Electric Vehicle Efficiency: Unlocking Consumer Savings and Environmental Gains

Peter Huether

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White Paper

About ACEEE

The **American Council for an Energy-Efficient Economy** (ACEEE), a nonprofit research organization, develops policies to reduce energy waste and combat climate change. Its independent analysis advances investments, programs, and behaviors that use energy more effectively and help build an equitable clean energy future.

About the author

Peter Huether conducts research and analysis for the ACEEE transportation program, focusing on light-duty fuel efficiency and electric vehicles. Peter works on promoting equitable access to electric vehicles and leads the annual life-cycle emissions analysis of light-duty vehicles for ACEEE's GreenerCars.

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Executive summary

Key findings

- Improving electric vehicle (EV) efficiency as we electrify vehicles brings benefits to drivers, the environment, and the electricity grid. More-efficient EVs consume less energy, save drivers money, and limit upstream emissions.
- Efficient EVs consume fewer resources for production, which can reduce upfront purchasing costs. Even modest improvements in efficiency can reduce upfront costs by $4,800 (by reducing the battery size) and reduce annual fueling costs by 29%.
- More-efficient EVs limit the strain of charging on the electricity grid and the need for future grid investments. A fully electric future with the average EV efficiency raised to today's best-in-class levels would save electricity equivalent to the usage of 21 million homes.
- Our current federal fuel efficiency and emissions standards should be updated to improve EV efficiency and reverse the recent trend toward larger vehicles. These updates may include upstream accounting as well as aligning federal standards for SUVs and pickup trucks with those for sedans.
- State and local solutions can encourage improved EV efficiency by changing fee and rebate structures to incentivize the purchase of more-efficient EVs.

Electric vehicles (EVs) have lower fueling costs, lead to cleaner air, and are a key way to reduce greenhouse gas (GHG) emissions from the transportation sector. However, there are vast differences in EV efficiency, and it is critical that manufacturers make efficiency a priority in designing new vehicles. EV efficiency means using less electricity to drive each mile. The United States has used federal standards to advance gasoline vehicle efficiency nationally for decades; the same must done for EVs. Increasing the efficiency of EVs will mean reversing the trend of larger, heavier vehicles. Policymakers should be incentivizing greater EV efficiency to ensure the most efficient use of resources.

Benefits of greater EV efficiency

More-efficient EVs benefit drivers, the environment, and the electricity grid. Greater efficiency means less electricity used per mile of driving, saving owners money. It means that for the same amount of charge a driver can go further, helping to alleviate "range anxiety." Drivers can also save money upfront: Batteries are a major contributor to EV price, and greater efficiency means that smaller batteries can achieve the same range. For example, improving the efficiency of a 300-mile range EV from 2.5 to 3.5 mi/kWh would save about $4,800 on an EV's cost at current battery prices and energy densities (BNEF 2023). This can fuel a faster transition to overall vehicle electrification because the same mineral supply and battery manufacturing capacity can produce more EVs (Riofrancos et al. 2023).

While EVs produce no emissions from their tailpipe, they do contribute to upstream emissions from the electricity they use, which is still largely fossil fuel based. Emissions are also produced when the vehicle components—particularly the battery—are being produced (EPA 2024b). Greater EV efficiency means a smaller battery pack for the same range. This smaller battery pack means a lighter EV, which itself improves efficiency. For EVs currently on the market, there is a correlation between more-efficient EVs and fewer emissions to produce the vehicle, as figure ES1's downward trend line indicates.

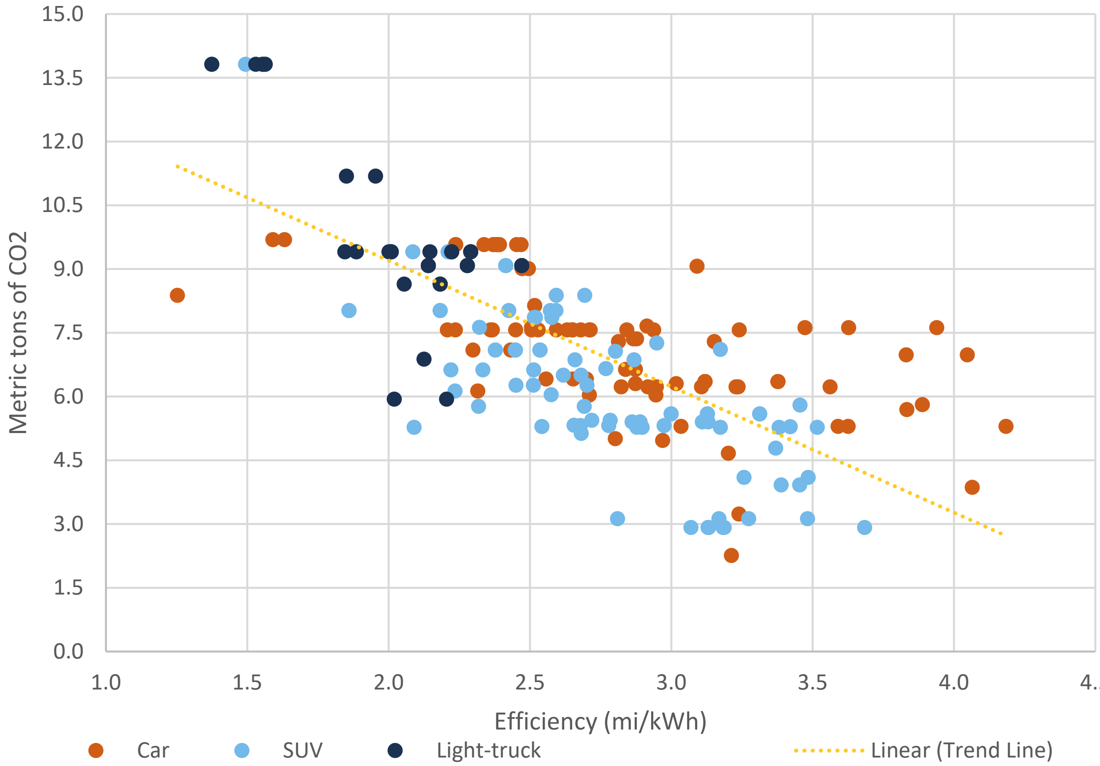

Figure ES1. Emissions to produce battery pack versus efficiency of model year 2024 EVs. Source: GreenerCars 2024.

Widespread vehicle electrification will require billions of dollars of investments in the grid, but more-efficient EVs will use less electricity, put less strain on the grid, and reduce these costs (Cutter et al. 2021). If all vehicles were electric and had an average efficiency equal to today's best-in-class efficiency (ignoring future improvements), it would save the amount of electricity used by 21 million homes in comparison to a fleet with today's average efficiency (Huether 2023).

Policy solutions to increase EV efficiency

In their current form, the two main levers to improve U.S. vehicle efficiency—that is, Department of Transportation efficiency standards and Environmental Protection Agency (EPA) GHG emissions standards—are not suited to incentivizing greater EV efficiency. The EPA standard treats all EVs as having zero emissions. It therefore provides no incentive to improve EV efficiency since inefficient and efficient EVs are treated the same for compliance purposes.

Further, neither standard is suited to limiting the recent trend toward larger vehicles. Average vehicle weight is up 34% since the early 1980s; in 2022, sedans made up only 27% of production, with the remainder being SUVs and pickup trucks. This trend has limited improvements in efficiency and reductions in emissions in internal combustion engine vehicles (ICEVs) and could do the same in EVs (EPA 2023c). The EPA's separate emissions standards for cars and light trucks has played a role in the shift toward larger vehicles, which has emissions impacts as well as impacts on pedestrian safety. Larger vehicles inflict greater damage on impact, and vehicles with higher hood heights reduce pedestrian visibility for drivers and strike pedestrians higher on their body, where they are more vulnerable (Barry 2021). Another federal policy includes greater financial support for battery research to improve battery energy density, which means smaller batteries and savings on minerals, emissions, and weight for the EV.

Beyond the federal level, one policy solution is to modify the registration fees that states and localities levy on vehicles. Most states levy specific fees on EVs to make up for a lack of gasoline tax revenue. These fees can be easily modified to incentivize greater EV efficiency, lighter EVs, or both; some states are already levying their fees in this way. The same changes could also be made in state and local EV rebates, with jurisdictions offering higher rebate levels for more-efficient EVs. Changes in fee and rebate structures at the state and local level can influence drivers' purchasing decisions and encourage them to buy more-efficient EVs, which will be on our roads for decades to come.

Introduction: efficiency still critical as we electrify vehicles

Passenger vehicles are a major contributor to climate change and local pollution, emitting more than 16% of U.S. greenhouse gases (GHGs) (EPA 2023a). Historically, the United States has tackled these emissions by setting fuel-efficiency and emissions standards for new vehicles. The federal fuel-efficiency standards, known as the Corporate Average Fuel Economy (CAFE) standards, have saved consumers trillions of dollars from reduced fuel usage—at least 1.5 trillion gallons of gasoline since their enactment in 1975. They have also been one of the most consequential emissions-reducing policies in U.S. history and have enhanced the domestic automotive industry's competitive advantage (Alliance to Save Energy 2018; Nadel 2019). CAFE standards and the corresponding Environmental Protection Agency (EPA) standards for GHG emissions are critical standards that have reduced fuel use and emissions while saving drivers money, and they will continue to do so in coming decades.

Today, the United States is tackling vehicle emissions with numerous other federal- and state-level policies that aim to increase the share of new vehicles that are electric. Electric vehicle (EV) purchase incentives, charging investments, and utility electric rate policies will all contribute to further electrification. Greater electrification will have numerous benefits, including lower emissions and reduced fueling costs (UCS 2018).

California also sets its own vehicle standards, Advanced Clean Cars, that other states can adopt. These standards go above and beyond the federal standards. As a result of both national and state standards, EVs will become an ever-growing share of the new vehicle market. While this will be undoubtably beneficial, electrification can be resource intensive. It is important that we continue to consider efficiency as we electrify vehicles to ensure the smallest environmental footprint and the largest benefits from this transition to EVs (EPA 2024a).

Electrification alone will bring many benefits to the environment and drivers, but not all EVs are created equal. In some cases, EVs may be continuing a concerning trend in the conventional vehicle market—namely, a shift toward larger, less efficient vehicle classes. We must continue to strive for greater efficiency in EVs as we push for greater electrification overall. More-efficient EVs are better EVs: They have greater range, lower costs, fewer materials requirements, and smaller impacts on the environment and electricity grid. Policymakers should be incentivizing EV efficiency improvements and updating vehicle efficiency regulations, which were designed before EVs existed and are poorly suited to an all-electric future.

The basics of EV efficiency

EV efficiency means using fewer materials and less electricity to go the same distance, resulting in a smaller impact on people and the planet. Greater efficiency comes from lighter vehicles, more aerodynamic vehicles, more technologically advanced vehicles, and vehicles with lighter, more energy dense batteries.

An EV's fuel efficiency is often expressed in miles per kilowatt-hour (mi/kWh) of driving, mirroring the miles per gallon used for internal combustion engine vehicles (ICEVs). EPA also reports EV efficiency in miles per gallon-equivalent (MPGe) for ease of comparison to ICEVs, and MPGe is reported on vehicle labels.[1] A third option for denoting EV efficiency is kWh per 100 miles, which is based on the same calculation as mi/kWh but displayed differently. Here, we use mi/kWh when measuring EV efficiency because a higher mi/kWh value denotes higher efficiency (for kWh/100 miles, a lower figure denotes higher efficiency). Also, we do not use MPGe when discussing only EVs because kilowatt-hours are the unit of measure for the fuel that EVs use.

EVs vary in efficiency for many of the same reasons as ICEVs. Regardless of fuel type, vehicles that are heavier have greater horsepower, have poor aerodynamics, and have less efficient engines, motors, power electronics, thermal systems, and other subcomponents. EVs are fundamentally more efficient at converting energy into forward motion: An EV can convert upwards of 73% of the energy stored in its battery into motion, whereas ICEV efficiency during city driving can be as low as 12%—that is, as little as 12% of the energy stored in gasoline is converted into vehicle movement, largely due to engine heating losses. EVs can also recharge their batteries with a portion of the energy lost when braking. This regenerative braking helps to explain their higher efficiency than ICEVs (although hybrid vehicles also use regenerative braking) (DOE 2024c).

Current (model year 2024) EVs have efficiencies that range from as little as 1.4 mi/kWh for the Hummer EV to as high as 4.2 mi/kWh for the Hyundai Ioniq 6; between the two are EVs that range significantly in size and power. The middle 50% of models have efficiencies ranging from 2.3 to 3.0 mi/kWh, but some popular models have above-average efficiency, including the Tesla Model Y (3.5 mi/kWh) and Volkswagen ID.4 (3.1 mi/kWh). EVs with below average efficiency tend to be larger vehicles, such as pickup trucks (e.g., the Ford F-150 Lightning) or luxury SUVs (e.g., the Audi SQ8 e-tron).

Greater efficiency is good for drivers

Federal efforts to improve vehicle efficiency have had profound benefits for drivers, including saving them thousands of dollars on fuel over a vehicle's life (Harto et al. 2023). For many families, gasoline fueling costs are a real burden, averaging 7% of income for all households and 14% for low-income households.[2] EVs will help reduce those costs due to the lower, more stable cost of electricity (Vaidyanathan, Huether, and Jennings 2021; Preston 2020). Although EV uptake is still limited by higher upfront costs due to battery price, tax credits are lowering their price (Lindwall 2023). The economics of switching to an EV are favorable, with lower costs over the vehicle's lifetime compared to a gas counterpart; greater EV efficiency can further strengthen the case for drivers to switch to EVs (Nigro and Wilkins 2024).

Less electricity per mile, lower fueling costs

By definition, greater EV efficiency would mean less fuel (i.e., electricity) per mile driven, making every trip in an EV cheaper. Driving an EV with a higher efficiency of 3.5 mi/kWh (e.g., the Kia EV6) would cost about $680 a year, while one with a lower efficiency of 2.5 mi/kWh (e.g., the Audi e-tron GT) would cost $960—a decrease of 29%[3] (GreenerCars 2024).

[1] This conversion is calculated based on the energy content of gasoline and electricity and how many gallons of gasoline would be needed to provide the same energy to the vehicle as one kilowatt-hour of electricity (EPA 2023b).

[2] Here, we define low-income households as those with annual incomes below 200% of the federal poverty level.

[3] Assuming 15,000 miles driven per year and an electricity cost of $0.16/kWh.

Going further on a single charge

Greater efficiency means going farther on a charge, helping to assuage the "range anxiety" that deters many potential EV buyers; in one survey, for example, 54% of respondents cited range anxiety as a reason they would not go electric (Barry 2023). Increasing the battery's size increases range but adds cost, requires more minerals, and increases the emissions to produce the battery pack and its components. In contrast, increasing efficiency can increase range without having to increase battery size. A vehicle with an efficiency of 2.5 mi/kWh and a 100-kWh battery can go about 250 miles, while a vehicle with 3.5 mi/kWh efficiency and the same battery can go 350 miles.

Greater efficiency also means getting to full range faster when charging because for every kilowatt-hour of charge added to the battery, more miles of range are gained. Drivers often care more about how many miles of charge they are getting per minute or hour rather than how much electricity they are getting; by getting more mileage from the same charge, drivers gain miles faster.

Increasing affordability

Greater efficiency can increase range with the same battery size. It can also mean that a smaller battery can go the same distance as a larger one, reducing one of the greatest contributors to an EV's price. For example, an EV with an efficiency of 2.5 mi/kWh and a 120-kWh battery can go 300 miles, but if efficiency is increased to 3.5 mi/kWh, we could reduce the battery to approximately 86 kWh while still maintaining that 300-mile range. At an average battery price of $140/kWh, that reduction would save about $4,800 on the vehicle's cost (BNEF 2023). A reduction in battery size also means more vehicles can be made from the same supply of minerals and the same battery manufacturing output, potentially accelerating the transition to EVs (Riofrancos et al. 2023).

Greater efficiency means lower emissions and environmental impact

EVs may not have tailpipes, but that does not mean they are not responsible for any emissions. The U.S. electricity grid is not yet emissions free, so when EVs draw power from the grid, they contribute to those upstream emissions. Manufacturing of EVs also produces emissions, because it takes energy to produce a vehicle's materials and subcomponents, and EVs with larger battery packs can have higher production or embedded emissions than other EVs (GreenerCars 2024). Greater EV efficiency can help to reduce EV emissions—which are already lower than gasoline vehicles—and thereby further improve local air quality and further mitigate climate change.

Lower upstream emissions

As with fueling costs, upstream emissions are directly proportional to EV efficiency. The more electricity needed to drive a vehicle a mile, the more emissions will be generated upstream by natural gas and coal power plants. The current U.S. electricity grid emits about 373 grams of CO_2 per kilowatt-hour on average, although this can vary considerably by region (EPA 2024b). That means a relatively efficient EV, driving 3.5 miles on one kWh, contributes to about 1,600 kilograms of CO_2 emitted upstream from electricity generation annually, while an inefficient EV that drives only 2.5 miles on one kWh would contribute to about 2,240 kilograms of CO_2 annually.[4] So, the difference between an efficient and

[4] National grid emissions are for 2022, and we assume 15,000 annual miles.

inefficient EV contributes to a 40% difference in not only CO_2 emissions, but also in the other pollutants such as SO_2, NO_x, and fine particles that affect public health and are emitted by fossil-fuel power plants. It is crucial to dramatically reduce these emissions to mitigate climate change and improve public health. However, our grid today is still polluting, and evidence shows that we are not transitioning it to renewables at the needed rate (St. John 2024). Improving EV efficiency is crucial to limiting the emissions from our transition to EVs as much as possible.

Lower manufacturing emissions and environmental impact

Greater efficiency can allow drivers to go farther on a single charge or use a smaller battery to travel the same range. As we noted early, an EV with an efficiency of 2.5 mi/kWh would need a 120-kWh battery to have a range of 300 miles, while one with an efficiency of 3.5 mi/kWh would need only an 86-kWh battery for the same range. Given the typical battery energy density of today's EVs—that is, 160 Wh/kg—the battery of the less efficient 2.5 mi/kWh EV would weigh almost 30% more—that is, more than 1,650 pounds compared to 1,180 pounds for the more-efficient EV (GreenerCars 2024). That is not only 30% less battery weight on the vehicle (which itself can improve efficiency) and the roads, but also 30% less minerals that need to be mined and processed and 30% less energy needed to produce the battery pack. EV battery packs are material- and energy-intensive components of the vehicle, and they contribute to the higher production emissions of EVs relative to a comparable gasoline-powered vehicle (Moseman and Paltsev 2022). Reducing these upfront, embodied emissions will further increase the emissions benefits of vehicle electrification, as well as reduce electricity grid emissions from charging.

Beyond emissions, mining and processing minerals for EV batteries can have a major impact on the environment and local communities. Mining can damage ecosystems, reduce biodiversity, lead to deforestation, and pollute and strain water supplies. It also has social impacts: Mines are disproportionately located in indigenous communities, and human rights violations have been associated with the mining of certain minerals (Riofrancos et al. 2023; Plug In America 2023; Climate Nexus 2024). The transition to EVs is still a net environmental benefit overall, and there are ways to improve the EV supply chain to limit these impacts. However, reducing the demand for battery materials is also crucial. Greater efficiency can lead to smaller battery packs and thereby limit the need for new mines without slowing down our transition to EVs.

Calculating the benefits of lower production emissions

ACEEE's GreenerCars is an annual assessment that scores new vehicles based on their life-cycle emissions. Because it assesses the emissions from driving, fueling, and production, GreenerCars is a valuable tool to understand the emissions impacts of greater EV efficiency and smaller battery packs. The model calculates production emissions for the entire vehicle based on weight, but separately calculates battery pack emissions based on cathode type and weight (GreenerCars 2024).

The CO_2 emissions impact of current 2024 EV battery packs can vary considerably, but it is strongly correlated with energy storage capacity. Our analysis found that emissions from producing the battery pack can vary from a little over 2 metric tons of CO_2 to almost 14 metric tons. To put that in perspective, the average new conventional vehicle—that is, not including EVs or plug-in hybrids—sold in 2022 had a real-world efficiency of 24.8 miles per gallon, which equates to annual CO_2 emissions of 5.4 metric tons of CO_2 (EPA 2023c).[5] This means the emissions associated with producing a battery pack can be

[5] Assuming 15,000 annual miles of driving for a new vehicle and 8,887 grams of CO_2 per gallon of gasoline.

equivalent to just one year of driving a gasoline vehicle. Battery pack emissions are not insignificant and should be reduced, but they also need to be compared to the emissions produced every year by gasoline-powered vehicles.

There is already considerable variation in the types of EVs being sold. As figure 1 shows, EVs with smaller battery sizes—and thus lower emissions from producing the battery pack—are correlated with higher efficiency based on ACEEE analysis. This is likely due in part to greater efficiency, meaning that a smaller battery pack is needed to achieve a certain range, as well as to the impact of battery size itself on the vehicle's efficiency. A larger (and therefore heavier) battery pack can reduce efficiency because more energy is needed to move the weight of the battery itself in addition to the EV's other components. This means that automakers have to make fewer improvements to the vehicle design or technology to improve efficiency, as reducing battery pack size on its own can partially achieve this improvement.

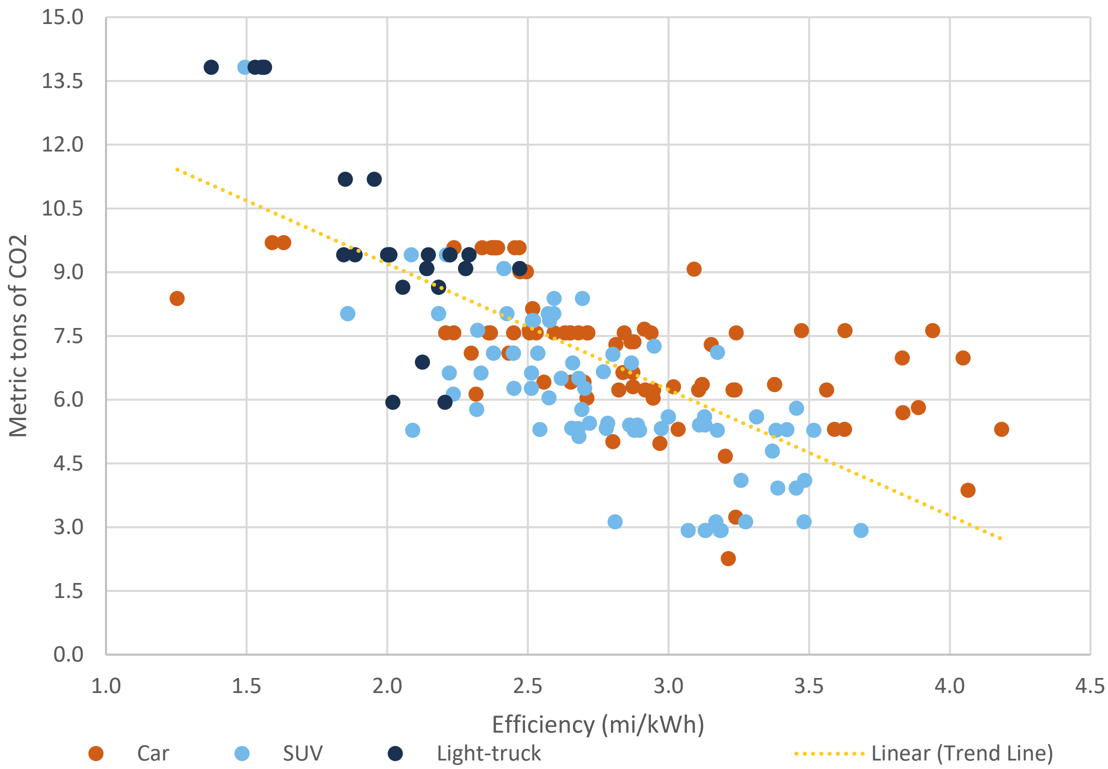

Figure 1. Emissions to produce battery pack versus efficiency of model year 2024 EVs. Source: GreenerCars 2024.

As figure 2 shows, even when looking at vehicles of the same range, battery pack emissions can vary considerably due in part to the vehicle's efficiency. For vehicles with roughly 200 miles of estimated range, battery emissions can range from 3.1 to 6.6 metric tons of CO_2, while for those with roughly 250 miles of range, it can vary from 3.1 to 9.7 metric tons of CO_2. This shows the importance of factors such as EV efficiency in improving range and reducing emissions.

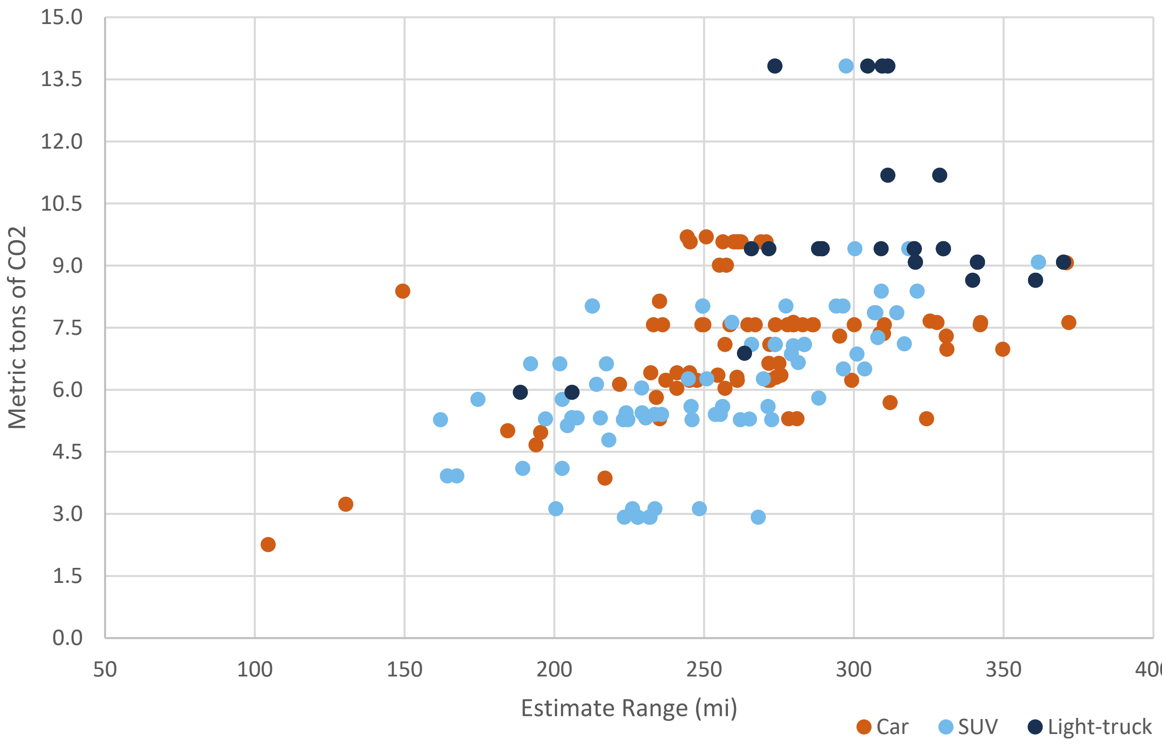

Figure 2. Emissions to produce battery pack versus ACEEE estimated range of model year 2024 EVs. Source: GreenerCars 2024.

Greater efficiency will reduce strain on the electricity grid

The transition to EVs will fundamentally change how we fuel our vehicles, requiring many new drivers to connect their vehicles to the electrical grid for the first time. Millions of EVs drawing power from the grid will require upgrades to utility transmission and distribution systems. One estimate has the cumulative investment in the distribution system at $116 billion by 2050 under a high vehicle electrification scenario due to significantly higher total electricity loads and peak charging demand (Cutter et al. 2021). Although such costs can be fully recouped from EV charging revenues and smart EV charging rate design and policies, it does not mean that reducing upfront investment costs is not important (Shenstone-Harris et al. 2024).

Greater EV efficiency can reduce the level of investment needed to fuel an electric future. If all the vehicles on the road were electric and had an average efficiency by today's standard of 3.4 mi/kWh, they would require approximately 1.2 million additional gigawatt-hours of electricity to power. That is enough electricity to power 113 million homes, and it would require significant increases in generation, transmission, and distribution capacity. However, if those EVs had an average efficiency equivalent to the highest level achieved today—that is, approximately 4.2 mi/kWh—the amount of electricity saved is equivalent to 21 million homes. In the decades to come, we can also achieve even better efficiency, so the savings might be far greater (Huether 2023).

How automakers can increase EV efficiency

To improve EV efficiency, automakers can choose from various strategies, including changes to the vehicle design and improvements to vehicle technology. Some strategies are unique to EVs, but many apply to gasoline-powered and hybrid vehicles as well and are in fact continuations of efforts to improve ICEV efficiency. However, without policies to incentivize greater EV efficiency, automakers will prioritize profitability alone and may not take advantage of the available strategies.

Vehicle design to reduce drag and limit weight

The design of a vehicle, regardless of its fuel type, can increase or decrease its efficiency. Current vehicles, including EVs, can be made more efficient in two primary ways: by reducing drag, or the force on the vehicle from the air around it when it is in motion, and by reducing overall vehicle weight. Both options reduce the amount of energy needed to move a vehicle down the road and are connected in part to the automaker's design choices.

The amount of drag on a vehicle is primarily determined by the size of its front area and its curvature (or lack thereof). Vehicles with large, flat fronts—common to many pickup trucks and SUVs—face more resistance from the air than sedans with more sloping fronts. The drag level of a pickup truck can be almost twice that of midsize cars due to its size and shape. This is important because a 10–20% reduction in drag can reduce fuel consumption by 2–4% (National Academy of Sciences, Engineering, and Medicine 2021).

Reducing a vehicle's weight also improves its efficiency and can be even more effective than reducing drag, with a 10% reduction in mass generally improving fuel efficiency by 4–7%. Weight can be reduced by switching to lighter materials, such as aluminum, and reducing the weight of components. Critically for EVs, reducing battery weight can also improve efficiency in addition to weight reductions elsewhere in the vehicle (National Academy of Sciences, Engineering, and Medicine 2021). Figure 3 shows the relationship between weight and efficiency: All of the most efficient EVs are in the lowest EV weight range (4,000–5,000 pounds). While this may be the lowest weight range of EVs, many ICEVs are lighter, with over 100 models weighing less than 4,000 pounds (GreenerCars 2024).

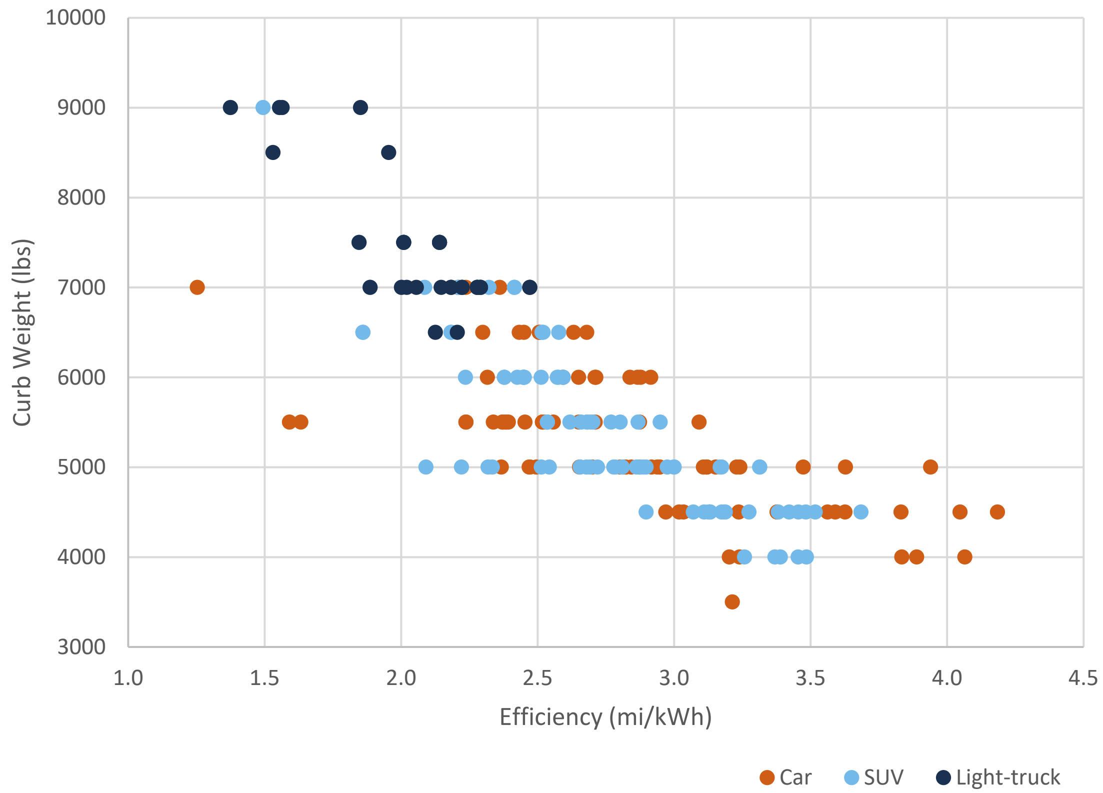

Figure 3. Curb weight versus efficiency of model year 2024 EVs. Source: GreenerCars 2024.

Efficiency-boosting technology

Efficiency gains can also be made in vehicle components that comprise the drivetrain, such as the motor and inverter, which converts the direct-current power from the battery to the alternating-current power used by the motor, to the batteries themselves. EVs are already much more efficient at converting energy to forward movement compared to ICEVs, limiting drivetrain improvement opportunities. However, there are advancements that can still be made in the electric drivetrain, including higher gear ratios for electric motors and the use of wide-bandgap semiconductor devices in inverters, higher voltage architectures, and improved thermal management (National Academy of Sciences, Engineering, and Medicine 2021). Current battery chemistries can also improve energy density, but large changes (upwards of doubling of energy density) will require new designs and chemistries like solid-state batteries (National Academy of Sciences, Engineering, and Medicine 2021; Hanley 2023). One study estimates that powertrain and battery energy use improvements could reduce electricity use per mile by 18% using today's available technologies (NRDC and EPRI 2024).

Policy solutions to increase EV efficiency

As the share of new vehicles that are electric increases, it is imperative that policymakers address the lack of policy incentives for automakers to improve EV efficiency. We have made huge strides in improving the efficiency of gasoline-powered vehicles and continue to do so, but current policies may not be adequate to continue this progress for EVs. Federal fuel-efficiency and emissions standards set by the Department of Transportation (DOT) and EPA have been the primary way to increase passenger vehicle efficiency, and they can continue to do this for EVs if EV emissions and efficiency are taken into account. Because EPA's current standards treat all EVs as zero-emissions vehicles, automakers have no policy incentive to improve efficiency. Further, both EPA and the DOT standards have failed to stop the trend toward larger, heavier vehicles, and this could persist as we electrify. Beyond federal standards for new vehicles, state and local governments can modify fees and rebates to incentivize the purchase of more-efficient EVs.

Federal policy solutions

Implementing upstream accounting in EPA's emissions standard

EPA's light-duty emissions standard for new vehicles sets a standard that all automakers must meet in terms of grams of CO_2 per mile of driving. This standard is a fleet-wide average that is adjusted according to the vehicle size and class for each automaker; it declines over time based on an EPA assessment of the cost-effective emissions-reducing improvements available to automakers. The light-duty standard, however, uses "tailpipe accounting," which treats EVs as non-emitting because they produce no tailpipe emissions. This ignores the emissions attributable to the electricity used to charge EVs. Further—and importantly—all EVs are treated the same by the standard. So, the EPA treats the sale of a highly inefficient EV and a highly efficient EV the same, and both comply with the standard. This removes any incentive to improve EV efficiency and reduces the standard's impact on overall emissions from passenger vehicles.

ACEEE has long argued to EPA that it should modify its standard to include EV electricity emissions, known as upstream emissions, when calculating EV emissions for standard compliance. It is the clearest way to reduce EV emissions, to treat them in a similar fashion to gasoline-powered vehicles, and to improve EV efficiency in the process. A more-efficient EV would have lower upstream emissions and would therefore be more advantageous for automakers when complying with the standard, mirroring the incentive that currently exists for gasoline-powered vehicles; it would also extend the standard's relevance. Without this or similar reforms, EPA's standard becomes less relevant as we approach full electrification because automakers will be selling increasing numbers of compliance-equivalent vehicles (Huether and Langer 2023).

Modify standards to reduce shift toward larger vehicles

The U.S. automotive market has transformed in the past decade or two, shifting toward larger vehicles classified as light trucks and away from those classified as cars. Much of this upsizing shift has been due to the growth in SUVs and crossovers—all classified as light trucks—which in 2022 accounted for 44% of production, the highest of any category. Although these vehicles have gotten more efficient over time, the shift to larger vehicles reduced the amount of efficiency gains that could have been realized over this period because larger vehicles and SUVs are typically less efficient than sedans (EPA 2023c). If this trend persists as the U.S. automotive market electrifies, the fleet of EVs will be larger and less efficient than they need to be, increasing emissions and costs.

The trend toward larger vehicles should be tackled for both ICEVs and EVs in future iterations of the federal fuel efficiency and emissions standards. This will likely require changes to the standards' design to improve fleetwide, real-world efficiencies and emissions levels, as well as to ensure that EV upsizing, in particular, is addressed. A modification that accounts for the need to tackle this problem for both vehicle types is critical, especially as millions of ICEVs are expected to be sold over the next decade—and on the road for at least a decade after that. The EPA has acknowledged this issue and has begun to tackle it in its latest greenhouse gas standards by bringing the requirements for cars and light trucks closer together and limiting the amount that larger vehicles can emit compared to previous rules (Huether and Langer 2023).

This shift toward larger vehicles has also had an impact on pedestrian safety. Pedestrian fatalities have grown 46% between 2010 and 2019. Over the past two decades, hood height has grown 11% for light trucks, and pickup trucks in particular became 24% heavier on average (GHSA 2021; Barry 2021). Higher vehicle hood heights decrease driver visibility, especially of children. Together, high hood heights and greater weight can increase the harm done when a pedestrian is hit. Safety standards that account for risk to pedestrians could address these changes and simultaneously improve efficiency for both ICEVs and EVs, as changing vehicle design can also reduce fuel consumption.

Greater research and development support for EV batteries

EV batteries can weigh anywhere from a few hundred to a few thousand pounds, and this weight can decrease EV efficiency. Reducing this weight while giving drivers the range they desire is an important consideration for policymakers. Improving battery energy density can reduce battery weight without sacrificing energy storage. The federal government already supports research into advanced EV battery technology, and it should continue to do so to accelerate innovation (DOE 2024a).

State and local policy solutions

Registration and other fees

All 50 states and the District of Columbia charge vehicles registration fees, which are typically paid annually, to fund transportation projects in the state. The amount and structure of these fees vary significantly, with many states assessing flat fees, while other states vary fees according to factors such as vehicle weight or age (NCSL 2020). EVs often have their own fee levied because they do not pay any gasoline tax, which is the primary funding tool for a state's road and highway projects, and few states tax EV charging to fund transportation projects. EV fees are generally flat fees paid on top of registration fees (NCSL 2023; Jaors and Hoffer 2023).

States have an opportunity to vary one or both of these fees to incentivize the purchase of more-efficient EVs. Some states have already varied these fees to achieve particular policy aims or promote fairness in their transportation funding systems. Of these states, some vary registration fees by weight, with higher fees for heavier vehicles, which also tend to be less efficient. In the District of Columbia, for example, the fee varies from $72 to $500 for the heaviest vehicles but includes an allowance for EVs, which are heavier on average due to their battery pack. It assesses EV registration fees based on vehicle weight minus 1,000 pounds for the battery pack, which makes an EV heavier than an equivalently sized ICEV vehicle (Lazo 2022). These weight-based fees are applied to all registered vehicles to incentivize the purchase of lighter ICEVs and help reverse the shift toward larger vehicles.

While most states have flat fees for EVs, Oklahoma varies its EV fee by weight. EVs that are 6,000 pounds or less pay $110 annually, while those 6,001–10,000 pounds pay $158, and vehicles heavier than 10,000 pounds pay even higher fees. Practically, however, most car and SUV EVs are 6,000 pounds or less and therefore pay the same (lowest) fee, but electric pickup trucks and other vehicles over 6,000 pounds pay more (DOE 2024b).

States can and should vary both fees based on vehicle efficiency to incentivize drivers to purchase more-efficient EVs. Varying the fees—especially the registration fee, since it applies to conventional vehicles and EVs—by weight is a good alternative. Doing so can indirectly lead to more-efficient vehicle purchases since heavier vehicles are often less efficient; they also tend to do more damage to the roads and should be paying more for their upkeep (Lazo 2022). While varying these fees by efficiency or weight are good opportunities for states to affect vehicle purchasing choices for the better, in the long term as we electrify, we will need to rethink our transportation funding model, which is currently funded primarily from taxes on fossil fuels used in ICEVs.

EV rebates and other subsidies

Many states provide tax credits or rebates for purchasers of new EVs, but none provide a higher subsidy for more-efficient EVs (Huether et al. 2023). This is another near-term opportunity for states to affect the EV market, incentivizing drivers to purchase more-efficient EVs and automakers to sell them.

Conclusion

EVs will bring numerous benefits to drivers and communities, including cleaner air and lower fueling costs. Not all EVs are the same, however, and policymakers cannot forget about fuel efficiency as the automotive market electrifies. Improving EV efficiency has its own benefits beyond those of electrification, and it can further reduce emissions, extend driving range, improve EV affordability, and lessen the demand on the grid. Currently, there is limited policy incentive to improve EV efficiency, but options exist at the federal, state, and local level that policymakers should explore.

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