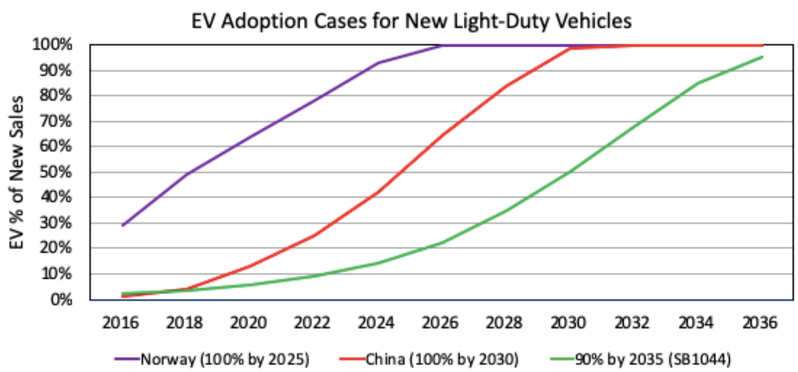
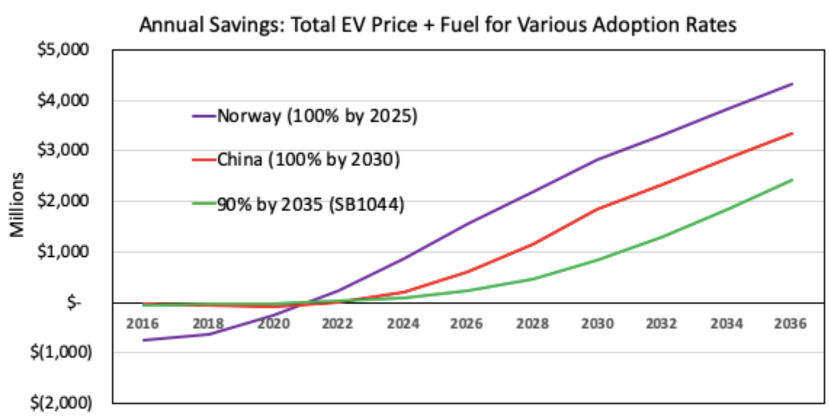
Independent clean-energy and policy analysis **November 2019** *by Eric Strid*

State Policy Design for Opening EV Floodgates

Summary

- Electric vehicles (EVs) are approaching cost tipping points that will trigger rapid adoptions.
- The co-benefits of vehicle decarbonization include huge cost savings on fuels, healthcare, and maintenance; plus benefits to local jobs, resilience, and grid assets.
- Remaining barriers include purchase-price gaps, charging infrastructure gaps, and incumbent industry sectors.
- State-level policies can accelerate or decelerate EV adoptions and the attendant savings.
- Details for Oregon are used to illustrate effective policy options.





A simplified comparison of annual savings from electrifying Oregon's 170,000 new vehicles per year for three adoption cases: Norway's pace, China's pace, and the Oregon SB 1044 target. This models EV purchase price trends for the medium-segment vehicle in Figure 1 and fuel costs at $3 per gallon or $0.10 per kWh for electric fuel. $2B is about 1% of state GDP.

I. The benefits of zero-emission vehicles (ZEVs)

1. **ZEVs cost about 1/3 as much to fuel.** The largest and fastest growing ZEV technology is the all-electric battery electric vehicle, or BEV, which is about four times as energy efficient as gasoline or diesel vehicles. The average American drives nearly 15,000 miles per year; at an average of 26 mpg and $3 per gallon, that's about **$1730** for gasoline or diesel; at $0.10 per kWh the electric fuel costs about **$525** annually. BEV fueling saves about $1200 a year, so consumer savings will ramp up while auto purchases simply shift from gas guzzlers to BEVs. Thusly will the floodgates open.

2. **ZEVs eliminate socialized costs of toxic pollution from vehicle operation.** More Americans die prematurely from vehicle emissions than from vehicle accidents. Toxic emissions cause very large healthcare costs from respiratory diseases.

3. **ZEVs eliminate socialized costs of greenhouse gas pollution from vehicle operation.** Greenhouse gas (GHG) emissions from transportation are the largest emission sector in Oregon and the US, and personal vehicles are the largest portion of transportation emissions. Global GHG reduction has become an unprecedented urgency, as documented by the IPCC and the latest National Climate Assessment.

4. **BEVs cost much less to maintain.** A BEV motor has only one moving part—no pistons, no timing belt, no radiator, no catalytic converter, no transmission, etc. The largest maintenance cost in a battery electric vehicle is tires.

5. **ZEVs keep energy spending in our region.** About 60% of Oregonians' energy spending is for transportation fuels. Oregon sends **over $5 billion** out of the state every year for vehicle fuels. If that cost was a tax, it'd be branded "a giant job-killing tax". We now have the technology to power our vehicles from energy sources in the state or in the Pacific Northwest.

6. **BEVs increase energy resilience.** Distributed energy generation and storage at the community level increases the ability to withstand power outages from major storms, wildfires, earthquakes, or cyber attacks. EVs can be charged from microgrids or from any building with electricity, instead of being dependent upon centralized fossil-fuel storage that is likely to slide into the Willamette River in an earthquake.

7. **BEVs increase grid efficiencies.** The added electric load from EVs increases utility asset utilization, enabling lower electricity rates.

Note that six of these seven benefits are co-benefits of decarbonization, that accrue to local communities. The International Monetary Fund notes, "About three quarters of global [fossil fuel] subsidies are due to domestic factors—energy pricing reform thus remains largely in countries' own national interest…" In other words, the global social costs of GHG emissions are far less than all the other economic and socialized costs of fossil fuels. There are overwhelming local cost savings from adopting clean energy technologies, particularly BEVs.

II. Three remaining hurdles

A. Purchase-price gaps

Figure 1 shows estimated costs to manufacture an EV and a comparable internal combustion engine (ICE) vehicle in a medium segment. Batteries are the largest component cost, and their cost trajectory implies cost parity with mainstream ICE vehicles around 2025. Adding ten years of typical fuel costs to these purchase costs accelerates cost parity by about 6 years, i.e., 2019. But consumers typically consider only two or three years of operating expense when buying a product, so the price gap is a major sales objection today.

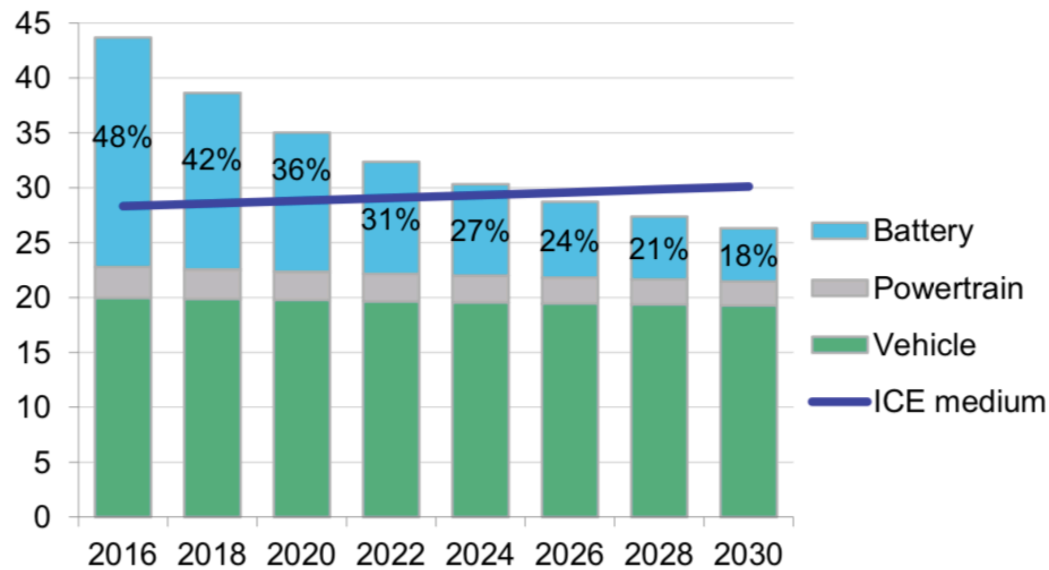


Figure 1. Battery electric vehicle (BEV) vs internal combustion engine (ICE) vehicle pre-tax (unsubsidized) costs in the US for comparable medium-segment vehicles. Source: BNEF

Such medium-segment EVs will be wildly popular after 2025, when all their costs are equal or better. But not all ten EPA classes of light-duty vehicles will achieve price parity by 2025, especially the larger vehicles that require larger, more costly batteries.

Thus the price gap will continue to impede EV adoptions for the next decade. Rebates or fees on ICE vehicles can reduce the purchase price gap. Note that the $7500 federal tax credit significantly accelerates price parity, but that credit fades away after a company ships 200,000 EVs (Tesla and GM have passed 200,000). State rebates also help, with the effect of accelerating cost parities by a couple years or so.

B. Infrastructure gaps

The second hurdle is building out enough electric fuel charging stations across the state and across the US. About 90% of charging occurs overnight, at home; but consumers need convenient fast-charging options for long trips. Currently, the fast-charger networks are spotty. Tesla built out a complete but proprietary charging network and beautifully integrated it with the navigation software in their cars; all the other automakers expect to use public charger networks which are generally insufficient today.

Figure 2 is a map of the CCS fast charger network in the west, illustrating major coverage gaps for routes to California, central Oregon, and anywhere east of Butte or Salt Lake City

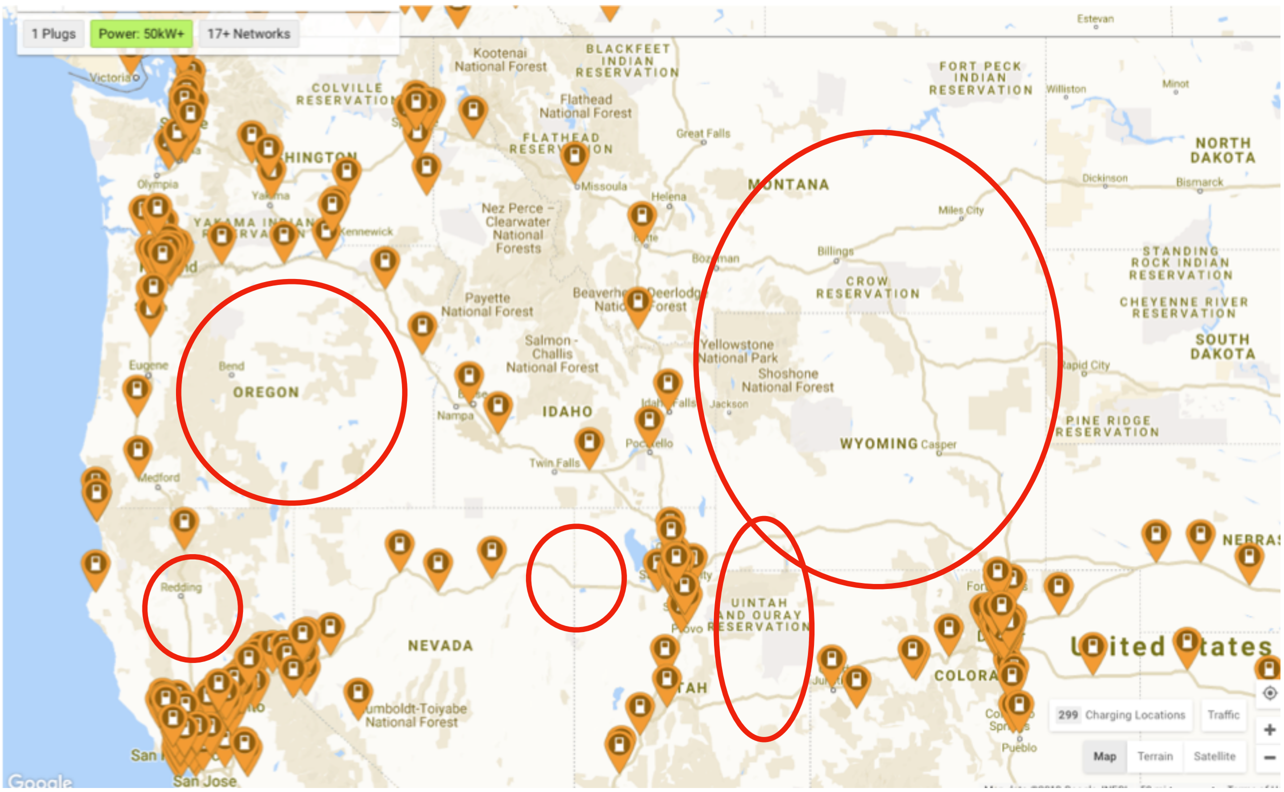


Figure 2. Current CCS charger locations (required by all automakers except Tesla, Nissan, and Mitsubishi), with at least 50kW power (~90 minutes to charge for 200 miles). Source: PlugShare. Red circles indicate routes with insufficient charger coverage.

The *incremental* infrastructure capital costs per added EV average roughly $1000 to purchase and install a 240-volt charger at the owner's residence; plus around $400 for the average usage rate of fast charger networks (see Appendix). Both are typically paid by the EV owner directly or indirectly. But as figure 2 demonstrates, building out the CCS network is not yet incremental expansion for volume; rather, it's still in a start-up phase of building out a minimally usable network.

The charging infrastructure gap is greater for underserved communities, specifically low-income and rural communities.

C. Incumbent sectors

The third hurdle is incumbent industries which are challenged by the transition away from gasoline/diesel vehicles. Oregon has no oil production or refining, but fuel distributors will be fundamentally impacted by ever lower volumes. Like coal mines, their business models will succumb to declining demand.

Auto dealerships are the biggest incumbent hurdle for Oregon, since most actively resist selling EVs. Most of their operating margins derive from service, not sales, and the largest EV maintenance cost is tires. To keep their business model afloat, most dealers avoid EV inventories and train their salespeople to steer buyers away from EVs. (Tesla uses direct sales to avoid this problem, which is one reason for their dominant market share in the US.) In this turmoil, dealerships and automakers are avoiding EV sales instead of advertising the benefits of EVs.

Dealerships must morph their business model to make up for the inevitable decline in service revenues over the next 30 years. Dealerships must add new sales or services, and yet Oregon needs knowledgeable auto salespeople to be enthusiastically selling EVs. Dealerships strongly participate in steering sales to clean vs dirty; thus, it's logical that dealers should somehow share in the carrots or sticks like buyers get for choosing clean vs dirty vehicles.

III. Savings vs adoption rate

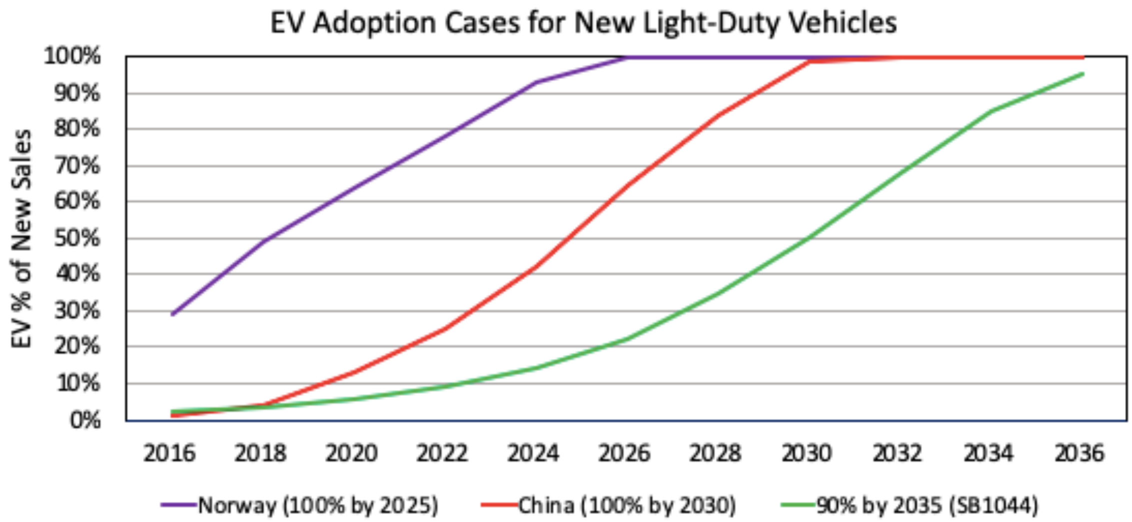
The stronger the EV adoption policy, the more and earlier Oregonians benefit from EVs. Oregonians will continue to buy around 170,000 new vehicles annually, regardless of what portion is EVs. Thus if EVs were the same prices today, the economic costs would all be savings on fuel and maintenance. But ZEVs are not yet the same prices, so there's a period of investment before cash breakeven.

Figure 3 illustrates how the higher purchase prices and fuel savings of the vehicle in Figure 1 accrues for different EV adoption rates, scaled to Oregon's new vehicle purchase rate. Three cases are modeled: Norway's historical and projected EV market share; China's history and forecast; and the trajectory targeted by SB 1044, which is 90% EV sales by 2035 (Each is assumed to follow a classic "S" curve typical of technology disruptions.)

As expected, the earlier the investments, the greater the costs in the first years and the greater the savings in future years. Conversely, if no EVs are purchased before 2025, then no extra investment is necessary but the rate of savings is much lower. In all cases the annual savings continue to increase after 2036, due to continued declines in fuel purchases until the entire fleet is electrified and due to continued moderate declines in battery costs.

Disclaimer: Figure 3 is oversimplified to illustrate the effects of different adoption rates. There are many unknowns which will affect the actual adoption rates, including the timing and costs of new EV models, federal policies, economic conditions, trade policies, and others.

The legislature will choose the ramp rate for Oregon. Norway has clearly demonstrated that a much faster ramp is possible. The earlier the EV adoptions, the greater the savings and the greater the reductions of toxic and climate emissions.



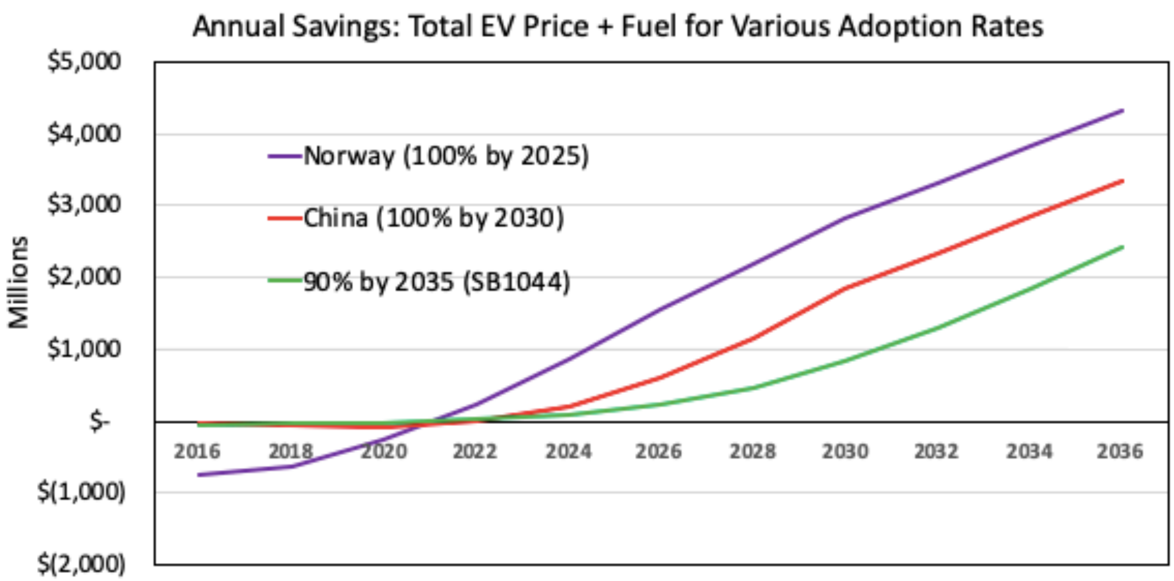


Figure 3. A basic comparison of annual savings from electrifying Oregon's 170,000 new vehicles per year for three cases: Norway's pace, China's pace, and the SB 1044 target. This models EV purchase price trends for the vehicle in Figure 1 and fuel costs at $3 per gallon or $0.10 per kWh for electric fuel. Assumes all sales are the medium-segment vehicle from Figure 1. Not included are infrastructure costs, savings on vehicle maintenance, savings on social costs of toxic or climate emissions, or economic benefits of keeping energy spending local or increased resilience in emergencies. ***These adoption rates correspond to 50% reduction in fleet emissions by about 2032 for the Norway case, 2038 for the China case, and about 2044 for the SB1044 case.***

IV. Policy alternatives

A. Requirements

States need EV policies that reduce the three hurdles:
- close more purchase price gaps,
- help to adequately fund more and faster chargers for all communities, and
- facilitate the technology transition of incumbent industry sectors,

in a highly uncertain market environment.

B. Status quo

With no further EV policies, Oregon EV adoptions could be very roughly estimated to follow the green line (SB 1044) in Figure 3, through 2025. That would correspond to roughly 60% of the decarbonization required by Oregon's Clean Fuels Program (CFP) to be contributed by EVs in 2025. However, other low-carbon fuels may achieve most of the CFP requirements, and the current ZEV program targets (now under attack by the federal government) require less than half of the EV adoptions of the SB 1044 trajectory by 2025. Thus, Oregon policy support for EV adoptions is limited to state and federal rebates and possible incentives from the CFP; we'd have to wait for more and cheaper EV models and hope for the best.

Hope is not a strategy.

C. Fees on fuels

Policies that charge fees on vehicle fuels have little pollution impact and are very unpopular. Most consumers have to fuel the vehicles they own, and they either can't afford more efficient vehicles or no better models are available. People will buy more gas if they need to get to work or visit relatives or haul what they need to haul.

The failures of pricing current emissions are illustrated by the British Columbia's carbon tax (at $24 Canadian). This was enacted just before the Great Recession and thus looked like it was working; instead, emissions increased as the economy recovered, and taxed sectors increased emissions more than untaxed sectors.

A painful lesson from carbon taxes is that emissions of used vehicles are locked in—besides riding a bicycle, the only opportunity for lowering one's emissions is to buy a cleaner vehicle. And carbon taxes only cut into the money that could be saved for buying a better vehicle.

D. Rebates and fees on vehicles

The buyer of a new vehicle is the party responsible for locking in the lifetime emissions of a vehicle. *The leverage point for transportation decarbonization is steering the purchase of new vehicles.*

To close the purchase-price gap, jurisdictions can offer carrots in the form of rebates or other incentives, or sticks in the form of vehicle fees. Consumers consider only 2-3 years of operating expenses, so a tax of 20 cents per gallon of fuel is useless for steering purchases. Rebates work, but are inefficient and expensive. Rebates are also inherently regressive, because buyers of new vehicles are relatively affluent.

“Feebate” programs pay rebates for more efficient vehicles, funded by fees on less efficient vehicles. Feebates have been effective for reducing emissions in France. Early feebate polling in Oregon found resistance to fees on larger vehicles. When there are no practical alternatives for businesses that need relatively inefficient pickups or vans, it’s just a tax on businesses. And the dividing line between efficiencies that get a fee vs a rebate is arbitrarily set by the government.

Driving a new Prius hybrid off the lot locks in about 30 MTCO2e (“tons” hereinafter) of GHG emissions over the typical vehicle lifetime. Should that Prius get a rebate, in the midst of a climate emergency? Should any new vehicle get a rebate, when most buyers are relatively affluent?

E. Fees on lifetime emissions

Norway has demonstrated that their combination of a significant lifetime vehicle emission fee (a stick, paid by buyers of gasoline/diesel vehicles), and significant ZEV waivers for the VAT and vehicle weight tax (tax carrots, paid by all taxpayers) are highly effective in steering new vehicle sales. The magnitude of Norway’s carrots and sticks have been large enough to close the purchase price gaps several years ago; apparently vehicle classes without EV options are taxed the same way. Norway’s CO_2 fee rate is progressive, from about $74 per ton of pollution for the lifetime emissions of a 29 mpg vehicle, to about $241 per ton for a 24 mpg passenger vehicle (in 2017; calculated with US EPA, not European, ratings). Norway has roughly the same population, new car sales volume, and average income as Oregon.

Combined fuel economy	US Gas Guzzler Tax (cars only)	Lifetime CO_2 fee, at $100/MTCO2e
100 mpg	No tax	$1500
80 mpg	No tax	$1875
60 mpg	No tax	$2500
50 mpg	No tax	$3000
40 mpg	No tax	$3750
30 mpg	No tax	$5000
25 mpg	No tax	$6000
20 mpg	$1700	$7500
15 mpg	$4500	$10,000

Table 1. A comparison of the 1991 Gas Guzzler Tax rate and a lifetime (150,000 mile) CO2 fee calculated at $100 per MTCO2e (“ton”). Such a lifetime emissions fee can be an effective stick, in addition to rebates or other carrots, to reduce purchase price gaps.

The US Gas Guzzler Tax was enacted in 1978 and updated in 1991. It charges automakers for cars (not SUVs or trucks) with worse than 25 mpg efficiency, at a marginal rate equivalent to about $110/ton for 150,000 miles of fuel consumption.

Table 1 compares the Gas Guzzler Tax to a simple lifetime fee for a vehicle's emissions. The purchaser should pay for the pollution they lock in, but a blanket application of the social costs of pollution is not politically feasible and it isn't productive to punish parties who need a large vehicle when there are few or no options for better fuel efficiency.

However, as substantially equivalent vehicle functionality becomes available with ZEVs in a given EPA class, then the buyer has options and society has reason to expect that buyers should pay for choosing to emit toxic and climate pollution.

A lifetime emission fee rate could be whatever the legislature sets. It could be progressive, as Norway does. It needn't and shouldn't relate to market prices for carbon offsets. The rate probably doesn't need to be as high as the estimated social costs of emissions, which range from $50/ton for climate damages only in the US, to $180-800/ton for global climate damages; plus another $2-3 per gallon (equivalent to $200-300 per ton) for the toxic emissions of gasoline or diesel fuel.

The fee rate could be phased in over several years to give businesses and consumers time to adjust to the fee, or to allow time for debugging the new policy. The legislature will probably also want a process that allows adjustment of the fee to throttle adoptions in response to unpredictable factors in the EV market.

V. An Oregon Example

A. Educate buyers with stickers on new vehicles

Like most states, Oregon is blessed with a portion of people who will pay a little extra to get clean energy. Portland General Electric consistently enjoys the nation's highest percentage (20%) of ratepayers who voluntarily buy clean electricity. It's logical to expect that a small portion of car buyers in Oregon would also bias their purchasing toward clean energy vehicles. But few buyers come armed with a calculator and knowledge of the social costs of emissions.

A simple approach for educating buyers is a state sticker on new light-duty vehicles for sale, similar to the federal EPA sticker. The sticker would display the vehicle's lifetime costs of fuel and its lifetime socialized costs of emissions from that much fuel. Instead of the EPA's arbitrary scale for emissions, buyers need to see real costs that they lock in, both fuel costs and externalized costs.

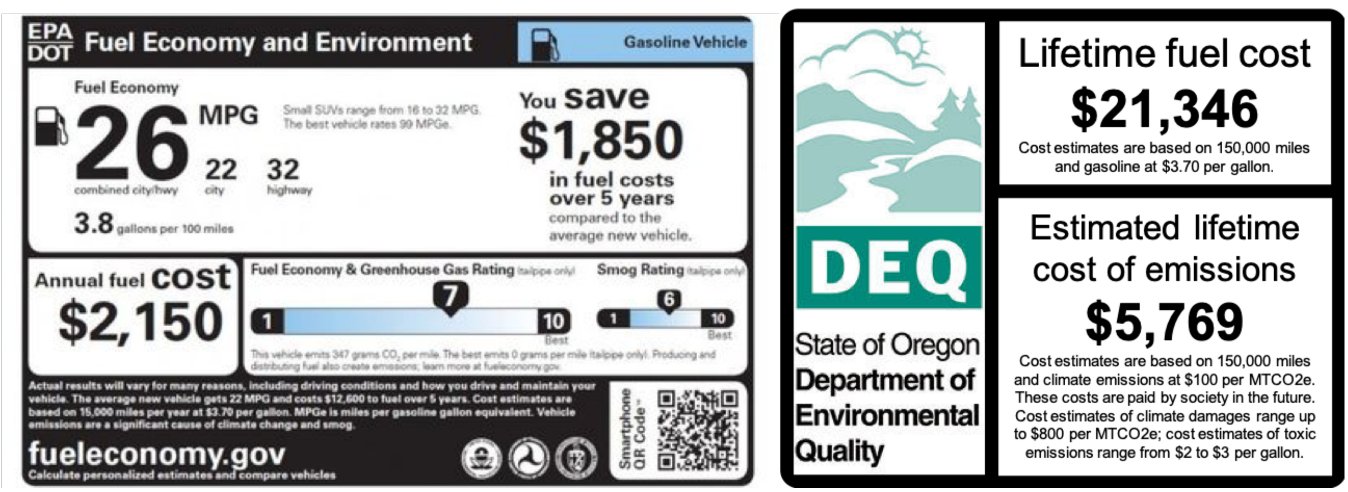


Figure 4. Example of a potential DEQ sticker required on new light-duty vehicles, next to a regular EPA sticker. Lifetime fuel costs for a BEV would display about $5250 and lifetime emissions would display zero. This example uses $100/MTCO2e and explains who pays it and other estimates in the fine print.

The implementing agency simply multiplies the EPA rated fuel efficiency by an assumed lifetime and fuel cost (like 150,000 miles and $3 per gallon); and the estimated social cost of its lifetime emissions (that much fuel at some cost per ton or gallon). Which social cost of GHG and toxic emissions to use is similar to the question of what fee rate to use for a lifetime emissions fee. The sticker could also function as an introduction to future emission fees.

B. Owners of affected vehicles pay a one-time registration fee

Starting around 2022, affected vehicles would be charged a one-time registration fee. Affected vehicles could be defined as:

1. All new non-ZEV, light-duty vehicles sold in Oregon in an EPA class that also has at least two ZEV models available for sale in Oregon; and

2. Any vehicle not sold in Oregon but that would have been an affected vehicle if purchased new in Oregon on the same purchase date. The fee for these vehicles could be prorated for the remaining lifetime miles.

The purpose of the requirement that the vehicle's class has at least two ZEVs available in Oregon is to avoid punishing buyers who have no better options. The fee impact on fleets is intended to be minimal —fleet managers already favor the most efficient vehicles because they minimize lifetime fuel costs. Two ZEV models presumably ensures that at least one has reasonably equivalent functionality. The two ZEVs could be required to be supplied by two different OEMs, to obviate any argument over whether the two models are actually different.

The purpose of the prorated fee is to reduce leakage from vehicles purchased outside of Oregon, whether new or used.

EPA class	BEVs available	Range (mi)	MSRP
midsize car	Nissan Leaf	150-226	$23,375-29,945
	Tesla Model 3	220-310	$34,725-47,315
small station wagon	Chevrolet Bolt	238-259	$33,745
	Kia Soul	243	$33,950
standard SUV 4WD	Tesla Model X	325	$84,315
small SUV 2WD	Hyundai Kona Electric	258	$30,495
large car	Tesla Model S	370	$79,315
compact car	Volkswagen e-Golf	125	$25,290
subcompact car	BMW i3	153	$37,945
minicompact car	Fiat 500e	84	$26,790

Table 2. Some of the more popular BEVs currently available in Oregon. With two or more ZEVs available, the midsize car and small station wagon classes would thus be affected in this example of an emissions fee. There are no electric pickups available yet. Range less than 200 miles is not likely in most new models. Sources: goelectric.oregon.gov; US DOE; Insideevs

C. The fee rate

The fee rate needs to be an effective stick for steering sales to ZEVs—thus, the magnitude of the fee has the same adoption function as a rebate, which is closing the purchase-price gap.

The fee rate should be simple enough that most people can understand and remember it, i.e., much simpler than rules for the Clean Fuels or ZEV programs.

The fee is intended to help achieve the chosen adoption targets, implying a process that can adjust the fee to throttle incentives up or down in response to actual ZEV registrations, perhaps every 2 or 4 years.

The price gaps are decreasing as battery costs decline, but the gaps will likely be largest for the larger vehicles. A few current and expected purchase-price gaps are discussed in the Appendix. A potential fee schedule appropriate for targeting 100% ZEVs by 2030 could simply be a fee rate of $100/ MTCO2e, except zero above 60 mpg to exclude PHEVs:

Combined fuel economy	**Lifetime emissions fee (calculated from $100/MTCO2e)**
> 60 mpg	no fee
60 mpg	$2500
50 mpg	$3000
40 mpg	$3750
30 mpg	$5000
25 mpg	$6000
20 mpg	$7500
15 mpg	$10,000

Table 3. A potential fee rate could be simply calculated at $100 per MTCO2e ("ton"), except vehicles with >60 mpg fuel efficiency, which are mostly pluggable-hybrid EVs.

The actual ZEV adoption impacts are impossible to predict, because we don't know the price or availabilities of the many new EV models being promised. However, we know that Norway's policies are sufficient to dramatically accelerate EV adoptions; therefore something between today's policies and Norway's policies will accelerate adoptions as desired.

By 2035 or so, few ICE vehicles will be economic. When sales are 100% ZEV, the fee and revenues will go to zero and they will have served their purpose.

D. Revenue resulting from the fees

The main purpose of the emissions fee would be to steer purchases, not to raise revenue for projects.

But significant revenue may be generated by the fees. For example, if 10% of new vehicle sales resulted in an average fee of $4000, the revenue would be about $68 million in that year.

Since the revenue generation would be highly variable as vehicle models change, the revenue should not be dedicated to funding a continuous activity such as administration or maintenance. Revenue would preferably be used to seed, or contribute to, a revolving loan fund(s) for financing transportation electrification projects. Since new loans would be continuously reviewed, spending can adapt to the varying revenue levels.

The fees must be dedicated to purposes that the public can understand and support, such as financing more ZEV fueling infrastructure, financing electric transit buses or school buses, grants or loans for ZEVs in underserved communities, helping auto dealerships to transition their business model, retraining workers displaced by the ZEV transition, etc.

Or the revenue could be contributed to the Oregon highway trust fund if that is determined to be the constitutional requirement.

E. The opposition—who would be upset?

If no one is upset, then nothing has been changed.

Auto dealerships are a powerful lobby, and dealers and salespeople need to be flipped from resisting the ZEV transition to catalyzing it. Dealers know they have a challenge coming. It'd be a bargain for society to help them out. Can we give them enough incentive money to flip their enthusiasm? Auto sales margins are slim and shrinking, only a few hundred dollars per car. How much added incentive for every ZEV would make a difference? Such sales commissions could be paid from the emission fees; or from other sources such as electric utilities if all the fees must go to the highway trust fund.

Other parties:

- Some will complain that this increases the cost of vehicles. The basic response is that some vehicle prices will indeed be increased for several years, but all EV cases offer a lower total cost of the price plus some years of fuel. The additional ZEV benefit is that the social costs of toxic and climate emissions go away.
- Current vehicle owners are not affected. They need transportation and the emissions of their vehicles have been locked in. The only possible changes for existing vehicles are minor decreases in how many miles they drive (although that allows the polluting vehicle to last longer in the fleet); or a hope that new biofuels will significantly decrease their carbon intensity.
- Vehicle purchasers in a class without at least two ZEV options are not affected by the fee, but they will see the state sticker and some will be steered to more efficient vehicles.
- Purchasers of used vehicles won't be affected unless the vehicle was an affected vehicle in Oregon when it was purchased new in another state.
- Oil companies and fuel distributors will scream loudly. Expect advertisements about the government intruding or limiting personal freedoms, or that the fees are too high or unfair or un-American. But oil companies have now pivoted to blaming customers for using their product, so their argument should

be loudly and preemptively used against them, especially when their story includes greenwashing around developing new transportation technologies.

- Buyers with specific vehicle requirements not covered by the available ZEVs will be paying fees. This is probably not fixable. They can either pay the fee or adapt to the available ZEVs or wait for new ZEV models.
- Buyers without adequate EV charging infrastructure would rightfully complain. But fast charger networks should be minimally built out by 2021, and some of the fee revenues should be applied to build out more infrastructure.

Appendix: More details

Fee examples at a feee rate of $100/ton

- The 2019 Toyota Prius Eco (56 mpg combined) is classified as a midsize car. The emission fee would be $2,679 and MSRP starts at $24,700, totaling $27,379. The Tesla Model 3 at $34,725 qualifies for $2500 rebate from Oregon and will soon not qualify for any federal rebate. The remaining gap has been cut in half: $32,225 - $27,379 = $4,846. Adding another $1000 for a home charger makes the gap almost $6,000.
- The 2019 Toyota Camry XLE/XSE (32 mpg combined) is classified as a midsize car. The emission fee would be $4,688 and MSRP starts at $28,450, totaling $33,138. The Tesla Model 3 at $34,725 qualifies for $2500 rebate from Oregon and will soon not qualify for any federal rebate. The remaining gap is $32,225 - $33,138 = ($913), enough to buy a home charger.

No one will know the models and costs available in future years, so some rough estimates are necessary for triangulating future fee rates. For example:

- A large portion of light-duty vehicle (LDV) emissions are from pickups and large SUVs, and at least two mass-market pickups are now under development (at Ford and Tesla). The price and availability of these models will help to triangulate the right fee rates. Lacking any real data, Figure 1 with twice the battery cost implies about a $10,000 gap in 2020. A $10,000 gap (Tesla without federal or Oregon rebates) implies ~$150/ton for a 25 mpg ICE vehicle; with a $7500 federal rebate (Ford) and $2500 gap, a $40/ton rate is implied. So ~$100/ton is a very rough average.
- The last vehicle class to cross price parity is likely to be vehicles with large batteries, such as a full-sized van with roughly three times the energy capacity and cost of the battery in figure 1. If the other vehicle costs increase with size about as much for the BEV as the ICE vehicle, then the purchase-price gap would still be around $5,000 in 2030. Most of the current federal rebates will be gone by then and the magnitude of Oregon's rebate in 2030 is uncertain; thus $6000 (the $100/ton fee rate in Table 1 for a 25 mpg ICE vehicle) would be in the range for targeting 100% ZEV sales by 2030. Such an estimate requires plenty of extrapolation, but it's based on studied cost trends.

More questions:

Q: What about pluggable hybrid electric vehicles (PHEVs)? What about fueling a gasoline/diesel vehicle with lower carbon-intensity fuels? What about the equivalent mpg used by EPA to account for emissions from electricity?
A: The main objective is to accelerate BEV adoptions and cut fossil fuel usage.

- The overall pollution requirement is rapid decarbonization, not incremental tweaks here and there.
- The market reality is that BEV costs will be superior to PHEV costs and all internal combustion vehicles with a decade, so PHEVs are a transitional strategy for automakers and customers who

don't yet trust charging networks. All automakers are scrambling to develop affordable BEVs, partly to survive China's aggressive EV developments.

- It would be impractical to predict or track the operational emissions of PHEV usage, alternative fuels used, or the pollution from the electricity used to charge a pluggable electric vehicle; and existing policies like Oregon's EV rebates, Clean Fuels Program and renewable portfolio standards address these cases. And zeroing the emissions fee rate above 60 mpg would exempt emission fees on PHEVs.
- We need a vehicle policy that is simple enough for the public to understand.

Q: How large are the costs of charging infrastructure?
A: These can be roughly estimated from average charger usage.

- 90% of charging at home implies 240-volt (Level 2) chargers at all residential parking stalls. The typical cost is ~$1000 each, including installation. This essentially adds $1000 to the purchase price of most EVs for the next decade or so.
- 10% of charging occurs on the road: 10% of average VMT equals about 1500 miles per registered EV annually. For an average charging rate of 200 miles per hour of charging (about 60kW, which is typical for a 150 kW fast charger, since the charging rate decreases during the session), then each registered EV averages about 8 hours per year at a fast charger. Since most charging is during the day and there are peak demand times, the implied stall requirement is more like 30 hours per year per registered EV. Assuming ~$100,000 to build one fast charger stall, each incremental EV requires an incremental fast charger investment of $100,000 X (30 charger hours per year)/(8760 hours per year) = $342 of investment in the charger type corresponding to the vehicle. Call it $400 per new EV, that comes from somewhere—Tesla funds their network from owners buying access, and private charger networks are typically funded by users paying at each charging session. The $400 for infrastructure capital does not cover the cost of electricity ("electric fuel") used, which for this average case is about 500 kWh per year per BEV. That's $50 per year at $0.10 per kWh, or much higher if demand charges are incurred.
- These costs don't address the inherent financing challenges from installing a reliable, nationwide network long before the usage fees pay for the equipment and installation.

Q: Wouldn't Ford delay availability of their EV pickup in Oregon if they knew that would add a big fee onto their bread-and-butter pickup lines?
A: Potentially, but that would also be a ripe time for a competitor to bring out an EV pickup to trigger fees on Ford's ICE models.

Q: What effects would this have on vehicle leasing?
A: A new vehicle in a leasing program would be subject to the emissions fee like any other vehicle. The lessor would probably treat the fee as part of their purchase cost.

Q: Why not charge the emissions fee to automakers instead of buyers, like the ZEV program?
A: It's not clear that any state but California can do that. This requires some legal research.

Q: What effects would this have on EV availability in Oregon?
A: Higher incentives should encourage more ZEV model availability in Oregon. Higher incentives for dealers could have even more impacts.

Q: Will purchasers of gas guzzlers rush to buy before ZEVs come?
A: Buyers will always react to a deadline, but the overall impact would be minor.

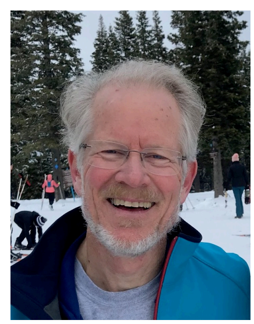
Q: How is this emissions fee different from a feebate?
A: Feebates are quite effective at reducing emissions, but a general application would be unfair for buyers who need large vehicles. A classic feebate (France, Ontario) charges a fee for fuel efficiency (mpg) worse than some target mpg and pays a rebate for vehicles better than the target.

- The lifetime emissions fee also charges a fee on dirty vehicles, but only if there are at least two ZEV model options in the EPA class. In this way there is no chosen efficiency that divides a fee from a rebate.
- Revenue from the fee is preferably invested in efficient revolving loan funds that finance ZEVs or ZEV infrastructure, etc., or invested in the highway trust fund if required.

Q: What about medium- and heavy-duty vehicles (MDVs and HDVs)?
A: This fee policy addresses only light-duty vehicles (LDVs). MDVs and HDVs are primarily fleet vehicles, and fleet managers already optimize the lifetime costs of ownership. Financing of public fleets or MDV/HDV charging infrastructure could be accelerated by funding from emission fee revenues.

Q: What about emissions embodied in vehicle manufacture?
A: Ideally these would be included in a one-time vehicle emission fee, but there is almost no infrastructure to track climate or toxic emissions from manufacturing supply chains. Objective studies conclude that EVs use a little more energy to manufacture than a gasoline/diesel vehicle, but that is dwarfed by the operational energy/emission savings.

Bio: Eric Strid is a retired high-tech entrepreneur and CEO, now working for our children on climate policy. Schooled as an electrical engineer at MIT and UC Berkeley, he worked as a microwave engineer and then cofounded Cascade Microtech in Beaverton, OR in 1983. Eric served as CEO, took it public in 2004, transitioned to the CTO role in 2008, and retired in 2012.



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