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North American Automotive EV vs ICE Total Cost of Ownership

OBJECTIVES

- Establish Avicenne Energy program to support the Nickel Institute's battery market understanding, needs and to set-up routine discussion and insights
- Global Automotive TCO Program ICE vs. EV for US, EU and AP region to start with US first, followed by EU and then AP. Project scope outline, focus outlines for EU and AP will be established for those regions in the future:
- The total cost of ownership program for North America will focus on the understanding automotive cost of ownership in the US of comparable internal combustion engine vehicles and electric vehicles

NORTH AMERICAN AUTOMOTIVE TOTAL COST OF OWNERSHIP SCOPE

- Three different geographies: CA, FL and NY
 - Subsidies
 - Utility rates
 - Differential Costs
- Vehicles – Mid-size and Luxury – 7 Vehicles Included in Study
 - Mid-size SUV or Car
 - Chevy Bolt, Malibu, Tesla Model 3
 - Luxury Car
 - Tesla Model S & X, BMW 5 series, Cadillac CT5
- Acquisition Cost Options
 - Vehicle Costs
 - Financing or lease costs
 - Home Charger Station

NORTH AMERICAN AUTOMOTIVE TOTAL COST OF OWNERSHIP SCOPE

- Subsidies
 - Federal
 - State
- Vehicle Life
 - 3 years – short-term owner
 - 7 years – average vehicle ownership
 - 10 years – long-term ownership
- Driving Distance
 - DOE average driver ~ 40 miles/day or 12,000 miles/year
 - High Mileage Driver ~120 miles/day or 40,000 miles/year
- Fuel Cost
 - Gas – no diesel based on low penetration in US
 - Home Utility Price – home based charging 90% with public chargers 10%
 - 100% Public Chargers – no home base charging

NORTH AMERICAN AUTOMOTIVE TOTAL COST OF OWNERSHIP SCOPE

- Maintenance
 - Oil and Filter Change
 - Tire Rotation and Replacement
 - Multi-point Inspection
 - Brake Pad & Rotors
 - Other
- Expected Residual Value
 - 3 years – short-term owner
 - 7 years – average vehicle ownership
 - 10 years – long-term ownership
- TCO Categories
 - Vehicle Cost
 - Fuel
 - Maintenance
 - Total

NORTH AMERICAN AUTOMOTIVE TOTAL COST OF OWNERSHIP DESCRIPTION

- The TCO was determined for each type of car by determining the cost per year considering the finance costs, fuel costs, maintenance costs and the residual market value of the vehicle at the time of trade-in. Both federal and state subsidies were also included.
- For electric vehicles, separate TCO models were developed for home charging and public charging.
- 3-, 7- and 10-year TCO models were developed for both low and high mileage driven per year for each vehicle.
- Each state was modelled separately
- All data was compiled in an Excel Spreadsheet.
 - Separate tabs were developed to compile each element of the TCO model
- Data sources include AAA, Car and Driver, Edmonds, KBB, OEMs, state and utility websites and others.
 - Averages of the data were used when a range was established from the sources

TOTAL COST OF OWNERSHIP NORTH AMERICA INSIGHTS AND FINDINGS

- ❶ Luxury vehicles TCO is dominated by initial vehicle cost, if ICE vehicle is substantially less expensive TCO remains lower in low mileage case, in high mileage case fuel, residual value and maintenance drives parity with EVs
- ❷ Midsize vehicle TCO is dominated by initial vehicle cost in low mileage, in the high mileage case, fuel, residual value and maintenance drives advantage to with EVs
- ❸ Subsidies have limited impact on TCO. Fuel costs, residual value and maintenance dominate TCO in the advantage of EVs over ICEs.
- ❹ Large US producers routinely have much lower residual trade-in values than EVs, which play a significant role on the TCO in the first few years.
- ❺ TCO for low mileage at 3 years remains close for EVs and ICE based on additional costs for purchasing home chargers for EVs.

TOTAL COST OF OWNERSHIP NORTH AMERICA INSIGHTS AND FINDINGS

- Leased luxury and midsize EVs are at a cost parity with ICE vehicles for 3 years, but the cost per year is substantially higher than ownership.
- Subsidies today from the US government are lower than early adopter subsidies, unclear whether these may maintain, be reduced or be raised with governmental stimulus in 2021
- State subsidies are in place in CA and NY, but not in FL
- On the average, electricity from home chargers is about 50% that of public charging
- Fuels costs for ICE vehicles is 2 to 3 times more than the electricity cost of EVs charged at home
- The maintenance costs for ICE vehicles is twice that of EVs
- Questions remain on how highway taxes are levied for electric vehicles as a significant portion of highway funding comes from tax on gasoline



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LUXURY VEHICLES PURCHASE - CALIFORNIA

ICE - BMW – 5 Series

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	\$5,242	\$12,462	\$64,983	\$68,593	\$69,640	\$73,250
Fuel Costs	\$5,294	\$15,881	\$12,352	\$37,055	\$17,645	\$52,935
Maintenance	\$0	\$2,372	\$4,744	\$6,167	\$8,302	\$10,793
Total Cost	\$10,535	\$30,714	\$82,078	\$111,814	\$95,587	\$136,977

EV – Tesla Model X

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	\$3,129	\$7,769	\$68,146	\$72,012	\$73,059	\$81,179
Fuel Costs	\$3,656	\$6,968	\$5,865	\$13,592	\$7,521	\$18,560
Maintenance	\$1,779	\$2,313	\$4,151	\$5,396	\$5,930	\$7,709
Total Cost	\$8,564	\$17,049	\$78,162	\$91,001	\$86,510	\$107,448

ICE - Cadillac CT5

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	\$5,508	\$9,687	\$40,449	\$42,538	\$45,675	\$46,929
Fuel Costs	\$4,886	\$14,659	\$11,401	\$34,204	\$16,288	\$48,863
Maintenance	\$2,700	\$3,510	\$7,444	\$9,677	\$11,002	\$14,303
Total Cost	\$13,094	\$27,856	\$59,294	\$86,420	\$72,965	\$110,094

EV – Tesla Model S

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	\$2,995	\$7,335	\$63,898	\$67,514	\$68,561	\$76,155
Fuel Costs	\$3,994	\$7,981	\$6,652	\$15,955	\$8,645	\$21,936
Maintenance	\$1,779	\$2,313	\$4,151	\$5,396	\$5,930	\$7,709
Total Cost	\$8,768	\$17,628	\$74,701	\$88,866	\$83,137	\$105,800



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MIDSIZE VEHICLES PURCHASE – CALIFORNIA

ICE – Chevy Malibu

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	\$3,735	\$6,254	\$25,352	\$26,612	\$28,918	\$29,674
Fuel Costs	\$3,970	\$11,910	\$9,264	\$27,791	\$13,234	\$39,701
Maintenance	\$2,700	\$3,510	\$7,444	\$9,677	\$11,002	\$14,303
Total Cost	\$10,406	\$21,675	\$42,059	\$64,080	\$53,154	\$83,678

EV – Chevy Bolt

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	\$4,095	\$5,688	\$37,458	\$39,051	\$40,496	\$43,881
Fuel Costs	\$3,372	\$6,115	\$5,201	\$11,602	\$6,572	\$15,717
Maintenance	\$1,350	\$1,755	\$3,722	\$4,839	\$5,501	\$7,151
Total Cost	\$8,816	\$13,558	\$46,380	\$55,491	\$52,569	\$66,749

EV – Tesla Model 3

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	\$1,989	\$4,103	\$32,365	\$34,126	\$35,173	\$38,872
Fuel Costs	\$3,615	\$6,844	\$5,768	\$13,304	\$7,383	\$18,148
Maintenance	\$1,779	\$2,313	\$4,151	\$5,396	\$5,930	\$7,709
Total Cost	\$7,383	\$13,260	\$42,284	\$52,826	\$48,486	\$64,729



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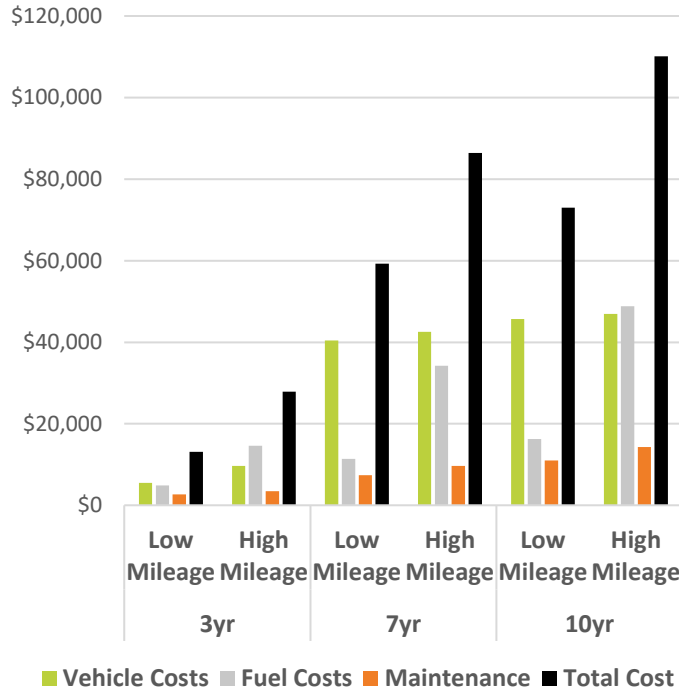
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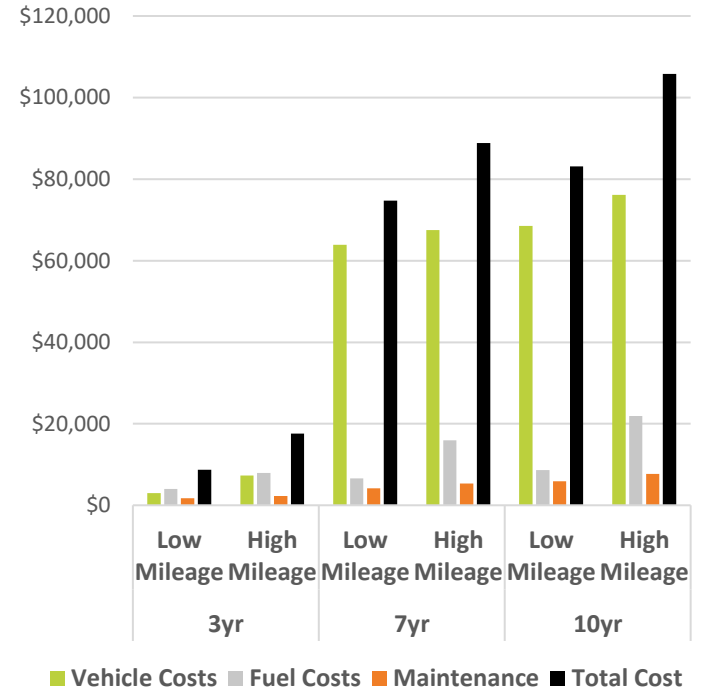
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LUXURY VEHICLE COSTS – CALIFORNIA

Cadillac Costs - California



Tesla S Costs - California



TCO is dominated by initial cost of vehicle – Cadillac \$41,800, Tesla S \$72,300
Residual value of vehicle is dominate in the first 3 years – Cadillac \$20,900, Tesla S \$42,000



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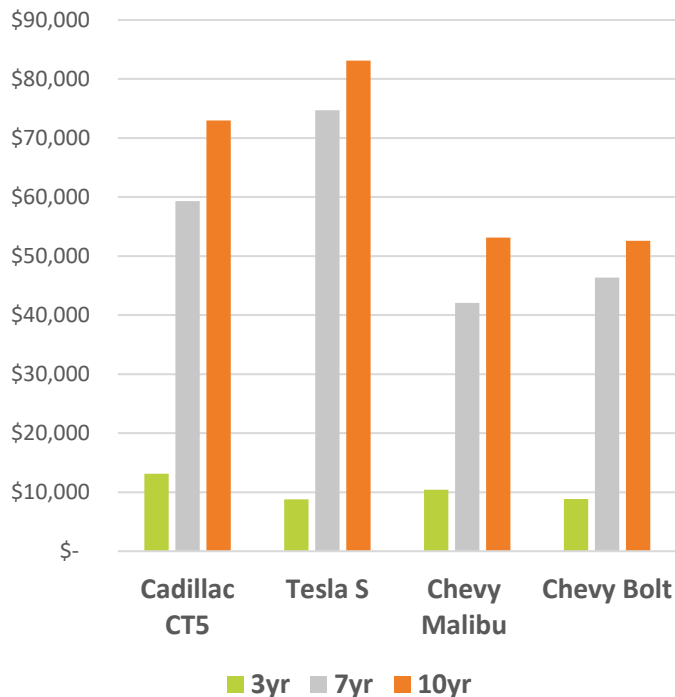
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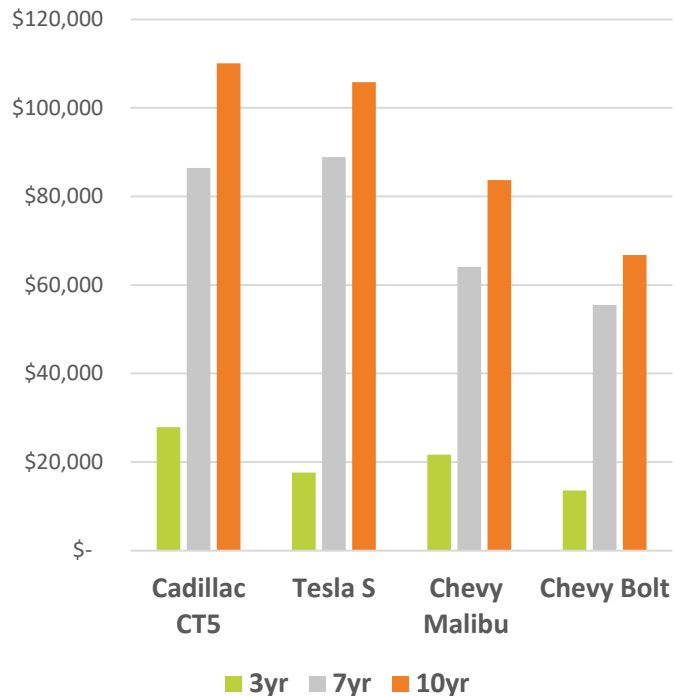
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TCO – CALIFORNIA

TCO California - low mileage



TCO California - high mileage



Both luxury and mid-size EVs have lower TCO at high mileage

Residual value of vehicle is dominate in the first 3 years – Cadillac \$20,900, Tesla S \$42,000



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LUXURY VEHICLES PURCHASE - FLORIDA

ICE - BMW – 5 Series

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	\$2,684	\$9,904	\$61,121	\$64,731	\$64,800	\$68,410
Fuel Costs	\$4,086	\$12,258	\$9,534	\$28,602	\$13,620	\$40,860
Maintenance	\$0	\$2,372	\$4,744	\$6,167	\$8,302	\$10,793
Total Cost	\$6,770	\$24,534	\$75,399	\$99,500	\$86,722	\$120,062

EV – Tesla Model X

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	\$2,813	\$6,779	\$66,579	\$70,546	\$70,615	\$78,547
Fuel Costs	\$3,012	\$5,036	\$4,361	\$9,084	\$5,373	\$12,120
Maintenance	\$1,779	\$2,313	\$4,151	\$5,396	\$5,930	\$7,709
Total Cost	\$7,604	\$14,128	\$75,092	\$85,026	\$81,918	\$98,376

ICE - Cadillac CTS

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	\$3,710	\$7,889	\$37,347	\$39,437	\$41,595	\$42,849
Fuel Costs	\$3,772	\$11,315	\$8,801	\$26,402	\$12,572	\$37,717
Maintenance	\$2,700	\$3,510	\$7,444	\$9,677	\$11,002	\$14,303
Total Cost	\$10,182	\$22,714	\$53,592	\$75,516	\$65,169	\$94,868

EV – Tesla Model S

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	\$2,654	\$6,370	\$62,406	\$66,122	\$66,191	\$73,624
Fuel Costs	\$3,179	\$5,654	\$4,751	\$10,527	\$5,929	\$14,181
Maintenance	\$1,779	\$2,313	\$4,151	\$5,396	\$5,930	\$7,709
Total Cost	\$7,612	\$14,337	\$71,308	\$82,046	\$78,051	\$95,514

MIDSIZE VEHICLES PURCHASE – FLORIDA

ICE – Chevy Malibu

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	\$2,352	\$4,872	\$22,665	\$23,925	\$25,253	\$26,009
Fuel Costs	\$3,065	\$9,194	\$7,151	\$21,452	\$10,215	\$30,645
Maintenance	\$2,700	\$3,510	\$7,444	\$9,677	\$11,002	\$14,303
Total Cost	\$8,117	\$17,575	\$37,259	\$55,053	\$46,470	\$70,957

EV – Chevy Bolt

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	\$2,449	\$4,122	\$36,110	\$37,783	\$38,271	\$41,826
Fuel Costs	\$2,838	\$4,514	\$3,956	\$7,867	\$4,794	\$10,381
Maintenance	\$1,350	\$1,755	\$3,722	\$4,839	\$5,501	\$7,151
Total Cost	\$6,637	\$10,391	\$43,788	\$50,489	\$48,565	\$59,358

EV – Tesla Model 3

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	\$1,476	\$3,337	\$31,449	\$33,310	\$33,379	\$37,101
Fuel Costs	\$2,987	\$4,960	\$4,302	\$8,907	\$5,289	\$11,867
Maintenance	\$1,779	\$2,313	\$4,151	\$5,396	\$5,930	\$7,709
Total Cost	\$6,242	\$10,610	\$39,902	\$47,613	\$44,598	\$56,677



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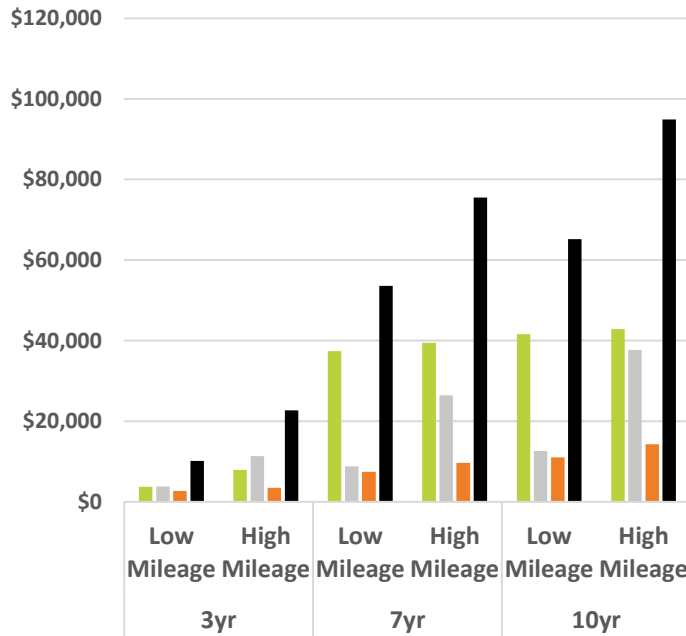
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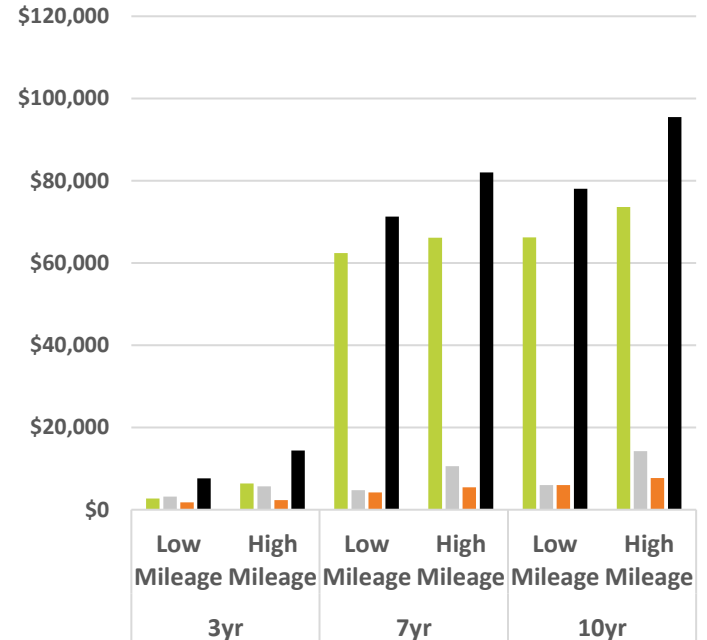
LUXURY VEHICLE COSTS – FLORIDA

Cadillac Costs - Florida



■ Vehicle Costs ■ Fuel Costs ■ Maintenance ■ Total Cost

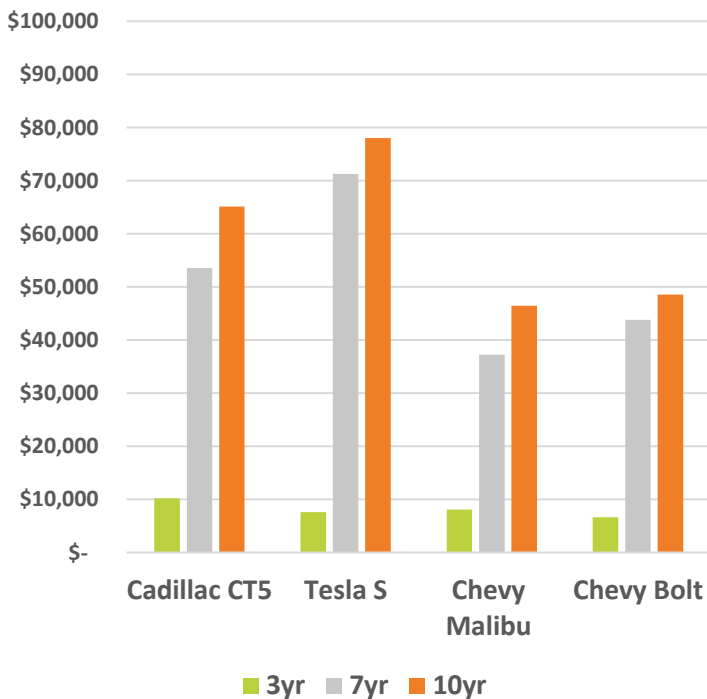
Tesla S Costs - Florida



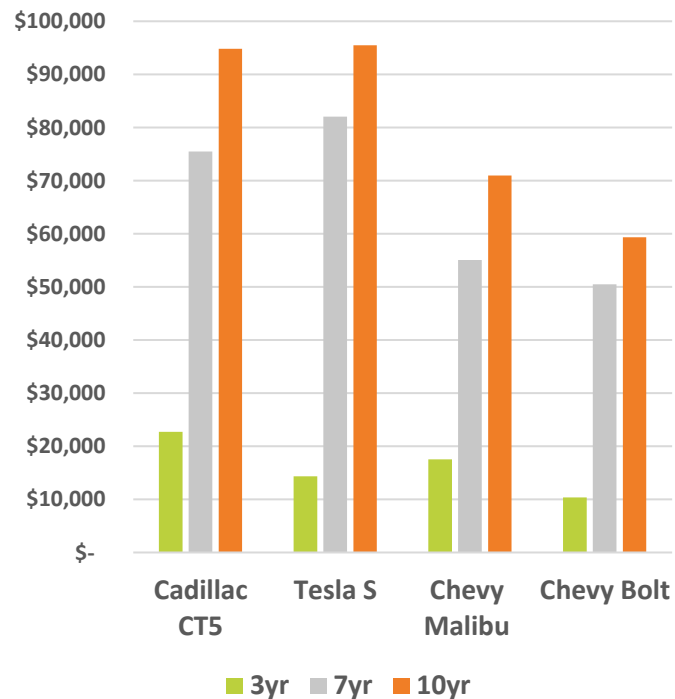
■ Vehicle Costs ■ Fuel Costs ■ Maintenance ■ Total Cost

TCO – FLORIDA

TCO Florida - low mileage



TCO Florida - high mileage



LUXURY VEHICLES PURCHASE – NEW YORK

ICE - BMW – 5 Series

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	\$19	\$7,239	\$58,572	\$62,182	\$62,338	\$65,948
Fuel Costs	\$3,870	\$11,610	\$9,030	\$27,090	\$12,900	\$38,700
Maintenance	\$0	\$2,372	\$4,744	\$6,167	\$8,302	\$10,793
Total Cost	\$3,889	\$21,221	\$72,346	\$95,439	\$83,540	\$115,440

EV – Tesla Model X

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	-\$2,452	\$2,277	\$62,619	\$66,560	\$66,725	\$75,002
Fuel Costs	\$3,642	\$6,926	\$5,831	\$13,494	\$7,473	\$18,420
Maintenance	\$1,779	\$2,313	\$4,151	\$5,396	\$5,930	\$7,709
Total Cost	\$2,969	\$11,516	\$72,601	\$85,450	\$80,128	\$101,131

ICE - Cadillac CT5

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	\$2,109	\$6,288	\$35,863	\$37,952	\$40,198	\$41,451
Fuel Costs	\$3,572	\$10,717	\$8,335	\$25,006	\$11,908	\$35,723
Maintenance	\$2,700	\$3,510	\$7,444	\$9,677	\$11,002	\$14,303
Total Cost	\$8,382	\$20,515	\$51,642	\$72,635	\$63,107	\$91,477

EV – Tesla Model S

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	-\$2,286	\$2,143	\$58,671	\$62,362	\$62,527	\$70,278
Fuel Costs	\$3,977	\$7,930	\$6,612	\$15,836	\$8,588	\$21,765
Maintenance	\$1,779	\$2,313	\$4,151	\$5,396	\$5,930	\$7,709
Total Cost	\$3,469	\$12,385	\$69,433	\$83,594	\$77,045	\$99,753

MIDSIZE VEHICLES PURCHASE – NEW YORK

ICE – Chevy Malibu

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	\$1,320	\$3,840	\$21,733	\$22,993	\$24,397	\$25,152
Fuel Costs	\$2,903	\$8,708	\$6,773	\$20,318	\$9,675	\$29,025
Maintenance	\$2,700	\$3,510	\$7,444	\$9,677	\$11,002	\$14,303
Total Cost	\$6,923	\$16,057	\$35,950	\$52,988	\$45,074	\$68,480

EV – Chevy Bolt

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	\$815	\$2,408	\$32,977	\$34,570	\$35,112	\$38,497
Fuel Costs	\$3,360	\$6,080	\$5,173	\$11,519	\$6,533	\$15,599
Maintenance	\$1,350	\$1,755	\$3,722	\$4,839	\$5,501	\$7,151
Total Cost	\$5,525	\$10,243	\$41,872	\$50,928	\$47,146	\$61,247

EV – Tesla Model 3

	3yr		7yr		10yr	
	Low Mileage	High Mileage	Low Mileage	High Mileage	Low Mileage	High Mileage
Vehicle Costs	-\$1,002	\$1,112	\$28,191	\$29,953	\$30,109	\$33,807
Fuel Costs	\$3,601	\$6,803	\$5,736	\$13,207	\$7,337	\$18,010
Maintenance	\$1,779	\$2,313	\$4,151	\$5,396	\$5,930	\$7,709
Total Cost	\$4,378	\$10,227	\$38,078	\$48,556	\$43,375	\$59,526



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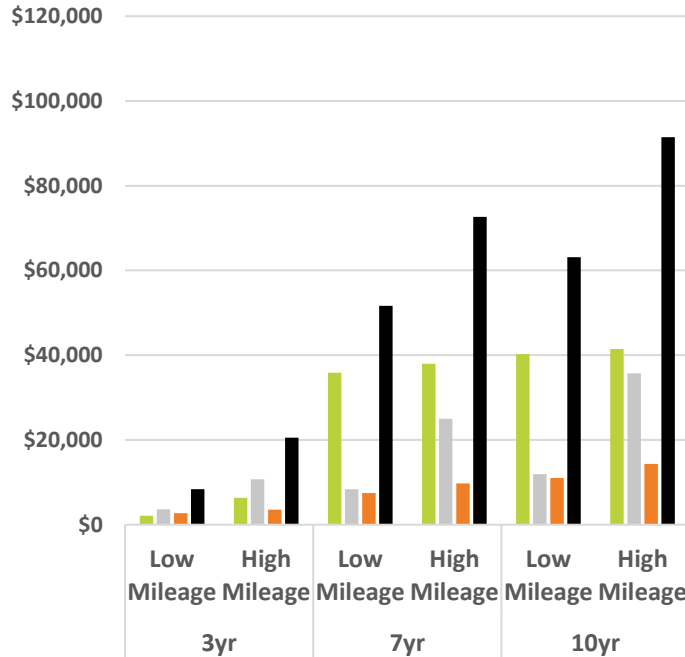
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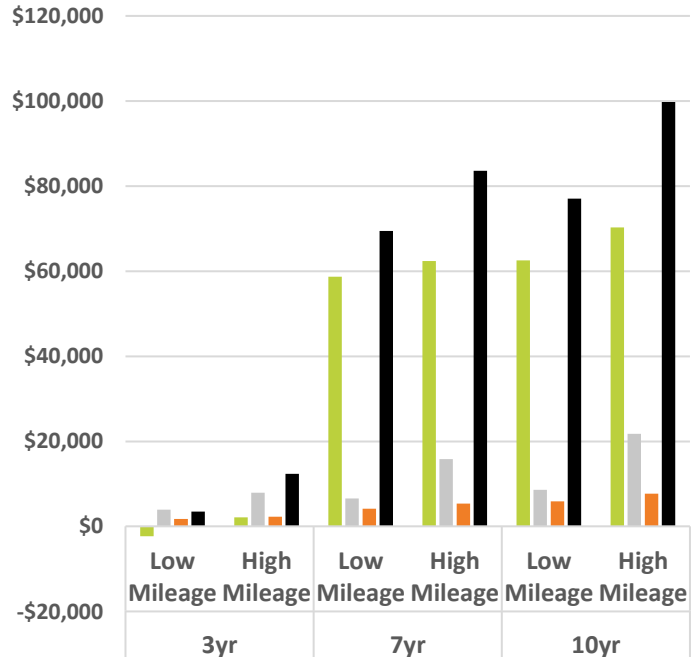
LUXURY VEHICLE COSTS – NEW YORK

Cadillac Costs - New York



■ Vehicle Costs ■ Fuel Costs ■ Maintenance ■ Total Cost

Tesla S Costs - New York



■ Vehicle Costs ■ Fuel Costs ■ Maintenance ■ Total Cost



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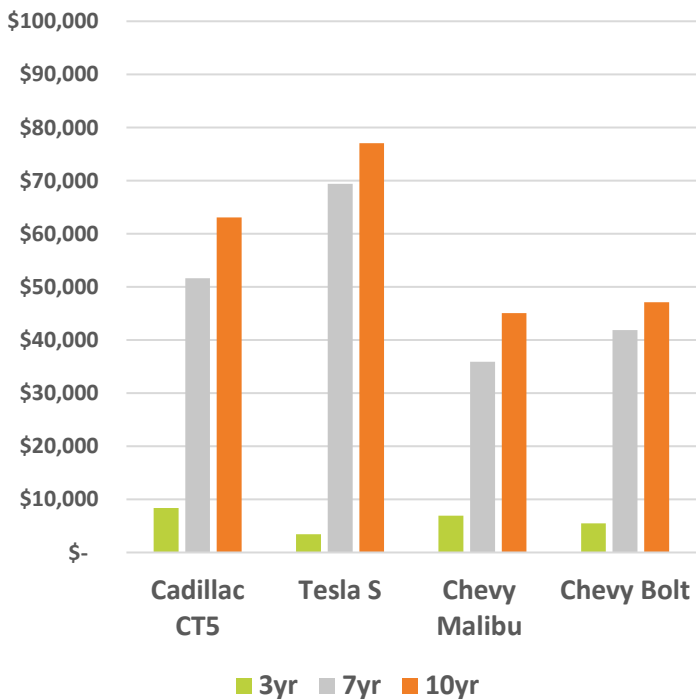
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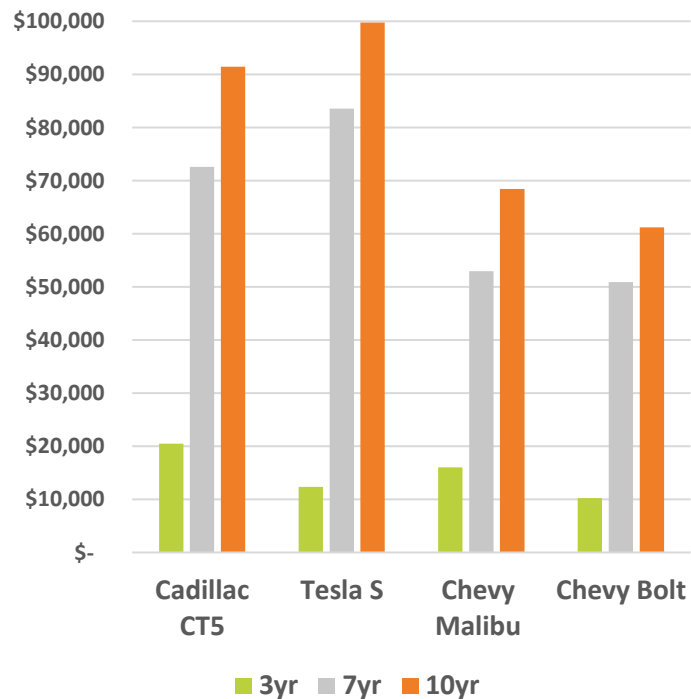
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TCO – NEW YORK

TCO New York - low mileage



TCO New York - high mileage



TAXES AND SUBSIDIES

- 🕒 The federal government provides a tax credit for new battery electric and plug-in hybrid EVs, depending on the capacity of the EV's battery.
- 🕒 The federal EV tax credit amount is affected by your tax liability.
- 🕒 If the EV is leased, the tax credit goes to the manufacturer.
- 🕒 Once a manufacturer's EV sales exceed 200,000, the available tax credit enters a phase out period that begins with full rebate amounts in that quarter and the following quarter. After this grace period, the tax credit is cut in half for the next two quarters. Then the amount is cut in half again for a final two quarters before it is phased out completely.
- 🕒 California – Applicants with low-to-moderate household incomes are eligible for increased rebate amounts.
- 🕒 Florida – No State assistance.

Tax Credits and Subsidies	BMW 5	Cadillac CT5	Chevy Bolt	Chevy Malibu	Tesla Model 3	Tesla Model X	Tesla Model S
Federal	0	0	1875	0	1875	1875	1875
California	0	0	2000	0	2000	2000	2000
Florida	0	0	0	0	0	0	0
New York	0	0	2000	0	2000	500	500

ELECTRICITY COSTS

- On average the cost to use a public charger is twice that of home charging

Home Charger Electricity Costs/year	BMW 5	Cadillac CT5	Chevy Chevy Bolt	Chevy Malibu	Tesla Model 3	Tesla Model X	Tesla Model S
CA - Low Mileage	\$0	\$0	\$457	\$0	\$538	\$552	\$665
CA - High Mileage	\$0	\$0	\$1,372	\$0	\$1,615	\$1,656	\$1,994
FL - Low Mileage	\$0	\$0	\$279	\$0	\$329	\$337	\$393
FL - High Mileage	\$0	\$0	\$838	\$0	\$987	\$1,012	\$1,218
NY - Low Mileage	\$0	\$0	\$453	\$0	\$534	\$547	\$659
NY - High Mileage	\$0	\$0	\$1,360	\$0	\$1,601	\$1,642	\$1,977

Public Charger Electricity Costs/year	BMW 5	Cadillac CT5	Chevy Chevy Bolt	Chevy Malibu	Tesla Model 3	Tesla Model X	Tesla Model S
CA - Low Mileage	\$0	\$0	\$914	\$0	\$864	\$886	\$1,067
CA - High Mileage	\$0	\$0	\$2,743	\$0	\$2,592	\$2,658	\$3,200
FL - Low Mileage	\$0	\$0	\$559	\$0	\$864	\$886	\$1,032
FL - High Mileage	\$0	\$0	\$1,676	\$0	\$2,592	\$2,658	\$3,200
NY - Low Mileage	\$0	\$0	\$907	\$0	\$864	\$886	\$1,067
NY - High Mileage	\$0	\$0	\$2,720	\$0	\$2,592	\$2,658	\$3,200

GASOLINE COSTS

- Gasoline prices vary considerably on a continuous basis but California has considerably higher prices than either Florida or New York

Gasoline Costs/year	BMW 5	Cadillac CT5	Chevy Bolt	Chevy Malibu	Tesla Model 3	Tesla Model X	Tesla Model S
CA - Low Mileage	\$1,765	\$1,629	\$0	\$1,323	\$0	\$0	\$0
CA - High Mileage	\$5,294	\$4,886	\$0	\$3,970	\$0	\$0	\$0
FL - Low Mileage	\$1,362	\$1,257	\$0	\$1,022	\$0	\$0	\$0
FL - High Mileage	\$4,086	\$3,772	\$0	\$3,065	\$0	\$0	\$0
NY - Low Mileage	\$1,290	\$1,191	\$0	\$968	\$0	\$0	\$0
NY - High Mileage	\$3,870	\$3,572	\$0	\$2,903	\$0	\$0	\$0