Electric Vevicles
Day 1

Center for Learning in Retirement
Delaware Valley University
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Format

Day 1 – Electric Cars (today)

- We'll focus today's class on "The State of EV Adoption in the US".
- A lot has changed in the last 30 years since GM's EV1 rolled off assembly lines (then disappeared 7 years later). Then Tesla Motors was born, and the rest is history.

Day 2 – Autonomous Cars (October 13)

- This session is called "Nothing Is Autonomous", which I'll explain.
- What is automation and why is it so hard to achieve? For those who have experienced Tesla's full self-driving capability (FSD), they understand, and there's a reason it's still called FSD "Supervised".

COMPLETE GUIDE TO GOING ELECTRIC

The State of US EV Adoption

Understanding the history, policy, and trajectory of electric vehicles in America

What We'll Cover

A six-part journey through the past, present, and future of US EV adoption

01	**Where We Started**	Tax credits, compliance cars, the Leaf, Tesla's revolution
02	**Why Costs Changed**	Battery price collapse, LFP chemistry, China's advantage
03	**How Policy Shaped Products**	IRA subsidies, the Hummer EV case study, protectionism
04	**How Regulation Shaped Behavior**	Carbon credits, the 2025 reversal, legacy auto retreat
05	**Why Adoption Still Lags**	Misinformation, dealer economics, salesperson knowledge gaps
06	**Where It Goes Next**	Charging buildout, falling costs, the inevitable transition

PART 0

In the beginning

The concept of an electric car is not all that new…

100 Years of Progress



Common EV Acronyms

- **EV**: **Electric Vehicle** — A general term for any vehicle powered in part or full by an electric motor.
- **BEV**: **Battery Electric Vehicle** — A 100% all-electric vehicle powered entirely by a rechargeable battery pack that must be plugged in to charge - no gasoline engine.
- **PHEV**: **Plug-in Hybrid Electric Vehicle** — A hybrid vehicle with an internal combustion engine and an electric motor/battery pack that can be plugged into an external power source to recharge.
- **HEV**: **Hybrid Electric Vehicle** — A traditional hybrid car that combines a gas engine with an electric motor, recharging its small battery via regenerative braking and the gas engine rather than plugging in.
- **EREV**: **Extended Range Electric Vehicle** — A subset of plug-in hybrids where the electric motor drives the wheels exclusively while the gas engine functions solely as an onboard generator to recharge the battery.

Less common:

- **FCEV**: **Fuel Cell Electric Vehicle** — A vehicle that runs on electricity generated on board via a hydrogen fuel cell rather than a large battery pack.

Examples

HEV – Toyota Prius (5th gen)



PHEV – Toyota RAV4 (2026 redesign)



BEV – Slate (new)



Honda CR-V e:**FCEV** (new)



EREV – Scout (new)



PART 1

Where We Started

From compliance cars to the Model S: the first two decades of 21st-century EVs

Compliance Cars: The Pre-Leaf Era (1996)

Before mass-market EVs, automakers built them to satisfy regulations

Before the federal tax credit, most EVs available in the US were "compliance cars" — vehicles built to reduce fleet emissions averages and avoid penalties from the California Air Resources Board (CARB).

Limited

Features & Capabilities

Early EVs were extremely limited compared to their internal combustion counterparts

Low

Unit Volumes

Production numbers were minimal, with no economies of scale

CA Only

Availability

Generally exclusive to California to meet CARB standards

*(MSRP) was **$33,995,** but GM didn't allow customers to buy the vehicle outright; it was available strictly through a **closed-end, 36-month lease.***

2010: The Nissan Leaf

The first full-scale global EV — not just a California experiment

9,178

EVs sold in the US in 2011 — the Leaf's first full year

L.E.A.F.

Leading Environmentally-friendly Affordable Family Car

The **2011 Nissan Leaf** had an MSRP of **$32,780-34,570,** or **$25,280–$26,100** if the buyer's eligible for the full Federal EV tax credit.

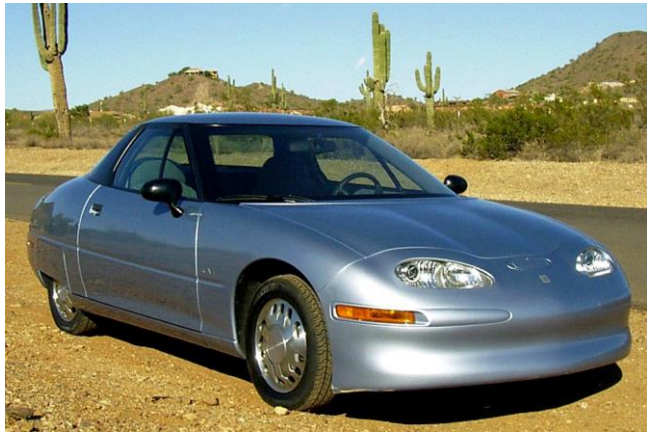
A Global Launch

The Leaf debuted simultaneously in Japan, parts of Europe, and throughout the entire United States. This was a full-scale global EV — not a compliance experiment.

Over the next decade, affordable mass-market competition arrived:

- BMW i3
- Honda Fit EV
- Fiat 500e
- Kia Soul EV
- Chevy Bolt

All shared a similar profile: compact, low range



General Motors EV1, the first compliance car in the United States (1996–1999)



The 1st generation Leaf was manufactured by Japanese automaker Nissan from 2010 to 2017. Its name is a backronym for "leading environmentally-friendly affordable family car".



BMW i3



Fiat 500e



Chevy Bolt



Honda Fit EV



Kia Soul EV

The 2008 Federal EV Tax Credit

The policy that launched the modern EV era

What It Was

The Energy Improvement and Extension Act of 2008 established the first federal EV tax credit.

$7,500

Maximum credit subtracted from income tax bill for qualifying EV purchases

The Catch

When an automaker sold 200,000 EVs to consumers who redeemed the credit, their vehicles began to phase out of eligibility.

200,000

EV sales threshold triggering phase-out — designed to control government spending and let the free market take over

2012: The Tesla Model S

The first premium, long-range, mass-market EV the world had ever seen

400+

Horsepower — a powerful full-size sedan unlike anything before

265 mi

Range — setting a new benchmark for what an EV could be

A Monumental Piece of Automotive History

Engineered by a startup denied access to the legacy automotive supply chain. Tier 1 and Tier 2 suppliers refused to sell to Tesla, forcing them to vertically integrate — building their own components and sourcing from other industries. Tesla was forced to invent new ways to consolidate parts and manufacture more efficiently.





Franz

Tesla started developing the Model S around 2007 under the codename WhiteStar, with Henrik Fisker appointed as lead designer. After a dispute with Elon Musk, Fisker was replaced by Franz von Holzhausen. Tesla unveiled a prototype of the vehicle in March 2009. The **Tesla Model S** is a battery-electric, four-door full-size car that was produced by Tesla from 2012 to 2026. The Model S has been described as one of the most influential electric cars in the industry.

The Charging Wars

Three competing standards created a fractured infrastructure landscape

CHAdeMO

Japanese consortium

Limited fast charging standard launched with the Nissan Leaf

Legacy

CCS

Combined Charging System

Adopted by the rest of the world's EVs as the competing standard

Became US standard

Tesla NACS

Proprietary connector

Simplified design for home and road charging from a single port

Eventual US standard

For non-Tesla EV owners, the great American road trip was somewhere between unpleasant and impossible. Tesla's integrated software, hardware, and infrastructure stood alone for over a decade as the only consistent, reliable solution.



IEC Type 4/CHAdeMO (left); CCS Combo 2 (center); IEC Type 2 outlet (right)

NACS



IEC Type 1/SAE J1772 inlet (left); **NACS (J3400)** (center); IEC Type 2 connector outlet (right)

And the winner is:
North American Charging System (NACS)

And the companys that have adopted NACS for the US market

Ford
General Motors
Rivian
Volvo
Polestar
Mercedes-Benz
Nissan
Honda
Jaguar Land Rover
Hyundai/Genesis
Kia
BMW Group
Toyota
Subaru
Lucid
Volkswagen Group
Mazda
Stellantis

A Decade of Explosive Growth

2011–2024: The EV sector grew ~45% annually on average

2011

9,178

EVs sold in the US

→

2024

1.2 Million

EVs sold in the US — up over 1,000% in ~10 years

Key Milestones

- By 2020, the $7,500 tax credit phased out for Tesla and General Motors
- Most major automakers launched fully electric models during this era
- EVs sold at a significant premium due to costly battery packs

PART 2

Why Costs Changed

Battery price collapse, LFP chemistry, and China's structural advantage

The Battery Price Revolution

Scale and technology improvements drove costs down dramatically

~99%

Drop in battery prices over the last 30 years

~10%

Average annual rate battery prices continue to fall

So why did EVs sold in America maintain such high price tags?

During the 2010s, most American EVs were powered by Nickel Manganese Cobalt (NMC) cell chemistry — costly materials that kept vehicle prices elevated despite battery cost improvements.

The LFP Story

An American invention that China turned into an advantage

1996

Goodenough Invents LFP

John B. Goodenough at the University of Texas invented a safe, low-cost battery chemistry: Lithium Iron Phosphate (LFP). No rare cobalt, no expensive nickel.

Patents

Canadian Refinement

A Canadian institution filed LFP patents globally — except in China. The Chinese could develop LFP technology without paying hefty licensing fees.

2022

LFP Exclusivity Ends

China's LFP exclusivity ended in late 2022, unlocking worldwide production without licensing fees. A gold rush of LFP factory construction began in the US and Europe.

China's fee-free access to LFP was a key structural advantage.

PART 3

How Policy Shaped Products

Subsidies, loopholes, and the Hummer EV case study

The Inflation Reduction Act (2022)

A new set of US government EV industry subsidies

The Intent

Limit subsidization to EVs and battery packs assembled in North America. At launch, only Tesla and General Motors qualified for full incentives.

$7,500

Direct purchase price reduction for qualifying EVs

The Leasing Loophole

A loophole in the law resulted in over 1 million EVs built outside of North America being subsidized through a leasing loophole. This was a highly visible subsidy, but behind the scenes, even more tax dollars were flowing.

The Leasing Loophole explained

The EV leasing loophole allowed consumers to bypass strict federal manufacturing, sourcing, and income limits to access the $7,500 clean vehicle tax credit.

Commercial Classification

Under IRS rules for the Commercial Clean Vehicle Credit (Section 45W), vehicles acquired for leasing were classified as commercial/fleet vehicles rather than personal consumer purchases.

Bypassing Restrictions

Because they were treated as commercial vehicles, leased EVs were exempt from North American final assembly mandates, foreign battery mineral/component sourcing rules, vehicle price caps, and buyer income limits.

Passing the Savings

The $7,500 credit was officially claimed by the dealership or the automaker's finance arm, which frequently passed the savings down to the consumer through lower monthly lease payments or capitalized cost reductions. Detailed explanations are available via [CarsDirect](carbuzz.com or https://www.carsdirect.com/deals-articles/ev-tax-credit-loophole-explained).

The Battery Production Subsidy

How per-kWh incentives incentivized bigger packs

$45

per kilowatt hour

of domestic batteries used in EVs — given to qualifying automakers. The bigger the battery pack, the bigger the check.

Why This Structure Was Problematic

This structure rewarded automakers for producing high volumes of battery cells quickly while funds were available — but didn't necessarily promote energy efficiency. Large, heavy battery packs force engineers to increase the mass of supporting framework, braking, suspension, cooling systems, and crash structures.

Result: unwieldy mass, high materials cost, high energy consumption — and fewer EVs on the road at elevated prices.

Case Study: GMC Hummer EV Subsidy Math

How subsidies stacked up on a single vehicle

2025 GMC Hummer EV 3X — Total Subsidy Breakdown

Battery capacity	**246 kWh**	More energy than 10 first-gen Leafs
Battery production subsidy ($45/kWh)	**~$11,000**	246 kWh × $45/kWh
Consumer EV tax credit	**$7,500**	Direct purchase price reduction
Carbon credits (4 × $5,000)	**$20,000**	Maxed out ZEV credit accumulation
TOTAL DIRECT SUBSIDIES		**$38,500**

Excludes indirect subsidies: factory loans, grants, and assembly incentives



CURB WEIGHT 9065 lb. (2,923 lb. for batteries alone)

By comparison, my Long Range Tesla Model 3 weighs 3,891 lb.

Powertrain and Performance

- **Motors:** 3-motor configuration (1 front, 2 rear) with torque-vectoring e4WD.
- **Horsepower:** Up to 1,000 hp (Pickup) / 830 hp (SUV).
- **Torque:** 11,500 lb-ft.
- **0–60 mph:** Approx. 3.5 seconds for the SUV
- **Range:** 312 - 381 miles

The Mass Snowball Effect

How misaligned incentives led to heavier, costlier, less efficient EVs

1. **Subsidies Reward Volume** — Per-kWh credits incentivize automakers to maximize battery pack size
2. **Bigger Battery Packs** — Larger packs require heavier supporting framework and systems
3. **Reinforced Everything** — Braking, suspension, cooling, crash structures all must scale up
4. **Unwieldy Mass** — Snowballing weight drives high materials cost and energy use
5. **Fewer EVs, Higher Prices** — Result: fewer EVs on the road at further elevated prices

Protectionist Policies

Western automakers appealed to the US government for relief

Connected Vehicle Rule

Essentially bans EVs made anywhere if ownership is Chinese, with 100% Chinese import tariffs making naturally inexpensive EVs too expensive.

The goal: buy time without competitive pressure from inexpensive Chinese EVs.

Supplier Restrictions

Additional legislation prohibiting Chinese suppliers from establishing US factories or selling components has also been proposed.

Meanwhile, China continues to increase its lead, winning more global automotive market share each quarter.

Chinese electric vehicles offer advanced technology, long driving ranges, and low prices that rival or beat many Western and Asian competitors

The China Problem

Trump's Big U-Turn Could Put BYD in America's Driveways



PART 4

How Regulation Shaped Behavior

Carbon credits, the 2025 reversal, and the legacy auto retreat

ZEV Credits Explained

How state emissions regulations shaped what automakers built

Some states mandated that a certain percentage of each manufacturer's yearly sales must be zero-emission vehicles — an upward ratcheting ratio. Insufficient credits meant prohibition from selling in that state.

Range-Based

Credit Formula

Credits calculated based on vehicle type and range. Longer range earns higher value

4 credits

Hummer EV Maximum

The 2022 Hummer EV maxed out at 4 ZEV credits with 429 mi of UDDS range

~27

Silverados Offset

One Hummer EV offset emissions penalties of roughly 27 gas-powered Silverados

The formula encourages long-range EVs — achieved easiest by adding more batteries.

The Carbon Credit Market

A multi-billion dollar transfer from combustion to EV makers

$10 Billion+

in profit realized by all-electric brands — Tesla, Rivian, and Lucid Motors — by selling ZEV credits to combustion vehicle makers

How the Credit Trade Worked

- Automakers with insufficient credits faced fines: $5,000 per missed credit (2025), scheduled to rise to $20,000 in 2026
- Buying credits from a competitor was typically a fraction of the cost of the fine
- Surplus credits could be stored and used until 2030, with a 4-year equalization period

The 2025 Policy Reversal

The government erased the carbon credit market and consumer subsidies

Cancelled

$7,500 Consumer EV Tax Credit

Eliminated entirely in 2025

Nullified

Emissions Penalties & Carbon Credits

Effectively erasing the carbon credit market

Impact: **In the United States:** Federal policy shifts and relaxed enforcement regarding fuel economy standards and fines have caused a sharp drop in domestic regulatory credit revenue for companies like Tesla and Rivian (YouTube)

Regulatory credits Tesla receives will go to zero

- 1 year ago -



Legacy Auto EV Retreat

When subsidies ended, automakers pivoted back to combustion

New ICE Investment

Ford and GM each announced new investment in combustion models in late 2025

Cancelled EVs

Many western automakers cancelled planned EVs and walked back commitments to go fully electric

Battery Redirection

Domestic battery supply built for cancelled EVs redirected to stationary energy storage

Shrinking ICE Share

Legacy brands retreating to less efficient combustion products while global ICE market share shrinks

"EVs are the endgame." — Mary Barra, GM CEO, even amid EV cuts

PART 5

Why Adoption Still Lags

Misinformation, dealer economics, and the knowledge gap

The US EV Education Gap

Misinformation drives lagging US EV demand

EVs pollute more than ICE vehicles	FALSE	All EVs run on coal	FALSE
EV batteries go into landfills	FALSE	All EV batteries use slave-mined cobalt	FALSE
EVs catch fire more than gas cars	FALSE	EVs don't work in the cold	FALSE
Batteries cost more than engines	FALSE	The grid can't handle EVs	FALSE

EV technology and infrastructure have made incredible advancements — but the general public is working with obsolete information.

The Global Context

The rest of the world is going electric about 3x faster than the US

6%

of vehicles sold in the US in 2026 are fully electric — 94% still have gas tanks and exhaust pipes

90%+

of new vehicle sales are fully electric in some countries. Norway has closed a third of its gas stations

What Going Electric Means

- Lower operational costs
- Better performance
- Longer vehicle lifespans
- Greater safety
- Home charging with domestic energy
- No oil changes, mufflers, transmission work, belts, smog tests, or frequent brake repairs

Incumbent Obstructionism

The distribution system is incentivized to push combustion vehicles

$164 Billion

spent by Americans at dealership service departments last year alone

The Dealer's Perspective

- ~50% of dealer profit comes from the service department
- EVs require no powertrain maintenance
- Widespread EV adoption could eliminate tens of billions in annual service income

The Advertiser's Dilemma

- Legacy brands spend less advertising on EVs
- They don't want money-losing EVs to cannibalize profitable ICE sales
- Only ~30 EV brands available in the US vs. hundreds worldwide

The Salesperson Knowledge Gap

Two different problems in franchise dealerships and direct-to-consumer brands

Franchise Dealerships

Most local dealerships have no employees who personally own or drive EVs.

- Sales reps earn commissions linked to vehicle margins
- High-margin trucks and SUVs pay the largest commissions
- Discounted EVs sitting on lots earn small commissions
- High turnover makes EV training costly and difficult
- Can be a source of misinformation

Direct-to-Consumer Brands

Tesla, Rivian, Lucid, Scout and Slate only sell a limited number of models. Staff tend to understand products well and drive EVs personally.

- Retail staff tend to be younger
- Lack deep knowledge of ICE competition
- Small dealership networks limit access
- Several states prohibit direct sales entirely
- Educated buyers can order online directly

PART 6

Where It Goes Next

Charging buildout, falling costs, and the inevitable transition

Charging Infrastructure Today

A dramatic transformation from fractured to unified

75,000+

Public DC fast charging ports in the US

25,000+

Tesla Supercharger dispensers opened to all brands (2024)

0.5%

of Supercharger customers wait any time to begin charging

NEVI Program & Industry Shift

- NEVI program targets DC fast charging every 50 miles along major US highway corridors
- ~100 NEVI-funded sites operational today; all funding intended to be allocated by 2027
- All major automakers have adopted Tesla's North American Charging Standard (NACS)
- California already has more EV charging ports than gas station nozzles

The Road Ahead

Despite domestic challenges, the trajectory points toward inevitable transition

5-min

Charging

Ultra-fast charging on the horizon

Fireproof

Batteries

Next-gen cell chemistry for safety

500 mi

Range

Extended range becoming reality

Auto

Driving

Self-driving capability advancing

EVs are becoming more affordable while range, performance, and technology improves. As long as US buyers want the very best vehicles available, our graduation from the combustion age appears inevitable.

Thank You

Continue Learning

The Current — A 10-minute weekly EV news show, the most viewed of its kind

Beginners' Guides to Going Electric — Full series covering finding the right EV, charging, ownership, and more

Miss GOElectric — 500+ videos: in-depth reviews, factory tours, interviews, and technical explainers