Impact of the Inflation Reduction Act of 2022 on Light-Duty Vehicle Electrification Costs for MYs 2025 and 2030

This report has been prepared for

Environmental Defense Fund

CONTRIBUTORS

Himanshu Saxena, Sajit Pillai

SUGGESTED CITATION

H. Saxena, S. Pillai, "Impact of the Inflation Reduction Act of 2022 on Light-Duty Vehicle Electrification Costs for MYs 2025 and 2030," 2023. Roush.
(insert pdf weblink)

Table of Contents

List of Figures

List of Tables

Abbreviations and Acronyms

BEV	Battery Electric Vehicle
DERA	Diesel Emissions Reduction Act
DOE	U.S. Department of Energy
EDF	Environmental Defense Fund
EIA	U.S. Energy Information Administration
EPA	U.S. Environmental Protection Agency
EV	Electric Vehicle
FCEV	Fuel cell electric vehicle
GHG	Green House Gas
IRA	Inflation Reduction Act
ITC	Investment Tax Credit
kWh	Kilowatt-hour
LDV	Light-duty vehicle
MSRP	Manufacturer's Suggested Retail Price
OCED	Office of Clean Energy Demonstrations
PEV	Plug-in Electric Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
PTC	Production Tax Credit
RPE	Retail Price Equivalent
SUV	Sport Utility Vehicle
TCO	Total Cost of Ownership
U.S.C.	United States Code
ZEV	Zero-Emission Vehicle

Key Highlights

Transportation decarbonization is one of the top priorities for meeting climate goals. Recent public policy decisions and manufacturer commitments, combined with rising demand for battery electric vehicles (BEVs), have expedited the adoption of clean transportation technology. Through incentives such as grants and tax credits, the Inflation Reduction Act (IRA) of 2022 seeks to stimulate domestic production and the adoption of clean transportation options such as zero-emission vehicles (ZEVs) and plug-in hybrid electric vehicles (PHEVs). This study evaluates and quantifies, to the greatest extent possible, the key impacts of the IRA on the cost of electrifying model year (MY) 2025 and 2030 light-duty vehicles (LDV), using costs from our previous study as a baseline [2].

The key takeaways of this study are:

a) The IRA clean vehicle credits have a direct impact on consumer savings in model years (MYs) 2025 through 2030.
b) IRA vehicle and charger credits enable the purchase prices of BEVs to be equal to or less than an equivalent internal combustion engine vehicle (ICEV) in both MYs 2025 and 2030 for compact cars, midsize cars, small SUVs, and midsize SUVs, in both the base and premium segments. In 2025, BEV purchasers could save more than $9,000 over an equivalent ICEV.
c) The IRA credits also reduce the time to achieve total cost of ownership (TCO) parity for all LDVs. In MY 2025, TCO parity is achieved immediately for compact cars, midsize cars, small SUVs, and midsize SUVs, while TCO parity is achieved in 4 years and 2 years for base-segment large SUVs and pickup trucks, respectively. In MY 2030 TCO parity is achieved immediately for all LDVs.
d) The IRA will also result in an estimated 30% reduction in charger-unit costs for all consumers. The consumer will save $300 on a $1,000 level-2, 11.5 kW charger. The affordability and savings associated with the purchase price and charger unit price improve significantly over time.
e) The advanced manufacturing production tax credit is a game-changer that could lower battery pack costs while allowing onshoring of the battery value chain.

Background

In 2021, light-duty vehicles (LDV), comprising passenger cars and light-duty trucks, contributed 58% of the U.S. transportation GHG emissions [1]. Prioritizing the decarbonization of the LDV fleet is a critical strategy for reducing GHG emissions. The previous study, "*Electrification Cost Evaluation of Light-Duty Vehicles in 2030,"* prepared for the Environmental Defense Fund (EDF), analyzed the costs of electrifying the LDV market [2]. It accounted for the cost of electrification of representative LDVs for model year (MY) 2030 by comparing the direct manufacturing cost (DMC) of ICEV and BEV powertrains. The report quantified the upfront electrification cost by applying a retail price equivalency factor to the powertrain's DMC. The total cost of ownership (TCO) over a vehicle's lifetime was then estimated by adding in discounted fuel and maintenance costs. The analyzed LDVs included six subclasses—compact cars, midsize cars, small SUVs, midsize SUVs, large SUVs, and pickup trucks—under two categories: base (non-performance) and premium (performance). Except for large SUVs and pickups, BEV200s are assumed to be a viable alternative to base ICEVs and BEV300s would be a comparable substitute for premium ICEVs; for large SUVs and pickups, the analysis assumes that BEV300s would be a feasible alternative to base ICEVs, and BEV400s would be a comparable substitute for premium ICEVs.

Due to the range of ICEV technology currently being employed and that is possible under future CAFE and GHG standards, we developed three scenarios covering a range of ICEV technology: non-hybrid, BISG, and strong hybrid technology. When assessing the TCO of these vehicles, we aligned three sets of fuel prices with the three ICEV technology scenarios. These were based on the high oil price case, reference case, and low oil price case from AEO2022.

That primary analysis, absent the IRA, concluded that in MY 2030:

a) For all BEVs up to a 300-mile range, purchase price parity with a comparable ICEV is reached by MY 2030, across all vehicle classes and segments evaluated.
b) By MY 2030, the total cost of ownership (TCO) for all BEVs up to a 400-mile range will be equal to or lower than their ICEV counterparts across all classes and segments.
c) BEVs purchased in 2030 result in an average cumulative net savings of about $15,000 over the lifetime of the vehicle compared to an ICEV, across all classes and segments.
d) For consumers who charge their vehicles equally at home and public fast charging stations, the TCO of a BEV is still lower than an ICEV, despite increases in energy costs.
e) Accounting for current real-world gasoline prices, all BEVs up to the 400-mile range compensate for any increase in upfront cost with reduced operating costs within the

first year of ownership at the latest. Owning and operating BEV results in an average savings of about $33,000 over the life of a BEV compared to an ICEV.

This study evaluates the impact of the Inflation Reduction Act (IRA) of 2022 on the electrification of these same LDV segments using the costs developed in the previous study [2] and could be considered an addendum to it. The IRA, signed into law on August 16, 2022, contains multiple provisions to decarbonize the transportation sector. It aims to stimulate the domestic production and adoption of clean transportation options such as zero-emission vehicles (ZEVs) and plug-in hybrid electric vehicles (PHEVs) to further mitigate climate and other health-harming emissions. It includes incentives, tax credits, and funding for various programs to fast-track the transition to clean energy by electrifying automobiles to address air pollution and strengthen energy security. It is an important step in accelerating the transition to a resilient, secure, and environmentally sustainable transportation sector while enhancing the economic viability of electric vehicles (EVs). The incentives contained in the IRA will accelerate the adoption of battery-electric LDVs advancing the benefits to prospective owners in the near term.

Our study focuses on the key effects of the IRA on the cost of electrifying LDVs in MYs 2025 and 2030. As we did not evaluate MY 2025 in our prior study, we use our projected powertrain DMCs for MY 2022 as a substitute for MY 2025. When projecting the upfront costs of electrification in MY 2025, we utilize an RPE factor of 1.5, as opposed to the multiplier of 1.2 applied in the 2030 timeframe. All other inputs used to estimate the operating costs and parity timeline remain the same. For both MY 2025 and 2030, we use the electrification costs for the middle of the three scenarios described above. This scenario assumed that ICEVs were equipped with BISG with fuel prices based on the reference case of AEO2022.

Summary of IRA Credits Evaluated

Our analysis of the impact of the IRA has been broadly divided into two sections: quantitative impact and qualitative impact, as shown in Figure 1. The quantitative impact focuses on the tax incentives applied at the time of vehicle purchase and on charging infrastructure to determine the benefit to the purchaser of a BEV. The qualitative assessment focuses on the various funding and financing programs, grants, rebates, and tax incentives that apply to the production of BEVs and their components or positioning BEVs as alternatives to ICEVs in the LDV segment. We apply these broader incentives hypothetically to BEV production in the LDV segment. There may be certain scenarios where the perceived indirect impact may be higher than estimated here.

SUBTITLE	PART	SECTION	IMPACT
Subtitle D—Energy Security	PART 4—CLEAN VEHICLES	SEC. 13401. CLEAN VEHICLE CREDIT.	Direct
		SEC. 13404. ALTERNATIVE FUEL REFUELING PROPERTY CREDIT.	Direct
	PART 5—INVESTMENT IN CLEAN ENERGY MANUFACTURING AND ENERGY SECURITY	SEC. 13501. EXTENSION OF THE ADVANCED ENERGY PROJECT CREDIT.	Indirect
		SEC. 13502. ADVANCED MANUFACTURING PRODUCTION CREDIT.	Indirect
	PART 7—INCENTIVES FOR CLEAN ELECTRICITY AND CLEAN TRANSPORTATION	SEC. 13701. CLEAN ELECTRICITY PRODUCTION CREDIT. & SEC. 13702. CLEAN ELECTRICITY INVESTMENT CREDIT.	Indirect
Subtitle A—Energy	PART 4—DOE LOAN AND GRANT PROGRAMS	SEC. 50141. FUNDING FOR DEPARTMENT OF ENERGY LOAN PROGRAMS OFFICE.	Indirect
		SEC. 50142. ADVANCED TECHNOLOGY VEHICLE MANUFACTURING.	Indirect
		SEC. 50143. DOMESTIC MANUFACTURING CONVERSION GRANTS.	Indirect
		SEC. 50144. ENERGY INFRASTRUCTURE REINVESTMENT FINANCING.	Indirect
	PART 6—INDUSTRIAL	SEC. 50161. ADVANCED INDUSTRIAL FACILITIES DEPLOYMENT PROGRAM.	Indirect
Subtitle A—Air Pollution		SEC. 60103. GREENHOUSE GAS REDUCTION FUND.	Indirect

Indirect Direct

Figure 1: Summary of IRA credits evaluated for the LDV segment in this study

Impact of Clean Vehicle Credits on Purchase Price Parity

The results of this study demonstrate that the IRA's clean vehicle credits of up to $7,500 per vehicle benefit end consumers immensely by decreasing the purchase price of a BEV and bringing it on par with its ICE counterparts in nearly all cases and scenarios by MY 2025. Purchasers of some subclasses will see savings of more than $9,000 over an equivalent ICEV in 2025. With IRA credits, large SUVs and pickup trucks will achieve purchase price parity by MY 2030, as shown in Table 1. We found that these credits will help offset higher purchase prices of BEVs, lowering purchase prices faced by consumers.

Table 1: Savings of BEV over an ICEV in 2025 and 2030 purchase timeframes

Subclass	2025		2030	
	Base	Premium	Base	Premium
Small Car	$7,741	$4,441	$13,788	$12,740
Midsize Car	$7,333	$3,783	$13,586	$12,426
Small SUV	$5,535	$1,373	$12,760	$11,368
Midsize SUV	$6,301	$1,740	$13,857	$12,181
Large SUV	-$3,778	-$13,531	$9,564	$5,596

Subclass	2025		2030	
	Base	Premium	Base	Premium
Pickup Truck	-$1,835	-$10,061	$10,443	$6,911

Furthermore, with the extension and modification of the alternative fuel refueling property credit of up to $1,000 for residences, consumers can avail of both the associated charger equipment sizing and pricing benefits. The charging unit-related savings can be $300 for a level 2 11.5 kW AC charger per vehicle priced at $1,000, reducing its cost to only $700.

Impact of Clean Vehicle and Charger Credits on TCO

Lifetime ownership and operating costs are critical criteria for determining a vehicle's economic viability for some consumers. The IRA credits results in lowers TCO per mile further for all types of BEVs (except for the premium large SUV) with respect to a comparable ICEV, as shown in Figure 2. In the base segment, the average TCO per mile with the IRA is $0.216, compared to $0.242 for an MY 2025 BEV without credits. In the premium segment, the average TCO per mile with the IRA is $0.284, compared to $0.315 for an MY 2025 BEV without credits. In the base segment, the average TCO per mile with the IRA is $0.178, compared to $0.209 for an MY 2030 BEV without credits. In the premium segment, the average TCO per mile with the IRA is $0.235, compared to $0.267 for an MY 2030 BEV without credits.

The net cumulative savings for a BEV with IRA credits compared to a BEV without credits amount to $7,800 in the 2025 and 2030 purchase timeframes. For MY 2025, the BEV savings over an equivalent ICEV are substantial, ranging from $935 to $26,021, considering all three scenarios. The only exceptions are the premium versions of large SUVs in scenarios 2 and 3 and pickup trucks in scenario 3, which do not result in any savings in 2025. However, in the 2030 timeframe, the savings range from $7,587 to $39,116 across all vehicle segments, including large SUVs and pickup trucks.

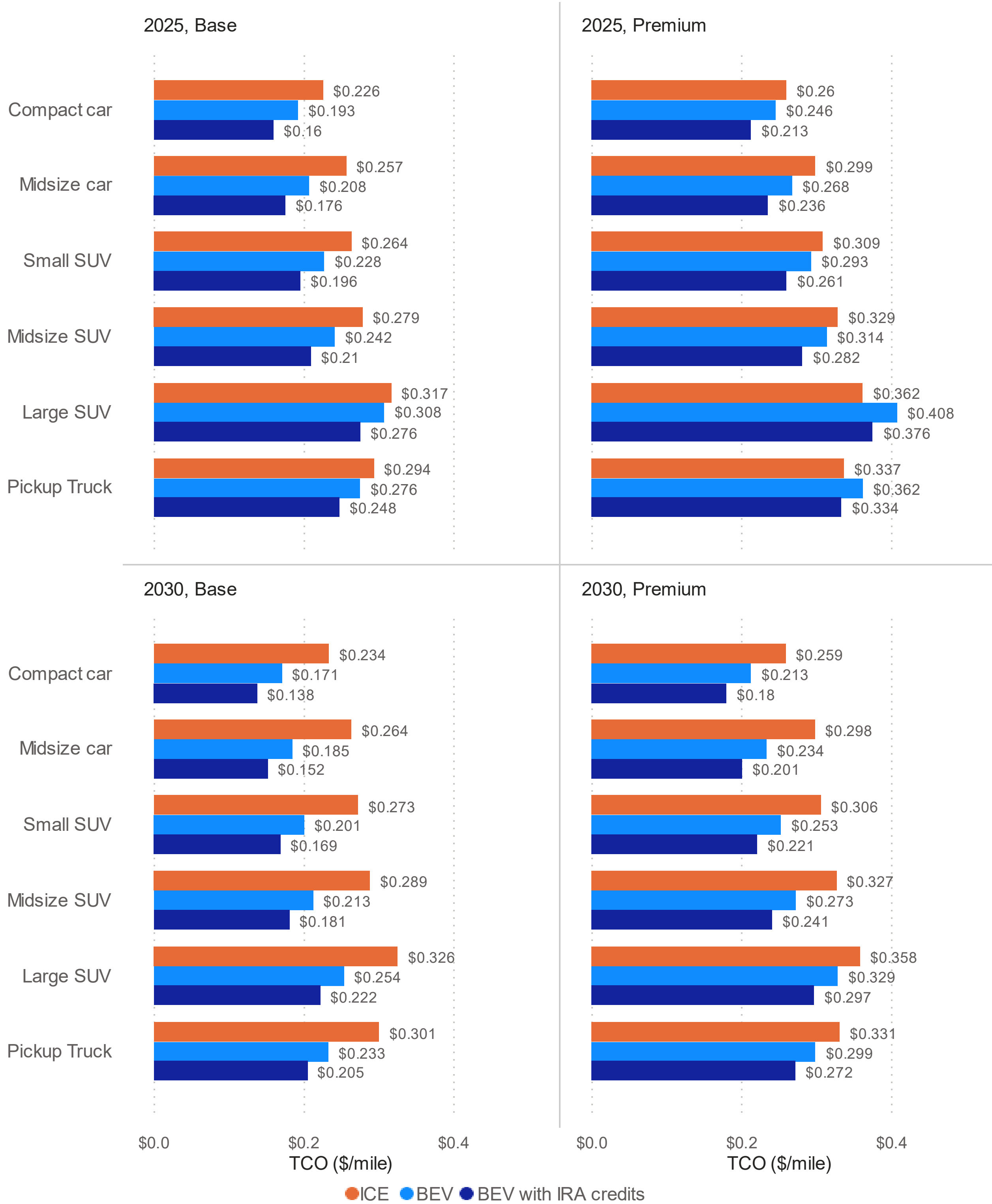

Figure 2: TCO in $ per mile for MYs 2025 and 2030 LDVs in Scenario 2.

Impact of Advanced Manufacturing Production Credit

To explore the benefit of tax credits in the form of purchase credits, advanced manufacturing production credits, and advanced energy project credits, a hypothetical exercise to assess the battery price ceiling in 2025 is also carried out in the study. In this exercise, we compute the maximum battery cost possible which would still allow a BEV to be sold at the same price as the equivalent ICEV, after the application of all of the available tax incentives This is done for each of the vehicle classes and trim lines. On average, a domestically manufactured battery pack meeting all of the requirements of the IRA could reach $276/kWh on average, or about 147% more than the battery cost of $112/kWh estimated in our previous study for MY 2022 [2], and still achieve immediate purchase parity in 2025 across the various segments and trims.

There are many external benefits to BEV adoption, including environmental benefits through the reduction of PM and NOx emissions, as well as the reduction in noise in congested environments that are not captured in our analysis. IRA-based incentives, subsidies, and loans/grants can offset or outright reduce the costs of BEV adoption. These provisions only further drive investment in BEV adoption, increasing the overall market penetration and economies of scale for BEV components.

1. Background

In 2021, light-duty vehicles (LDV), comprising passenger cars and light-duty trucks, contributed 58% of the U.S. transportation GHG emissions [1]. Thus, prioritizing the decarbonization of the LDV fleet is a critical strategy for reducing GHG emissions. A previous study, "*Electrification of Light-Duty Vehicles,*" prepared for the Environmental Defense Fund (EDF), analyzed the cost of electrifying the LDV market [2]. This study evaluates the impact of the IRA of 2022 on the electrification of the LDV segment using the costs developed in the previous study [2] and could be considered an addendum to it.

Our initial analysis estimated the direct manufacturing cost (DMC) of a wide range of light-duty ICEVs and their equivalent BEVs based on differences in their powertrains in model year (MY) 2030. The report then estimated the retail price equivalent of these ICEVs and BEVs, as well as their total costs of ownership (TCO) over the life of each vehicle. The analyzed LDVs included six subclasses—compact cars, midsize cars, small SUVs, midsize SUVs, large SUVs, and pickup trucks—divided into two categories: base (non-performance) and premium (performance). For all but large SUVs and pickups, BEVs were assumed to have a 200-mile range for base vehicles and a 300-mile range for premium vehicles; for large SUVs and pickups, BEVs were assumed to have a 300-mile range for base vehicles and a 400-mile range for premium vehicles, as shown in Table 2.

Table 2: LDV subclasses considered in the previous study [2]**.**

Vehicle type	Subclass	Segment	Max Motor Power (kW)	Battery size (kWh)	Range (Miles)
Car	Compact (Small) car	Base	82	40	200
		Premium	113	63	300
	Midsize (Medium) car	Base	99	41	200
		Premium	138	65	300
SUV	Small SUV	Base	117	50	200
		Premium	162	77	300
	Midsize SUV	Base	111	54	200
		Premium	158	87	300
	Large SUV *(assumed 10% more than pickup truck)*	Base	196	108	300
		Premium/Towing	227	168	400
Pickup	Pickup Truck	Base	178	98	300
		Premium/Towing	206	152	400

The primary analysis concluded that:

a) For all BEVs up to a 300-mile range, purchase price parity with a comparable ICEV is reached by MY 2030, across all vehicle classes and segments evaluated.
b) By MY 2030, the total cost of ownership (TCO) for all BEVs up to a 400-mile range will be equal to or lower than their ICEV counterparts across all classes and segments.
c) BEVs purchased in 2030 result in an average cumulative net savings of about $15,000 over the lifetime of the vehicle compared to an ICEV, across all classes and segments.
d) For consumers who charge their vehicles equally at home and public fast charging stations, the TCO of a BEV is still lower than an ICEV, despite increases in energy costs.
e) Accounting for current real-world gasoline prices, all BEVs up to the 400-mile range compensate for any increase in upfront cost with reduced operating costs within the first year of ownership at the latest. Owning and operating BEV results in an average savings of about $33,000 over the life of a BEV compared to an ICEV.

This study evaluates the impact of the IRA of 2022 on the electrification of the LDV segment using the costs developed in the previous study [2]. The Inflation Reduction Act (IRA), signed into law on August 16, 2022, contains multiple provisions to decarbonize the transportation sector. It aims to stimulate the growth and adoption of clean transportation options such as zero-emission vehicles (ZEVs) and plug-in hybrid electric vehicles (PHEVs) to further mitigate emissions. It includes incentives, tax credits, and funding for various programs to fast-track the transition to clean energy by electrifying automobiles to address air pollution and strengthen energy security. It is an important step to accelerate the clean energy transition to develop a resilient, secure, and environmentally sustainable transportation sector while enhancing the economic viability of electric vehicles (EVs). The incentives contained in the IRA will accelerate the adoption of battery-electric LDVs advancing the benefits to prospective owners in the near term.

This study analyzes the effects of the IRA on the cost of electrifying LDVs, both quantitatively and qualitatively. Furthermore, it assesses the near-term effects of IRA by substituting previously costed MY 2022 projections for MY 2025 projections. This study does not take into account geopolitical risks to the battery supply chain, as well as rising raw material costs. This study assumes that long-term raw material supply grows in tandem with demand, with no shortages. Clean vehicle credits are applied to the LDV segment based on generous assumptions. To achieve the projected battery pack cost, which is a key determinant of the vehicle's purchase price in the 2025 and 2030 purchase timeframes, we assumed 50% penetration with a large scale of production economies. Currently, the BEV market is in its early stages of development, with an estimated 6% penetration in the United States by 2022. The BEV would gain a significant market share in the future as OEMs ramp up production and consumer adoption increases; however, it is difficult to predict what percentage of vehicle sales would qualify for IRA purchase credits.

Our original study [2] estimated the purchase price and TCO of ICEVs and BEVs in the 2030 purchase timeframe. This study investigates the impact of credits in the near-term scenario of 2025 as well as the previously examined timeframe of 2030. Only the RPE for the 2025 timeframe was changed to 1.5 from the original multiplier of 1.2 in the 2030 timeframe. All other inputs for estimating operating costs and the parity timeline remain unchanged.

2. Impact of IRA Credits

The impact analysis of the IRA of 2022 has been broadly divided into two sections: quantitative (or direct) impact and qualitative (or indirect) impact. The quantitative impact applies the tax incentives towards the vehicle purchase price and the charging infrastructure to ascertain the cost-benefit to the end user. The qualitative assessment delves into the indirect impact of various funding and financing programs, grants, rebates, and emission reduction programs that stimulate and encourage the adoption of BEVs over comparable gasoline vehicles in the LDV segment. The endeavor is to present the results generated from the application of all these provisions on the LDV segment and gauge its impact on electrifying LDVs. There may be certain scenarios where the indirect impact on the drive to electrify the LDV segment may be higher than estimated here.

2.1 Quantitative Impact

2.1.1 Clean Vehicle Credit – 26 U.S.C. §30D

This provision amends the tax credits for plug-in electric vehicles under 26 U.S.C. §30D while expanding the eligibility to include fuel cell vehicles (FCVs), which had a previous tax credit under 26 U.S.C. §30B that expired on December 31, 2021. The provision defines “clean vehicles” as those vehicles propelled primarily by electricity with a battery capacity of at least 7 kWh and capable of being recharged from an external source of electricity. The clean vehicle definition is expanded to include hydrogen FCVs. The maximum allowable credit per vehicle is capped at $7,500 for vehicles with a gross vehicle weight rating (GVWR) of less than 14,000 lbs., which would include light-duty and class 2b–3 vehicles. The provision includes income and price limits to qualify for the credit. Qualifying vehicles must also meet:

a) North American final assembly requirements,
b) Critical minerals sourcing requirements, and
c) Battery component manufacturing requirements.

The final assembly requirement took effect on August 16, 2022, when the bill was signed into law. Additional provisions came into effect on January 1, 2023. Further guidance on these provisions is forthcoming from the IRS and the Department of Treasury. This provision would also eliminate the current per-manufacturer cap of 200,000 vehicles qualifying for credits, a cap that has already been exceeded by OEMs such as Tesla and GM. Sellers would be required to provide taxpayer and vehicle information to the Department of Treasury for tax credit-eligible vehicles. Only vehicles manufactured by qualified manufacturers who have signed written agreements with the Treasury and submit periodic reports to it may be eligible. Figure 3 summarizes the vehicle credit allowances in the pre- and post-IRA 2022 periods for easy reference. The provisions

Environmental Defense Fund ROUSH

described in each cell of the column headed “Clean Vehicles Credit” of Figure 3 are described in more detail below.

	Pre-IRA 2022		Post-IRA 2022		
	Plug-in EV Credit	Fuel Cell Vehicle Credit	Clean Vehicles Credit	Credit for Previously-Owned Clean Vehicles	Credit for Commercial Clean Vehicles
Maximum Amount	$7,500 base amount of $2,500 plus $417 for each kWh of capacity above 5 kWh (up to $5,000)	$8,000 or $40,000 base amount of $4,000 plus up to $4,000 additional based on fuel economy; credit of up to $40,000 for heavy vehicles	$7,500 $3,750 for vehicles meeting the critical minerals requirement; $3,750 for vehicles meeting the battery components requirement	$4,000 limited to 30% of the sales price	$7,500 or $40,000 credit is limited to the lesser of 15% of the vehicle's cost (30% for vehicles not gasoline or diesel powered) or the incremental cost of the vehicle, as compared to vehicles powered with a gasoline or diesel ICE; credit of up to $40,000 for heavy vehicles
Qualifying Vehicles	battery with 4 kWh of capacity with external charging	vehicles propelled by fuel cells	battery with 7 kWh of capacity with external charging; vehicles propelled by fuel cells; after 2024, no credits allowed for batteries containing critical minerals sourced from a foreign entity of concern; after 2023, no credit for batteries with components sourced from a foreign entity of concern	previously-owned clean vehicles having a model year that is two years earlier than the calendar year; credit can only be claimed on the first transfer of the vehicle; vehicle must be purchased from a dealer	clean vehicles and mobile machinery; larger EVs required to have a battery with 15 kWh of capacity; vehicle must be subject to a depreciation allowance (i.e., for business use), except in the case of vehicles used by tax-exempt entities
Manufacturering Location Requirements	n.a.	n.a.	final assembly must occur within North America (effective 8/16/2022)	n.a.	n.a.
Manufacturer Limitations	phaseout after 200,000 plug-in EVs manufactured	n.a.	n.a.	n.a.	n.a.
Eligible Taxpayers	individuals & businesses; for tax-exempt entities seller can claim credit		individuals & businesses	individuals (limited to one credit every 3 years)	businesses & tax-exempt entities; tax-exempt entities could receive credit as direct pay
Price Limits	n.a.	n.a.	no credit allowed for vans, SUVs, pickup trucks with MSRP > $80,000; other vehicles with an MSRP > $55,000	no credit allowed if the sales price is $25,000 or more	n.a.
Income Limits	n.a.	n.a.	no credit if MAGI > $300,000 (married filing jointly); MAGI > $225,000 (head of household); MAGI > $150,000 (single); income thresholds apply to the lesser of current year or prior year MAGI	no credit if MAGI > $150,000 (married filing jointly); MAGI > $112,500 (head of household); MAGI > $75,000 (single); income thresholds apply to the lesser of current year or prior year MAGI	n.a.
VIN Reporting Requirements	n.a.	n.a.	seller must report VIN to the Treasury; taxpayers must report VIN on tax return		taxpayers must report VIN on tax return
Transferability	only for tax-exempt entities	only for tax-exempt entities	taxpayers can elect to transfer credit to dealer (effective after 12/31/2023)	taxpayers can elect to transfer credit to dealer (effective after 12/31/2023)	n.a.
Expiration	none	12/31/2021	12/31/2032	12/31/2032	12/31/2032

EV = electric vehicle; **kWh** = kilowatt hour; **MAGI** = modified adjusted gross income; **MSRP** = manufacturer's suggested retail price; **SUV** = sport utility vehicle; **ICE** = internal combustion engine; **VIN**= vehicle identification number; **n.a.** = not applicable

Figure 3: Clean Vehicle Credits in the Inflation Reduction Act of 2022. Source: CRS analysis of P.L. 117-169.

The first step in describing the provisions of the clean vehicles credit requires an understanding of the meaning of the various dates mentioned. This section of the IRA focuses on the date on which a vehicle is “placed in service.” For light-duty vehicles, this date is usually understood as being 2025 and 2030. When doing so, the IRA usually refers to vehicles placed in service before January 1 of a specified calendar year or after December 31 of a specified calendar year. For simplicity here, when we state after a “specified year”, we mean after December 31 or the previous year. When we state starting in a specific year, we mean starting on January 1 of that year.

Starting in 2023 (i.e, for vehicles placed in service on January 1, 2023, or later), an EV qualifies for a credit of up to $7,500 if the vehicle’s battery meets threshold percentages for critical mineral sourcing and battery component manufacturing or assembly, as listed in Table 3. Each of these two conditions carries a credit of $3,750. Vehicles can qualify for one or both credits.

Table 3: Applicable percentage of critical mineral and battery component requirements.

<table>
<tr><th>Service date</th><th>Critical Mineral ($3,750)</th><th>Battery Component ($3,750)</th></tr>
<tr><td>Placed in service before January 1, 2024</td><td>40%</td><td>50%</td></tr>
<tr><td>Placed in service during the calendar year 2024</td><td>50%</td><td rowspan="2">60%</td></tr>
<tr><td>Placed in service during the calendar year 2025</td><td>60%</td></tr>
<tr><td>Placed in service during the calendar year 2026</td><td>70%</td><td>70%</td></tr>
<tr><td>Placed in service during the calendar year 2027</td><td rowspan="3">80%</td><td>80%</td></tr>
<tr><td>Placed in service during the calendar year 2028</td><td>90%</td></tr>
<tr><td>Placed in service after 2028 and before 1/1/2033</td><td>100%</td></tr>
</table>

To qualify for the $3,750 critical minerals portion of the credit, at least 40% of the value of the battery’s applicable critical minerals must have been extracted or processed in the United States or in a country with which the United States has a free trade agreement, or from critical minerals recycled in North America. Beginning in 2024, the required threshold percentage increases by 10% every year until it reaches 80% for vehicles placed in service in 2027 and thereafter.

Similarly, to qualify for the $3,750 battery component portion of the credit, at least 50% of the value of the battery’s components must have been manufactured or assembled in North America. Beginning in 2024, the threshold percentage rises to 60%, then 10% per year after that until it reaches 100% for vehicles placed in service in 2029 through the end of 2032.

Figure 4 provides an overview of the tax incentives related to the sourcing and production criteria for §30D and §45X (§45X is covered in detail below in section 2.2.1.2). The green color indicates the geographic areas from which critical minerals and battery component manufacturing must be sourced for vehicles to qualify for applicable credits. The yellow color indicates the geographic areas that do not qualify for §30D credits. The dark blue shading for §45X indicates that only eligible components manufactured in the United States qualify for applicable credits. An "X" indicates that vehicles using batteries sourced from these areas do not qualify for credit.

IRA Credits		Conditions	United States	North America	FTA partner	Foreign Entity of Concern
30D Clean Vehicle Credit (all 3 conditions to be met to define qualifying vehicle)	$3,750 to Consumer	Ia. Critical Minerals Extraction or Processing	Applicable % to be met from 2023			Vehicle does not qualify for any credit after **2024**
		Ib. Critical Minerals Recycling			X	X
	$3,750 to Consumer	II. Battery Components	Applicable % to be met from 2023		X	Vehicle does not qualify for any credit after **2023**
		III. Final Assembly			X	X
45X	Variable $$ to OEM	Advanced Manufacturing Production Credit		X	X	X

Figure 4: Applicability of tax credits under §30D and §45X under the IRA of 2022.

Vehicles containing battery components (after 2023) – manufacturing or assembly – or critical minerals (after 2024) – extraction, processing, or recycling – from foreign entities of concern (as defined in 42 U.S.C. 18741(a)(5)), are ineligible for the credit. All credit provisions, regardless of source or component content, expire on December 31, 2032. Before that time, tax credits are only allowed for vehicles that do not exceed the following manufacturer's suggested retail price (MSRP):

a) Vans: $80,000
b) SUVs: $80,000
c) Pick-up Trucks: $80,000
d) Any other vehicle: $55,000

It should be noted that OEMs actively lobbied the Administration and Congress regarding the definition of an SUV. On February 3, 2023, the Treasury updated the vehicle classification standard allowing crossover vehicles that share similar features to be treated consistently. To enable electric vehicles from manufacturers such as Tesla (Model Y), Ford (Mustang Mach-E), and General Motors (Cadillac Lyriq) to qualify for up to

$7,500 in federal tax credits despite their higher prices, the definition of an "SUV" was redefined [3].

Finally, the taxpayer receiving the credit(s) cannot have a modified AGI of more than $150,000 (if filing singly), $225,000 (if filing as a head of a household), or $300,000 (if filing jointly or as a surviving spouse) in the tax year in which the credit is claimed, nor in the prior tax year. The eligible vehicle purchaser can elect to transfer tax credits to the vehicle dealer at the point of sale beginning in 2024, once the Department of Treasury and IRS come out with a credit transfer mechanism. All credit eligibility requirements will still apply.

For this analysis, the provisions described above are used to determine the applicable purchase price credits for each of the considered vehicle subclasses. To determine the potential impact of the IRA, the full credit amount of $7,500 is applied to the purchase price of BEVs in MYs 2025 and 2030. The impact of these tax credits is applied to projected BEV costs which do not necessarily fulfill the requirements of §30D of the IRA, as the projected battery pack costs used in the original study were derived assuming globalized supply chains. This should be kept in mind as the impact of the tax credits is presented and discussed.

2.1.2 Alternative Fuel Vehicle Refueling Property Credit – 26 U.S.C. §30C

This provision of the IRA extends and modifies the available credits in 26 U.S.C. §30C for alternative fuel vehicle refueling property (as related to charging infrastructure for this analysis). A tax credit for the cost of any qualified alternative fuel vehicle refueling property installed by a business or at a taxpayer’s principal residence was in existence until 2021 and is extended by the IRA through the end of 2032. The credit is equal to 30% of refueling property costs, capped at $1,000 for residences (personal use property i.e., property not subject to depreciation). For business/investment use property (i.e., property subject to depreciation), the credit is extended at a rate of 6% (30% if prevailing wage and registered apprenticeship requirements are met) of the charger unit and installation cost and the credit is capped at $100,000. The credit expires on December 31, 2032, but starting in 2023, regarding either the residential and business credit, the charging or refueling property must be within a low-income or rural census tract.

In this analysis, an 11.5 kW level 2 residential charger is assumed to cost $1,000. We have assumed a flat 30% credit on charger unit costs, or $300. Overall, charger costs decline from $1,000 to $700 in the case of a residential charging scenario. Some BEV recharging at public charging stations is included in our analyses below. We did not include any IRA-related tax credits when estimating the cost of this public charging, though some might occur if the station was located in a rural or low-income area.

2.2 Qualitative Impact

The qualitative impact on the class 2b–3 segment can be broadly divided into three categories: tax incentives; funding and financing; and emission reduction program incentives, as shown in Figure 5. The provisions of the IRA are discussed under each of these general headings based on their qualitative (or indirect) effect on electrifying the LDV segment.

SECTION	*IMPACT*	*ENDPOINT*
EXTENSION OF THE ADVANCED ENERGY PROJECT CREDIT ($10 bn.)	• Stimulate and scale up domestic manufacturing • Develop clean energy supply chains	• Benefits automakers and EV battery makers • Promotes manufacturing of advanced **LDVs**
ADVANCED MANUFACTURING PRODUCTION CREDIT	• Energy Generation related credits • Promotes clean electricity technologies	• Benefits utility providers • 0.3-1.5 ₵/kWh • Technology-neutral credits from 2025
CLEAN ELECTRICITY PRODUCTION CREDIT & INVESTMENT CREDITS		
FUNDING FOR DOE LOAN PROGRAMS OFFICE ($3.6bn., +$40 bn.)	• Increase domestic supply of critical minerals through production, processing, manufacturing, recycling or fabrication of mineral alternatives • Domestic production of HEVs, PHEVs, PEVs and FCEVs • Emission reduction technologies in energy infrastructure • Reducing emissions from energy intensive industries	• Benefits upstream operators, automakers, battery makers, and energy producers • Secures supply chain
ADVANCED TECHNOLOGY VEHICLE MANUFACTURING ($3 bn.)		
DOMESTIC MANUFACTURING CONVERSION GRANTS ($2 bn.)		
ENERGY INFRASTRUCTURE REINVESTMENT FINANCING ($5 bn.)		
ADVANCED INDUSTRIAL FACILITIES DEPLOYMENT PROGRAM ($5.812 bn.)		
GREENHOUSE GAS REDUCTION FUND ($27 bn.)	• Deploy low- and zero- emission technologies	• Encourages adoption of BEVs

TAX INCENTIVES	*FUNDING & FINANCING*	*EMISSION REDUCTION PROGRAM*

Figure 5: Summary of the qualitative impact of the IRA on the LDV segment

2.2.1 Tax Incentives

2.2.1.1 Extension of the Advanced Energy Project Credit – 26 U.S.C. §48C

This provision extends the 26 U.S.C. §48C advanced energy project credit. It provides additional allocations of the qualified advanced energy manufacturing tax credit, which is a 30% tax credit for investments in projects that reequip, expand, or establish certain energy manufacturing facilities. An additional $10 billion is earmarked to provide credits for advanced energy projects. The term “qualifying advanced energy project” includes one of the three following project types,

a) A project that re-equips, expands, or establishes an industrial or manufacturing facility for the production or recycling of one of the following nine property types:
   i) Property designed to be used to produce energy from the sun, water, wind, geothermal deposits, or other renewable resources.
   ii) Fuel cells, microturbines, or energy storage systems and components.
   iii) Electric grid modernization equipment or components.

iv) Property designed to capture, remove, use, or sequester carbon oxide emissions.
v) Equipment designed to refine, electrolyze, or blend any fuel, chemical, or renewable product or low-carbon and low-emission.
vi) Property designed to produce energy conservation technologies (including residential, commercial, and industrial applications).
vii) Light, medium, or heavy-duty electric or fuel cell vehicles, as well as technologies, components, or materials for such vehicles, and associated charging or refueling infrastructure.
viii) Hybrid vehicles with a gross vehicle weight rating of not less than 14,000 lbs., as well as technologies, components, or materials for such vehicles.
ix) Advanced energy property designed to reduce greenhouse gas emissions.

b) A project that re-equips an industrial or manufacturing facility with equipment designed to reduce greenhouse gas emissions by at least 20% through the installation of
   i) Low- or zero-carbon process heat systems,
   ii) Carbon capture, transport, utilization, and storage systems,
   iii) Energy efficiency and reduction in waste from industrial processes, or
   iv) Any other industrial technology designed to reduce greenhouse gas emissions.
c) A project that re-equips, expands, or establishes an industrial facility for the processing, refining, or recycling of critical materials (as defined in § 7002(a) of the Energy Act of 2020 (30 USC § 1606(a)).

Projects receive a base credit rate of 6% of the total cost or a bonus rate of 30% if the projects meet prevailing wage and registered apprenticeship requirements.

2.2.1.2 Advanced Manufacturing Production Credit – 26 U.S.C. §45X

This provision creates a new production tax credit, 26 U.S.C. §45X, that could be claimed for domestic battery production. The following credits apply to cell material or production:

a) A credit of 10% of the cost of production would also be available for the domestic production of critical minerals. Per the USGS, a "critical mineral" is a non-fuel mineral or mineral material essential to the economic or national security of the U.S. and which has a supply chain vulnerable to disruption. Critical minerals are also characterized as serving an essential function in the manufacturing of a product, the absence of which would have significant consequences for the economy or national security. A list of critical minerals per 26 U.S.C. §45X can be found in Appendix 7.2 for reference.
b) For electrode active materials, the credit would be 10% of the production cost. The term "electrode active material" means cathode materials, anode materials, anode foils, and electrochemically active materials, including solvents, additives, and

electrolyte salts that contribute to the electrochemical processes necessary for energy storage.

c) Battery cells could qualify for a credit of $35/kWh, and battery modules could qualify for a credit of $10/kWh. The term “battery cell” means an electrochemical cell—
   i) comprised of 1 or more positive electrodes and 1 or more negative electrodes,
   ii) with an energy density of not less than 100 Wh/liter, and
   iii) capable of storing at least 12 Wh of energy.
d) In the case of a battery module that does not use battery cells, they could qualify for a credit of $45/kWh. The term “battery module” means a module—
   i) (aa) in the case of a module using battery cells, with 2 or more battery cells which are configured electrically, in series or parallel, to create voltage or current, as appropriate, to specified end use, or (bb) with no battery cells, and
   ii) with an aggregate capacity of not less than 7 kWh (or, in the case of a module for a hydrogen fuel cell vehicle, not less than 1 kWh).

The sales of eligible components are considered only if their production is within the US or a US territory (including continental shelf areas). Full credits are provided for eligible components produced and sold before January 1, 2030. The credit would begin to phase out for eligible components sold at a fixed rate of 25% each year i.e., 75%, 50%, and 25% of the credits described above would be available in 2030, 2031, and 2032, respectively. No credit would be available for components sold after December 31, 2032. The phaseout does not apply to the production of critical minerals. Table 4 illustrates the applicability of credits specific to the battery-related components and materials.

Table 4: Advanced Manufacturing Production Credit applicable battery materials

Advanced Manufacturing Production Credit to Batteries	*Credits remain same*								*Most credits phase-out*			
	2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**
Electrode active materials	10%	10%	10%	10%	10%	10%	10%	10%	7.5%	5%	2.5%	-
Cells ($/kWh)	$35	$35	$35	$35	$35	$35	$35	$35	$26.3	$17.5	$8.8	-
Modules ($/kWh)	$10	$10	$10	$10	$10	$10	$10	$10	$7.5	$5	$2.5	-
Modules that don't use cells ($/kWh)	$45	$45	$45	$45	$45	$45	$45	$45	$33.8	$22.5	$11.3	-
Production of Critical Minerals *(Credits do not phase out)*	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%

Provision §45X contains some ambiguity regarding the following issues, which will be clarified through Treasury actions[1].

a) **Critical minerals**:

i) Since critical minerals go through several transformation steps and the allocated capital is amortized over several years, determining the incurred costs in the production of critical minerals and electrode active materials is ambiguous. It is unclear if the definition of production costs includes overhead costs (such as the cost of consumables), upfront costs, and indirect production-related costs.

ii) Moreover, it is unclear whether the requirement for sourcing, extraction, or processing of critical minerals from a non-foreign entity of concern is stipulated—that is, whether the critical mineral requirement in this section aligns with the definition in §30D.

iii) Furthermore, the provision does not state whether the critical minerals must be converted and purified into battery-grade material.

[1] This report was drafted in 2022 and early 2023 before the release of the prepublication draft Treasury guidance.

iv) The eligibility of recycled critical minerals is unclear.

b) **Electrode active materials**: Whether other common battery materials or those under development, such as conductive additives (for example, carbon black), binder materials (fluoropolymers), ionically conductive separators, carbon nanotubes, pouches, cathode foils, solid electrolytes, tabs, tapes, adhesives and the raw materials used to make them, would be included in the definition of electrode active materials for credit eligibility.

c) **Module production tax credit**: If the battery pack is eligible for the module production tax credit in the absence of a module configuration in a cell-to-pack or cell-to-chassis configuration, or if combining multiple modules to form larger modules to form a pack would be considered individually for the credit.

d) Clauses such as “sale of components to a related and unrelated person” and “integrated, incorporated or assembled” obscure credit applicability.

2.2.1.3 Clean Electricity Production Credit and Investment Credit

These provisions bolster the energy generation sector by providing credits to clean energy producers, with a choice to avail of the credits either upfront to reduce their required investment or during production. The IRA extends, expands, and modifies the 26 U.S.C. §45 production tax credit (PTC) and the 26 U.S.C. §48 investment tax credit (ITC) through 2024. The producers can choose between a production tax credit (PTC) under section 45Y or an investment tax credit (ITC) under section 48D, which is provided based on the carbon emissions of the electricity generated – measured as grams of carbon dioxide equivalents (CO_2e) emitted per kWh generated. The provisions add a new §45Y known as the clean energy production credit and §48E known as the clean electricity investment credit. The provisions create an emissions-based incentive that would be neutral and flexible between clean electricity technologies. The credits would end after 2032 or when the emission targets are achieved i.e. when the electric power sector emits equal to or less than 25% of their 2022 levels, the incentives will be phased out over 3 years.

This could have a potential impact downstream on charging rates for businesses and public charging facilities by allowing the energy producers to absorb high investment and production costs.

2.2.2 Federal Funding and Financing Opportunities

2.2.2.1 Funding For Department Of Energy Loan Programs Office

The IRA provides $40 billion in additional commitment authority for eligible projects under Title XVII section 1703 through Sept. 30, 2026. This funding will be available for existing eligible projects and will expand the eligibility for projects that increase the domestic supply of critical minerals through the production, processing, manufacturing, recycling, or fabrication of mineral alternatives. Additionally, the provision will provide $3.6 billion in credit subsidy costs through September 30, 2026. It also establishes a time-limited (available through FY2026), $250 billion Title XVII loan guarantee commitment authority—Section 1706—for “Energy Infrastructure Reinvestment Financing”. This loan guarantee program includes the fossil fuel energy infrastructure facilities, and electricity generation and transmission energy infrastructure encouraging them to reduce GHG emissions.

DOE would provide access to debt capital for large-scale energy projects that use innovative technology. Projects such as but not limited to energy infrastructure storage and modernization would benefit the producers and suppliers tied to the EV sector.

2.2.2.2 Advanced Technology Vehicle Manufacturing.

The IRA of 2022 eliminated the loan program cap of $25 billion on the total amount of ATVM loans established under the Energy Independence and Security Act of 2007. The ATVM direct loan program finances U.S. auto manufacturing across the value chain as long as the projects meet stipulated criteria. This means that the program's total loan capacity is no longer limited, as long as credit subsidies are available to offset the cost of those loans. The IRA provides $3 billion through September 30, 2028, to the Advanced Technology Vehicles Manufacturing (ATVM) Loan Program for re-equipping, expanding, or establishing a manufacturing facility in the United States to produce, or for engineering integration performed in the US of low- or zero-emission vehicles. According to DOE, eligible borrowers can be one of the following:

a) Manufacturers of advanced technology vehicles that achieve defined fuel economy targets. Eligible vehicles are light-duty vehicles that meet or exceed a 25% improvement in fuel efficiency beyond a MY 2005 baseline of comparably-sized vehicles; and/or ultra-efficient vehicles that achieve a fuel efficiency of 75 miles per gallon equivalent.
b) Manufacturers of components or materials that support eligible vehicles' fuel economy performance. Examples of eligible components include:
    i) Advanced engines & powertrain components including electrified powertrains, batteries, and electronics
    ii) Materials for light-weighting such as aluminum, advanced steels, composites, and fuel-efficient tires
    iii) Electric Vehicle Charging & Alternative Fuel Vehicle Fueling Infrastructure Components. For example, associated hardware and software for fuel cell hydrogen fueling stations
    iv) May also be able to support projects that include the processing or manufacturing of critical minerals in support of eligible vehicles

According to 42 U.S.C. §17013(a)(1), the term "advanced technology vehicle" means—

a) an ultra-efficient vehicle or a light-duty vehicle that meets—
    i) the Bin 5 Tier II emission standard established in regulations issued by the Administrator of the Environmental Protection Agency under section 202(i) of the Clean Air Act (42 U.S.C. 7521(i)), or a lower-numbered Bin emission standard;
    ii) any new emission standard in effect for fine particulate matter prescribed by the Administrator under that Act (42 U.S.C. 7401); and
    iii) at least 125% of the average base year combined fuel economy for vehicles with substantially similar attributes.
b) a medium-duty vehicle or a heavy-duty vehicle that exceeds 125% of the greenhouse gas emissions and fuel efficiency standards established by the final rule of the

Environmental Protection Agency entitled "Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2" (81 Fed. Reg. 73478 (October 25, 2016));

c) a train or locomotive;
d) a maritime vessel;
e) an aircraft; and
f) hyperloop technology

To name a few, the ATVM loan program has benefitted automakers like Ford, Nissan, and Tesla. According to the U.S. DOE Loans Program Office, Ford received a direct loan of $5.9 billion, to retool their manufacturing facilities which aided the production of 13 separate models with electric, hybrid, or improved conventional powertrains and the introduction of a family of Ford EcoBoost™ engines; Nissan was awarded a loan of $1.45 billion to retool its plant to build BEVs and for a LIB manufacturing plant which aided the Nissan LEAF BEV; Tesla received $465 million loan to develop the Fremont manufacturing facility to produce the Model S. In July 2022, DOE issued a $102.1 million loan to Syrah Technologies LLC to expand its Syrah-Vidalia facility, which processes battery-grade natural graphite. Furthermore, in November 2022, DOE issued a direct loan of $2.5 billion to Ultium Cells, LLC to help finance the construction of new lithium-ion battery cell manufacturing facilities in Ohio, Tennessee, and Michigan. Ultium Cells is a joint venture between General Motors and LG Energy Solution which will manufacture nickel-cobalt-manganese-aluminum (NCMA) based large format, pouch-type cells for EVs.

Elimination of the loan program cap and the additional funding to ATVM could prove beneficial to various producers and manufacturers in the EV ecosystem, as essentially all EV technology would qualify for this credit. This $3 billion is expected to provide an additional ~$40 billion (under Title XVII) in loan authority, bringing the total estimated available loan authority under ATVM to ~$55.1 billion.

2.2.2.3 Domestic Manufacturing Conversion Grants

This provision appropriates $2 billion to remain available through September 30, 2031, as grants and loan guarantees under 42 U.S.C. §16062 to automobile manufacturers and suppliers and hybrid component manufacturers to encourage domestic production of efficient hybrid, plug-in electric hybrid (PHEV), plug-in electric drive (PEV), and hydrogen fuel cell electric vehicles (FCEV) stimulating the EV industry. Priority shall be given to the refurbishment or retooling of manufacturing facilities that have recently ceased operation or will cease operation in the near future.

2.2.2.4 Energy Infrastructure Reinvestment Financing

This provision appropriates $5 billion through September 30, 2026, to be leveraged for up to $250 billion in loan guarantees. Energy Infrastructure Reinvestment (EIR) will guarantee loans to projects that retool, repower, repurpose, or replace energy infrastructure that has ceased operations, or enable operating energy infrastructure to avoid, reduce, utilize, or sequester air pollutants or anthropogenic emissions of greenhouse gases. Potential projects could include repurposing shuttered fossil energy facilities for clean energy production, retooling infrastructure from power plants that have ceased operations for new clean energy uses, or updating operating energy infrastructure with emissions control technologies, including carbon capture, utilization, and storage (CCUS). It adds section 1706 to 42 U.S.C. §16516. As defined in the bill, energy infrastructure would include:

a) Electricity generation and transmission, or
b) Production, processing, and delivery of fossil fuels, petroleum-derived fuels, or petrochemical feedstocks

2.2.2.5 Advanced Industrial Facilities Deployment Program

The IRA provides $5.812 billion under 42 U.S.C. §17113(c) through September 30, 2026, to create a new program within the Office of Clean Energy Demonstrations (OCED) to invest in projects aimed at reducing emissions from energy-intensive industries. It will provide financial assistance to projects for—

a) The purchase and installation, or implementation, of advanced industrial technology at an eligible facility;
b) Retrofits, upgrades to, or operational improvements at an eligible facility to install or implement advanced industrial technology; or
c) Engineering studies and other work needed to prepare an eligible facility for activities as described in paragraphs (a) or (b).

Iron and steel producers serving the automotive industry may benefit from this appropriation.

2.2.3 Emission Reduction Program

2.2.3.1 Greenhouse Gas Reduction Fund

The IRA will provide $7 billion to EPA for a new GHG Reduction Fund to make competitive grants to states, municipalities, tribal governments, and eligible recipients to provide financing and technical assistance to enable low-income and disadvantaged communities to deploy or benefit from zero-emission technologies, including distributed technologies on residential rooftops, and to carry out other GHG emission reduction activities; $11.97 billion for general assistance; $8 billion for low-income and disadvantaged communities; and $30 million for EPA administrative costs.

The program would also stimulate and promote the electrification of the medium-duty segment, which could benefit light-duty trucks, and discourage the use of fossil fuel-powered vehicles.

3. Results

The purchase price credits under the clean vehicle credits (§30D) have been applied to the vehicles evaluated in this analysis to determine potential purchase price reductions in 2025 and 2030. Additionally, the 30% alternative fuel infrastructure credit provision is applied to charger purchase costs. The RPE multiplier for MY 2025 vehicles has been kept the same as the equivalent ICEVs at 1.5 to recognize the nascent market for light-duty BEVs. For simplification of the 2025 TCO analysis, operating expenses for 2025 BEVs are kept the same as such expenses for MY 2030 BEVs. The figures in the following sections illustrate the effect of potential IRA credits on purchase parity and TCO parity in electrification Scenario 2 (the medium-cost scenario) for each vehicle class in purchase years 2025 and 2030. Results for all three scenarios can be found in Appendices 7.3, 7.4, 7.4, 7.5, and 7.6.

3.1 Impact of Clean Vehicle Credit on Purchase Price

A flat $7,500 credit has been applied to all vehicle subclasses purchased in 2025 and 2030. Assuming the consumer qualifies for the entire $7,500 purchase credit, the possible benefits could manifest as greater savings or increased affordability (using the credit to upgrade to a more expensive vehicle with, for example, a larger battery option or a greater range). We recognize that not many of the vehicles would be eligible for the entire credit of $7,500 for MY 2025 (and possibly MY 2030) due to the difficulty of meeting the critical mineral sourcing and battery component manufacturing criteria, or the income restrictions on BEV purchasers. It may take some years for the industry to ramp up production, regionalize, and strengthen the battery supply chain. However, the analysis intends to evaluate the full range of potential effects under a robust market, so it does not factor in the geopolitical risks to the battery supply chain or the potentially associated rising raw material costs or supply chain issues, nor the income distribution of BEV buyers.

The purchase price credits have been applied to each class of vehicle to determine their effective purchase price in 2025 and 2030. Savings of a BEV over a comparable ICEV because of IRA clean vehicle credits are listed in Table 5. Except for the MY 2024 large SUVs and pickup trucks, all other BEVs in respective MYs have a lower retail price than comparable ICEVs resulting in savings anywhere between $1,373 to $13,857.

Table 5: Savings of BEV over an ICEV in 2025 and 2030 purchase timeframes

Subclass	2025		2030	
	Base	Premium	Base	Premium
Small Car	$7,741	$4,441	$13,788	$12,740

Subclass	2025		2030	
	Base	Premium	Base	Premium
Midsize Car	$7,333	$3,783	$13,586	$12,426
Small SUV	$5,535	$1,373	$12,760	$11,368
Midsize SUV	$6,301	$1,740	$13,857	$12,181
Large SUV	-$3,778	-$13,531	$9,564	$5,596
Pickup Truck	-$1,835	-$10,061	$10,443	$6,911

3.2 Manufacturer's Suggested Retail Price (MSRP) Ceiling

As seen in the preceding sections, the application of credits results in BEVs achieving immediate purchase parity in the near term in 2025 for most vehicle segments. This section attempts to establish a BEV MSRP ceiling in each segment which defines a maximum BEV MSRP which would still allow price parity after $7,800 in IRA credits. Though it is not an IRA requirement, the availability of the IRA credits provides flexibility to the automakers and/or cell makers to:

a) Increase battery size
b) Absorb battery price fluctuations
c) Develop a domestic supply chain
d) Handle lower economies of scale in the early years of production

A sample Scenario 2 of a small SUV in the base segment is illustrated in Figure 6 to demonstrate the BEV MSRP ceiling. In general, with the increase in ICEV price, the BEV MSRP ceiling is raised. The maximum MSRP of a BEV with ICEV as the baseline is $36,481 and $37,446 in the years 2025 and 2030, respectively, since the purchase credit remains the same at $7,500. For the computation of the BEV MSRP ceiling, a $7,500 purchase credit has been added to the equivalent ICEV MSRP. The credit stays the same across 2025 and 2030 purchase timeframes.

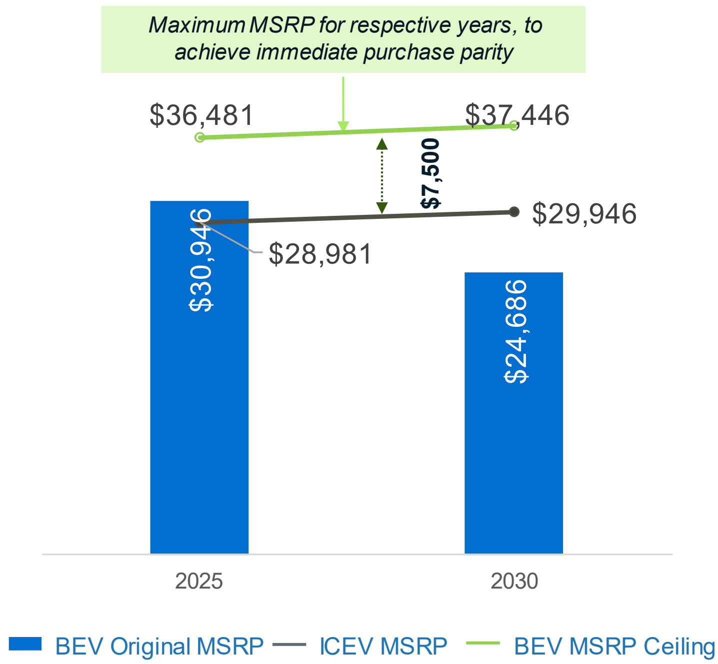

Figure 6: Maximum MSRP of a Small SUV in the base segment

Table 6 shows the BEV MSRP ceiling for considered LDVs under Scenario 2, with a $7,500 clean vehicle credit added to the ICEV price of each. Details of the MSRP Ceiling of BEVs under the other two scenarios can be found in Appendix 7.3. It is important to note that in the case of MY 2025 large SUVs and pickup trucks the BEV MSRP ceiling is still lesser than the projected purchase price. This is due to the larger battery packs (with longer ranges) which are costlier than the other subclasses. Hence, the BEV MSRP ceiling for those two categories of vehicles would not be a true reflection of the market prices.

Table 6: Availability of clean vehicle credit allows raising of the MSRP of BEVs by $7,500 while achieving immediate purchase parity. Scenario 2 is shown here.

Vehicle type	Subclass	Segment	ICEV Purchase Price		BEV MSRP Ceiling	
			MY 2025	MY 2030	MY 2025	MY 2030
Car	Compact (Small) Car	Base	$23,981	$24,946	$31,481	$32,446
		Premium	$32,737	$33,410	$40,237	$40,910
	Midsize (Medium) Car	Base	$26,981	$27,946	$34,481	$35,446
		Premium	$37,237	$37,910	$44,737	$45,410
SUV	Small SUV	Base	$28,981	$29,946	$36,481	$37,446

Vehicle type	Subclass	Segment	ICEV Purchase Price		BEV MSRP Ceiling	
			MY 2025	MY 2030	MY 2025	MY 2030
		Premium	$40,237	$40,910	$47,737	$48,410
	Midsize (Medium) SUV	Base	$32,368	$33,334	$39,868	$40,834
		Premium	$44,865	$45,508	$52,365	$53,008
	Large SUV	Base	$35,106	$35,768	$42,606	$43,268
		Premium	$47,964	$48,597	$55,464	$56,097
Pickup	Pickup Truck	Base	$37,106	$37,768	$44,606	$45,268
		Premium	$51,526	$51,597	$59,026	$59,097

3.3 Total Cost of Ownership (TCO)

The purchase price and charger unit credits have been applied to each class of vehicle to determine their purchase price in 2025 and 2030. A flat $7,500 credit has been applied to all vehicle subclasses purchased in the 2025 and 2030 timeframes. The 30% charging equipment credit is applied only to the charger unit, which reduces the residential charger price by $300. These inputs are considered here for TCO analysis for MYs 2025 and 2030. The operating expenses, i.e., maintenance and energy costs, have been kept the same between the MYs analyzed here.

To summarize, only two inputs to the TCO analysis change: vehicle purchase price and charger price. Both of these occur during the vehicle purchase process. The total sum of the upfront price and operating costs less $7,800 is discounted by 3% on an annual basis for the lifetime of 15 years for the ICEVs and BEVs to arrive at a discounted cumulative TCO. TCO per mile is calculated by dividing the cumulative TCO by the lifetime miles traveled (annual VMT × 15 years). TCO in terms of USD per mile is simply the original TCO in dollars [2] less $7,800.

The $7800 in IRA tax credits reduce the TCO of MY 2025 BEVs by 13% and 10% on average across all vehicle subclasses in the base and premium segments, as shown in Figure 7. Similarly, the credits reduce the TCO in the base and premium segments of MY 2030 BEVs by 15% and 12%, respectively. The TCO of base MY 2025 BEVs were already less than that for their ICEV counterparts across all vehicle segments. Thus, these IRA-related reductions only serve to increase savings even further. The same was true for premium MY 2025 BEV cars and small and medium SUVs, Due to their higher initial cost, the TCO of premium MY 2025 BEV large SUVs and pickups were higher than that of their ICEV equivalent without the tax credits but were lower with the tax credits.

By MY 2030, the TCO of BEVs in all vehicle segments and trim levels was lower than that of ICEVs without tax credits. Thus, these lifetime savings only increased further with the tax credits. All of these comparisons pertain to Scenario 2. TCOs per mile for the other two scenarios are shown in Appendix 7.4.

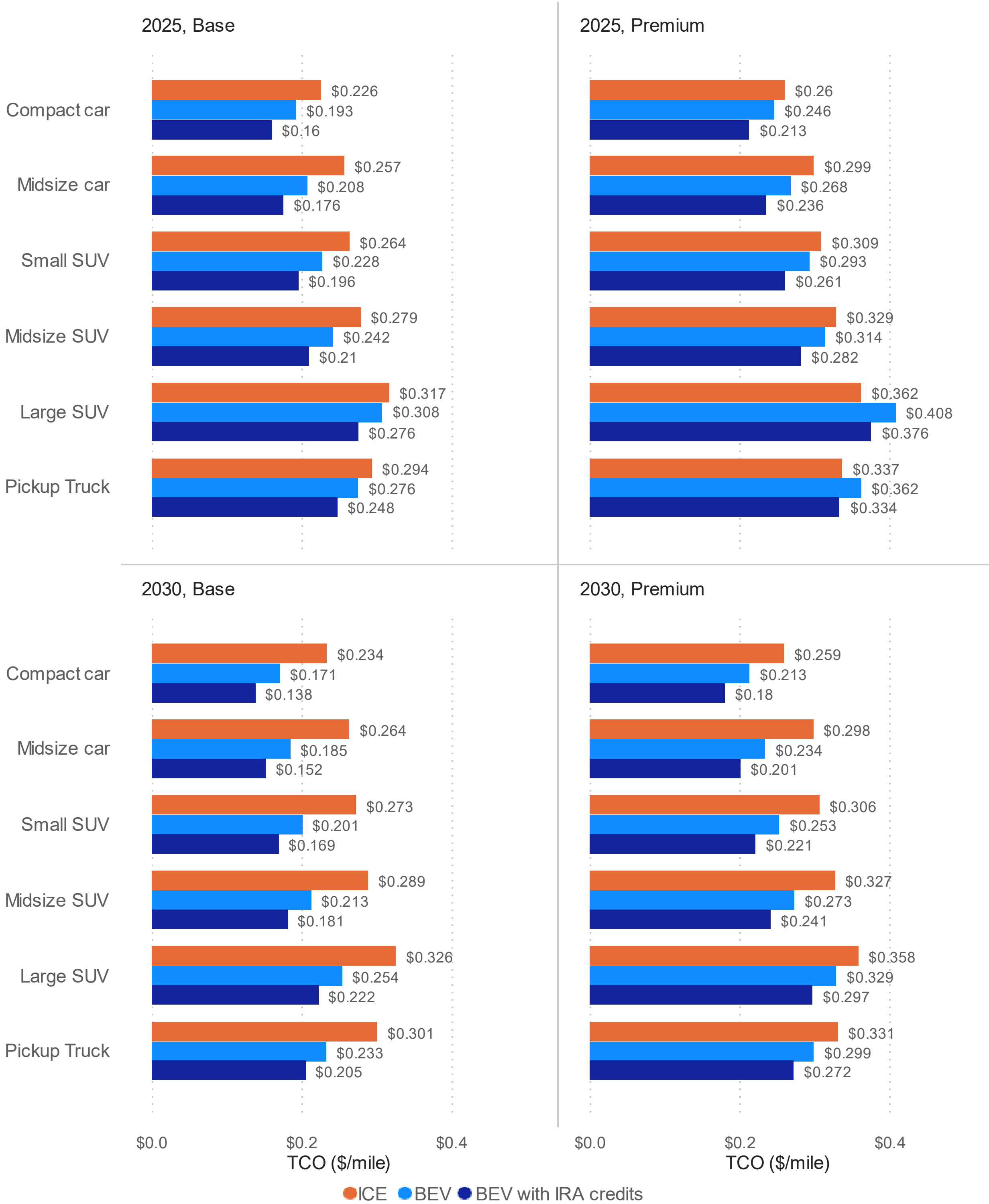

Figure 7: TCO in $ per mile for MYs 2025 and 2030 LDVs in Scenario 2.

3.4 Operational Year When Cumulative Ownership and Operating Costs of ICEVs and BEVs are Equal

The operating costs of BEVs are always lower than those of ICEVs. In those cases when the BEV's purchase price is less than that of the ICEV, the cumulative ownership and operating costs of the BEV are always lower than that of the ICEV. However, in those cases when the BEV costs more to purchase than the ICEV, there is usually a time in the life of the vehicle when the reduction in operating costs compensates for the higher purchase cost and cumulative costs are equal. The purpose of this analysis is to estimate the number of years of operation required for this to occur.

Table 7 lists the calendar year in which the equivalence of ownership and operating cost is reached when a BEV is purchased in MY 2025, both without and with the $7800 in IRA tax credits. As can be seen, MY 2025 BEVs recover their high initial costs in 1–9 years, from compact cars to midsize SUVs, across both segments. MY 2025 BEVs in the base large SUV and pickup truck segments recover their higher initial BEV costs in 9–12 years of operation. However, premium BEVs in these two large vehicle segments do not recover their higher initial costs within the assumed 15-year vehicle life.

With the application of IRA credits, MY 2025 BEVs immediately have lower costs than their ICEV equivalents in the smaller four vehicle types across both segments. In the larger two vehicle types, it takes 2–4 years for the base BEVs to recover their higher initial costs. It takes 13 years for the premium BEV pickup truck to do so while it would require more than 15 years for the premium BEV large SUV to do. Again, this is primarily due to the high delta in the upfront purchase price due to a larger battery pack in these two subclasses and the higher battery pack costs assumed for MY 2025 (those estimated for MY 2022 in the previous study [2]).

Table 7: Year MY 2025 BEV Cumulative Ownership and Operating Costs are Equal to or Lower than ICEV Costs, without and with IRA credits.

Vehicle type	Subclass	Segment	Without IRA Credits		With IRA Credits	
			Calendar Year	Time to Parity	Calendar Year	Time to Parity
Car	Compact (Small) Car	Base	2026	1	2025	Immediate
		Premium	2032	7	2025	Immediate
	Midsize (Medium) Car	Base	2026	1	2025	Immediate
		Premium	2030	5	2025	Immediate

Vehicle type	Subclass	Segment	Without IRA Credits		With IRA Credits	
			Calendar Year	Time to Parity	Calendar Year	Time to Parity
SUV	Small SUV	Base	2028	3	2025	Immediate
		Premium	2034	9	2025	Immediate
	Midsize (Medium) SUV	Base	2027	2	2025	Immediate
		Premium	2034	9	2025	Immediate
	Large SUV	Base	2037	12	2029	4
		Premium	-	End of Life	-	End of Life
Pickup	Pickup Truck	Base	2034	9	2027	2
		Premium	-	End of Life	2038	13

Table 8 shows analogous estimates for MY 2030 BEVs. Premium BEV large SUVs and pickup trucks are the only vehicles that do not have lower costs immediately without the IRA tax credits. For these vehicles, it takes 2–4 years to recover the higher initial costs. By MY 2030, all vehicle segments and trim levels show immediate cost equivalence or better.

Table 8: Year MY 2030 BEV Cumulative Ownership and Operating Costs are Equal to or Lower than ICEV Costs, without and with IRA credits.

Vehicle type	Subclass	Segment	Without IRA Credits		With IRA Credits	
			Year	Time to Parity	Year	Time to Parity
Car	Compact (Small) Car	Base	2030	Immediate	2030	Immediate
		Premium	2030	Immediate	2030	Immediate
	Midsize (Medium) Car	Base	2030	Immediate	2030	Immediate
		Premium	2030	Immediate	2030	Immediate
SUV	Small SUV	Base	2030	Immediate	2030	Immediate
		Premium	2030	Immediate	2030	Immediate

Vehicle type	Subclass	Segment	Without IRA Credits		With IRA Credits	
			Year	Time to Parity	Year	Time to Parity
	Midsize (Medium) SUV	Base	2030	Immediate	2030	Immediate
		Premium	2030	Immediate	2030	Immediate
	Large SUV	Base	2030	Immediate	2030	Immediate
		Premium	2034	4	2030	Immediate
Pickup	Pickup Truck	Base	2030	Immediate	2030	Immediate
		Premium	2032	2	2030	Immediate

Appendix 7.6 lists out the time to achieve parity for the other scenarios in the 2025 and 2030 purchase timeframes.

3.5 Cumulative Net Savings

Here we compare the lifetime TCO of a BEV in dollars to that of an equivalent ICEV. The results are shown in Figure 8. As expected, the IRA tax credits increase net savings (or reduce net costs) by $7,800 due to the clean vehicle and charger credits.

For the four smaller vehicle types, net savings for MY 2025 increase from $3,450–$11,538 to $11,250–$19,338; and for MY 2030, net savings increase from $11,077–$18,849 to $18,877–$26,649 The IRA tax credits effectively move the BEV-related savings expected for MY 2030 to MY 2025. The IRA credits allow the end customer to reduce the upfront cost of buying a BEV and take advantage of its lower operating costs relative to an equivalent ICEV.

For the larger two vehicle types, the net savings for MY 2025 base vehicles similarly increase from $2,144–$5,072 to $9,944–$12,872, and from $17,507–$19,481 to $25,307–$27,281 for MY 2030 base vehicles. The effect of the IRA tax credits is more complicated for MY 2025 premium large SUVs and pickups. For MY 2025, before the IRA, we projected a net cost of $6,865–$11,123 for BEVs in these two segments. With the IRA, the net cost for the premium SUV decreases to $3,323, but the net cost for a premium pickup turns into a net savings of $935. For MY 2030, as with the smaller vehicles, the net savings for BEVs in these two larger segments increase from $7,099-$9,164 to $14,899–$16,964.

The effect of clean vehicle credit on the purchase price for all three scenarios can be found in Appendix 7.6.

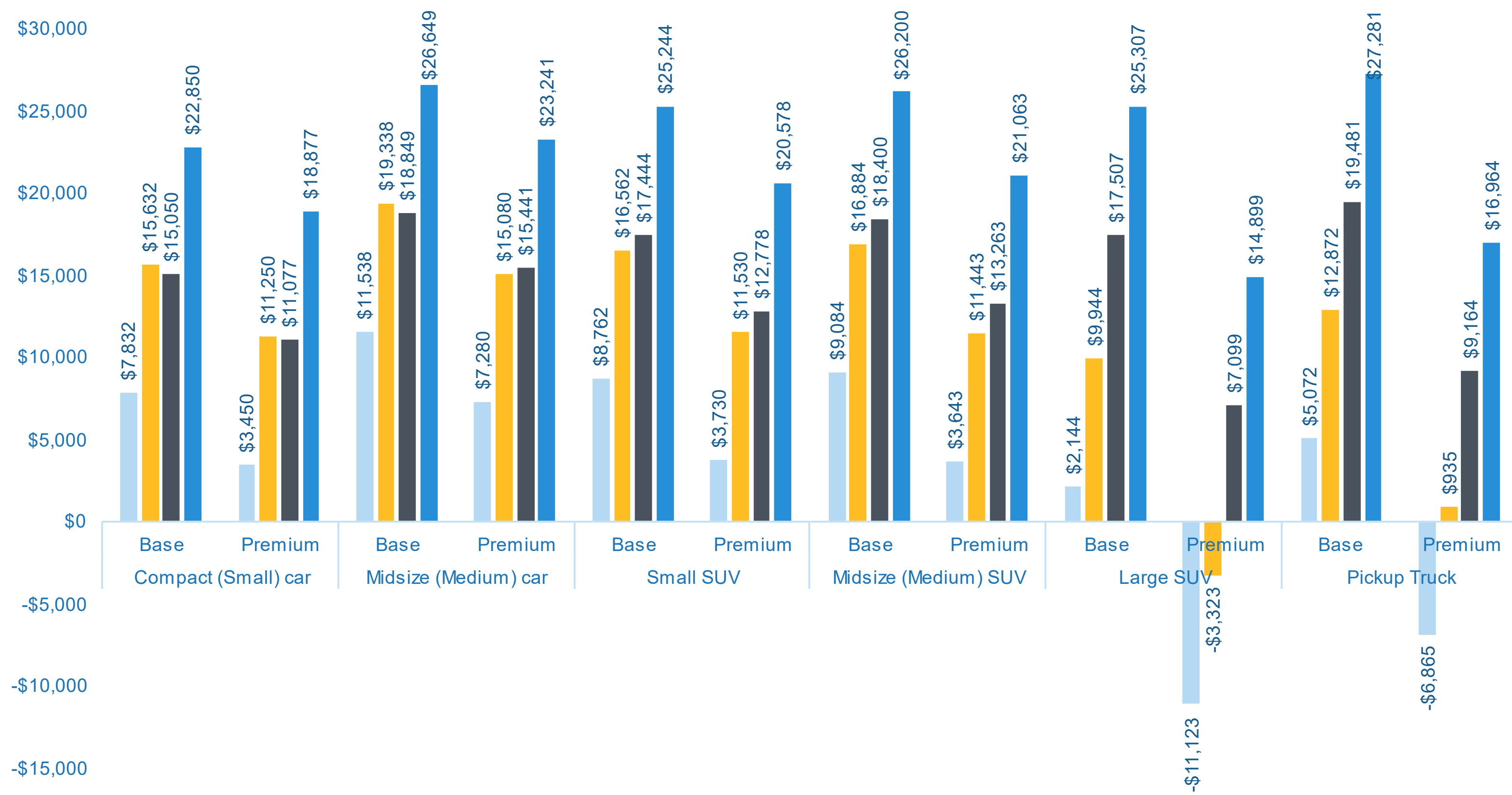

Figure 8: Cumulative savings of BEV over equivalent ICEV in Scenario 2 over its lifetime. The net savings in the purchase years of 2025 and 2030 with the application of IRA credits are computed and indicated in the text above the columns.

4. Hypothetical Application of Credits to Establish Battery Pack Cost Ceiling

4.1 Benefit of Advanced Manufacturing Production Credit (§45X) to OEMs

As an exploratory exercise, the impact of advanced manufacturing production credit (§45X) on the battery pack cost and the possible benefit to OEMs is assessed here, as illustrated in Figure 9. As an example, we examine the battery cost of a base BEV midsize SUV with an NMC811 55 kWh battery pack in 2025. We are using the battery cost developed for MY 2022 in our previous study for MY 2025 battery costs here: $112/kWh. Assuming that the OEM is eligible for all the advanced manufacturing production credits amounting to $55/kWh, the battery pack cost prior to these tax credits could be as high as $167/kWh and still be able to be sold for $112/kWh.

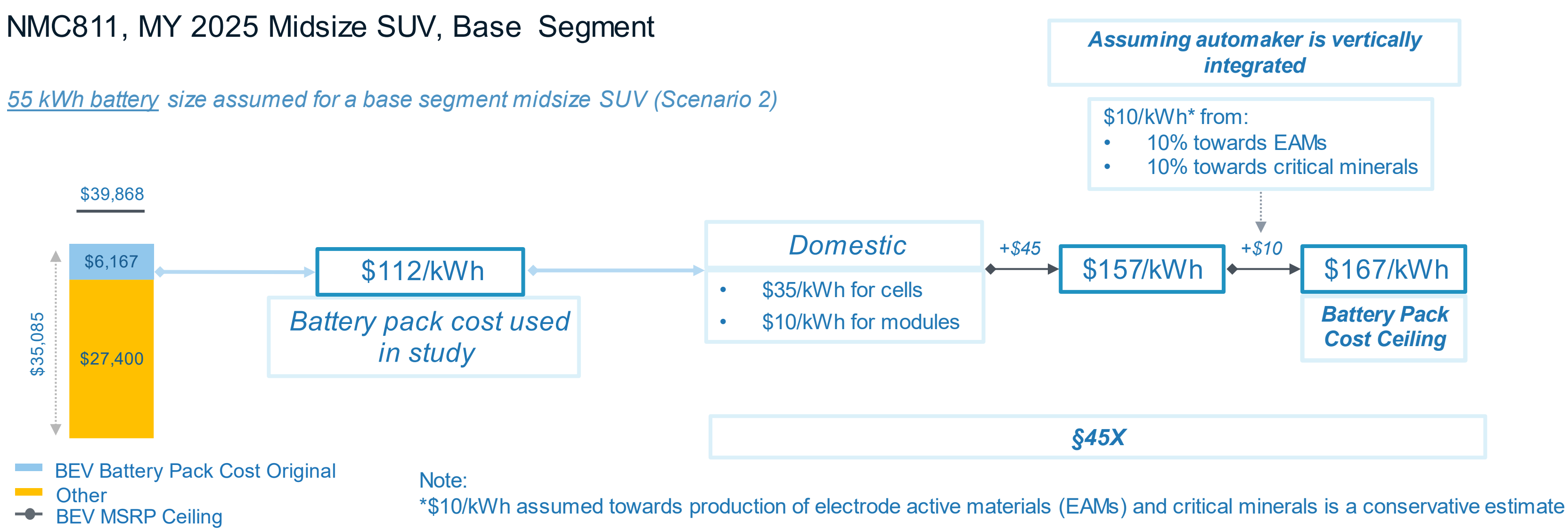

Figure 9: Hypothetical application of advanced manufacturing production credit (§45X) to determine the maximum battery pack cost of a 55 kWh battery pack sized for a base segment midsize SUV.

Or, put another way, the cost of producing battery packs that comply with the provisions of the IRA could be 49% more than the cost we estimated (for MY 2022) without considering the IRA constraints. The relative BEV and ICEV price projections would still hold with these more expensive battery packs. While 49% is a considerable window to account for higher production costs, we have not determined that this would be sufficient. Of course, it will be more difficult to comply with the stipulations of the IRA for these incentives in the near term (2025) than it will be five years later (2030).

4.2 Hypothetical Application of Credits to Establish Ceiling of Battery Pack Cost

To assess the impact of advanced manufacturing production and purchase credits on OEMs and consumers, we ran a hypothetical exercise in which we applied both types of credits to an MY 2025 midsize SUV in the base segment and calculated the maximum pack cost per kWh for a battery manufactured in the United States, as illustrated in Figure 10. The goal was to determine the maximum pack cost that a battery could reach while still allowing the end user to achieve immediate purchase price parity in most cases.

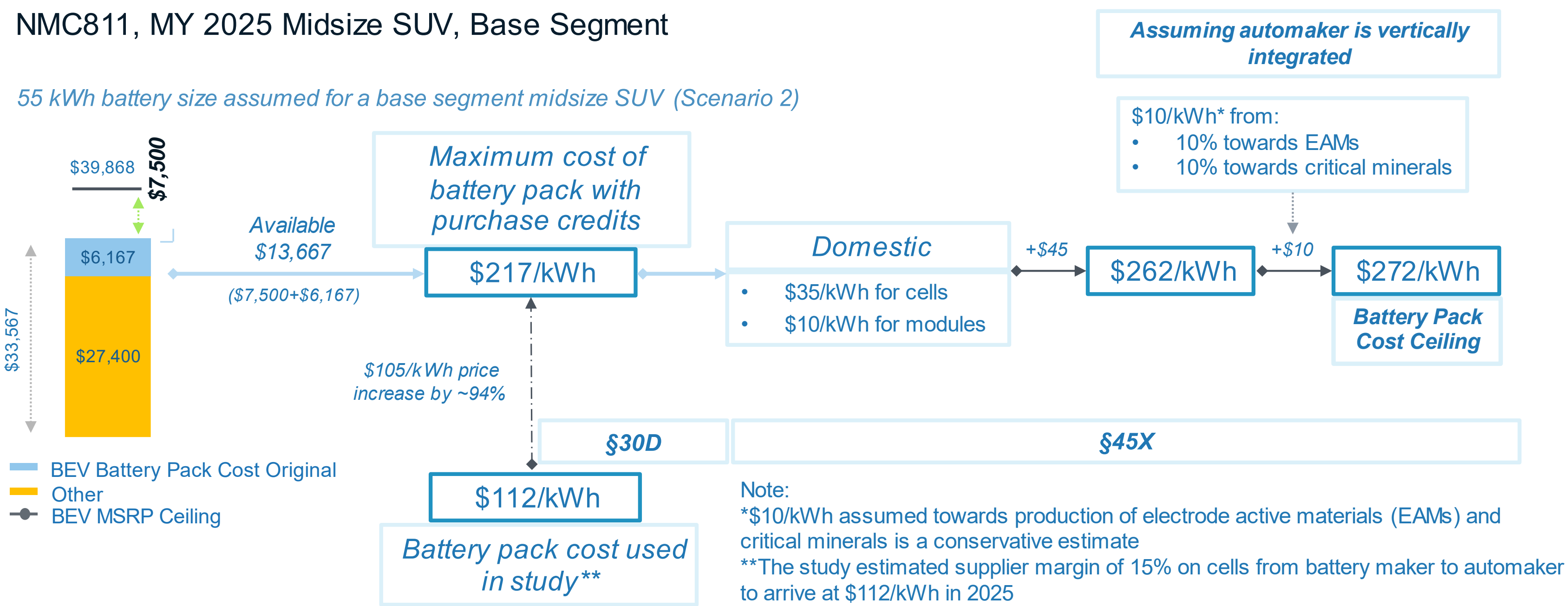

Figure 10: Hypothetical application of purchase credit (§30D) and advanced manufacturing production credit (§45X) to determine the maximum battery pack cost of a 55 kWh battery pack sized for a base segment midsize SUV.

The battery pack accounted for $6,167 of the vehicle's original price for a battery capacity of 55 kWh at a pack cost of $112/kWh. If the entire purchase credit (clean vehicle credit) is assumed to offset battery investments and costs, the price of a 55 kWh battery could rise to $13,667, implying a battery pack cost of $217/kWh. In this case, the clean vehicle credit would allow the original $112/kWh battery cost to increase by $105/kWh (94%).

If we assume that a manufacturer meets all the requirements for an advanced manufacturing production credit (§45X), the following credits apply:

a) $35/kWh for cells
b) $10/kWh for modules (assuming the manufacturer does not make cell-to-pack or cell-to-chassis configurations)
c) $10/kWh (assumed $/kWh) from 10% towards the production of electrode active materials and battery-associated critical minerals

In addition, for any taxable year, there is a qualifying advanced energy project credit (§48C) equal to 30% of the qualified investment in an eligible property:

a) which re-equips, expands, or establishes an industrial or manufacturing facility for the production or recycling of light-, medium-, or heavy-duty electric or fuel cell vehicles, as well as technologies, components, or materials for such vehicles, as well as associated charging or refueling infrastructure.
b) which re-equips, expands, or establishes an industrial facility for the processing, refining, or recycling of critical materials.

The advanced manufacturing production credit (§45X) cannot be claimed for components produced at a facility (or property) for which a credit was claimed under §48C (double dipping is not allowed). A wide range of projects are eligible for credits under §48C, but the following scenarios may shed more light on their potential impact on battery pack cost:

a) In cases where the automaker is essentially a vehicle integrator, i.e., sourcing a battery pack from a battery producer, then the tax incentives under §48C can be claimed by the automaker, while the credits under §45X can be claimed by the battery producer, allowing “stacking” of credits. Multiple automakers have joint ventures with battery producers, and most are anticipated to carry out the integration of batteries on a pack level in their BEVs. This allows them to claim the 30% tax incentive under §48C for an EV manufacturing facility; however, it is difficult to estimate the effect of §48C credits on the battery cost on a per kWh basis. Such incentives greatly benefit the EV value chain.
b) In cases where the automaker is vertically integrated, then they can claim the credits under §48C and §45X as long as the battery-related manufacturing activities and vehicle manufacturing or pack integration are done on separate properties. There’s a whole gamut of activities in battery and BEV production and as long as “double benefit”

is not claimed, the OEM would be able to use these credits to their advantage to produce cost-effective BEVs by lowering battery cost.

The battery value chain is incredibly complex, with segmented supply chains involving numerous components and raw materials and spanning multiple vendors from various regions. This exercise attempts to demonstrate the cost buffer provided to various stakeholders in the battery ecosystem, which meets all of the IRA requirements to be eligible for all the available credits. This is a simplified view of battery production, and numerous additional factors and elements influence the price of a battery. We recognize that we have made generous assumptions to arrive at the battery pack cost ceiling, and it is up to the automaker as to how they apportion the credits, such as §48C. Furthermore, since the 30% tax credit under §48C is for a manufacturing or industrial facility, the capital cost per unit of production could be much lower. However, if the automakers were to use these credits towards arresting the battery price volatility by securing long-term strategic supply contracts, then it could directly impact the battery prices; however, we have not stacked them onto the battery cost in this analysis. It is also worth noting that the credits have been stacked on the estimated battery pack cost, which was calculated in the previous study [2] before the IRA of 2022 became law, without taking into account the restrictions it imposes. Onshoring of battery manufacturing-related activities (upstream and midstream) could result in significantly higher battery pack costs than the one used here ($112/kWh). Nevertheless, it is a first-order attempt to illustrate the potential "calming" effect that IRA credits could have on a potentially volatile battery supply chain.

Figure 11 depicts the maximum cost of a battery pack in the case of other LDVs when purchase credit (or clean vehicle credit) and advanced manufacturing production credit are applied. A base-segment compact car has the highest possible pack cost of $352 (i.e., 214%), while a premium-segment large SUV has the lowest pack cost of $210 (i.e., 88%). The price of the pack is determined by the size of the battery and the availability of credits for the vehicle of choice. On average, battery pack costs could reach $276/kWh, a 147% increase, and still achieve purchase price parity immediately in most of the cases upon purchase in 2025. Exceptions are seen in the MY 2025 large SUVs and pickup trucks. This is purely a hypothetical exercise in which all credits are applied to the cost of a battery pack and is in no way a projection of battery pack cost. We understand that OEMs will prioritize profits over producing cost-effective BEVs and that all of these credits may not be passed on to the end consumer.

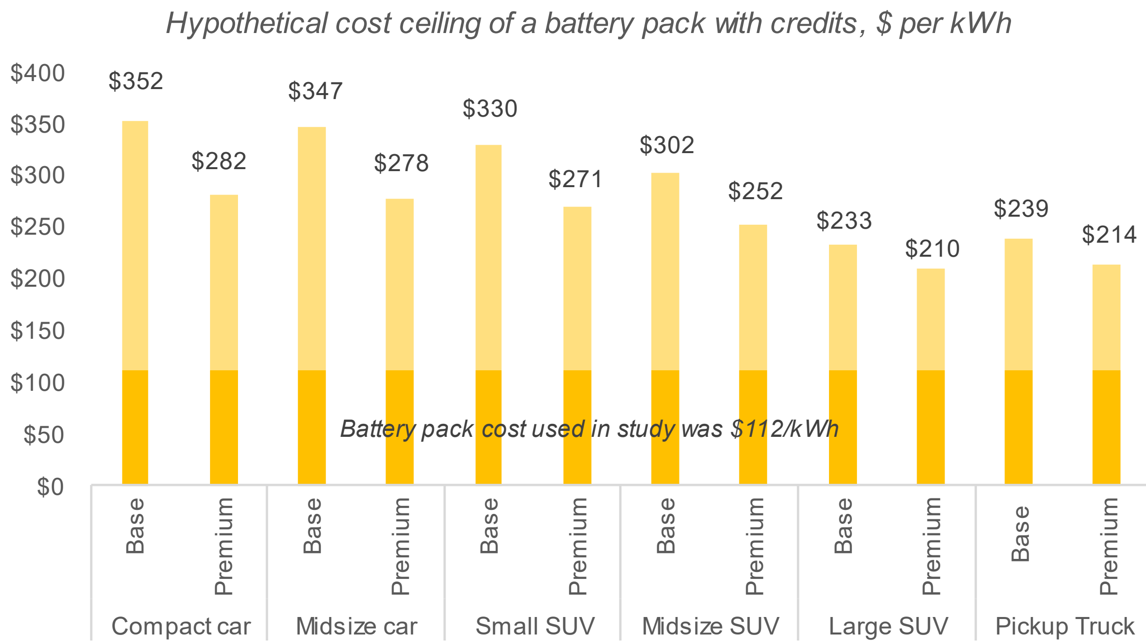

Figure 11: Hypothetical application of purchase credit (§30D) and advanced manufacturing production credit (§45X) to determine maximum battery pack cost for MY 2025 LDVs.

5. Conclusion

The provisions in the IRA of 2022 on the electrification of the LDV segment would stimulate and promote the growth of BEVs. The provisions provide tax and other incentives which benefit the upstream mineral producers, midstream cell makers, and automakers to end consumers who adopt BEVs in this segment. In general, BEVs in the LDV vehicle segments could be sold at the same effective price roughly five years earlier than otherwise possible (e.g., in MY 2025 versus MY 2030).

These tax credits do come with stipulations pertaining to: a) how and where the BEV and its components are produced, b) the income bracket of the BEV purchaser, and c) where the BEV charger is installed. The impacts of the IRA described below assume that these stipulations are met. The BEV retail price equivalent projections made here also assume that the BEV manufacturing incentives included in the IRA allow batteries that meet IRA stipulations to be produced at costs commensurate with those projected in the original analysis which did not comply with those stipulations.

The key takeaways of the study are:

a) IRA 2022 provisions related to purchase and charger equipment credits will potentially reduce the effective purchase price of a BEV by $7800.
b) Without IRA credits, BEVs purchased in MY 2025 were generally projected to be more expensive than their equivalent ICEVs. However, with IRA credits, BEVs in the four smaller vehicle types are now projected to be less expensive than their ICEV counterparts. BEVs in the large SUV and pickup segments are still projected to be more expensive than ICEVs in MY 2025 even with IRA credits, but their incremental cost has decreased from $9,335–$21,030 to $1,835–$13,531.
c) In MY 2030, BEVs in all vehicle types and segments except two were projected to be less expensive than their ICEV equivalents. These two segments were the premium large SUVs and premium pickups. With IRA credits, BEVs are projected to be less expensive across all types and segments by $5,596–$13,857.
d) The IRA credits enable drivers who switch to BEVs in 2025 to effectively reduce their lifetime TCO by an additional 13% and 10% on average across all vehicle subclasses in the base and premium segments, respectively. These are substantial reductions in the lifetime cost of owning a vehicle. As the TCO for BEVs purchased in MY 2030 is lower than that for MY 2025, these TCO reductions increase to 15% and 12% across all vehicle subclasses in the base and premium segments for MY 2030, respectively.
e) The upfront savings for BEVs projected would provide even more cushion to OEMs if batteries meeting the IRA’s stipulations led to higher battery costs than projected here, or if consumers desired even longer-ranged BEVs than assumed here.

6. References

[1] U.S. Environmental Protection Agency, “Facts,” 2021. [Online]. Available: https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

[2] H. Saxena, V. Nair, and S. Pillai, “Electrification Cost Evaluation of Light-Duty Vehicles in 2030,” 2023.

[3] “U.S. Treasury Changes Definition of ‘SUV’ in Boost for Tesla, GM, and Other Car Manufacturers - The Capitalist,” *The Capitalist*, Feb. 03, 2023. https://thecapitalist.com/u-s-treasury-changes-definition-of-suv/ (accessed Apr. 19, 2023).

[4] U S Energy Information Administration, “Annual Energy Outlook 2022 AEO2022 Highlights,” 2022. doi: EIA, AEO2022 National Energy Modeling System run ref2022.d011222a.

[5] Y. D. Costs, “Your driving costs 2021,” pp. 1–9, 2021, [Online]. Available: AAA.com

[6] A. Burnham *et al.*, “Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains,” 2021, [Online]. Available: https://www.osti.gov/biblio/1780970

7. Appendix

7.1 Total Cost of Ownership Inputs

The data is sourced from U.S. Energy Information Administration Annual Energy Outlook (AEO) 2022 for the 2030-2044 timeframe [4]. The prices have been used as inputs in the respective incremental cost scenarios included in the column headers.

Table 9: AEO 2022: Real Petroleum Prices Refined Petroleum Product Prices Motor Gasoline ($/gal) and End-Use Prices of Residential Electricity ($/KWh)

Year	Gasoline High oil price $/gal (Scenario 1)	Gasoline Reference case $/gal (Scenario 2)	Gasoline Low oil price $/gal (Scenario 3)	Electricity Residential High oil price $/kWh (Scenario 1)	Electricity Residential Reference case $/kWh (Scenario 2)	Electricity Residential Low oil price $/kWh (Scenario 3)
2030	4.23	2.80	2.07	0.127	0.130	0.130
2031	4.26	2.89	2.16	0.127	0.130	0.131
2032	4.29	2.91	2.17	0.127	0.131	0.131
2033	4.26	2.94	2.20	0.127	0.132	0.132
2034	4.30	2.96	2.21	0.127	0.132	0.133
2035	4.34	2.97	2.24	0.126	0.132	0.133
2036	4.34	2.99	2.25	0.125	0.132	0.133
2037	4.36	3.01	2.26	0.124	0.131	0.132
2038	4.36	3.04	2.27	0.124	0.131	0.132
2039	4.39	3.04	2.26	0.124	0.131	0.132
2040	4.39	3.07	2.25	0.124	0.131	0.132
2041	4.37	3.09	2.24	0.124	0.130	0.132
2042	4.40	3.09	2.24	0.124	0.131	0.132
2043	4.41	3.12	2.24	0.124	0.130	0.131
2044	4.41	3.15	2.25	0.124	0.130	0.131

Table 10: Maintenance Costs from AAA 2021 [5]

Category	Vehicle Subclass	Maintenance cost per mile
ICE	Compact Car	$0.088
	Medium Sedan	$0.104
	Subcompact SUV	$0.099
	Medium SUV (4WD)	$0.100
	Midsize Pickup	$0.099
BEV	Electric Vehicle (all classes)	$0.077

Table 11: Annual Vehicle Miles Traveled (VMT) from ANL study [6]

Class	Annual VMT (miles)
Cars	15,922
SUVs	16,234
Pickup trucks	18,964

7.2 List of Critical Minerals Eligible for IRA Credits Under §45X

The term “applicable critical mineral” means any of the following:

a) Aluminum which is—
   i) converted from bauxite to a minimum purity of 99% alumina by mass, or
   ii) purified to a minimum purity of 99.9% aluminum by mass.

b) Antimony which is—
   i) converted to antimony trisulfide concentrate with a minimum purity of 90% antimony trisulfide by mass, or
   ii) purified to a minimum purity of 99.65% antimony by mass.

c) Barite which is barium sulfate purified to a minimum purity of 80% barite by mass.

d) Beryllium which is—
   i) converted to copper-beryllium master alloy, or
   ii) purified to a minimum purity of 99% beryllium by mass.

e) Cerium which is—
   i) converted to cerium oxide which is purified to a minimum purity of 99.9% cerium oxide by mass, or
   ii) purified to a minimum purity of 99% cerium by mass.

f) Cesium which is—
   i) converted to cesium formate or cesium carbonate, or
   ii) purified to a minimum purity of 99% cesium by mass.

g) Chromium which is—
   i) converted to ferrochromium consisting of not less than 60% chromium by mass, or
   ii) (purified to a minimum purity of 99% chromium by mass.

h) Cobalt which is—
   i) converted to cobalt sulfate, or
   ii) purified to a minimum purity of 99.6% cobalt by mass.

i) Dysprosium which is—
   i) converted to not less than 99% pure dysprosium iron alloy by mass, or
   ii) purified to a minimum purity of 99% dysprosium by mass.

j) Europium which is—
   i) converted to europium oxide which is purified to a minimum purity of 99.9% europium oxide by mass, or
   ii) purified to a minimum purity of 99% by mass.

k) Fluorspar which is—
   i) converted to fluorspar which is purified to a minimum purity of 97% calcium fluoride by mass, or
   ii) purified to a minimum purity of 99% fluorspar by mass.

l) Gadolinium which is—

  i) converted to gadolinium oxide which is purified to a minimum purity of 99.9% gadolinium oxide by mass, or
  ii) purified to a minimum purity of 99% gadolinium by mass.

m) Germanium which is—
  i) converted to germanium tetrachloride, or
  ii) purified to a minimum purity of 99.99% germanium by mass.

n) Graphite which is purified to a minimum purity of 99.9% graphitic carbon by mass.

o) Indium which is—
  i) converted to—
    a. indium tin oxide, or
    b. indium oxide which is purified to a minimum purity of 99.9% indium oxide by mass, or
  ii) purified to a minimum purity of 99% indium by mass.

p) Lithium which is—
  i) converted to lithium carbonate or lithium hydroxide, or
  ii) purified to a minimum purity of 99.9% lithium by mass.

q) Manganese which is—
  i) converted to manganese sulphate, or
  ii) purified to a minimum purity of 99.7% manganese by mass.

r) Neodymium which is—
  i) converted to neodymium-praseodymium oxide which is purified to a minimum purity of 99% neodymium-praseodymium oxide by mass,
  ii) converted to neodymium oxide which is purified to a minimum purity of 99.5% neodymium oxide by mass
  iii) purified to a minimum purity of 99.9% neodymium by mass.

s) Nickel which is—
  i) converted to nickel sulphate, or
  ii) purified to a minimum purity of 99% nickel by mass.

t) Niobium which is—
  i) converted to ferronibium, or
  ii) purified to a minimum purity of 99% niobium by mass.

u) Tellurium which is—
  i) converted to cadmium telluride, or
  ii) purified to a minimum purity of 99% tellurium by mass.

v) Tin which is purified to low alpha emitting tin which—
  i) has a purity of greater than 99.99% by mass, and
  ii) possesses an alpha emission rate of not greater than 0.01 counts per hour per centimeter square.

w) Tungsten which is converted to ammonium paratungstate or ferrotungsten.

x) Vanadium which is converted to ferrovanadium or vanadium pentoxide.

y) Yttrium which is—
   i) converted to yttrium oxide which is purified to a minimum purity of 99.999% yttrium oxide by mass, or
   ii) purified to a minimum purity of 99.9% yttrium by mass.

z) Any of the following minerals provided that such mineral is purified to a minimum purity of 99% by mass:
   i) Arsenic.
   ii) Bismuth.
   iii) Erbium.
   iv) Gallium.
   v) Hafnium.
   vi) Holmium.
   vii) Iridium.
   viii) Lanthanum.
   ix) Lutetium.
   x) Magnesium.
   xi) Palladium.
   xii) Platinum.
   xiii) Praseodymium.
   xiv) Rhodium.
   xv) Rubidium.
   xvi) Ruthenium.
   xvii) Samarium.
   xviii) Scandium.
   xix) Tantalum.
   xx) Terbium.
   xxi) Thulium.
   xxii) Titanium.
   xxiii) Ytterbium.
   xxiv) Zinc.
   xxv) Zirconium.

7.3 Purchase Price

Table 12: MY 2025 ICEV and BEV purchase prices with IRA §30D clean vehicle credits.

Subclass	Segment	ICE Price			Initial BEV Price (with RPE = 1.5)			Final BEV Price (with RPE = 1.5)			BEV MSRP Ceiling		
		Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Compact (Small) car	Base	$26,993	$23,981	$23,981	$23,535	$23,740	$24,416	$16,035	$16,240	$16,916	$34,493	$31,481	$31,481
	Premium	$35,878	$32,737	$32,737	$35,464	$35,796	$36,890	$27,964	$28,296	$29,390	$43,378	$40,237	$40,237
Midsize (Medium) car	Base	$30,151	$26,981	$26,981	$26,936	$27,148	$27,844	$19,436	$19,648	$20,344	$37,651	$34,481	$34,481
	Premium	$40,533	$37,237	$37,237	$40,611	$40,954	$42,082	$33,111	$33,454	$34,582	$48,033	$44,737	$44,737
Small SUV	Base	$32,378	$28,981	$28,981	$30,686	$30,946	$31,801	$23,186	$23,446	$24,301	$39,878	$36,481	$36,481
	Premium	$43,840	$40,237	$40,237	$45,957	$46,363	$47,702	$38,457	$38,863	$40,202	$51,340	$47,737	$47,737
Midsize (Medium) SUV	Base	$35,730	$32,368	$32,368	$33,286	$33,567	$34,492	$25,786	$26,067	$26,992	$43,230	$39,868	$39,868
	Premium	$48,595	$44,865	$44,865	$50,178	$50,625	$52,098	$42,678	$43,125	$44,598	$56,095	$52,365	$52,365
Large SUV	Base	$39,346	$35,106	$35,106	$45,807	$46,384	$48,284	$38,307	$38,884	$40,784	$46,846	$42,606	$42,606
	Premium	$51,844	$47,964	$47,964	$68,108	$68,994	$71,911	$60,608	$61,494	$64,411	$59,344	$55,464	$55,464
Pickup	Base	$41,346	$37,106	$37,106	$45,917	$46,441	$48,169	$38,417	$38,941	$40,669	$48,846	$44,606	$44,606
	Premium	$54,844	$51,526	$51,526	$68,282	$69,087	$71,739	$60,782	$61,587	$64,239	$62,344	$59,026	$59,026

Table 13: MY 2030 ICEV and BEV purchase prices with IRA §30D clean vehicle credits.

Subclass	Segment	ICE Price			Initial BEV Price (with RPE = 1.2)			Final BEV Price (with RPE = 1.2)			BEV MSRP Ceiling		
		Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Compact (Small) car	Base	$26,049	$24,946	$23,940	$18,539	$18,658	$18,964	$11,039	$11,158	$11,464	$33,549	$32,446	$31,440
	Premium	$34,891	$33,410	$32,631	$27,981	$28,170	$28,656	$20,481	$20,670	$21,156	$42,391	$40,910	$40,131
Midsize (Medium) car	Base	$29,170	$27,946	$26,940	$21,739	$21,861	$22,175	$14,239	$14,361	$14,675	$36,670	$35,446	$34,440
	Premium	$39,508	$37,910	$37,131	$32,789	$32,984	$33,484	$25,289	$25,484	$25,984	$47,008	$45,410	$44,631
Small SUV	Base	$31,310	$29,946	$28,940	$24,536	$24,686	$25,071	$17,036	$17,186	$17,571	$38,810	$37,446	$36,440
	Premium	$42,704	$40,910	$40,131	$36,812	$37,042	$37,632	$29,312	$29,542	$30,132	$50,204	$48,410	$47,631
Midsize (Medium) SUV	Base	$34,638	$33,334	$32,327	$26,815	$26,977	$27,396	$19,315	$19,477	$19,896	$42,138	$40,834	$39,827
	Premium	$47,398	$45,508	$44,729	$40,566	$40,827	$41,497	$33,066	$33,327	$33,997	$54,898	$53,008	$52,229
Large SUV	Base	$38,201	$35,768	$34,989	$33,380	$33,704	$34,536	$25,880	$26,204	$27,036	$45,701	$43,268	$42,489
	Premium	$50,600	$48,597	$47,818	$49,999	$50,501	$51,792	$42,499	$43,001	$44,292	$58,100	$56,097	$55,318
Pickup	Base	$40,201	$37,768	$36,989	$34,531	$34,825	$35,582	$27,031	$27,325	$28,082	$47,701	$45,268	$44,489
	Premium	$53,600	$51,597	$51,381	$51,730	$52,186	$53,360	$44,230	$44,686	$45,860	$61,100	$59,097	$58,881

7.4 Total Cost of Ownership, $/mi

Table 14: Total Cost of Ownership in $/mile for LDVs purchased in 2025 without and with IRA credits.

Subclass	Category	2025 (RPE 1.5)											
		Original						With IRA Credits					
		Base Segment			Premium Segment			Base Segment			Premium Segment		
		Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Compact car	ICE	$0.259	$0.225	$0.211	$0.284	$0.253	$0.242	$0.259	$0.225	$0.211	$0.284	$0.253	$0.242
	BEV	$0.193	$0.195	$0.198	$0.249	$0.251	$0.257	$0.161	$0.162	$0.166	$0.216	$0.219	$0.224
Midsize car	ICE	$0.291	$0.254	$0.239	$0.319	$0.290	$0.278	$0.291	$0.254	$0.239	$0.319	$0.290	$0.278
	BEV	$0.209	$0.210	$0.214	$0.272	$0.275	$0.280	$0.176	$0.178	$0.181	$0.239	$0.242	$0.247
Small SUV	ICE	$0.302	$0.261	$0.245	$0.346	$0.298	$0.285	$0.302	$0.261	$0.245	$0.346	$0.298	$0.285
	BEV	$0.229	$0.231	$0.235	$0.298	$0.301	$0.308	$0.197	$0.199	$0.203	$0.266	$0.269	$0.276
Midsize SUV	ICE	$0.320	$0.278	$0.261	$0.355	$0.320	$0.306	$0.320	$0.278	$0.261	$0.355	$0.320	$0.306
	BEV	$0.243	$0.246	$0.250	$0.320	$0.323	$0.330	$0.211	$0.214	$0.218	$0.288	$0.291	$0.298
Large SUV	ICE	$0.358	$0.305	$0.284	$0.388	$0.347	$0.329	$0.358	$0.305	$0.284	$0.388	$0.347	$0.329
	BEV	$0.315	$0.319	$0.329	$0.421	$0.427	$0.442	$0.283	$0.287	$0.297	$0.389	$0.395	$0.410
Pickup Truck	ICE	$0.337	$0.290	$0.269	$0.357	$0.321	$0.305	$0.337	$0.290	$0.269	$0.357	$0.321	$0.305
	BEV	$0.281	$0.284	$0.291	$0.371	$0.376	$0.387	$0.253	$0.257	$0.264	$0.344	$0.349	$0.360

Table 15: Total Cost of Ownership in $/mile for LDVs purchased in 2030 without and with IRA credits.

Subclass	Category	2030 (RPE 1.2)											
		Original						With IRA Credits					
		Base Segment			Premium Segment			Base Segment			Premium Segment		
		Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Compact car	ICE	$0.256	$0.229	$0.211	$0.280	$0.256	$0.242	$0.256	$0.229	$0.211	$0.280	$0.256	$0.242
	BEV	$0.168	$0.170	$0.171	$0.209	$0.211	$0.213	$0.136	$0.137	$0.138	$0.177	$0.178	$0.180
Midsize car	ICE	$0.287	$0.258	$0.239	$0.315	$0.293	$0.277	$0.287	$0.258	$0.239	$0.315	$0.293	$0.277
	BEV	$0.182	$0.183	$0.184	$0.229	$0.231	$0.233	$0.149	$0.150	$0.152	$0.197	$0.198	$0.200
Small SUV	ICE	$0.297	$0.265	$0.245	$0.327	$0.301	$0.285	$0.297	$0.265	$0.245	$0.327	$0.301	$0.285
	BEV	$0.198	$0.200	$0.201	$0.251	$0.253	$0.255	$0.166	$0.168	$0.169	$0.218	$0.220	$0.223
Midsize SUV	ICE	$0.316	$0.282	$0.260	$0.350	$0.323	$0.305	$0.316	$0.282	$0.260	$0.350	$0.323	$0.305
	BEV	$0.210	$0.212	$0.214	$0.269	$0.271	$0.274	$0.178	$0.180	$0.182	$0.237	$0.239	$0.242
Large SUV	ICE	$0.354	$0.308	$0.283	$0.383	$0.349	$0.328	$0.354	$0.308	$0.283	$0.383	$0.349	$0.328
	BEV	$0.249	$0.252	$0.256	$0.322	$0.326	$0.331	$0.217	$0.220	$0.224	$0.290	$0.294	$0.299
Pickup Truck	ICE	$0.333	$0.293	$0.268	$0.353	$0.324	$0.305	$0.333	$0.293	$0.268	$0.353	$0.324	$0.305
	BEV	$0.229	$0.231	$0.234	$0.294	$0.297	$0.301	$0.202	$0.204	$0.207	$0.266	$0.269	$0.273

7.5 Cumulative Net Savings

Table 16: Cumulative Net Savings of MY 2025 BEVs without and with IRA credits.

Vehicle type	Subclass	Segment	Net Savings Original			Net Savings with IRA Credits		
			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Car	Compact car	Base	$14,363	$7,832	$3,183	$22,163	$15,632	$10,983
		Premium	$10,605	$3,450	-$1,462	$18,405	$11,250	$6,338
	Midsize car	Base	$18,221	$11,538	$6,498	$26,021	$19,338	$14,298
		Premium	$13,684	$7,280	$1,845	$21,484	$15,080	$9,645
SUV	Small SUV	Base	$16,772	$8,762	$3,048	$24,572	$16,562	$10,848
		Premium	$11,637	$3,730	-$2,369	$19,437	$11,530	$5,431
	Midsize SUV	Base	$17,641	$9,084	$3,214	$25,441	$16,884	$11,014
		Premium	$12,433	$3,643	-$2,720	$20,233	$11,443	$5,080
	Large SUV	Base	$13,049	$2,144	-$6,698	$20,849	$9,944	$1,102
		Premium	-$188	-$11,123	-$20,398	$7,612	-$3,323	-$12,598
Pickup	Pickup Truck	Base	$16,241	$5,072	-$3,955	$24,041	$12,872	$3,845
		Premium	$3,748	-$6,865	-$16,202	$11,548	$935	-$8,402

Table 17: Cumulative Net Savings of MY 2030 BEVs without and with IRA credits.

Vehicle type	Subclass	Segment	Net Savings Original			Net Savings with IRA Credits		
			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Car	Compact car	Base	$21,159	$15,050	$9,849	$28,959	$22,850	$17,649
		Premium	$16,957	$11,077	$6,666	$24,757	$18,877	$14,466
	Midsize car	Base	$25,288	$18,849	$13,396	$33,088	$26,649	$21,196
		Premium	$20,296	$15,441	$10,506	$28,096	$23,241	$18,306
SUV	Small SUV	Base	$25,158	$17,444	$11,327	$32,958	$25,244	$19,127
		Premium	$19,243	$12,778	$7,542	$27,043	$20,578	$15,342
	Midsize SUV	Base	$26,737	$18,400	$12,033	$34,537	$26,200	$19,833
		Premium	$20,542	$13,263	$7,782	$28,342	$21,063	$15,582
	Large SUV	Base	$28,923	$17,507	$9,165	$36,723	$25,307	$16,965
		Premium	$16,392	$7,099	-$213	$24,192	$14,899	$7,587
Pickup	Pickup Truck	Base	$31,316	$19,481	$10,868	$39,116	$27,281	$18,668
		Premium	$18,764	$9,164	$2,261	$26,564	$16,964	$10,061

7.6 Time to Achieve Parity

Table 18: Year TCO parity is achieved from 2025 purchase timeframes without and with IRA credits

Vehicle type	Subclass	Segment	2025 (RPE 1.5)					
			Original			With IRA Credits		
			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Car	Compact car	Base	Immediate	1	4	Immediate	Immediate	Immediate
		Premium	Immediate	7	End of Life	Immediate	Immediate	Immediate
	Midsize car	Base	Immediate	1	2	Immediate	Immediate	Immediate
		Premium	Immediate	5	10	Immediate	Immediate	Immediate
SUV	Small SUV	Base	Immediate	3	7	Immediate	Immediate	Immediate
		Premium	2	9	End of Life	Immediate	Immediate	1
	Midsize SUV	Base	Immediate	2	6	Immediate	Immediate	Immediate
		Premium	2	9	End of Life	Immediate	Immediate	1
	Large SUV	Base	4	12	End of Life	Immediate	4	12
		Premium	End of Life	End of Life	End of Life	7	End of Life	End of Life
Pickup	Pickup	Base	3	9	End of Life	Immediate	2	7
		Premium	11	End of Life	End of Life	4	13	End of Life

Table 19: Year TCO parity is achieved from 2030 purchase timeframes without and with IRA credits

Vehicle type	Subclass	Segment	2030 (RPE 1.2)					
			Original			With IRA Credits		
			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Car	Compact car	Base	Immediate	Immediate	Immediate	Immediate	Immediate	Immediate
		Premium	Immediate	Immediate	Immediate	Immediate	Immediate	Immediate
	Midsize car	Base	Immediate	Immediate	Immediate	Immediate	Immediate	Immediate
		Premium	Immediate	Immediate	Immediate	Immediate	Immediate	Immediate
SUV	Small SUV	Base	Immediate	Immediate	Immediate	Immediate	Immediate	Immediate
		Premium	Immediate	Immediate	Immediate	Immediate	Immediate	Immediate
	Midsize SUV	Base	Immediate	Immediate	Immediate	Immediate	Immediate	Immediate
		Premium	Immediate	Immediate	Immediate	Immediate	Immediate	Immediate
	Large SUV	Base	Immediate	Immediate	Immediate	Immediate	Immediate	Immediate
		Premium	Immediate	4	End of Life	Immediate	Immediate	Immediate
Pickup	Pickup	Base	Immediate	Immediate	Immediate	Immediate	Immediate	Immediate
		Premium	Immediate	2	8	Immediate	Immediate	Immediate