifetime emissions of this study against others in this brief, a 150,000-mile life was used to convert g CO_{2e}/mi to metric tons of CO_{2e} /lifetime.

22 MIT Energy Initiative. 2019. Insights into Future Mobility. Cambridge, MA: MIT Energy Initiative. http://energy.mit.edu/insightsintofuturemobility

EU 2014

The 2014 European Parliament study[23] shows that BEVs are capable of producing considerably higher levels of lifecycle carbon dioxide emissions than ICEVs when BEV charging is dependent on a grid that relies entirely on coal for power generation. BEV operating emissions are lower when the fuel source composition for the grid includes less coal.

The figure below shows how the manufacturing and in-use emissions contribute to lifetime CO_{2e} emissions for ICEVs (petrol/gasoline and diesel) and BEVs. Different scenarios are depicted for the carbon intensity of electricity generation showing the wide range of BEV lifetime emissions.



BEV on 100% renewables: 75 gCO_{2e}/km = 18.1 metric tons CO_{2e} /lifetime*
BEV EU avg: 170 gCO_{2e}/km 41.04 metric tons CO_{2e} /lifetime*
BEV on coal: 300 gCO_{2e}/km 72.42 metric tons CO_{2e} /lifetime*
ICEV: ~240 gCO_{2e}/km = 57.93 metric tons CO_{2e} /lifetime*

23 European Parliament. 2019."CO2 emissions from cars: facts and figures." https://europarl.europa.eu/news/en/headlines/society/20190313STO31218/co2-emissions-from-cars-facts-and-figures-infographics

6. WHAT ARE THE COSTS?

EVs continue to be more expensive than ICEVs. For example, one automaker sells a model that is available as a BEV or ICEV. The BEV version is about $15,000 more expensive or about 68% higher to the consumer, before tax incentives. Whether that automaker makes a profit (before or after government regulatory programs are considered) is unknown.

The MIT Energy Initiative 2019 report, Insights into Future Mobility, noted the current manufacturing cost gap between BEVs and ICEVs is on the order of $10,000 per vehicle for similarly sized models with ranges of more than 200 miles. MIT believes a mid-sized BEV with a range of 200-plus miles will likely remain upwards of $5,000 more expensive to manufacture than a similar ICEV through 2030.

Because BEVs are more expensive to produce, incentivizing or forcing consumers to purchase BEVs will have a cost. So, what are the costs to mandate or incentivize BEVs? That is an important question because the best, fastest, and least expensive ways to reduce emissions should be considered. The precise cost of reducing emissions through BEVs is difficult to ascertain because there are so many different forms of mandates and subsidies, and it is not always clear which particular subsidy or policy preference – if any – was instrumental in encouraging an individual to buy a BEV who would have not otherwise made the purchase. Some people would buy a BEV without any incentive. Others may make the purchase primarily for special access to carpool lanes. Still, others may need various incentives, all combined, to decide to purchase a BEV over an ICEV. Below are some of the policies to incentivize BEV sales:

- BEV charging station costs subsidized by taxpayers and utility ratepayers
- Utilities providing BEV charging station rates ($/kWh and $/kW) well below the actual cost
- Distribution transformer upgrades (cross-subsidy from other ratepayers)
- Federal and state revenue lost from liquid fuel taxes (BEVs do not pay into the Highway Trust Fund federally, nor similar programs in some states)
- State BEV buyer and manufacturer tax credits
- Federal grants (e.g., U.S. DOT, U.S. EPA, U.S. DOE, FEMP)
- State/city grants
- Air pollution control district and state environmental agency grants
- State ZEV and LCFS credits
- Utility home charger subsidies
- Federal/state renewable subsidies (to lower BEV carbon intensity)
- HOV and parking preference
- State/local building codes for ‘make-ready’ BEV charging

Sales of BEVs have increased over the last few years but were relatively flat between 2018 and 2019 – and more than 95 percent of Americans continue to choose ICEVs.

A few analysts have sought to answer the question of "what does it cost" by estimating the "cost of abatement" – what a particular policy costs in order to abate GHG emissions.

The Obama Administration started a workgroup to determine the "social cost of carbon." That group wanted to estimate the societal costs of each ton of CO_{2e} emitted. That workgroup's social cost of carbon estimate is $46 per metric ton of CO_{2e} in 2017 dollars.[24] In effect, any policy that costs more than $46 per ton of CO_{2e} would not be worth the investment.

A few third parties have examined the relative cost of abatement and have also concluded that forced switching to electric vehicles is an expensive way to reduce emissions, particularly when compared to other policies. For example, a 2018 study conducted for the National Bureau of Economic Research (NBER) by Harvard and Yale economics professors estimated the relative cost of abatement for a dedicated, federal BEV subsidy to be between $350 and $640 per ton of CO_{2e} (in 2017 dollars).[25] The BEV subsidy ranks among the highest costs included in the NBER study.

Clearview Energy Partners looked at a range of GHG abatement policies and concluded the current BEV tax credit had an implied price on carbon of $237 per ton of CO_{2e}, based on the average carbon intensity of the current U.S. grid. Of the more than 20 policies considered by Clearview, the federal EV tax credit at the average emission intensity was higher than all, except "cash-for-clunkers" and the PMJ Solar Renewable Electricity Certificate. Indeed, the federal EV tax credit was more expensive than every power sector or economy-wide policy considered.

Of note, neither the NBER nor the Clearview analysis seems to have considered that some people would buy a BEV without the subsidy. A study performed by Ernst & Young on behalf of the American Fuel and Petrochemical Manufacturers - a group opposed to BEV subsidies – looked at the typical price elasticity of vehicles and estimated that an expansion of the federal BEV tax credit would be relatively ineffective and result in a tax expenditure of $22,400 to $34,400 per additional BEV sold. Anecdotal evidence points in both directions, with sales of Tesla vehicles remaining strong after tax incentives phased out (perhaps in part because Tesla reduced prices when tax incentives expired), while in some places sales dropped precipitously when tax credits expired (Georgia,[26] Hong Kong[27]).

Many others have also investigated abatement costs associated with a transition to BEVs. McKinsey, the global consulting firm, estimates that the cost of abatement for BEVs is about €100 (about $118) per ton of CO_{2e}.[28] This estimate assumes a transition from 90 percent ICEV sales and 10 percent "other powertrains" from 2016 to 2020 to 40 percent "other powertrain" sales from 2026 to 2030. In this scenario, HEVs account for 22 percent of sales, plug-in hybrids account for 16 percent of sales, and BEVs replace 2 percent of ICEVs.

---

24 Gillingham, Kenneth, and James H. Stock. (2018). "The Cost of Reducing Greenhouse Gas Emissions." Journal of Economic Perspectives, 32 (4): 53-72. DOI: 10.1257/jep.32.4.53, https://scholar.harvard.edu/files/stock/files/gillingham_stock_cost_080218_posted.pdf

25 Gillingham, Kenneth, and James H. Stock. (2018). "The Cost of Reducing Greenhouse Gas Emissions." Journal of Economic Perspectives, 32 (4): 53-72. DOI: 10.1257/jep.32.4.53, https://scholar.harvard.edu/files/stock/files/gillingham_stock_cost_080218_posted.pdf

26 "Here's why electric car sales are plummeting in Georgia," Chris Joyner, Atlanta Journal-Constitution, 1/12/17

27 "Tesla Sales Fall to Zero in Hong Kong After Tax Break Is Slashed," Tim Higgins & Charles Rollet, Wall Street Journal, 7/9/17

28 Naucler, T. & Enkvist, P. (2009). Pathways to a Low-Carbon Economy. McKinsey & Company. https://www.mckinsey.com/business-functions/sustainability/our-insights/pathways-to-a-low-carbon-economy

A different NBER analysis[29] shows that for the state of California to successfully achieve its goal of 1.5 million BEVs on the roads by 2025, the state must spend $12 billion to $18 billion. On a per BEV basis, that is a cost of $8,000 to $12,000 per EV.

When compared to other methods of carbon abatement,[30] such as switching from coal to natural gas in electricity generation or efficiency improvements in buildings, the relative abatement costs associated with electric vehicles is high. Switching from a coal-fired generation energy source to a combined-cycle natural gas power source (which uses both natural gas and steam) costs $27 per metric ton of CO_{2e}[31] — orders of magnitude less expensive than BEV subsidies. Behavioral energy efficiency programs, such as education programs that inform utility customers how they can save energy and reduce their monthly bills, are among the most cost-effective measures at negative $190 per ton of CO_{2e} abated.

Using the studies above and basing BEV costs solely on the $7,500 federal subsidy available for BEV purchases, the table below shows the abatement costs per ton of CO_{2e} for that program.

Table 2: Abated CO_{2e} (ICEV vs. BEV) and Associated Costs

Study	GHG (CO_{2e}) Abated (MT)	EV Subsidy Cost Per MT CO_{2e} Abated
IEA	7 – 11	$682 - $1,071
Argonne	14.4 - 18.2	$412 - $521
MIT/Ford Motor Co.	-10.9* - +39.2	-$688 - +$191
European Union	16.9	$444
MIT	25.1	$299

**Note: Because BEVs produce more CO_{2e} than ICEVs in certain regionalities according to the MIT/Ford study, the abatement of CO_{2e} is represented by a negative value.*

When adjusted for costs, it is clear that forcing or subsidizing the purchase of EVs is an inefficient method of reducing CO_{2e} emissions.

29 National Bureau of Economic Research. 2018. Subsidizing Mass Adoption of Electric Vehicles: Quasi-Experimental Evidence from California. Working Paper 25359. https://www.nber.org/papers/w25359

30 Gillingham, Kenneth, and James H. Stock. (2018). "The Cost of Reducing Greenhouse Gas Emissions." Journal of Economic Perspectives, 32 (4): 53-72. DOI: 10.1257/jep.32.4.53, https://scholar.harvard.edu/files/stock/files/gillingham_stock_cost_080218_posted.pdf

31 Ibid

7. CONCLUSION

There is no such thing as a zero-emission vehicle; all types of vehicles contribute to GHG emissions. The studies and analyses above indicate that a variety of circumstances can impact GHG emission levels of the different vehicle technologies that are only revealed through lifecycle analysis. In some cases, BEVs outperform ICEVs, and in others, ICEVs and HEVs outperform BEVs. There is a wide range of results, but the lifecycle analysis studies show that electric vehicles (BEV and HEV) are not substantially better than ICEVs. These studies show there are benefits to be realized by innovating across all vehicle platforms and that it is shortsighted and inefficient to encumber any of them by promoting only one vehicle type (e.g., sales mandates, state and federal tax credits, rebate programs, free tolls and free parking for BEVs).

Policymakers should recognize the science presented in these studies and the criticality of promoting technology-neutral policies to reduce GHG emissions across the economy most efficiently in transportation for the following reasons:

1. The source of GHG emissions is not relevant to their impact on the environment, so reductions should be sought as efficiently as possible across all sectors of the economy; it does not make sense to force less efficient emissions in transportation if more accessible and efficient (and less costly) reductions can be found elsewhere.
2. There is no such thing as a true *zero-emission vehicle*; policies should consider the lifecycle of vehicle technology platforms and their energy sources – rather than a single point of emissions such as the vehicle tailpipe or the power plant.
3. The studies reviewed for this report show no clear leader when it comes to GHG emissions reductions for passenger vehicles, punctuating the false pretense of policies that favor BEVs when the full lifecycle of a vehicle's emissions are considered.
4. Policies should acknowledge that significant progress continues to be made in vehicles having an internal combustion engine, such as advanced ICEVs, that are still preferred by more than 95 percent of U.S. consumers. According to the U.S. Energy Information Administration, vehicles equipped with internal combustion engines (ICEVs, HEVs, and PHEVs) are expected to comprise 4 out of 5 vehicle sales by 2050.[32] BNEF alternatively anticipates BEV sales to reach 20 percent before 2030 and reach about 60 percent by 2040.[33] Each analysis reflects the uncertainties regarding the BEV market, consumer preference, and government mandates.
5. Technology-neutral policies are necessary to encourage innovative advances capable of achieving the most cost-competitive GHG reductions across the transportation sector for all vehicle platforms.
6. Technology-neutral policies within the transportation sector ensure consumers bear the lowest possible cost of carbon abatement for passenger transport. Making newer vehicles relatively more affordable enables the entire vehicle fleet to elevate its energy efficiency – and accelerate carbon dioxide emission reductions -- in the least amount of time.

32 Energy Information Administration, 2020 Annual Energy Outlook: Transportation, https://www.eia.gov/outlooks/aeo/pdf/AEO2020%20Transportation.pdf

33 "Electric Vehicle Outlook 2020," BloombergNEF, Colin McKerracher, et al. (2020), https://about.bnef.com/electric-vehicle-outlook

CONSERVAMERICA
Conservation *is* Conservative

www.conservamerica.org