REGIONAL ZERO-EMISSION VEHICLE INFRASTRUCTURE STUDY

November 2025

HOUSTON GALVESTON AREA COUNCIL

CONTENTS

INTRODUCTION

The Houston-Galveston Area Council (H-GAC) is a voluntary association of local governments and elected officials across a 13-county region in Southeast Texas. As the designated Metropolitan Planning Organization (MPO) for the eight-county Houston-Galveston Metropolitan Planning Area — covering Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller counties — H-GAC is responsible for coordinating regional transportation planning efforts.

Through data-driven research, stakeholder engagement, and long-range planning, the MPO plays a central role in shaping a multimodal transportation network that is safe, efficient, and responsive to the region's evolving needs.

One area of growing focus is the integration of zero-emission vehicles (ZEVs) into the regional transportation system. ZEVs include battery-electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell electric vehicles (FCEVs). These technologies have the potential to significantly transform mobility across the region. As of May 2025, more than 87,000 BEVs and PHEVs were registered within the H-GAC metropolitan planning area.

As the region's MPO, H-GAC is committed to providing member governments and the public with timely, accurate, and actionable information on emerging transportation trends.

A smooth transiion to ZEVs is critical to supporting regional goals around mobility, sustainability, and public health. As consumer choice expands, residents will be better equipped to select vehicles that meet their daily needs, further encouraging the adoption of these clean technologies.

ZEVs offer a range of benefits, including meaningful reductions in emissions that contribute to the region's longstanding air quality challenges. Based on emissions inventory work conducted by the Texas Commission on Environmental Quality (TCEQ) , on-road transportation accounts for nearly 25 percent of nitrogen oxide (NOx) emissions — key precursors to ground-level ozone. Expanding the use of ZEVs will be essential in improving air quality and meeting federal attainment goals.

This initial study serves as a foundation for future MPO efforts and is intended to:

- Provide background and introductory-level insights into ZEV technologies.
- Evaluate sector-level trends, challenges, and advancements in adoption.
- Identify regional and statewide advantages for ZEV implementation.
- Conduct preliminary analysis of local adoption rates and public charging infrastructure.
- Recommend opportunities for future MPO action to support ZEV integration.

REGIONAL CONTEXT

Demographic Growth

The 2020 Census counted 7,092,073 individuals residing within the metropolitan planning area. More than half of the region's population lives in Harris County (4,731,145 residents), with Houston being the most populous city in the region at 2,304,580 people. Regional growth forecasts produced by H-GAC in 2024 estimate the area's population will reach nearly 11 million by 2050.

Figure 1: The Houston-Galveston Metropolitan Planning Area

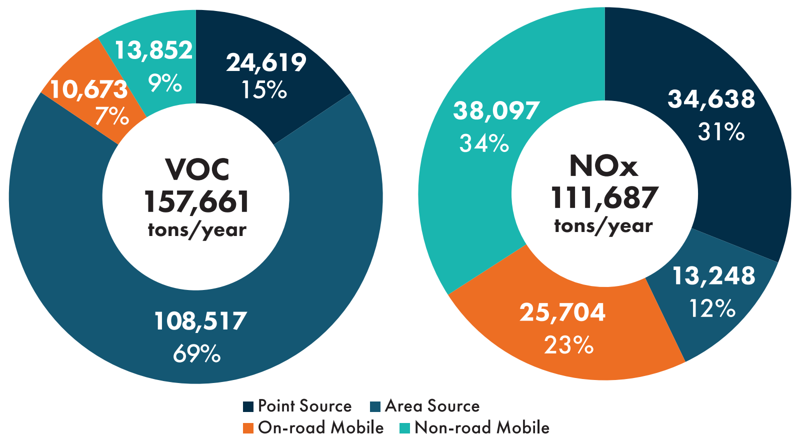
Air Quality Challenges

As the region's population grows, transportation-related emissions also increase. The Clean Air Act (CAA) of 1970, and a later amendment in 1990, require the U.S. Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) for several air pollutants. The primary standards to protect public health, including sensitive populations such as asthmatics, children, and the elderly. Secondary standards protect public welfare, including protection against damage to crops, animals, buildings, etc.

As of August 2025, all eight counties in the metropolitan planning area are designated as being in severe nonattainment for the 2008 ozone primary NAAQS, which set the standard at 0 .075 parts per million (ppm). In 2015, the EPA strengthened this standard to 0.070 ppm, to further protect public health.

Currently, six counties — Brazoria, Chambers, Fort Bend, Galveston, Harris, and Montgomery —in the metropolitan planning area are in serious nonattainment for the 2015 ozone standard.

Figure 2 and 3: Volatile Organic Compounds (VOC) and Nitrogen Oxides (NOx) emissions by source in tons per year.



Source: The TCEQ 2023 Regional Inventory

Transportation, particularly on-road mobile sources, contributes significantly to emissions of ozone precursors, including volatile organic compounds (VOCs) and nitrogen oxides (NOx). These pollutants react in the presence of heat and sunlight to form ground-level ozone, a key contributor to poor air quality in the region.

According to 2023 emission inventories published by the TCEQ, on-road mobile sources are responsible for approximately 23 percent of NOx emissions and 7 percent of VOC emissions in the metropolitan planning area.

In addition to ozone, fine particulate matter ($PM_{2.5}$) is an emerging concern. $PM_{2.5}$ refers to a complex mixture of microscopic particles measuring $_{2.5}$ microns or less in diameter or about 30 times smaller than the width of a human hair. The extremely small particles originate from both natural and man-made sources.

Due to their size, these particles can bypass the body's natural defenses and penetrate deep into the respiratory system, posing significant health risks. Public health officials, scientists, and health researchers are increasingly interested in the health consequences of $PM_{2.5}$.

As of August 2025, all eight counties in the metropolitan planning area meet the 2012 $PM_{2.5}$ primary NAAQs, which set the standard at 12.0 micrograms per cubic liter. In 2024, the EPA strengthened this standard to 9.0 micrograms per cubic liter. Full implementation of strengthened standards is a lengthy process. Before the completion of this process the EPA announced that in conjunction with President Trump's Day One executive orders and the EPA's Power the Great American Comeback initiative, the 2024 $PM_{2.5}$ NAAQs was being reconsidered.

Although the Houston region currently meets the 2012 $PM_{2.5}$ primary standard, recent monitoring data show concentrations in the metropolitan planning area have been rising. In addition to vehicle exhaust, $PM_{2.5}$ is also generated by brake wear, tire degradation, and other forms of mechanical wear associated with everyday driving.

ZERO-EMISSION VEHICLE BACKGROUND

Car manufacturers are continually adopting new technologies to improve vehicle efficiency, reduce carbon dioxide (CO2) emissions from tailpipes, and increase fuel economy. In response to both regulatory requirements and consumer demand, many manufacturers are integrating electric features to vehicles. These features vary widely in complexity — from small electrical components that enhance fuel efficiency to fully electric drivetrains with zero tailpipe emissions.

At one end of the electrification spectrum are internal combustion engines (ICE). By equipping these vehicles with technologies, such as stop-start systems, manufacturers engage in a mild form of electrification. This feature shuts off the engine when the vehicle comes to a complete stop (e.g., at a traffic light) and restarts it when the driver accelerates, thereby reducing idle time, conserving fuel, and reduces tailpipe emissions .

At the other end of the spectrum are the fully electric drivetrains, such as battery-electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs). These vehicles rely entirely on on-board electricity — either stored in a battery or produced by a hydrogen fuel cell — to power all components of the drivetrain.

Figure 4 highlights key differences and similarities between the major vehicle types currently on the market. While any level of electrification offers gains in fuel efficiency, performance, and emissions reduction, this report focuses specifically on zero-emission vehicles (ZEVs).

Discussions about ZEVs are often complicated by a mix of unfamiliar acronyms and overlapping terminology. While these terms may seem technical or tedious, they reflect important distinctions between vehicle types.

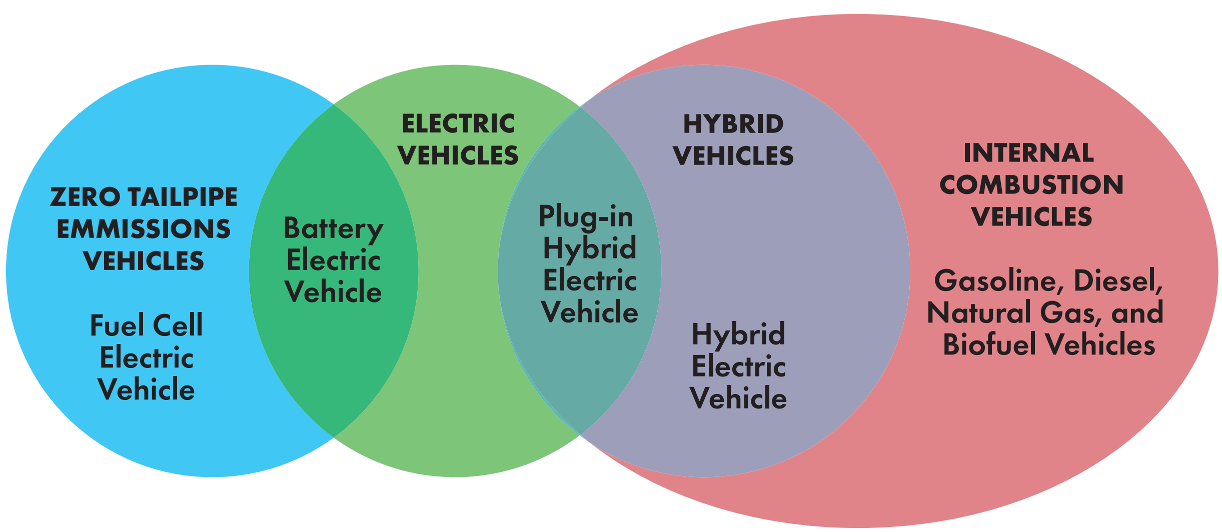
For example, the commonly used term "hybrid car" is often misattributed. Many people assume that a hybrid can be both fueled with gasoline and charged with electricity. However, this is only accurate for a plug-in hybrid electric vehicle (PHEV), which can be powered by fuel or electricity from an external source.

In contrast, a hybrid electric vehicle (HEV) has a small battery that is charged internally, through regenerative breaking, and cannot be plugged in. The HEVs' batteries assist the internal combustion engine but do not offer electric-only driving over meaningful distances. The small batteries may power vehicle systems such as cabin heating, cooling, or low speed driving over short distances.

The term electric vehicle (EVs) is an umbrella term that includes battery electric vehicles (BEVs), fuel cell electric vehicles (FCEVs), and plug-in hybrid electric vehicles (PHEVs). However, in common usage, EV typically refers to battery electric vehicles — vehicles that are powered solely by electricity and charged through an external power source.

This study will use and define the most accurate terms where appropriate. However, for clarity and readability, commonly accepted terms may be used following their initial definition. For example, "fully electric vehicles" may be used in place of BEVs, and "hydrogen vehicles" may be used in reference to FCEVs.

Figure 4: Vehicles by Technology Type



Source: U.S. Energy Information Administration

Battery Electric Vehicles

BEVs use battery packs to store the electrical energy that powers the motor, charging either through an external electric power source or through regenerative braking.[1] BEVs have no onboard combustion engine.

REGENERATIVE BRAKING

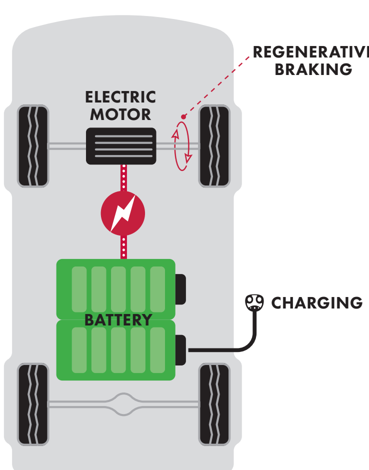
Regenerative braking is the process by which kinetic energy from braking is converted into electric power and stored in the battery. In contrast, conventional mechanical braking, converts the kinetic energy into heat through friction, which is not recovered by the vehicle.[2]

Most of the energy stored in BEV batteries is derived from external electrical power sources. These include dedicated EV chargers — installed at residences or public stations — and standard household electrical outlets.

While BEVs produce no tailpipe emissions and do not contribute to local air quality concerns, the environmental impact of generating electricity for charging must be considered. The cleaner the energy source, the lower the total emissions attributable to BEV use.

Even in regions where coal dominates electricity production, BEVs remain less emission intensive than new internal combustion engine (ICE) vehicles.[3] The national trend toward renewable energy further reduces the BEV lifecycle emissions.

Figure 5: Internal Mechanism of EV Charging



CHARGING

There are three levels of EV charging, defined by the voltage (V) and charging speed, which is defined by miles of driving range added per unit of charge time:

Level 1 is advantageous for BEV owners who drive 30 to 40 miles a day[5] and want to avoid installing specialized equipment. It uses a standard household outlet.

Level 2 offers faster charging and is commonly found at workplaces, public locations, and homes. It requires modest installation costs, simply a 240 V circuit, similar to those used for large appliances , such as clothes dryers.

Level 3, or direct-current fast-charging (DCFC), is best suited for public charging locations due to its high voltage demands. It dramatically shortens charging times for longer road trips. The high electricity demand means it may be unsuitable for most individual residences. These chargers are common at public charging facilities, including shopping centers and along major travel corridors. These fast chargers reduce much of the charge time that may be associated with longer road trips in full electric vehicles.

EV Charging Level Comparisons

Charging Level	Power Type	Voltage	Charge Speed	Typical Location
Level 1	Alternating Current (AC)	120V	3.5-6.5 miles per hour	Residences, some workplace
Level 2	AC	208-240V	14-35 miles per hour	Residences, workplaces, public facilities
Level 3 (DCFC)	Direct Current (DC)	480V	10 miles per minute	Public facilities

CONNECTORS

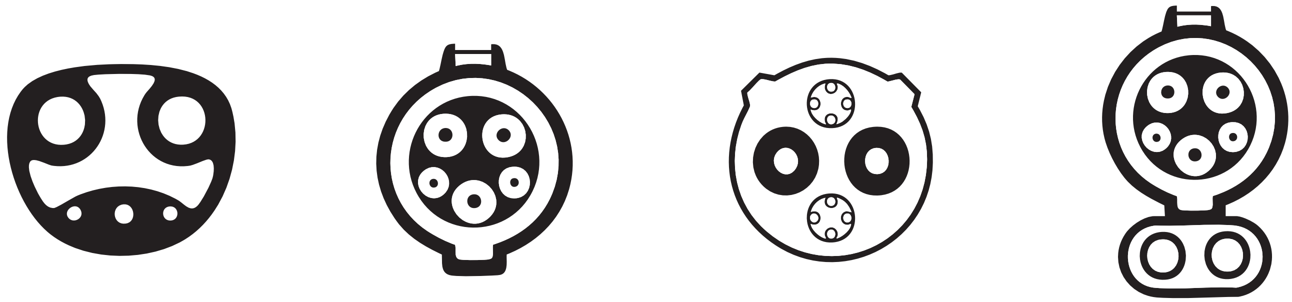
Connector compatibility is a common source of confusion. Figure 6 provides an overview of connector types and their compatibility with supported charging levels.

The J3400 connector was originally launched in 2012 as Tesla's proprietary charging connector. It is smaller and lighter than other connectors and supports Levels 1, 2, and 3 charging. In 2022, Tesla released the design as an open standard to encourage industry-wide adoption, renaming it the North American Charging Standard (NACS).[6] The automotive industry and other stakeholders moved quickly toward adopting the connector.

In fact, all major automotive manufacturers and EV charging companies have announced plans to adopt the J3400 connector as early as 2025. SAE International (formerly the Society of Automotive Engineers), a leading standards organization, has formally adopted the J3400 as its standard. Although it lacks the official U.S. government designation, the Federal Highway Administration has recognized it as a "Recommended Practice.[7]

The CHAdeMO connector, developed in 2010, was the first to offer direct current fast-charging (DCFC) compatibility. Due in part to its early popularity, vehicles equipped with CHAdeMO and stations offering the connector may continue to operate despite its steep decline in usage. Similarly, the phase-out of the CSS and J1772 connectors is expected as the J3400 becomes more widely deployed.

Figure 6: Charging Connector Compatibility



J3400/NACS
Level 1
Level 2
Level 3

J1772
Level 1
Level 2

CHAdeMO
Level 3

CSS
Level 3

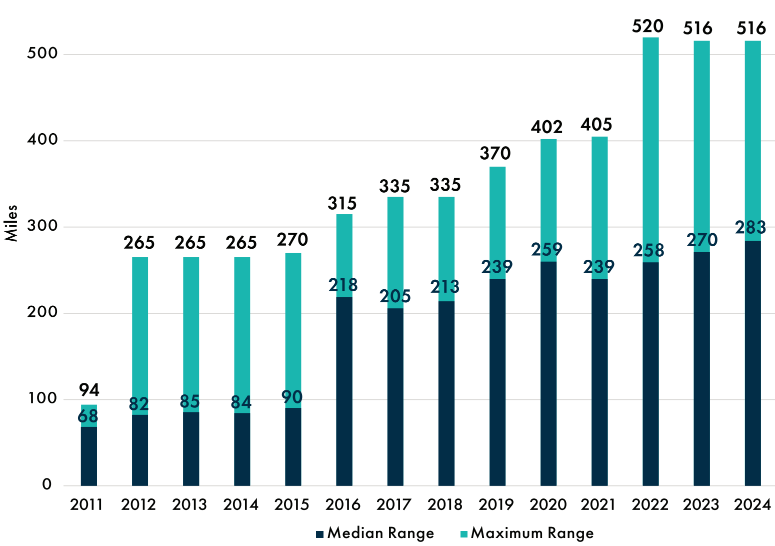
RANGE

Vehicle range remains a top concern among potential BEV drivers. Range refers to the distance a BEV can travel on a full charge.[8] In the past eight years, the average maximum range of new BEV models has increased by nearly 250 miles — from 270 miles in 2015 to 516 miles in 2023.

While both the median (283 miles) and maximum (516 miles) BEV ranges continue to rise, they have not yet reached parity with ICE vehicles, which have a median range of 403 miles and maximum exceeding 700 miles.

The Federal Highway Administration's National Household Travel Survey, a key source of information on American travel behavior, found in its 2022 iteration that approximately 98 percent of passenger trips are 75 miles or less.[9] This suggests that the vast majority of daily driving needs are well within the range capabilities of today's fully electric vehicles.

Figure 7: Battery Electric Vehicle Range (Model Years 2011-2024)[10]



Source: U.S. Department of Energy and U.S. Environmental Protection Agency

MAINTENANCE COSTS

BEVs have lower maintenance costs than ICE vehicles. With fewer moving parts and reduced reliance on fluids, such as engine oil, BEVs require less frequent scheduled maintenance. In 2021, Argonne National Laboratory — a federally funded Department of Energy research lab — found that maintenance costs for fully electric vehicles were 53 percent lower than those of ICE vehicles: $0.06 per mile versus $0.11 per mile, respectively.[11]

BATTERY LIFECYCLE

Most EV batteries use lithium-ion technology, which offers high power-to-weight ratios, long life, and high energy density. This same technology powers most portable electronics, such as cell smartphones and laptops.

BEV batteries are generally expected to last between 10 and 20 years, with all major automakers offering warranties of at least eight years or 100,000 miles.[12] Tesla's warranty also stipulates that if battery capacity degrades by more than 30 percent during the warranty period, the battery will be replaced at no cost.

In 2019, Geotab, a Canadian telematics company, found that EV batteries degraded at an average rate of 2.3 percent per year. A follow-up analysis in 2024 showed improvement, with battery degradation slowing to an average rate of 1.8 percent per year.[13]

Best Practices to Extend Battery Life:

- Regularly charge to no more than 80 percent
- Use Level 2 charging when possible
- Park in a garage to maintain optimal battery temperatures

Lithium-ion batteries operate most efficiently between 20 and 80 percent capacity. Many drivers use far less than their full battery range during daily commutes, making routine charging to 80 percent both practical and beneficial. While charging to 100 percent is not harmful, it is best reserved for long-distance travel.

BATTERY MANUFACTURING

A 2023 report by the Environmental Defense Fund and WSP highlighted a dramatic increase in U.S. battery manufacturing capacity starting in 2021. That year, domestic manufacturing could supply batteries for about 250,000 passenger vehicles annually. By 2027, capacity is projected to support production for 12 million vehicles per year.

BATTERY RECYCLING AND SECOND LIFE

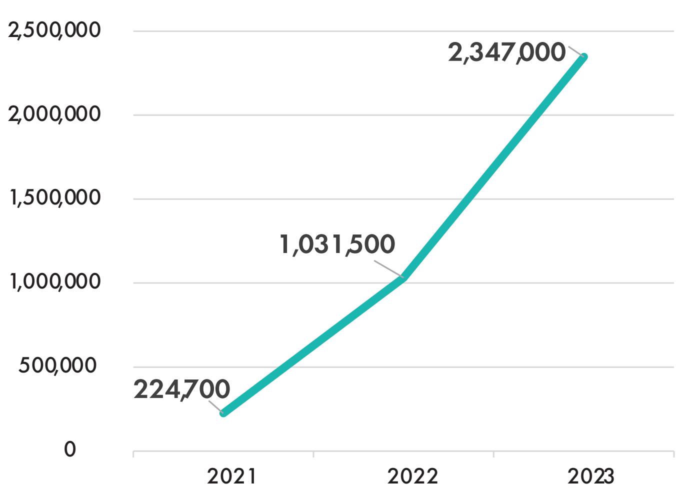
The EV battery recycling industry remains in its early stages, largely because most EVs on the road today have not yet reached end-of-life. Existing facilities primarily process manufacturing scrap rather than used batteries.

A 2023 estimate by the International Council on Clean Transportation found that current and planned recycling capacity will be sufficient to handle end-of-life BEV and PHEV battery materials into the 2040s.[14]

The 2024 Texas Department of Transportation (TxDOT) National Electric Vehicle Infrastructure (NEVI) plan identified 34 operational or planned battery recycling facilities in North America. Recycling batteries after their useful life in vehicles will be critical for reducing lifecycle emissions and improving cost-effectiveness of EVs. While significant portions of battery materials can be recovered, the complexity and cost of battery recycling remain barriers to rapid expansion.

Second-life applications offer an alternative to recycling. After their automotive life, EV batteries often retain up to 80 percent of their storage capacity, making them a suitable candidate for stationary energy storage — such as enhancing building resiliency for buildings.

Figure 8: EV Battery Manufacturing Capacity in the United States



Source: Environmental Defense Fund

FIRES

Though comparisons are challenging due to the relatively smaller EV population, several studies suggest that EVs catch fire less frequently than ICE vehicles.

According to National Transportation Safety Board data:

- EVs: 25.1 fires per 100,000 vehicles sold
- ICS vehicles: 1,530 fires per 100,000 vehicles sold[15]

Tesla reports approximately one fire (including arson and structural fires) for every 210 million miles traveled compared to a national average of one fire per 19 million miles, according to the National Fire Protection Association.[16]

However, when EVs do catch fire, they often take longer to extinguish than ICE fires. This is often due to thermal runaway, a chain reaction triggered when a high-voltage battery is damaged and the remaining energy causes the battery to begin self-heating. These fires can reach temperatures of 3,000 to 4,000 degrees Fahrenheit,[17] compared to about 1,500 degrees Fahrenheit for ICE fires.

EV fire response is an emerging topic of research and practice, with training and guidance available from organizations such as:

- The National Fire Protection Association
- The U.S. Fire Administration
- The International Association of Fire Chiefs

PLUG-IN HYBRID ELECTRIC VEHICLES

PHEVs combine the technology of ICE vehicles and BEVs, allowing them to run on both gasoline and electricity.

PHEVs are equipped with both an electric motor and an internal combustion engine. Their battery packs are smaller than those in full electric vehicles, offering up to approximately 60 miles of electric-only range. The fuel tank is also slightly smaller than that of a traditional ICE vehicle, typically holding around 12 to 15 gallons.

When the battery is depleted — or during rapid accelerations — the ICE automatically activates to power the vehicle. The transition is seamless, and most passengers are unlikely to notice the switch between power sources.

PHEVs charge similarly to full electric vehicles. Many users charge at their residence using Level 1 (standard, 120 V) outlets. It is generally the best option for those who drive 30 to 40 miles per day and have access to home parking during off-use hours.

Level 2 charging, which is faster than Level 1, is commonly found at public facilities and workplaces. It requires a 240 V circuit — the same used for large home appliances, such as clothes dryers or electric ranges — and modest installation costs, making it a popular upgrade for home use.

Due to their smaller batteries, PHEVs are generally not compatible with Level 3 (DCFC) stations, which are designed for vehicles with larger battery capacities.

In addition to external charging, PHEVs can also recapture energy through regenerative braking, similar to fully electric vehicles.

Because PHEVs can also fuel with gasoline, they make use of the well-established nationwide network of gas stations. This significantly reduces, or even eliminates, the "range anxiety" that can deter some drivers from choosing a fully electric vehicle.

As of October 2024, J.D. Power reported 39 PHEV models available, compared to 60 fully electric models.[18] Despite this availability, PHEV sales and consumer interest have lagged behind BEVs. In June 2024, PHEVs accounted for roughly 2 percent of new vehicle sales, while BEVs made up approximately 7 percent.

Because of their dual powertrains, PHEVs require similar scheduled maintenance to conventional gasoline vehicles. On a cost-per-mile basis, maintenance for ICE vehicles averages \$0.10, for PHEVs \$0.09, and for BEVs \$0.06.[19] BEVs require less scheduled maintenance largely due to fewer moving parts and fewer fluids, such as engine oil.

FUEL CELL ELECTRIC VEHICLES

FCEVs use electricity to power an electric motor, much like BEVs. However, instead of storing electricity in batteries charged from external electricity sources, FCEVs generate electricity on board using pure hydrogen gas (H_2).

FCEV users refuel their vehicles using a fuel pump — technology familiar to those who have fueled ICE vehicles. Refueling takes approximately 5 to 10 minutes depending on the size of the vehicle's hydrogen tank. Hydrogen is stored in carbon-fiber, high-pressure tanks engineered to withstand high-speed crashes.[20]

Electricity is generated on board through a chemical reaction in a fuel cell stack, where hydrogen combines with oxygen from the air. This reaction produces electricity to power the electric motor. The only by-product of this process is water vapor, which is emitted through the tailpipe. While this is technically an emission, it is not harmful like those from ICE vehicles.

As with BEVs and PHEVs, the overall environmental impact of FCEVs depends significantly on how hydrogen fuel is produced. Several methods are used, each with distinct carbon emissions[21] and classified by color codes:

- Black/Brown Hydrogen: Produced through coal gasification; this is the most carbon-intensive method.
- Gray Hydrogen: The most common form, accounting for about 95 percent of global hydrogen use. It is produced by steam methane reforming, which emits significant CO2.
- Blue Hydrogen: Similar to gray and brown, but with carbon capture and storage or reuse applied to reduce net emission.
- Green Hydrogen: Produced exclusively with renewable energy sources, such as wind or solar, with no CO2 emissions.

As of fall 2025, light-duty FCEVs are only available and operable in a few states. California and Hawaii are currently the only markets with publicly accessible hydrogen fueling stations — 57 stations in California and 1 in Hawaii.

Despite limited availability, significant public and private investment is being directed toward the hydrogen sector. Trends in this evolving technology are explored further in this report.

NATIONAL AND STATE ZERO EMISSION VEHICLE TRENDS

Battery Electric Vehicles

LIGHT-DUTY VEHICLES

Light-duty vehicles (LDVs) refer to smaller-sized vehicles primarily designed for passenger and small cargo transport. This category includes sedans, sport utility vehicles (SUVs), and light pickup trucks.

Modern battery-electric vehicles (BEVs) have gained momentum since the early 2010s, with significant acceleration beginning in 2016. From 2016 to 2023, BEV registrations in the U.S. grew by an average of 42.7 percent annually, with the largest increase (67.9 percent) occurring between 2021 and 2022.

- In 2021, BEVs accounted for 0.5 percent of registered LDVs — 1,454,400.
- By 2022, this rose to 0.9 percent (2,442,300 vehicles).[22]
- In 2023, BEV registrations reached 3,299,502 vehicles.

New vehicle sales provide further insight into BEV adoption trends. Sales of BEVs and hybrids rose gradually from 2014 with a sharp uptick starting in 2020. In 2023, BEVs comprised approximately 7 percent of all LDV sales. However, market penetration varies across segments. For example, in the luxury vehicle segment, BEVs made up nearly one-third of all sales.[23]

During model year 2024, 33 new BEV models were introduced, bringing the total number of available BEV LDV models to 128.[24] While BEVs in 2015 were almost exclusively sedans or wagons, today the category includes a wide variety of sport utility vehicles (SUVs), trucks, and pickups.[25]

MEDIUM- AND HEAVY-DUTY VEHICLES

Though medium- and heavy-duty vehicles (MHD) represent less than 10 percent of vehicles on the road, they account for more than 60 percent of nitrogen oxide (NOx) and particulate matter (PM) tailpipe emissions.[26] Electrifying this segment offers promising emissions reductions but faces unique challenges due to the diversity and operational demands of these vehicles, which include:

- Heavy-duty pickups
- Work trucks
- Delivery vans
- Tractor trailers
- Dump trucks
- Refuse haulers
- Transit buses

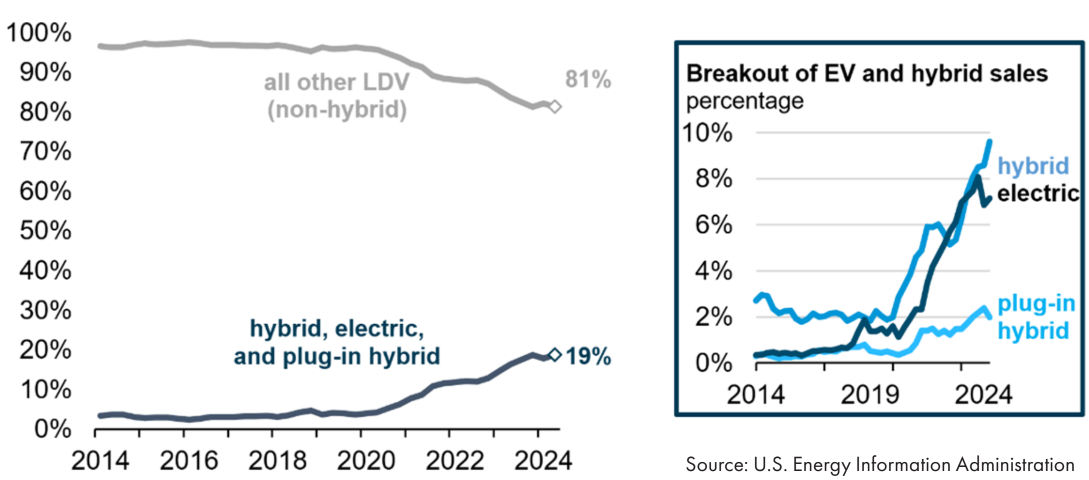
BEV transit and school buses were the earliest to mature in the BEV MHD market. As of 2020, every diesel bus manufacturer in North America also offered BEV models.

Reductions in tailpipe emissions from this vehicle segment are significant, but various hurdles complicate BEV adoption.

The MHD BEV segment is far less homogenous than the LDV segment requiring careful evaluation of appropriate use cases MHD BEVs are used across a wide range of applications and vehicle types.

The BEV MHD market is growing as more major manufacturers expand their offerings. As recently as 2020, only transit and school buses were considered "mature" BEV segments, with multiple manufacturers offering commercial models.[27]

Figure 9: Quarterly U.S. Light-Duty Vehicle Sales by Powertrain (Jan 2014 to June 2024)



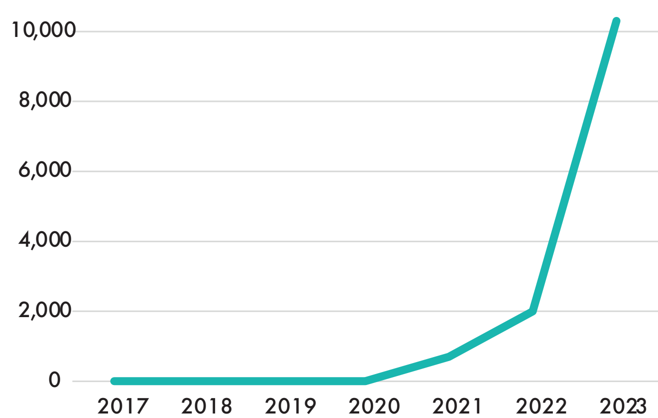
Source: U.S. Energy Information Administration

MHD vehicles are largely owned and operated for commercial or public use. These vehicles often reside in a depot or home bases with on-site fueling. Depot charging stations typically charge vehicles overnight and support local or regional trips.

Long-haul trucks may be the last to transition fully to BEVs due to the need for widespread public charging infrastructure. Even with a fully developed nationwide charging network, BEVs may not be suitable for long-haul applications due to increased drive time associated with charging and additional battery payload.

As of 2021, fewer than 1 percent of all MHD vehicles were hybrid or battery electric.[28] However, BEV deployments in Classes 2a-8 have increased dramatically. In 2023, 10,265 BEV trucks were deployed — up from 2,000 in 2022 and just 80 in 2021.[29] This fivefold increase from 2022 to 2023 suggests rapid growth as orders are fulfilled.

Figure 10: Medium- and Heavy-Duty Battery Electric Vehicle Deployments by Year



Source: Environmental Defense Fund

Commitments and investment from large companies such as Amazon, UPS, and FedEx have spurred this increase in BEV truck deployment. Notably, a years-long lag can exist between vehicle order to deployment.

As of late 2023, the Environmental Defense Fund reported that BEV MHD vehicle orders totaled 275,000 — 100,000 of which came from Amazon. Amazon's Rivian truck order is expected to be fully delivered by 2030.[30]

DECLINING COSTS

As BEV popularity grows, costs, including both purchase price and total cost of ownership, are declining. Manufacturing costs continue to fall as more companies shift more production to BEVs. Increased competition and integration into existing production lines are further driving down prices.

From May 2022 to May 2024, average BEV transaction prices dropped 15 percent from $65,000 to $56,600.[31] These prices exclude any federal, state, or local incentives. In comparison, ICE vehicles averaged around $48,000 during the same period.

A major contributor to declining BEV prices is the drop in battery costs. Advances in technology, increased use of recycled materials, and greater availability of key metals have also contributed. Battery prices are forecast to fall 40 percent to $99 per kilowatt-hour (kWh) of storage capacity by 2025, from 2022 prices.[32] This is a major drop from over $1,100/kWh in 2010.[33]

Several lower-cost BEV models have recently entered the U.S. market. Car and Driver lists seven 2025 models under $40,000, including the Subaru Solterra, Hyundai Ioniq 6, Ford Mustang Mach-E, Toyota bZ4x, Chevrolet Equinox EV, and Hyundai Kona Electric. The least expensive is the Nissan Leaf at $29,280. With increased price diversity, BEVs are becoming more accessible to a wider range of consumers.

Environmental Defense Fund researchers, in their 2021 report on MHD vehicles, observed that MHD battery prices lag about five years behind LDV battery cost trends. Though improvements in technology may shorten this gap, MHD battery costs are expected to fall below $90/kWh by 2030 — a 76 percent reduction from 2021.[34]

FEDERAL INVESTMENT IN ZEVS

Hundreds of millions of dollars are being invested in the EV sector through the Infrastructure Investment and Jobs Act (IIJA) of 2021 and the Inflation Reduction Act (IRA) of 2022. This funding supports purchase incentives, charging and fueling infrastructure, manufacturing and supply chain growth, and continuing electrification of the federal fleet.

Together, the IIJA and IRA include approximately $19.25 billion for ZEV charging infrastructure.

The National Electric Vehicle Infrastructure program (NEVI) established under the IIJA allocates $7.5 billion for non-proprietary, publicly accessible EV charging stations that accept open-access payment methods. A key NEVI goal is to fully build out direct current fast charging (DCFC) along designated Alternative Fuel Corridors (AFCs).

AFCs are national highway corridors with regularly spaced fueling stations — including electric, hydrogen, propane, and natural gas. A state's network is considered "fully built out" when NEVI-complaint DCFC stations are spaced no more than 50 miles apart and are located within 1 mile of an AFC exit. Once this designation is achieved, states may use NEVI funding for EV charging infrastructure elsewhere.

The Charging and Fueling Infrastructure (CFI) discretionary grant program provides $2.5 billion for publicly accessible charging and alternative fueling infrastructure. It includes two funding grant tracks:

1. Community Program: Supports infrastructure on public roads, at schools, in parking lots, and near multifamily housing.
2. Corridor Program: Funds infrastructure along designated AFCs for electricity, hydrogen, propane, and natural gas.

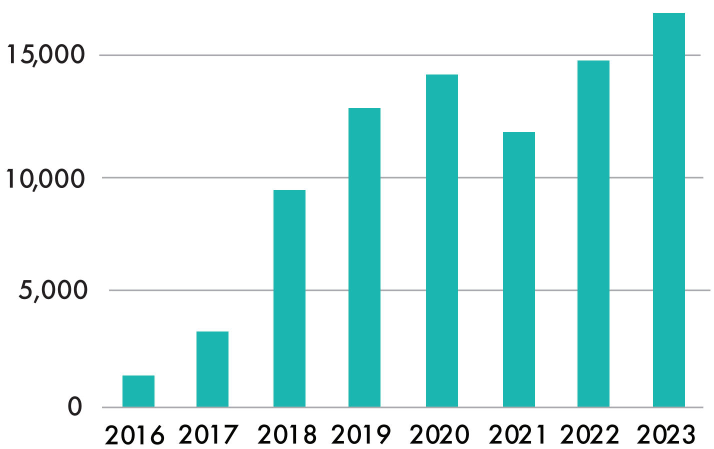
Fuel Cell Electric Vehicle Trends

LIGHT-DUTY VEHICLES

FCEV adoption in light-duty vehicles began in the mid-2010s with three models: the Honda's Clarity Fuel Cell, Hyundai's Nexo SUV, and the Toyota Mirai. Combined registrations total approximately 16,000 vehicles — around 0.5 percent of all alternative-fuel vehicle registrations.

Honda has since ended production of the Clarity but announced the upcoming lease-only comfortable runabout vehicle (CR-V) e:FCEV model for California. Due to limited adoption and an less developed fueling network, LDV FCEV trends remain difficult to project.

Figure 11: Light-Duty Registrations 2016-2023 (USA)



Source: U.S. Department of Energy Alternative Fuels Data Center

MEDIUM– AND HEAVY–DUTY VEHICLES

Despite BEV advancements, FCEVs offer better advantages in range and refueling time. The heavier weight and reduced payload capacity of BEVs are non-issues for FCEVs. However, MHD FCEVs adoption remains limited.

Medium-duty vehicles (e.g., Class 3-6 work trucks) operate in rugged conditions, with high payload demands and, in some cases, near continuous uptime. Ford has reported that while the total cost of ownership for BEV medium-duty trucks remains prohibitive for many, FCEVs are cheaper to operate than diesel or gas trucks.[35]

General Motors is developing a fleet of FCEV medium-duty trucks under a $65 million contract with the U.S. Department of Energy's SuperTruck program. The trucks will mirror the design of the familiar Chevy Silverado 5500.

Heavy-duty FCEV trucks are only now reaching commercial deployment.[36] Currently, just six refueling stations serve MHD vehicles — three of which are dedicated to transit bus fleets.

Transit agencies are further along in FCEV adoption, though deployments remain small, and largely remain in pilot phases. California operates 66 FCEV buses, Ohio's Stark Area Regional Transit Authority runs 18, and Pennsylvania launched 10 pilot buses in fall 2024.[37]

FEDERAL INVESTMENT IN FCEVS

Federal investment in hydrogen mobility focuses on launching broad hydrogen markets rather than just for transportation use. The IIJA, also known as the Bipartisan Infrastructure Law, allocated $7 billion to establish seven regional clean hydrogen hubs, to accelerate the domestic market for low-cost, clean hydrogen . Including public and private investment, these hubs are expected to catalyze nearly $50 billion economic activity.

These hubs are:

- Appalachian Hydrogen Hub
- California Hydrogen Hub
- Gulf Coast Hydrogen Hub
- Heartland Hydrogen Hub
- Mid-Atlantic Hydrogen Hub
- Midwest hydrogen Hub
- Pacific Northwest Hydrogen Hub

An additional $2 billion supports the Clean Hydrogen Electrolysis Program and research in hydrogen manufacturing and recycling.

State Trends

BEV TRENDS

Texas had the third-highest number of BEVs in the country as of 2023[38] — the most recent year with complete national data — with more than 230,000 light-duty registrations. It trailed California (approximately 1,256,00) and Florida (approximately 255,000). More recent monthly data from Dallas-Fort Worth Clean Cities shows that, as of January 2025, BEV registrations in Texas had risen to 349,000, representing a 36.6 percent increase from January 2024.

The Houston-Galveston metropolitan planning area saw the highest BEV registration growth in the state, with a 39.5 percent year-over-year increase. Registrations in that region account for 24.9 percent of all Texas registrations.

The Texas Department of Transportation's (TxDOT) NEVI plan offers two projections of when the state may reach the one million electric vehicles on the road: the Electric Reliability Council of Texas projects 2028, while the Texas Department of Motor Vehicles projects 2031.

A 2023 survey conducted by the University of Houston and Texas Southern University found that 45.9 percent of respondents said a "lack of charging stations near me" as a key reason for not purchasing a BEV. Concerns about public charger availability and range anxiety remain key barriers to BEV adoption.

However, Texas' public charging network is growing quickly, fueled by both private investment and NEVI funding. As of the second quarter of 2024, Texas ranked second only to California, accounting for 6.6 percent of all new DCFC ports installed nationwide.

Texas received the largest allocation of NEVI funding, approximately $400 million, followed by California, which received around $380 million. TxDOT's NEVI plan outlines a phased approach to develop the public charging capacity needed to support one million vehicles within approximately three to five years.

- Phase 1 calls for the installation of about 56 DCFC chargers along interstate highways to complete the AFDC corridor.
- Phase 2 proposes the development of more than 1,000 DCFC chargers near county seats and in metropolitan areas across the state.

HYDROGEN AND INDUSTRIAL PRESENCE IN THE GREATER HOUSTON REGION

The Houston area and the broader Gulf Coast region are well-positioned to lead globally in hydrogen production and distribution. Known as the energy capital of the world, the region is home to 4,500 energy-related firms and accounts for one-third of the nation's oil and gas jobs.

The area already hosts more than 1,000 miles of hydrogen pipelines and 48 hydrogen production plants.[39] Texas also has some of the nation's densest concentrations of skilled labor in fields such as architecture and engineering, construction, equipment installation.

The region's extensive industrial activity provides a robust and growing supply of potential fuel sources for emerging vehicle technologies — chiefly FCEVs.

COUNTY EV VEHICLE REGISTRATIONS AND INFRASTRUCTURE PROFILES

(Data as of May 2025)

COUNTY-LEVEL PROFILES

Each of the eight counties in the Houston-Galveston metropolitan planning area is listed below with electric vehicle (EV) registration data from the past five years. Concentrated pockets of adoption within each county are highlighted, along with the annual percentage increase in registrations.

Public charging infrastructure is also detailed, including the total stations, charging ports, categorized as Level 2 and Level 3 direct current fast chargers (DCFC). For comparison, the ratio of vehicles to stations and ports are provided.

A useful metric for evaluating access to public charging is the EV-to-port ratio. This figure represents how many vehicles each port must support based on the basic assumption that any EV could potentially use any available port.

According to HERE Technologies, a leading data and technology company, and SBD Automotive, a global automotive research firm, an optimal and mature EV charging market is indicated by a ratio of 10-to-15 BEVs per charging port.[40]

County-Level Comparison of Share of Regional EVs and Regional Ports (Level 2 + Level 3)*

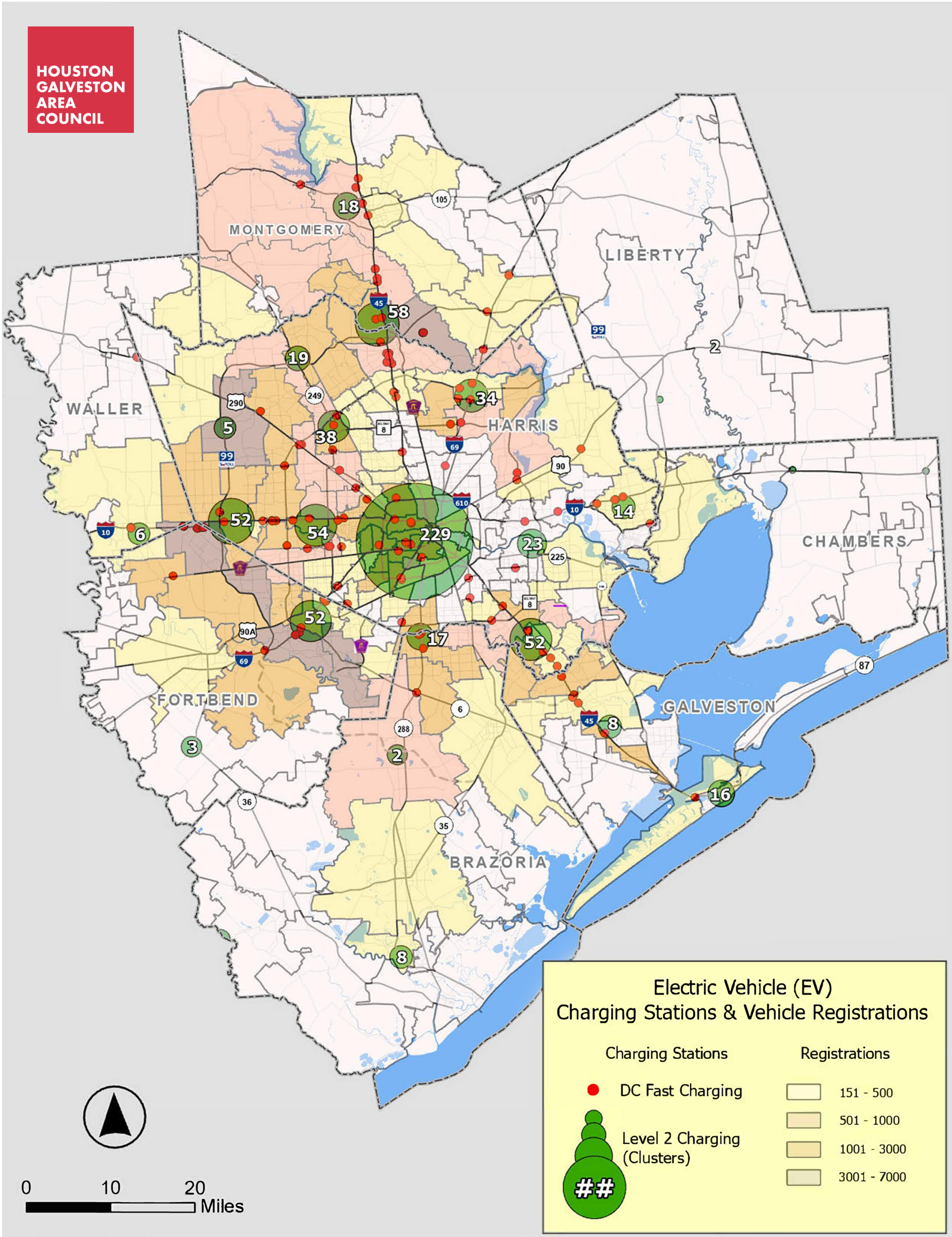
County	Percentage Share of Regional EVs	Percentage Share of Regional Ports (Level 2 + Level 3)	Difference (Percentage)
Harris	58.6%	73.2%	+ 14.6%
Fort Bend	21.6%	10.3%	- 11.3%
Montgomery	9.9%	7.0%	- 2.9%
Brazoria	4.9%	2.4%	- 2.5%
Galveston	4.0%	4.9%	+ 0.9%
Waller	0.5%	1.8%	+ 1.3%
Chambers	0.3%	0.4%	+ 0.01%
Liberty	0.2%	0.1%	- 0.2%
TOTAL	100.0%	100.0%	

Summary Table of County EV Registrations and Infrastructure Distribution*

County	Number of EV Registrations	Percentage Annual Increase (2019-2025)*	Number of Level 2 EV Ports	Number of Level 3 Ports	EV Public Charging Stations
Harris	51,261	56.3%	38	87	87
Fort Bend	18,898	67.8%	125	154	255
Montgomery	8.661	62.1%	68	147	115
Brazoria	4,290	60.2%	116	153	187
Galveston	3,470	60.1%	36	108	85
Waller	430	120.5%	39	12	27
Chambers	263	120.7%	26	N/A	52.6
Liberty	212	83.5%	106	N/A	212

* The 2025 data is incomplete, with data included through May 2025.

Figure 12: Map of Electrical Vehicle Charging Stations and Vehicle Registrations



HARRIS COUNTY

Vehicle Registrations

Harris County has 51,261 registered EVs, including both BEVs and plug-in hybrid electric vehicles (PHEVs). BEVs and PHEVs account for 83.4 percent and 16.6 percent of the total, respectively.

From 2019 to December 2024, EV registrations in Harris County increased by an average of 53.9 percent annually. Even the slowest growth year during this period saw a 45.1 percent increase EV stock. The 2025 data is incomplete, with data through May. Harris County accounts for 58.6 percent of electric vehicles registered in the metropolitan planning area.

Year	EV Registrations	Percent Change
2019	3,595	(baseline year)
2020	6,425	+78.7%
2021	9,320	+45.1%
2022	15,993	+71.6%
2023	23,311	+45.8%
2024	34,766	+49.1%
2025	51,261	+47.4 %

EV registrations are not evenly distributed across the county. In fact, there are major geographic discrepancies; The western half accounts for roughly 75 percent of all the registered EVs.

The countywide EV rate is 2.7 per 100 households, several ZIP codes on the west side far exceed that average.

The top five ZIP codes in Harris County are:

- 77433 (Cypress): 8.1 per 100 households
- 77007 (Washington Ave): 7.2
- 77008 (Greater Heights): 6.9
- 77493 (Katy): 7.5
- 77005 (University Place): 11.9

Income date from 2023 shows the percentage of households earning $50,000 to $100,000, in those ZIP codes is 85.5, 88.8, 82.3, 79.3, and 87.7 percent, respectively.

Charging Infrastructure

There are 588 total EV charging stations in Harris County, 592 DCFC ports and 1,356 Level 2 ports. A charging station refers to a physical location that has one or more charging ports. A charging port provides power to one vehicle at a time.

	Total Charging Stations by Type	EV to Charging Port Ratio
DCFC Ports	592	87
Level 2 Ports	1,356	37
Charging Stations	588	87

FORT BEND COUNTY

Vehicle Registrations

Fort Bend County has 18,898 registered BEVs and PHEVs, with BEVs making up 89.1 percent and PHEVs 10.9 percent of the total.

From 2019 to December 2024, EV registrations increased by an average of 65.4 percent annually. The slowest year still saw a 50.7 percent increase. Data for 2025 is incomplete, with data available through May. Fort Bend County accounts for 21.6 percent of EVs registered in the Houston-Galveston metropolitan planning area.

Year	EV Registrations	Percent Change
2019	871	(baseline year)
2020	1,717	+97.1%
2021	2,587	+50.7%
2022	4,723	+82.6%
2023	7,649	+61.9%
2024	2,417	+62.3%
2025*	18,898	+52.2%

ZIP codes 77479 (Sugar Land), 77494 (Katy), and 77459 (Missouri City) account for 55 percent of all EVs registered in the county. Income data from 2023 show the percentage of households earning $50,000 to $100,000 in these ZIP codes is 87.8, 84.6, and 85.8 percent, respectively.

The countywide EV rate is 6.4 per 100 households, but dense ZIP code pockets — especially in the west — far exceed that number. The Sugar Land ZIP code, 77479, doubles the county average with 12.8 EVs per 100 households.

Charging Infrastructure

There are 74 total EV charging stations in Fort Bend County, with 122 DCFC ports and 151 Level 2 ports. A charging station refers to the physical location that has one or more charging ports. A charging port provides power to one vehicle at a time.

	Total Charging Stations by Type	EV to Charging Port Ratio
DCFC Ports	122	154
Level 2 Ports	151	125
Charging Stations	74	255

MONTGOMERY COUNTY

Vehicle Registrations

Montgomery County has 8,661 registered BEVs and PHEVs, with BEVs comprising 78 percent and PHEVs 11 percent.

From 2019 to December 2024, EV registrations rose by an average of 59.8 percent per year, with the slowest year still seeing 48.4 percent growth. The 2025 data is incomplete, with information available through May 2025. Montgomery County accounts for 9.9 percent of registered in the metropolitan planning area.

Year	EV Registrations	Percent Change
2019	488	(baseline year)
2020	891	+82.6%
2021	1,427	+60.2%
2022	2,605	+82.6%
2023	3,885	+49.1%
2024	5,666	+45.4%
2025	8,661	+52.3%

The countywide EV rate is 3.5 per 100 households is 3.5. Several South Montgomery County ZIP codes exceed that rate:

- 77386 (Spring): 7.8
- 77382 (The Woodlands): 6.6
- 77381 (The Woodlands): 5.4

In 2023, the share of households in these ZIP codes earning \$50,000 to \$100,000 was 85.4, 88.5, and 79.2 percent, respectively.

Charging Infrastructure

Montgomery County has 75 charging stations, 59 DCFC ports and 127 Level 2 ports. A charging station refers to the physical location that has one or more charging ports. A charging port provides power to one vehicle at a time.

	Total Charging Stations by Type	EV to Charging Port Ratio
DCFC Ports	59	147
Level 2 Ports	127	68
Charging Stations	75	115

BRAZORIA COUNTY

Vehicle Registrations

Brazoria County has 4,290 registered BEVs and PHEVs, with BEV making up 85.4 percent and PHEVs 14.6 percent.

From 2019 to December 2024, registrations increased by an average of 57.6 percent annually. The lowest year still saw a 49.8 percent increase. The 2025 data is current through May. Brazoria County accounts for 4.9 percent of EVs in the metropolitan planning area.

Year	EV Registrations	Percent Change
2019	258	(baseline year)
2020	466	+80.6%
2021	702	+50.6%
2022	1,218	+73.5%
2023	1,888	+55.0%
2024	2,830	+49.9%
2025	4,290	+51.6%

There is significant concentration in the ZIP codes near Pearland and Manvel — 77584, 77578, 77583, and 77581 — with more than 40 percent of the county's EVs registered in 77584. Income data from 2023 shows that 82.9, 86.9, 85.4, and 82.9 percent of households in these ZIP codes earn \$50,000 to \$100,000.

Charging Infrastructure

Brazoria County has 23 charging stations, with 28 DCFC ports and 37 Level 2 ports. A charging station refers to the physical location that has one or more charging ports. A charging port provides power to one vehicle at a time.

	Total Charging Stations by Type	EV to Charging Port Ratio
DCFC Ports	28	153
Level 2 Ports	37	115
Charging Stations	23	186

GALVESTON COUNTY

Vehicle Registrations

Galveston County has 3,470 registered BEVs and PHEVs, with BEVs accounting for 83.8 percent and PHEVs 16.2 percent.

From 2019 to December 2024, registrations increased by an average of 57.7 percent per year. The slowest growth year still achieved a 41.1 percent increase. The 2025 data is available through May. Galveston County accounts for 3.9 percent of electric vehicles registered in the metropolitan planning area.

Year	EV Registrations	Percent Change
2019	211	(baseline year)
2020	374	+77.3%
2021	564	+50.8%
2022	1,018	+80.5%
2023	1,437	+41.2%
2024	2,288	+59.2%
2025	3,470	+51.6%

ZIP codes 77573 (League City) and 77546 (Friendswood) account for more than half of the county's EVs. Income data from 2023 show that 84.1 percent and 81.6 percent of households in these ZIP codes earn $50,000 to $100,000.

Charging Infrastructure

There are 41 EV charging stations in Galveston County, with 32 DCFC ports and 97 Level 2 ports. A charging station refers to the physical location that has one or more charging ports. A charging port provides power to one vehicle at a time.

	Total Charging Stations by Type	EV to Charging Port Ratio
DCFC Ports	32	108
Level 2 Ports	97	36
Charging Stations	41	85

WALLER COUNTY

Vehicle Registrations

Waller County has 430 registered BEVs and PHEVs, with BEVs making up 82.8 percent and PHEVs 17.2 percent.

From 2019 to December 2024, registrations rose by an average of 114.4 percent annually. Even the slowest growth year saw a 43.8 percent increase. The 2025 data is incomplete, with data included through May 2025. Waller County accounts for 0.5 percent of regional EV registrations.

Year	EV Registrations	Percent Change
2019	5	(baseline year)
2020	16	+220.0%
2021	23	+43.8%
2022	73	+217.4%
2023	128	+75.3%
2024	233	+82.0%
2025	345	+84.5%

A total of 68.55 percent of Waller County EVs are registered in ZIP code 77423 (Brookshire).

Income data from 2023 shows that 75.6 percent of households in ZIP code 77423 earn $50,000 to $100,000.

Charging Infrastructure

There are 15 charging stations in Waller County, with 37 DCFC ports and 11 Level 2 ports. A charging station refers to the physical location that has one or more charging ports. A charging port provides power to one vehicle at a time.

	Total Charging Stations by Type	EV to Charging Port Ratio
DCFC Ports	37	12
Level 2 Ports	11	39
Charging Stations	15	29

CHAMBERS COUNTY

Vehicle Registrations

Chambers County has 263 registered BEVs and PHEVs, with BEVs accounting for 82.9 percent and PHEVs 71.1 percent.

From 2019 to December 2024, EV registrations rose by an average of 118.2 percent per year. Even the slowest year saw 70.2 percent growth. Chambers County accounts for 0.3 percent of EVs registered in the metropolitan planning area.

Year	EV Registrations	Percent Change
2019	4	(baseline year)
2020	19	+375.0%
2021	35	+84.2%
2022	67	+91.4%
2023	114	+70.2%
2024	176	+54.4%
2025	263	+49.4%

A total of 84.55 percent of EVs are registered in ZIP code 77523 (Baytown), where 82 percent of households earn $50,000 to $100,000.

Charging Infrastructure

Chambers County has five charging stations, with no DCFC ports and 10 Level 2 ports. A charging station refers to the physical location that has one or more charging ports. A charging port provides power to one vehicle at a time.

	Total Charging Stations by Type	EV to Charging Port Ratio
DCFC Ports	0	N/A
Level 2 Ports	10	26
Charging Stations	5	52

LIBERTY COUNTY

Vehicle Registrations

Liberty County 212 registered BEVs and PHEVs, with BEVs making up 77.8 percent and PHEVs 22.2 percent.

From 2019 to December 2024, registrations grew by an average of 79.9 percent annually, with even the slowest year seeing a 38.5 percent increase. Liberty County accounts for 0.2 percent of EVs registered in the metropolitan planning area.

Year	EV Registrations	Percent Change
2019	6	(baseline year)
2020	12	+100 .0%
2021	25	+108.3%
2022	52	+108.0%
2023	78	+50.0%
2024	108	+38.5%
2025	212	+96.3%

More than 80 percent of EVs in the county are registered in ZIP codes 77535 (Dayton) and 77327 (Cleveland), both of which are located in western Liberty County. Income data for 2023 shows that 72.7 percent and 58.2 percent of households in these ZIP codes earn $50,000 to $100,000.

Charging Infrastructure

Liberty County has one charging station, with no DCFC ports and two Level 2 ports. A charging station refers to the physical location that has one or more charging ports. A charging port provides power to one vehicle at a time.

	Total Charging Stations by Type	EV to Charging Port Ratio
DCFC Ports	0	N/A
Level 2 Ports	2	106
Charging Stations	1	212

RECOMMENDED NEXT STEPS

To prepare the Houston-Galveston metropolitan planning area for the increased zero-emission vehicle (ZEV) adoption and to support current users, the Houston-Galveston Area Council (H-GAC) staff recommend four key actions:

1. Expand and streamline public charging infrastructure deployment

Prioritize ZEV infrastructure during transportation funding considerations, especially for municipal properties, park-and ride-locations, and areas near high-density and multi-family dwellings. Work with member organizations to address permitting challenges through standardized permitting guides.

Expanding the region's public charging and fueling network is critical to supporting ZEV growth. As shown in the county Infrastructure profiles, each county in the metropolitan planning area fall outside the optimal range of vehicles to electric charging station.

Public charging benefits the public broadly, especially those without access to home charging . By incorporating public charging infrastructure into future transportation project selection, the Transportation Policy Council can accelerate deployment and help reduce transportation-related emissions.

H-GAC staff should:

- Meet internally to determine reasonable changes to project scoring criteria (e.g., air quality or natural resources scoring)
- Review municipal permitting processes
- Engage stakeholders to identify use cases and needs for standardized permitting guides for ZEV infrastructure

2. Foster strategic partnerships through workforce development initiatives

Support infrastructure rollout while creating local job opportunities aligned with the growing ZEV industry.

ZEV adoption is driving significant shifts in workforce needs. A wide range of careers — from manufacturing to battery recycling to electrical installation, safety services, and data analytics — will be in greater demand.

Emerging technologies often lead to shifts in workforce needs. It is in the region's interest to thoughtfully plan for and develop the skills and talent necessary as ZEVs gain popularity and adoption. There is a tremendous breadth of jobs and career paths that do and will support the adoption of ZEVs, from manufacturing and assembly, battery recycling, electricians . By leveraging H-GAC's existing initiatives, the region can position itself for economic growth and innovation.

H-GAC staff should:

- Identify ongoing workforce development initiatives related to ZEVs (e.g., university programs, trade schools, non-profits)
- Convene program leaders to explore opportunities for collaboration and expansion
- Leverage existing analyses, such as the Climate Pollution Reduction Grant workforce study, to avoid duplication

3. Develop and distribute public education materials and experiences

Using existing (e.g., Clean Cities Coalition, HGACBuy) and expanded outreach networks to provide well-vetted information to support informed ZEV decision-making.

Emerging technologies require targeted education to build understanding and trust. Studies show that increased exposure to ZEVs lead to greater openness to adoption. effort. Education must meet people where they are to be most effective. By providing factual tools and information, H-GAC can cut through the noise and best support decision making at every level. These can plan a key role by delivering factual, accessible materials ad offering hands-on experiences.

H-GAC staff should:

- Identify gaps in available public-facing educational material
- Develop a range of resources (e.g., brochures, one-pagers, presentations) tailored to different audiences, including the general public, fleet operators, and elected officials
- Plan and execute in-person ZEV demonstrations such as Ride and Drive events

4. Complete a comprehensive Regional ZEV Infrastructure Plan

Develop a forward-looking plan that includes:

- Advanced vehicle forecasting
- Equitable public charging distribution
- Strategies for multi-unit dwellings
- A survey of ZEV adoption barriers and accelerators
- Grid readiness analysis of grid readiness and more

ZEV adoption is accelerating across the metropolitan planning area, with annual BEV registration increases ranging from 55 percent to more than 120 percent in recent years. To support local decision-makers, a comprehensive plan is needed.

H-GAC staff should:

- Use findings from this study to develop an RFP from qualified consultants
- Oversee and manage the development of the Regional ZEV Infrastructure Plan

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