INTERSTATE HIGHWAY 45 CORRIDOR

Zero Emission Vehicle Plan

From Dallas to Houston on Zero Emissions

What is NCTCOG?

The **North Central Texas Council of Governments** (NCTCOG) is a voluntary association of, by, and for **local governments** within the 16-county North Central Texas Region. The agency was established by state enabling legislation in 1966 to assist local governments in **planning** for common needs, **cooperating** for mutual benefit, and **coordinating** for sound regional development. Its purpose is to strengthen both the individual and collective power of local governments, and to help them recognize regional opportunities, resolve regional problems, eliminate unnecessary duplication, and make joint regional decisions – as well as to develop the means to implement those decisions.

North Central Texas is a 16-county **metropolitan region** centered around Dallas and Fort Worth. The region has a population of more than 7 million (which is larger than 38 states), and an area of approximately 12,800 square miles (which is larger than nine states). NCTCOG has 229 member governments, including all 16 counties, 167 cities, 19 independent school districts, and 27 special districts.

NCTCOG’s **structure** is relatively simple. An elected or appointed public official from each member government makes up the **General Assembly** which annually elects NCTCOG’s **Executive Board**. The Executive Board is composed of 17 locally elected officials and one ex-officio non-voting member of the legislature. The Executive Board is the policy-making body for all activities undertaken by NCTCOG, including program activities and decisions, regional plans, and fiscal and budgetary policies. The Board is supported by policy development, technical advisory and study **committees** – and a professional staff led by **R. Michael Eastland**, Executive Director.

NCTCOG's offices are located in Arlington in the Centerpoint Two Building at 616 Six Flags Drive (approximately one-half mile south of the main entrance to Six Flags Over Texas).

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NCTCOG's Department of Transportation

Since 1974 NCTCOG has served as the Metropolitan Planning Organization (MPO) for transportation for the Dallas-Fort Worth area. NCTCOG's Department of Transportation is responsible for the regional planning process for all modes of transportation. The department provides technical support and staff assistance to the Regional Transportation Council and its technical committees, which compose the MPO policy-making structure. In addition, the department provides technical assistance to the local governments of North Central Texas in planning, coordinating, and implementing transportation decisions.

Prepared in cooperation with the Federal Highway Administration, US Department of Transportation, and the Texas Department of Transportation.

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H2 Ranch LLC – Michael Martinez

Houston-Galveston Clean Cities Coalition – Andrew J. DeCandis/Ben Finley

Kaizen Clean Energy – Robert P. Meaney

Oncor Electric Delivery – Randy M. Boys

Shell USA – Chris Angelides

Texas Hydrogen Alliance – David W. Raney

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Volta Charging – Gerald Mann

Letters of support from key stakeholders are included in Appendix 1 of this document.

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Introduction

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Introduction

The Interstate Highway 45 (IH 45) Corridor Zero-Emission Vehicle (ZEV) Plan was created to provide a planning framework for development and deployment of ZEV projects along IH 45, which connects the two largest Metropolitan Planning Organization areas in the state: the North Central Texas Council of Governments (NCTCOG) and the Houston-Galveston Area Council (H-GAC). These two regions also happen to contain the two largest, and longest-standing, ozone nonattainment areas in the State of Texas: the Dallas-Fort Worth (DFW) ozone nonattainment area lies within NCTCOG boundaries, and the Houston-Galveston-Brazoria (HGB) nonattainment area lies within H-GAC. In both nonattainment areas, a significant proportion of ozone-forming pollution is attributable to the on-road transportation sector, which comprises 38 percent and 25 percent of all ozone-forming nitrogen oxides pollution in the DFW and HGB nonattainment areas, respectively.[1] As a result, both NCTCOG and H-GAC invest substantial resources in transportation projects that reduce ozone-forming emissions. It is this connection between transportation and air quality that provides the context for the ZEV Plan.

In this plan, the term 'ZEV' includes both battery electric vehicles (BEVs) and hydrogen fuel cell electric vehicles (FCEVs), as both platforms are electric drive and produce zero tailpipe emissions. Both technologies hold promise in different segments of the transportation sector. However, the term ZEV does not necessarily encompass all hydrogen and electric vehicles. Hydrogen-fueled internal combustion engine vehicles are being introduced, but these produce tailpipe emissions and are outside the scope of the ZEV definition. Likewise, the definition of electric vehicles (EVs) can sometimes encompass hybrid electric vehicles and plug-in hybrid electric vehicles. Since these produce tailpipe emissions, they are also outside the scope of ZEV. Thus, when developing recommendations for hydrogen fueling and EV charging infrastructure, this plan does so from the perspective of providing fuel for FCEVs and BEVs.

Air quality and transportation issues in the NCTCOG and H-GAC regions are highly impactful to a large proportion of Texans. The July 1, 2021 Census population was 7,656,221 and 7,176,461 for the DFW and HGB nonattainment areas, respectively. Thus, over 14 million people live in ozone nonattainment counties across these two regions. Given a state population of 29,527,941 people, 50.2 percent of all Texans live in the nonattainment counties of these two regions (see **Exhibit 1**).[2]

Exhibit 1: Populations of the HGB and DFW Ozone Nonattainment Areas

County	Total
Brazoria County	379,689
Chambers County	48,865
Fort Bend County	858,527
Galveston County	355,062
Harris County	4,728,030
Liberty County	97,621
Montgomery County	648,886
Waller County	59,781

[1] Texas Commission on Environmental Quality Texas State Implementation Plan Revisions (March 2020), https://www.tceq.texas.gov/airquality/sip/sipplans.html#:~:text=A%20SIP%20revision%20is%20made,initially%20approved%20in%20May%201972

[2] US Census Quick Facts: County and Texas Population, Census, July 1, 2021, https://www.census.gov/quickfacts/fact/table/TX/POP010220, Accessed 6/22/2022

County	Total
Population of the HGB Ozone Nonattainment Area	7,176,461
County	**Total**
Collin County	1,109,462
Dallas County	2,586,050
Denton County	941,647
Ellis County	202,678
Johnson County	187,280
Kaufman County	157,768
Parker County	156,764
Rockwall County	116,381
Tarrant County	2,126,477
Wise County	71,714
Population of the DFW Ozone Nonattainment Area	7,656,221

Nonattainment designation means that the residents of these counties are exposed to levels of ozone that are higher than those deemed safe by the Environmental Protection Agency, and thus are at risk of negative health impacts – especially respiratory problems – because of ozone exposure. The potential for ZEV adoption to reduce pollution in and between these nonattainment areas is relevant to efforts to attain federal ozone standards, improve air quality, and consequently, improve quality of life and public health outcomes.

For ZEV adoption to grow, infrastructure must be in place to fuel the vehicles. This document provides recommended locations for infrastructure build-out for three applications:

- EV charging for passenger BEVs
- EV charging for medium- and heavy-duty BEVs
- Hydrogen fueling for medium- and heavy-duty FCEVs

Beyond infrastructure siting, the plan inventories potentially impactful policy items that both support and hinder ZEV adoption and identifies key constraints in existing incentive programs.

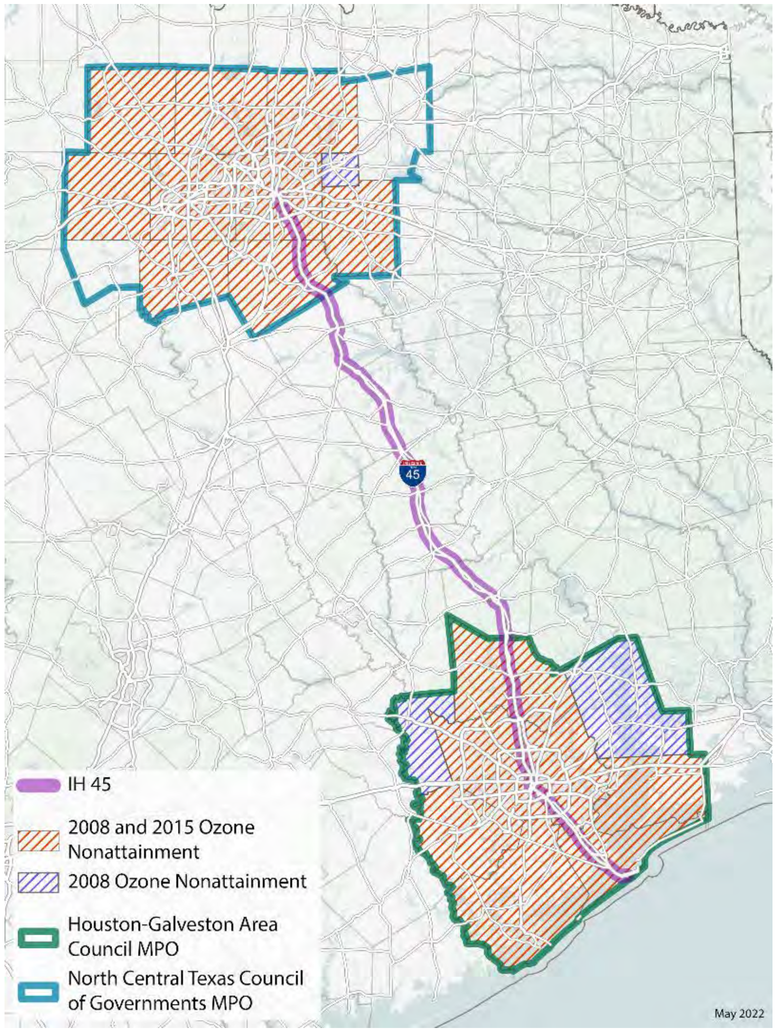
The emphasis on medium- and heavy-duty (MHD) vehicles is reflective of both the prevalence of MHD vehicles along the corridor, and the disproportionate amount of transportation emissions that are attributable to the MHD sector. Trucks are by far the single most-used mode to move freight in the United States. Reducing diesel emissions through fleet electrification, particularly on roadways prone to congestion, is key to improving air quality, as further illustrated in Chapter 2. This plan does not address the development of hydrogen fueling for passenger FCEVs, as few stakeholders

Key Corridor Statistics

- Distance: 290 miles
- Over $62.6 billion in cargo transported in 2017
- 71,270 average total traffic count at 8 weight-in-motion locations on corridor
- Current infrastructure
  - EV charging stations in Ennis, Madisonville, Huntsville, two in Spring, and two in League City
- Passes through 10 counties, 5 of which are nonattainment for the pollutant ozone (see **Exhibit 2**)

anticipate a market to develop for adoption of FCEV in Texas among the passenger vehicle segment until after adoption first occurs in the MHD sector.

Exhibit 2: The IH 45 Corridor with NCTCOG and H-GAC Regions



This plan was drafted by NCTCOG, which serves as the host agency of Dallas-Fort Worth Clean Cities (DFWCC), and is funded by a planning award from the Federal Highway Administration (FHWA) under the *Alternative Fuels Corridor Deployment Plans* project to assist with planning for the deployment of alternative vehicle fueling and charging facilities.[3] Significant input and support was provided by key stakeholders, including H-GAC, which serves as the host agency for Houston-Galveston Clean Cities; the Texas Department of Transportation; and a variety of other stakeholders representing perspectives, including, but not limited to, fuel providers, vehicle manufacturers, fleets, and utilities. NCTCOG/DFWCC staff appreciate the time, expertise, and engagement these organizations provided over the course of completing this plan.

Other plans funded by FHWA under the *Alternative Fuels Corridor Deployment Plans* initiative include relevant content that is not duplicated here, but that NCTCOG recommends as complementary resources for reference,[4] notably:

[3] FHWA Alternative Fuels Corridor Deployment Plans, https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/deployment_plan/

[4] https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/deployment_plan/

- Chapter 2 of the *I-40 Alternative Fuel Corridor Deployment Plan* includes useful siting considerations for various stakeholder entities (e.g., property owner, utility, governing authority, business owner, etc.)
- The Introduction of the *Alternative Fuels Deployment Plan for I-81 and I-78 in Pennsylvania* describes important information about potential business models for compressed natural gas and EV charging sites, and the Outreach & Implementation chapter describes an outreach process for facilitating station deployment

FHWA Alternative Fuel Corridor Program and Current Designation Status

Through Title 23 of US Code Section 151, FHWA has established an Alternative Fuels Corridors Program to identify a national network of highways that provide EV charging, and hydrogen, propane, and natural gas fueling.[5] A network of designated alternative fuel corridors has been developed over a series of nomination cycles during which FHWA issued a "Request for Nominations." During each nomination cycle, State Departments of Transportation (and, during Round 1 nominations, other public entities) responded with nominations for highway designations. These nominations typically included technical justification related to existing fueling infrastructure, market development, traffic characteristics, and other information designed to assess whether the highway 1) is significant enough to be relevant to a national network of designated corridors and 2) has adequate infrastructure to support designation as part of the corridor network. FHWA then reviewed the nominations to assess whether the nominee segments met criteria to become designated as part of the national system of corridors. FHWA completed five rounds of Alternative Fuels Corridor Designations from 2016 to 2020. One of two designations has been assigned to each highway segment:

- Corridor Ready: A sufficient number of facilities exist on the corridor – generally determined by the maximum distance between fueling facilities of a given fuel type – to allow for corridor travel using one or more alternative fuels, and FHWA would support placement of signage alerting motorists that the corridor has been designated for that alternative fuel. An example sign is shown in **Exhibit 3**.
- Corridor Pending: An insufficient number of facilities currently exist on the corridor to allow for corridor travel using one or more alternative fuels, but there is some infrastructure in place and evidence of near-term infrastructure build-out.

Exhibit 3: Sample Alternative Fuel Corridor Highway Sign

While corridor designation did not have any direct connection to funding programs at the outset of the Alternative Fuel Corridors Program, the Bipartisan Infrastructure Law (BIL), enacted on November 15, 2021, established new funding programs for alternative fuel infrastructure located along designated alternative fuel corridors.[6] This is discussed in more detail in Chapter 7.

[5] United States Code, https://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title23-section151&num=0&edition=prelim
[6] National Electric Vehicle Infrastructure Program Formula Guidance, https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/nominations/90d_nevi_formula_program_guidance.pdf

FHWA maintains interactive geographic information system maps showing the designation status of alternative fuel corridors at https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/maps/. Because mobile source emissions are so consequential to ozone attainment efforts for both the NCTCOG and H-GAC regions, both agencies emphasize a transition to ZEVs. Thus, the scope of this plan is limited to recommendations for hydrogen fueling and electric recharging sites. Snapshots of current designations for these two fuels nationwide are provided in **Exhibits 4** and **5**.

Exhibit 4: FHWA-Designated Electric Corridors, Round 1 Through Round 5 Designations

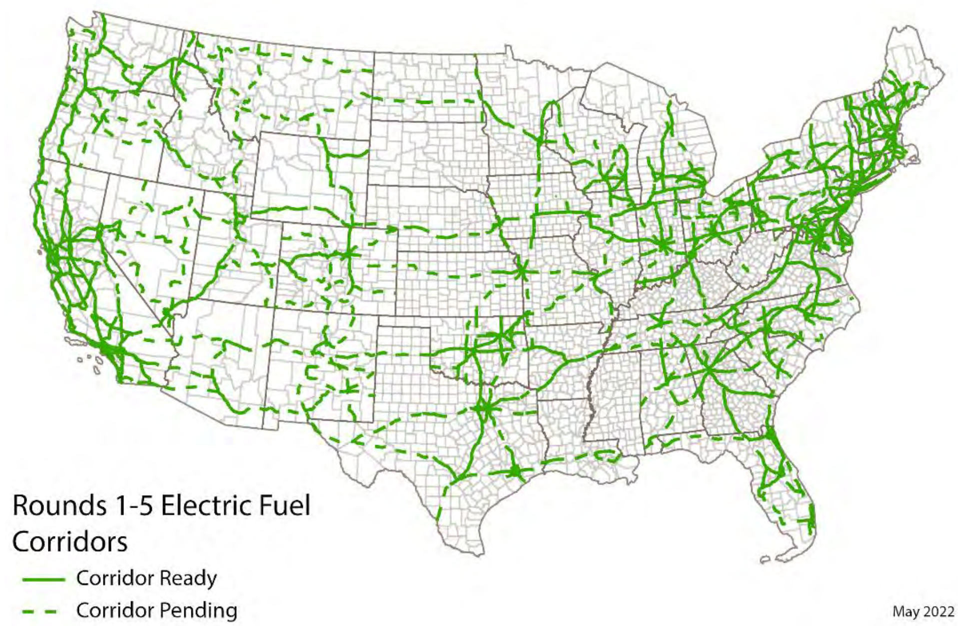
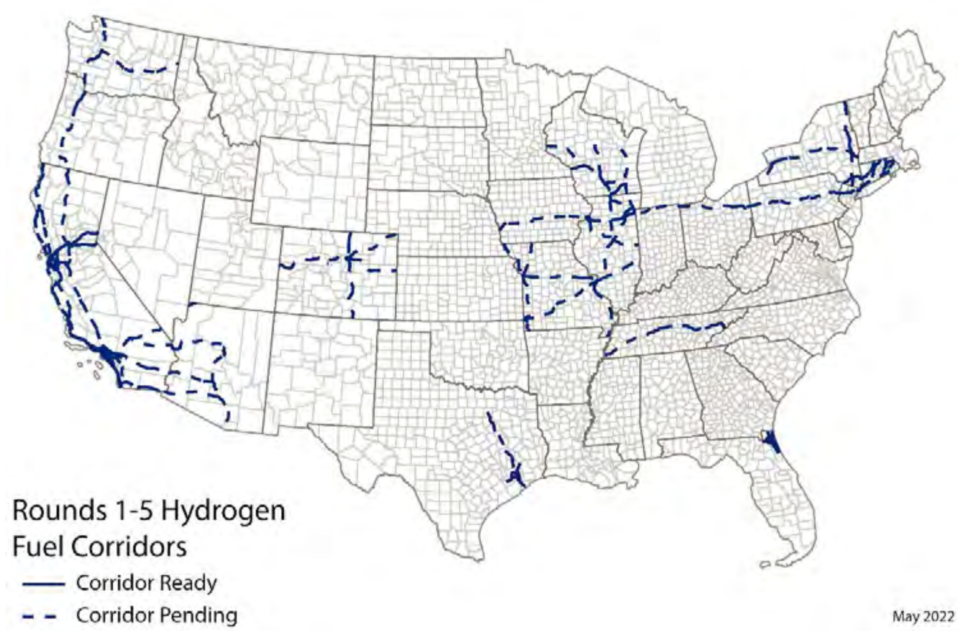


Exhibit 5: FHWA-Designated Hydrogen Corridors, Round 1 Through Round 5 Designations



With each request for nominations, FHWA published minimum standards/guidelines that must be met for a refueling or recharging site to be considered relevant to the corridor designation process. Criteria have evolved from Round 1 in 2016 to Round 6, which was released in February 2022, with nominations due May 2022. The changes have been most pronounced for EV charging infrastructure, in that the technology has evolved. While meaningful updates were made in criteria from Round 5 to Round 6, FHWA is not updating corridor designations based on Round 6 criteria, so the designation status as of Round 5 remains in place. Minimum infrastructure criteria per FHWA for both Round 5 and Round 6 are shown in **Exhibit 6** below. Round 6 criteria governed recommendations made in this plan.

Exhibit 6: FHWA Round 5 and Round 6 Infrastructure Criteria for Corridor Designation[7]

Fuel/Technology	Corridor Ready Criteria	Corridor Pending Criteria
EV Charging (Public DC Fast Charging, Excludes Tesla Sites)	**Round 5 Criteria:** Public DC (Direct Current) Fast Charging no greater than 50 miles between one station/site and the next on corridor, and no greater than 5 miles off the highway. Additionally, each DC Fast Charging site should have both J1772 combo (Society of Automotive Engineers Combined Charging System (CCS)) and Charge de Move (CHAdeMO) connectors. **Updates for Round 6:** • Reduced distance from the highway to be no more than 1 mile from Interstate exits or highway intersections along the corridor.[1] • Removed the requirement for CHAdeMO connectors. • Added minimum criteria for CCS connectors: station should include at least 4 CCS connectors capable of simultaneously charging 4 EVs at 150 kilowatts. • Site power should be no less than 600 kilowatts. • Charge power per DC port should never fall below 150 kilowatts.	**Round 5 Criteria:** Public DC Fast Charging stations separated by more than 50 miles. Location of station/site no greater than 5 miles off the highway. **Updates for Round 6:** A strategy/plan and timeline for public DC Fast Charging stations separated by no more than 50 miles. Location of station/site reduced to be no more than 1 mile from Interstate exits or highway intersections along the corridor

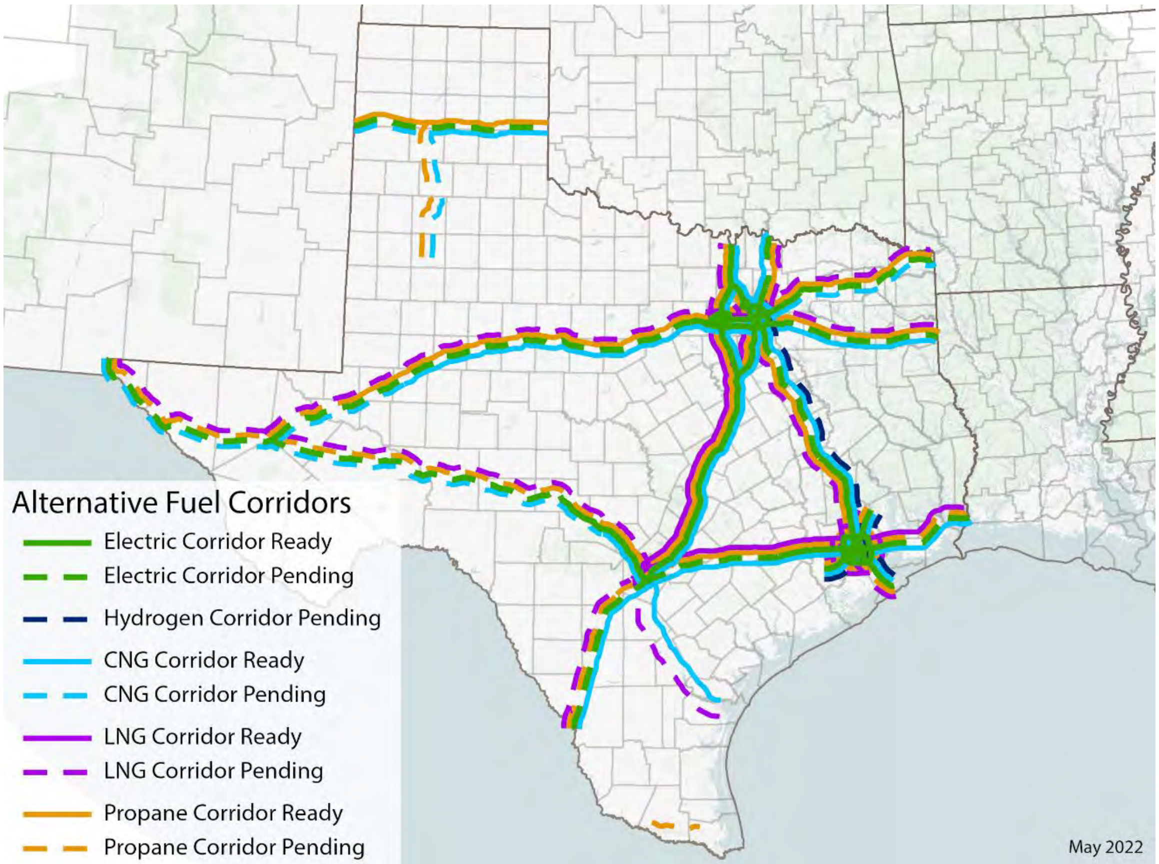
[7] FHWA 2022 Round 6 Request for Nominations, https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/nominations/2022_request_for_nominations_r6.pdf.

Fuel/Technology	Corridor Ready Criteria	Corridor Pending Criteria
Hydrogen[1]	**Round 5 Criteria:** Public hydrogen stations no greater than 100 miles between one station and the next on the corridor, and no greater than 5 miles off the highway. **Updates for Round 6:** Increased allowed distance interval to 150 miles; clarified that the location should be no more than 5 miles from Interstate exits or highway intersections along the corridor.[1]	**Round 5 Criteria:** Public hydrogen stations separated by more than 100 miles. Location of station no greater than 5 miles off the highway. **Updates for Round 6:** Increased allowed distance interval to 150 miles; clarified that the location should be no more than 5 miles from Interstate exits or highway intersections along the corridor.[1]
Propane	**Round 5 Criteria:** Public, primary propane stations no greater than 150 miles between one station and the next on the corridor, and no greater than 5 miles off the highway. **Updates for Round 6:** Clarified that the location should be no more than 5 miles from Interstate exits or highway intersections along the corridor.[1] Additionally, consistent with funding requirements in BIL, specified that propane fueling infrastructure should be designed to support medium- and heavy-duty vehicles.	**Round 5 Criteria:** Public, primary propane stations separated by more than 150 miles. Location of station no greater than 5 miles off the highway. **Updates for Round 6:** Clarified that the location should be no more than 5 miles from Interstate exits or highway intersections along the corridor.[1]
Compressed Natural Gas (CNG)	**Round 5 Criteria:** Public fast fill, 3,600 psi CNG stations no greater than 150 miles between one station and the next on the corridor, and no greater than 5 miles off the highway. **Updates for Round 6:** Clarified that the location should be no more than 5 miles from Interstate exits or highway intersections along the corridor.[1]	**Round 5 Criteria:** Public, fast fill, 3,600 psi CNG stations separated by more than 150 miles. Location of station no greater than 5 miles off the highway. **Updates for Round 6:** Clarified that the location should be no more than 5 miles from Interstate exits or highway intersections along the corridor.[1]
Liquified Natural Gas (LNG)	**Round 5 Criteria:** Public LNG stations no greater than 200 miles between one station and the next on the corridor, and no greater than 5 miles off the highway. **Updates for Round 6:** Clarified that the location should be no more than 5 miles from Interstate exits or highway intersections along the corridor.[1]	**Round 5 Criteria:** Public LNG stations separated by more than 200 miles. Location of station 5 miles or less off the highway. **Updates for Round 6:** Clarified that the location should be no more than 5 miles from Interstate exits or highway intersections along the corridor.[1]

[1] *Exceptions are permitted for distance from Interstate exits or highway intersections and between stations along the corridor, if justified.*

NCTCOG/DFWCC have been involved in corridor designation efforts in Texas since the initial nomination cycle in 2016. During Round 1, NCTCOG submitted an extensive nomination packet for highways across the State of Texas. Staff also provided input to the Texas Department of Transportation (TxDOT) during subsequent nomination cycles. As of the completion of Round 5, Texas has received designations for 16 Interstate Highways, 1 US Highway, and 1 State Highway covering 13,000 miles of the National Highway System (all fuels combined). **Exhibit 7** details the status of corridor designations in Texas as of May 2022.

Exhibit 7: FHWA-Designated Alternative Fuels Corridors in Texas, Round 1 to Round 5



As shown in **Exhibit 8**, the IH 45 corridor is arguably the most "complete" corridor in the state, as it has been designated as either "pending" or "ready" for all five alternative fuels included in the FHWA Alternative Fuel Corridor Program. It is designated "ready" in its entirety for both compressed natural gas and propane; designated as a mix of "pending" and "ready" segments for electricity; and designated as "pending" for both liquified natural gas and hydrogen. It is the only major highway in Texas with a designation for hydrogen. This was the basis for the selection of this corridor for development of the ZEV infrastructure deployment plan. **Exhibit 9** summarizes current designations along this corridor.

Exhibit 8: Corridor Designation Status of IH 45

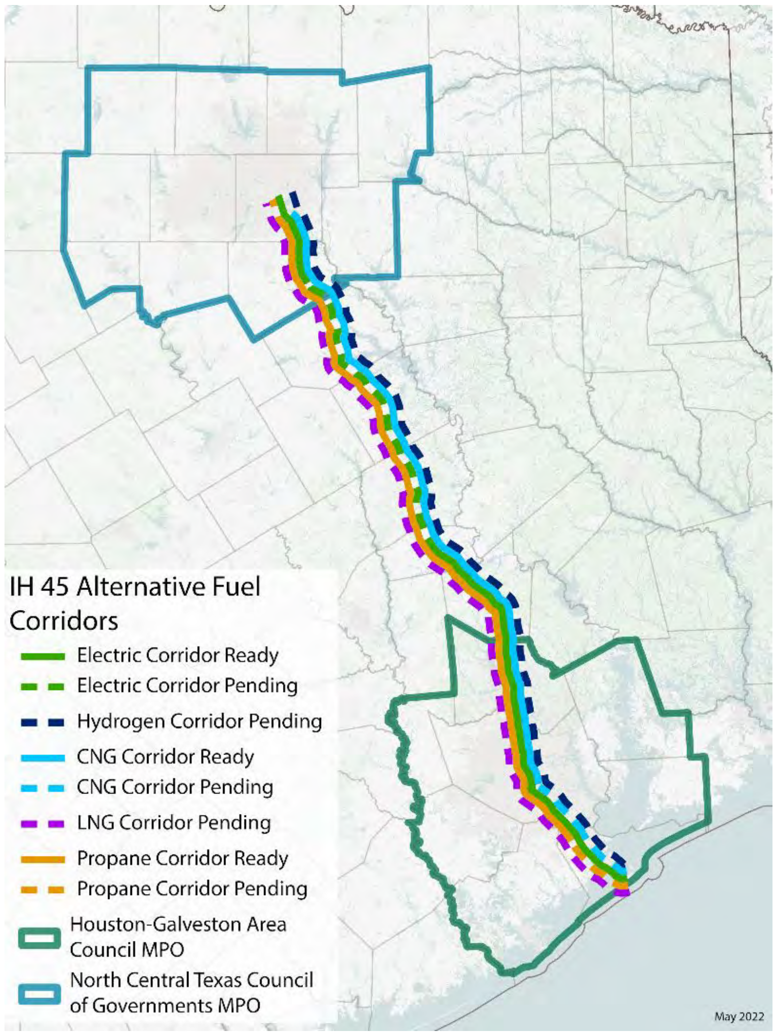


Exhibit 9: Current Designation Status of IH 45 Corridor

	Electric	Hydrogen	CNG	LNG	Propane
Current Designation	"Ready" from northern terminus in Dallas to Ennis; "Pending" from Ennis to Madisonville (111 miles); "Ready" from Madisonville to Galveston	"Pending" (entire corridor)	"Ready" between Dallas and Houston; "Pending" from Houston to Galveston	"Pending" (entire corridor)	"Pending" from northern terminus in Dallas to Hutchins (14 miles);* "Ready" between Hutchins and Houston; "Pending" from Houston to Galveston
Existing Infrastructure	19 DC Fast Charge Stations	No Stations to Date	5 Existing Stations	None	9 Existing Stations
Prospects for Buildout	High	Moderate	Moderate	Minimal	Moderate

**The "Pending" segment north of Hutchins is believed to be technical error/oversight associated with the fact the corridor transitions from IH 45 to US 75 in this area.*

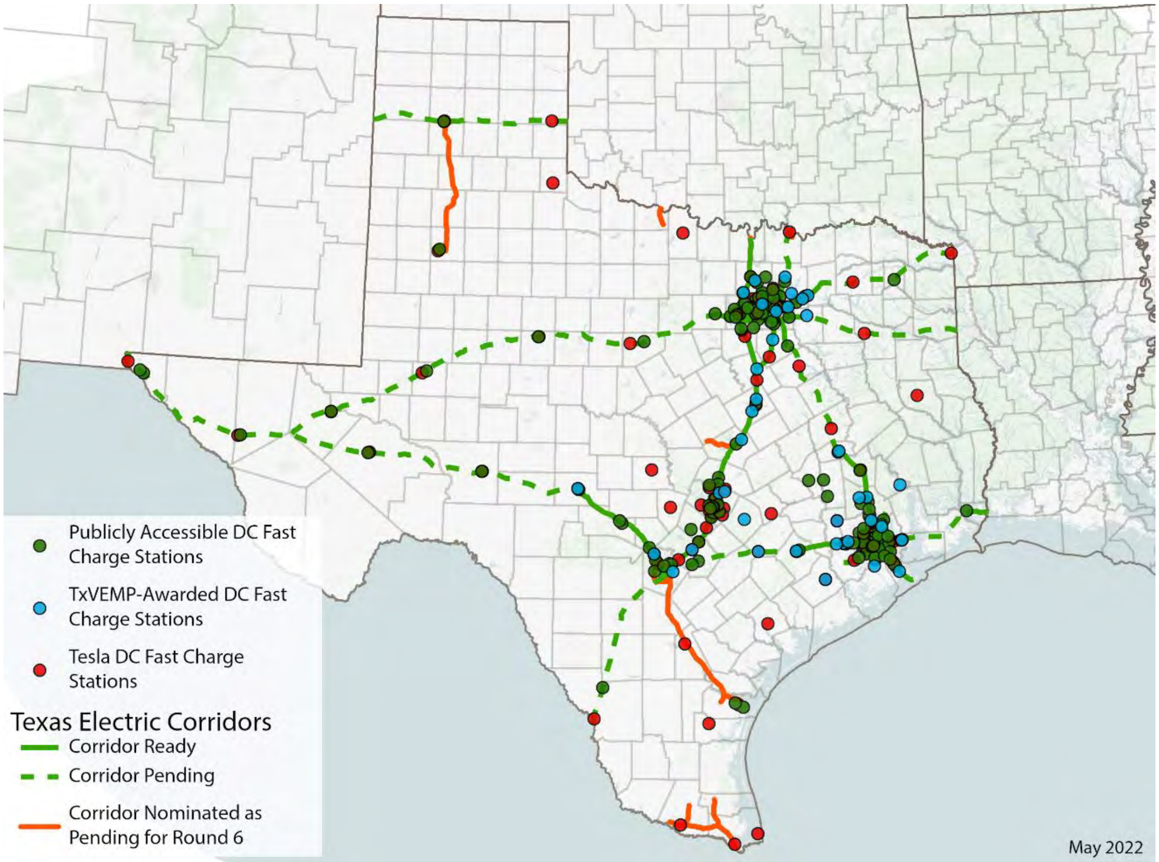
Conversely, momentum around both fuels that can power ZEV vehicles – electricity and hydrogen – is gaining. New investment in electrification through the BIL, including both EV charging and hydrogen fueling, will advance infrastructure development and is discussed in detail in Chapter 7.

According to the TxDOT EV Dashboard, Texas already boasts over 2,100 public Level 2 and over 270 Direct Current (DC) Fast Charge locations, as of June 30, 2022.[8] Recent awards from the Texas Volkswagen Environmental Mitigation Program will lead to build-out of additional stations, including an award of 4,160 new Level 2 charging sites and 170 additional DC Fast Charge BEV charging sites. In addition, the most recent Texas Emissions Reduction Plan (TERP) Alternative Fueling Facilities Program funding cycle will result in deployment of another 78 EV charging sites (mix of Level 2 and DC Fast Charge).[9] **Exhibit 10** shows the geographic distribution of existing DC Fast Charge infrastructure, as well as locations recently awarded funding. Note that Level 2 stations are not mapped as they are not relevant to corridor designation.

[8] TxDOT EV Dashboard, https://txdot.maps.arcgis.com/apps/dashboards/d27f48e770fa483c81c4af7dfec28e45

[9] https://www.tceq.texas.gov/downloads/air-quality/terp/reports/reports-project-list-affp.pdf (Texas Commission on Environmental Quality website accessed 5/31/2022)

Exhibit 10: Electric Corridor Designations and Locations of DC Fast Charge Stations Across Texas



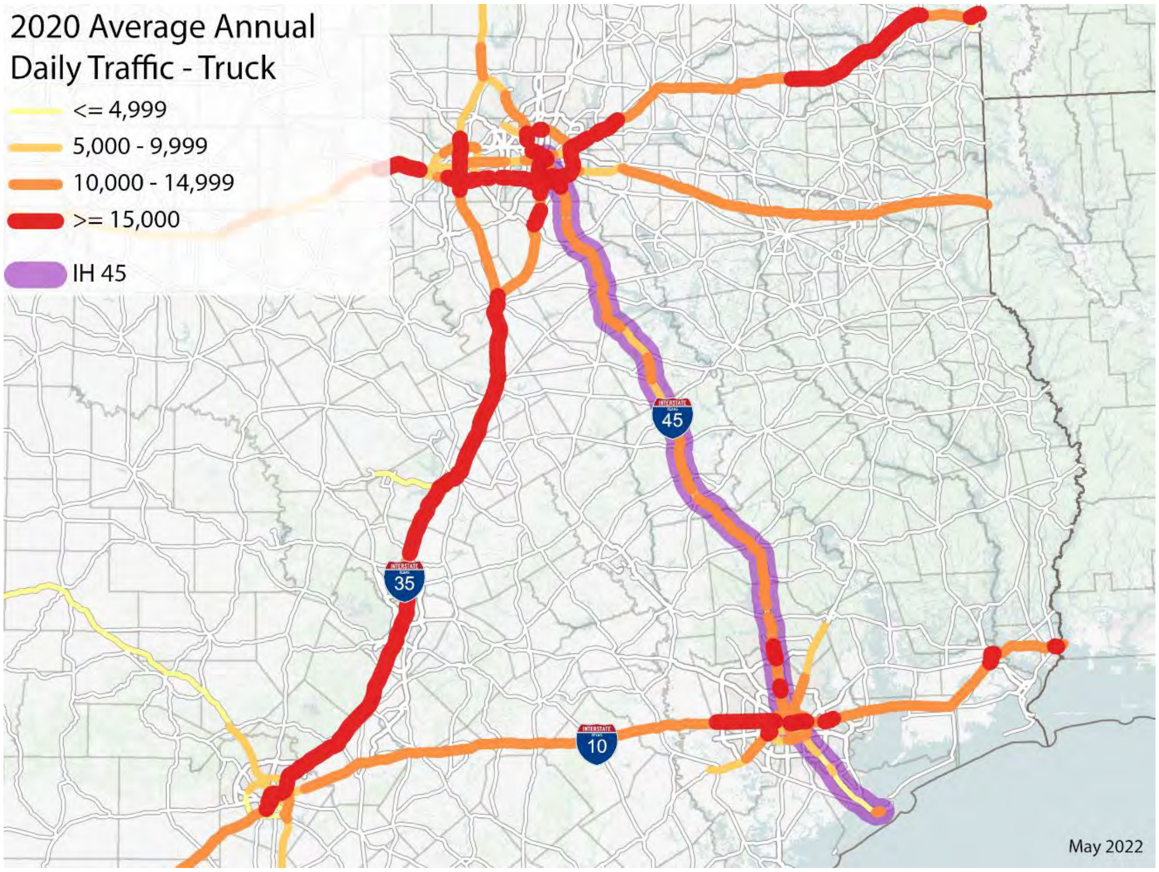
Industry interest in hydrogen fuel cell ZEV as a likely solution for long-haul Class 8 freight transport is growing, and along with that comes interest in building publicly accessible hydrogen fueling (more on this in Chapter 2). As IH 45 serves as a key freight corridor for the state and nation, this plan is scoped around build-out of electric recharging and hydrogen refueling infrastructure for the freight sector. It should be noted that issues of production and distribution are not considered in this plan. That is, discussions of whether electricity is renewable or conventional generation, or whether hydrogen is gray, blue, or green, are outside the scope of this document. However, key considerations regarding production and upstream emissions impacts are outlined in Chapter 2.

Corridor Characteristics

The IH 45 corridor runs north and south, connecting the seaports in both Houston and Galveston to the urban core of DFW and its various inland ports. The study area spans 290 miles and crosses 10 counties: Dallas, Ellis, Navarro, Freestone, Leon, Madison, Walker, Montgomery, Harris, and Galveston. Although IH 45 is key for connecting the DFW and Houston metro regions, ports, and points beyond, the areas along the corridor are mostly rural. The corridor also serves as a primary hurricane evacuation route from the metropolitan Houston and Galveston areas to the DFW metroplex.

The IH 45 corridor is a prominent highway in Texas and has substantial importance for both passenger and freight travel. It is one of three legs of the "Texas Triangle" – three segments of Interstate that connect Houston, DFW, Austin, and San Antonio – and thus connect most of Texas' population and economic activity. The other segments of the Texas Triangle are IH 35 from San Antonio to DFW, and IH 10 from San Antonio to Houston. **Exhibit 11** illustrates daily truck traffic along these segments.

Exhibit 11: 2020 Average Annual Daily Truck Traffic Along IH 45 and Other Interstates



Importance of Medium- and Heavy- Duty Trucks Along the Corridor

The IH 45 corridor carries a significant amount of freight traffic that travels between and within the metropolitan areas on either end. It also connects to major east-west Interstates, including IH 10, IH 20, and IH 30, and is in close proximity to IH 35 (the United States-Mexico-Canada corridor) as both approach Dallas. Additionally, the major international maritime ports in Houston and Galveston, on the southern end of the corridor, and the presence of major inland ports in the DFW area, including DFW International Airport, BNSF Intermodal Facilities, Alliance Airport, Union Pacific Intermodal Facilities, and the International Inland Port of Dallas, make the IH 45 corridor significant to US trade. The importance of ZEV technology is particularly relevant in the freight sector, which not only comprises a large proportion of traffic on IH 45 (see **Exhibit 12**), but also produces a disproportionately high amount of ozone-forming pollution, as discussed in more detail in Chapter 2.

While MHD vehicles account for only 4.5 percent of vehicles on the road nationally, MHD trucks are responsible for approximately 20 to 25 percent of the energy consumption and air emissions of the US transportation sector.[10] According to the US Environmental Protection Agency (EPA), in the United States, nearly half of MHD trucks are used for urban, local, and short-haul operation, with a daily travel distance less than 200 miles. MHD vehicles are estimated to emit over 50 tons per day of ozone-forming nitrogen oxides (NO_X) in the DFW region and about 49 tons per day in the H-GAC region, which is

[10] Argonne GREET Publication: Assessment of Potential Future Demands for Hydrogen in the United States (anl.gov), https://greet.es.anl.gov/publication-us_future_h2

approximately 22 percent in the DFW region and approximately 15 percent in the H-GAC region, of the entire NO_X emissions inventory for 2020.[11]

Exhibit 12: Average Traffic Counts and Weight Distribution on IH 45

FHWA-Scheme F Classification	Corresponding EPA GVWR Classes for Trucks Based on TxDOT Weigh-in-Motion Data	Average Traffic Counts (2-Way) for 8 Weigh Stations along IH 45 Corridor from Dallas to Houston
Light Duty		
Class 1 – Motorcycles	-	51
Class 2 – Passenger Cars	-	43,937
Class 3 – Four Tire, Single Unit	-	14,510
Total “Light Duty” Vehicle Class Average		58,498
“Light Duty” % of Total Traffic		82.08%
Bus		
Class 4 – Buses	-	207
Total “Bus” Vehicle Class Average		207
“Bus” % of Total Traffic		0.29%
Medium Duty		
Class 5 – 2 Axle, 6 Tire Single Unit	Class 3-6; 10,000-26,000 lbs. GVWR	1,952
Total “Medium Duty” Vehicle Class Average		1,952
“Medium Duty” % of Total Traffic		2.74%
Heavy Duty		
Class 6 – 3 Axle, Single Unit	Class 7; 26,0001 – 33,000 lbs. GVWR	813
Class 7 – 4 or More Axle, Single Unit		30
Class 8 – 4 or Less Axle, Single Trailer	Class 8a; 33,001 – 60,000 lbs. GVWR	9,364
Class 9 – 5-Axle Tractor Semitrailer		
Class 10 – 6 or More Axle, Single Trailer	Class 8b; More than 60,001 lbs. GVWR	408
Class 13 – 7 or More Axle, Multi-Trailer		
Total “Heavy Duty” Vehicle Class Average		10,615
“Heavy Duty” Vehicle % of Total Traffic		14.89%
Average Total Count at Each Station		71,270

As illustrated by **Exhibit 11**, IH 35 carries more truck traffic, but IH 45 is critically important for freight activity. According to the TxDOT *I-45 Freight Corridor Plan*, nearly half of all truck freight in Texas is moved along the IH 45 corridor between the Houston-Galveston and DFW areas. This multimodal corridor is the most heavily traversed freight corridor in the State of Texas. Connecting Houston-Galveston and Dallas-Fort Worth, two of the largest metropolitan areas in the nation and the two largest in the state, the corridor provides primary access for freight movement between those two major markets, and to or from major seaports in the Houston Gulf Coast area.[12] Over 10,000 ton-miles of cargo traveled between Dallas and Houston in 2017, totaling over $62.6 billion.[13] According to the TxDOT *I-45 Freight Corridor Plan*, gasoline is the highest *volume* commodity on the corridor today and through 2040. Electrical equipment is forecasted to have the greatest *tonnage* increase on the corridor from now through 2040, and due to the need for timely delivery of these components, is expected to be

[11] Texas Commission on Environmental Quality Texas State Implementation Plan Revisions (March 2020), Texas SIP Revisions - Texas Commission on Environmental Quality - www.tceq.texas.gov.

[12] TxDOT *I-45 Freight Corridor Plan*, https://ftp.txdot.gov/pub/txdot/move-texas-freight/studies/i45-freight-corridor-plan.pdf

[13] FHWA Freight Analysis Framework Freight Flows (data provided by NCTCOG Freight Team), https://ops.fhwa.dot.gov/freight/freight_analysis/faf/

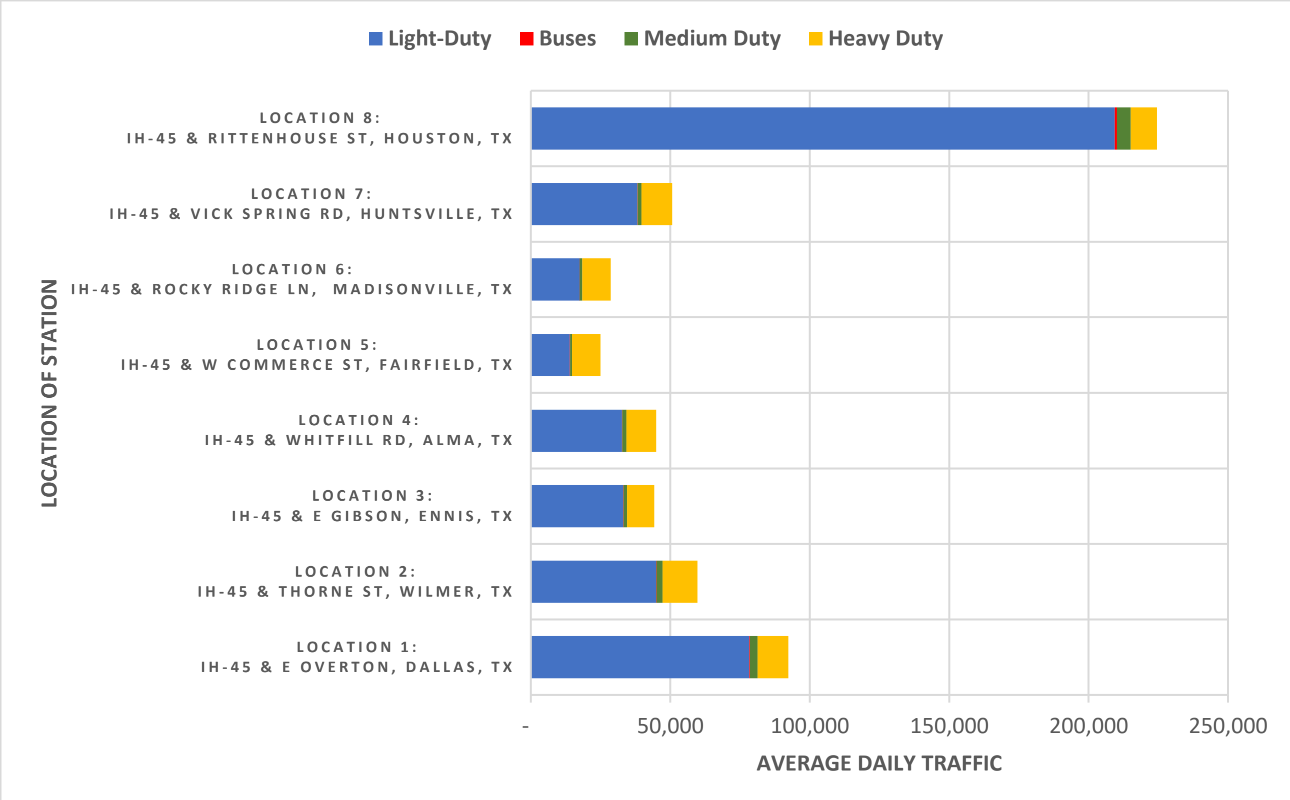
carried by truck.[14] The TxDOT *I-45 Freight Corridor Plan* also estimates a 262 percent increase of automotive parts tonnage by truck in the corridor.

One of the key takeaways from stakeholder meetings was that while light-duty vehicles are expected to transition to BEV, MHD sectors are evaluating both FCEV and BEV. The two platforms are best suited to different applications, with weight being a major factor in determining which technology is best suited for a particular route or application (see Chapter 2 for more discussion). Thus, NCTCOG wished to assess the volume and distribution of MHD vehicles along IH 45 by weight classification to evaluate whether traffic seemed best suited to one ZEV platform versus the other. To evaluate traffic along the highway, NCTCOG retrieved total annual average daily traffic counts from TxDOT's Traffic Count Database System.[15] There were eight data points from Dallas to Houston found manually that fit within the parameters of being quality control accepted, two-way counts in 2019, that are also able to be separated by vehicle classification and not frontage/service roads. These points are on the freeway main lanes, and counts are separated by vehicle classification. MHD vehicles were identified based on FHWA Scheme F size classification and encompassed all vehicles classified as three axle single unit and larger. However, this categorization did not convey information about weight categories, which is a critical element of evaluating whether a FCEV or BEV platform might be better suited. To incorporate weight data, staff used TxDOT's 2015 weight in motion (WIM) data at WIM station W539 located on IH 45, which closed in 2015, and had captured truck weight according to the EPA Gross Vehicle Weight Rating (GVWR) categories. **Exhibit 12** provides the final vehicle count and equivalent GVWR weight class. As the data shows, MHD traffic along this route is predominantly in the Class 8a GVWR category.

NCTCOG also evaluated the distribution across weight classes at each WIM station and found that the fraction of MHD traffic is highest between the urban cores, where the corridor is more rural and light-duty passenger vehicle traffic declines, as illustrated in **Exhibit 13**. This is consistent with similar findings in the TxDOT *I-45 Freight Corridor Plan*.[16] The highest number of heavy-duty vehicle counts is located at the IH 45 and Thorne Street, Wilmer, TX station location, with 12,492 vehicles. As a note, this location is in close proximity to the International Inland Port of Dallas.

[14] TxDOT *I-45 Freight Corridor Plan*, https://ftp.txdot.gov/pub/txdot/move-texas-freight/studies/i45-freight-corridor-plan.pdf
[15] TxDOT Traffic Count Database System, https://txdot.public.ms2soft.com/tcds/tsearch.asp?loc=Txdot&mod=TCDS
[16] TxDOT *I-45 Freight Corridor Plan,* Feb 2016, Page 26, Accessed 6/23/2022 https://ftp.txdot.gov/pub/txdot/move-texas-freight/studies/i45-freight-corridor-plan.pdf

Exhibit 13: Traffic Counts by Weight Distribution at Points Along IH 45



Prospects for Successful Project Deployment

As the first ZEV corridor plan developed in Texas, key steps taken in developing this document have included understanding the driving factors for EV and hydrogen infrastructure development in Texas; identifying existing refueling infrastructure gaps along the corridor; identifying exits best suited for EV and hydrogen fueling infrastructure; identifying funding and incentives for new infrastructure; and engaging with fueling providers, ZEV manufacturers, fleets, and other partners to establish momentum for generating future projects and grant applications. Over the course of plan development, it became apparent that project success is dependent on alignment of a variety of stakeholders who have different roles to play in project deployment:

- Original equipment manufacturers who provide ZEV vehicles/equipment
- Fuel providers
- Recharging/refueling station developer/providers
- Fleet end users of the ZEV vehicles/equipment
- Fueling/charging site host location/property owners
- Applicable utility collaborators

NCTCOG believes that the prospects for project development and successful deployment are high due to several factors. Passage of the Bipartisan Infrastructure Law in November 2021 ushered in a wealth of financial investment that practically guarantees build-out of EV charging infrastructure for passenger vehicles along the "pending" segment within two years. It also presents an opportunity for Texas to compete for discretionary funding for hydrogen hubs, hydrogen fueling, and other ZEV activities, as further discussed in Chapters 7 and 8.

Given the favorable business climate, competitive total cost of ownership for both BEV and FCEV relative to diesel, and costs for electricity and hydrogen fuel that are lower than national averages, NCTCOG believes that Texas is a key market for early ZEV deployments even absent state-level mandates or regulations. Goods movement using heavy-duty BEV trucks is already taking place around Texas, including BEV drayage trucks at Port Houston,[17] and the North Texas Emissions Reduction Call for Projects,[18] through which 16 heavy-duty BEVs are being funded by NCTCOG to implement and replace existing diesel trucks. Momentum around development of hydrogen hubs has accelerated realization of opportunities that Texas can play in early deployment of FCEV trucks, given the readily available supply of hydrogen fuel, which can be available for transportation use at costs lower than those currently seen in California. Thus, NCTCOG believes that, assuming infrastructure is in place, Texas will be ready to support deployment of heavy-duty FCEVs in 2023, when commercial vehicles are expected to become available.

Stakeholder relationships for both BEV and FCEV projects became well established over the course of plan development and have already resulted in several follow-on activities which are highlighted in Chapter 8.

[17] 2022-June-Electric-truck-Press-Release-FINAL.pdf (porthouston.com)

[18] North Central Texas Council of Governments - Transportation and Air Quality Funding Archive (nctcog.org)

CH 2

The Importance of ZEV Projects Along the IH 45 Corridor

Chapter 2

The Importance of ZEV Projects Along the IH 45 Corridor

Role of Transportation in Local Air Quality Issues

Transportation is a major source of several criteria air pollutants – ozone, fine particulate matter, and carbon monoxide. Neither the Dallas-Fort Worth (DFW) nor the Houston areas have problematic levels of carbon monoxide, but both are designated as nonattainment for ozone and may soon face challenges related to particulate matter.

Ozone in the North Central Texas Council of Governments and Houston-Galveston Area Council Regions

Ten counties in the DFW area (Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise) and eight counties in the Houston-Galveston-Brazoria (HGB) area (Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller) have been designated as nonattainment for the pollutant ground-level ozone under at least one of the federal ozone standards. Both regions currently face reclassification by the Environmental Protection Agency (EPA) after ozone levels failed to decrease enough to meet attainment deadlines in 2021. The current and pending designation status for each county is shown below in **Exhibit 14**. Redesignation to a 'worse' nonattainment classification brings consequences in the form of additional control strategy requirements. Few of these requirements are placed on the transportation sector, so the opportunity to reduce emissions from the transportation sector through voluntary measures can alleviate regulatory requirements for other industries.

Exhibit 14: Current and Pending Ozone Designation Status of Counties in the North Central Texas Council of Governments and Houston-Galveston Area Council Regions

Region	Current Status	Proposed EPA Reclassification
10-county DFW Area (Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise)	Serious under the 2008 Ozone Standard	Severe under the 2008 Ozone Standard
9-County DFW Area (Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Tarrant, and Wise)	Marginal under the 2015 Ozone Standard	Moderate under the 2015 Ozone Standard
8-County HGB area (Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller)	Serious under the 2008 Ozone Standard	Severe under the 2008 Ozone Standard
6-County HGB area (Brazoria, Chambers, Fort Bend, Galveston, Harris, and Montgomery)	Marginal under the 2015 Ozone Standard	Moderate under the 2015 Ozone Standard

Exhibits 15 and **16** below illustrate the boundary of ozone nonattainment designations.

Exhibit 15: DFW Ozone Nonattainment Area

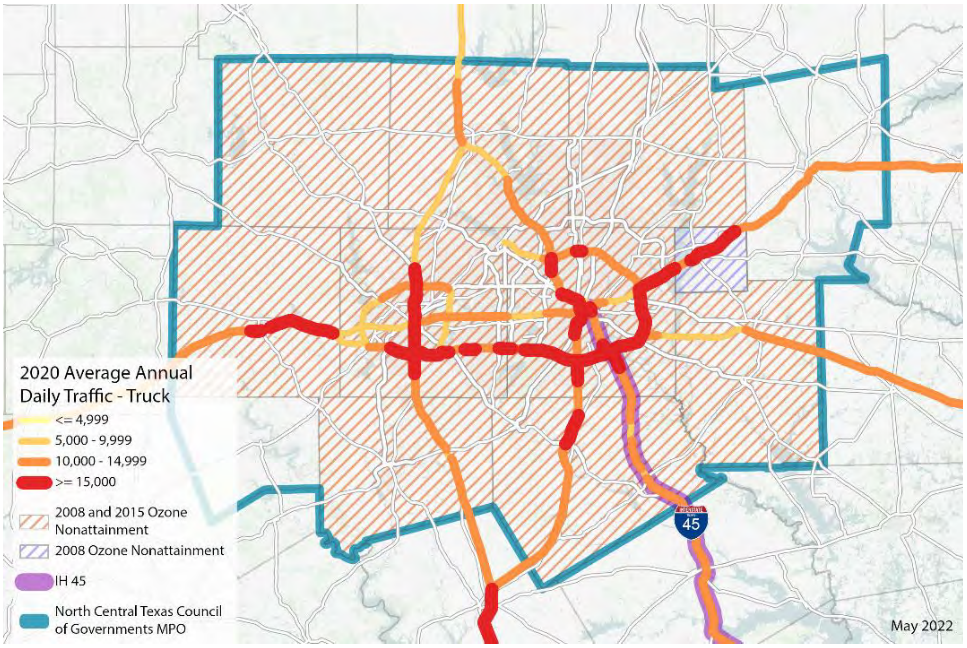
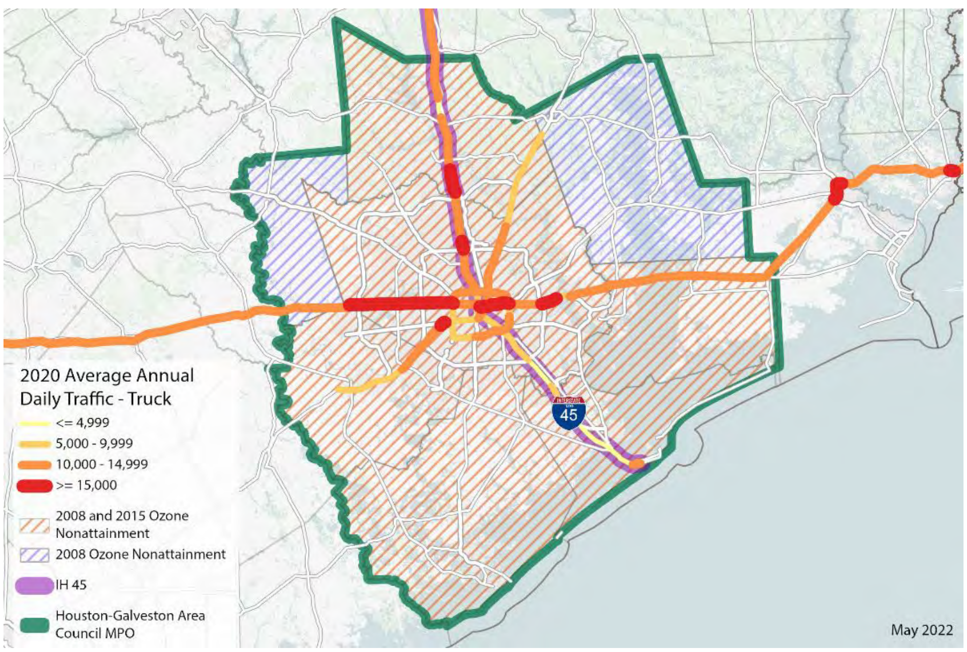


Exhibit 16: HGB Ozone Nonattainment Area



Particulate Matter in the North Central Texas Council of Governments and Houston-Galveston Area Council Regions

Both the North Central Texas Council of Governments (NCTCOG) and Houston-Galveston Area Council (H-GAC) areas currently are in attainment of EPA standards for fine particulate matter. However, the EPA has recently released a Final Policy Assessment that suggests that they will likely lower the federal ozone standard for fine particulate matter, potentially to a new primary annual standard in the range of 8 to 10 micrograms per cubic meter, and a potential 24-hour standard in the range of 25 to 30 micrograms per cubic meter. Depending on the final EPA decision, both NCTCOG and H-GAC could face nonattainment status in at least part of the region. In the NCTCOG region, two regulatory monitors measured above 9 micrograms per cubic meter, and another two monitors measured above 8 micrograms per cubic meter, for the primary annual standard's 2019-2021 analysis period. All four of these monitors are in Dallas and Tarrant counties, which suggests that nonattainment issues may be limited to the most densely urbanized parts of the region. For the 24-hour standard, the prospective revision is unlikely to trigger any nonattainment ramifications immediately in the DFW region.

In the H-GAC region, there are similar concerns. Of the nine regulatory fine particulate matter ($PM_{2.5}$) monitors within the region, three monitors' regional design values are above 10 micrograms per cubic meter, another two monitors are above 9 micrograms per cubic meter, and finally another two are above the 8 micrograms per cubic meter threshold. It seems likely that the Houston region will face a nonattainment designation for particulate matter in the near future.

Transportation Impact on Air Quality

Air quality and nonattainment status in both the DFW and Houston regions is heavily impacted by the transportation sector. Medium- and heavy-duty truck traffic is particularly impactful, and a zero emission vehicle (ZEV) transition within this sector holds particular promise. The emissions reduction potential of alternative fuel vehicles, which typically have lower nitrogen oxides (NO_X) emissions, was a leading cause of NCTCOG seeking to become designated as the Dallas-Fort Worth Clean Cities (DFWCC) during the 1990s. DFWCC has always prioritized projects that help reduce ozone-forming pollutants. As ZEVs have become commercially available, NCTCOG/DFWCC, as well as other Clean Cities coalitions throughout Texas, have shifted more focus toward supporting adoption of ZEV technology when feasible versus other alternative fuels. As with other criteria pollutants, ozone nonattainment is a local air quality problem, impacted largely by emissions within and upwind of the specific nonattainment area geography. Thus, ZEVs offer substantial opportunities for air quality improvement in these regions.

Because ground-level ozone is not emitted directly, but rather is the product of photochemical reactions between NO_X and volatile organic compounds (VOCs), both H-GAC and NCTCOG pursue initiatives to reduce emissions of NO_X and VOCs. These are known as ozone precursor pollutants. Both NCTCOG and H-GAC nonattainment areas are known as 'NO_X-limited,' meaning the amount of NO_X emissions are the primary determinant of ozone formation. NO_X emissions are primarily attributable to combustion of fuels and other anthropogenic activities.[1] On-road mobile sources, including cars and trucks of all class sizes, are estimated to emit approximately 88.27 tons per day of ozone-forming NOx in the DFW region and 83.04 tons in the Houston-Galveston region according to H-GAC, which is about 38 and 25 percent, respectively, of the entire NO_X emissions inventory for 2020.[2,3] **Exhibit 17** illustrates the contribution of each major emissions source to the overall NO_X emissions inventory in both the DFW and HGB ozone nonattainment areas.

[1] North Central Texas Council of Governments: Spring 2022 Air Quality Handbook. Spring 2022, Accessed 6/23/2022, https://www.nctcog.org/getattachment/trans/quality/air/AQ2022printer_Spring.pdf.aspx?lang=en-US

[2] Dallas-Fort Worth Serious Classification Attainment Demonstration State Implementation Plan Revision for the 2008 8-Hour Ozone National Ambient Air Quality Standard Adopted March 2020 (accessed 11/10/2021), https://www.tceq.texas.gov/airquality/sip/dfw/dfw-latest-ozone

[3] Texas Commission on Environmental Quality Texas State Implementation Plan Revisions (March 2020), https://www.tceq.texas.gov/airquality/sip/sipplans.html#:~:text=A%20SIP%20revision%20is%20made,initially%20approved%20in%20May%201972.

Exhibit 17: NO_X Emissions Sources in the DFW and HGB Ozone Nonattainment Areas

	On-Road Mobile (NO_X-TPD)		Non-Road Mobile (NO_X-TPD)		Area Source (NO_X-TPD)		Point Source (NO_X-TPD)		Total
DFW 10-County Region[4]	88.27	38%	69.13	29%	34.47	15%	42.88	18%	234.75
HGB 8-County Region[5]	83.04	25%	76.44	23%	30.47	9%	145.44	43%	335.39

Exhibits 18 and **19** break down the On-Road Mobile Sector to illustrate the relative emissions impact of light-duty, medium-duty, and heavy-duty vehicles in both the HGB and DFW ozone nonattainment areas. In these tables, the categories for light-duty, medium-duty, and heavy-duty vehicles are defined based on the EPA Motor Vehicle Emission Simulator (MOVES) vehicle types. Light-duty vehicles include motorcycles, passenger cars, and passenger trucks. Medium-duty vehicles include light commercial trucks and motor homes. Heavy-duty vehicles include buses and refuse, single-unit short- and long-haul trucks, and combination short- and long-haul trucks.

Exhibit 18: DFW Ozone Nonattainment Area On-Road Mobile NO_X Sources by Vehicle Type[6]

DFW 10-County Region	Light-Duty Gas	Light-Duty Diesel	Medium-Duty Gas	Medium-Duty Diesel	Heavy-Duty Gas	Heavy-Duty Diesel
Vehicle Miles Traveled (miles)	197,808,527	2,064,260	16,397,692	1,027,318	2,253,548	13,259,735
Vehicle Miles Traveled (percentages)	85%	1%	7%	0%	1%	6%
NO_X (tons/day)	35.27	0.92	8.13	1.68	1.44	40.84
NO_X Percentages	40%	1%	9%	2%	2%	46%

Exhibit 19: HGB Ozone Nonattainment Area On-Road NO_X Sources by Vehicle Type[7]

HGB 8-County Region	Light-Duty Gas	Light-Duty Diesel	Medium-Duty Gas	Medium-Duty Diesel	Heavy-Duty Gas	Heavy-Duty Diesel
Vehicle Miles Traveled (miles)	178,212,297	1,990,747	9,040,392	602,910	2,277,645	11,868,359
Vehicle Miles Traveled (percentages)	87%	1%	4%	0%	1%	6%
NO_X (tons/day)	32.81	1.10	3.81	0.94	1.49	42.88
NO_X Percentages	40%	1%	5%	1%	2%	52%

Note that in both regions, light-duty gasoline vehicles make up over 80 percent of the vehicle miles traveled but make up approximately 40 percent of NO_X emissions. In contrast, heavy-duty trucks make up 7 percent of total vehicle miles traveled, but approximately half of all ozone-forming NO_X emissions (48 and 54 percent in the DFW and HGB regions, respectively). This illustrates the disproportionate

[4] Texas Commission on Environmental Quality Texas State Implementation Plan DFW Region (March 2020), DFW Serious Classification AD SIP Revision for the 2008 Eight-Hour Ozone NAAQS

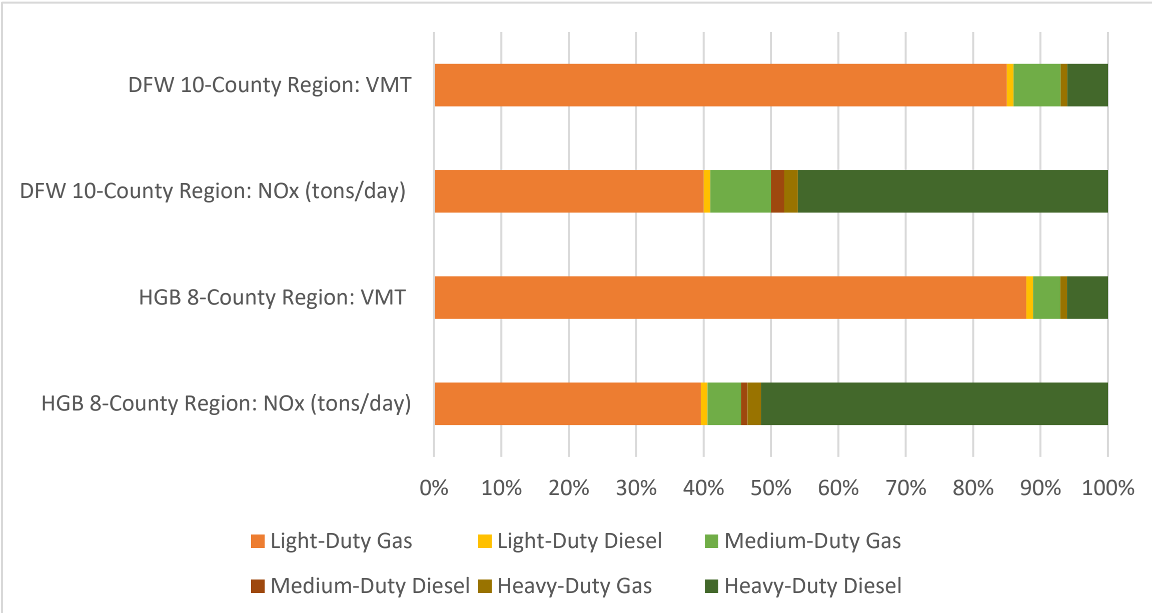
[5] Texas Commission on Environmental Quality Texas State Implementation Plan HGB Region (March 2020), HGB Serious Classification AD SIP Revision for the 2008 Eight-Hour Ozone NAAQS

[6] Texas Commission on Environmental Quality Texas State Implementation Plan DFW Region (March 2020), DFW Serious Classification AD SIP Revision for the 2008 Eight-Hour Ozone NAAQS

[7] Texas Commission on Environmental Quality Texas State Implementation Plan HGB Region (March 2020), HGB Serious Classification AD SIP Revision for the 2008 Eight-Hour Ozone NAAQS

impact that heavy-duty vehicles have on the overall air quality of the transportation sector and underscores the importance of reducing those emissions. This is visualized in **Exhibit 20**.

Exhibit 20: Vehicle Miles Traveled and NO_X Contribution by On-Road Vehicle Type in the DFW and HGB Ozone Nonattainment Areas[8,9]

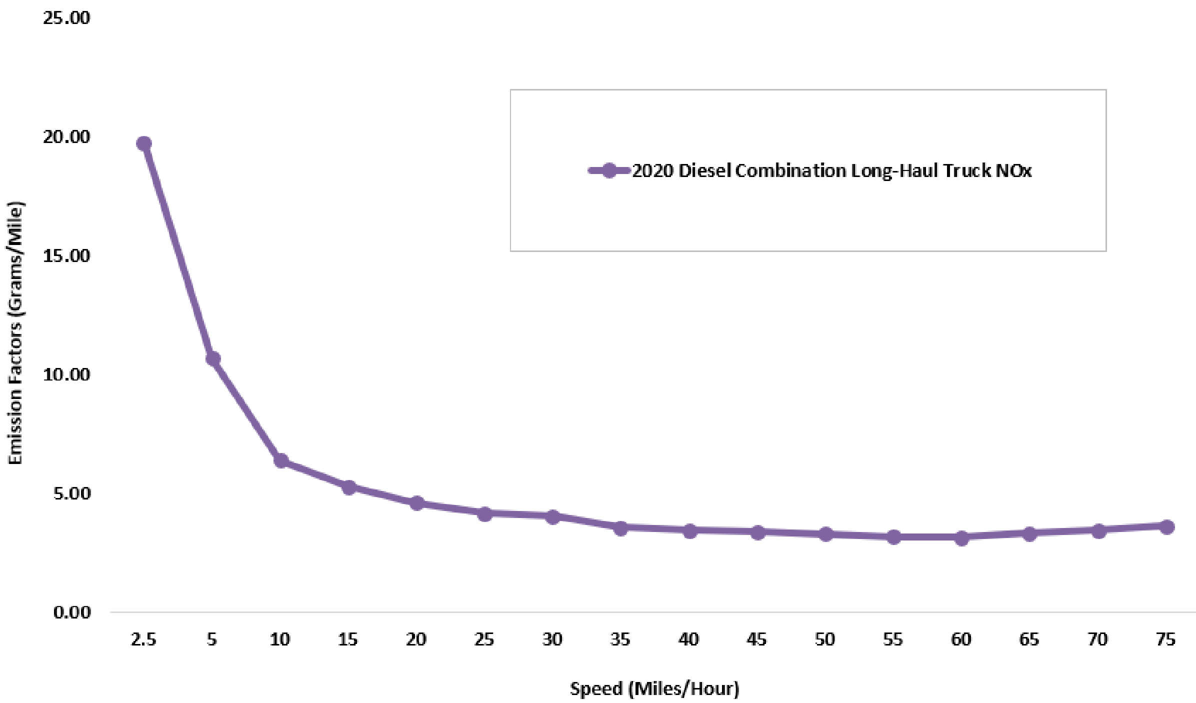


It should be noted that a ZEV transition helps achieve emissions reductions during all phases of vehicle operations – not only when a vehicle is traveling down the road, but also at slow speeds and when at idle. This is especially problematic for medium- and heavy-duty (MHD) diesel vehicles, which rely on on-board emission control systems that perform poorly at slow speeds and idle conditions. **Exhibit 21** illustrates speed versus NO_X exhaust emissions rates for 2020 Diesel Combination Long-Haul Truck, based on the EPA MOVES model.

[8] Texas Commission on Environmental Quality Texas State Implementation Plan DFW Region (March 2020), DFW Serious Classification AD SIP Revision for the 2008 Eight-Hour Ozone NAAQS

[9] Texas Commission on Environmental Quality Texas State Implementation Plan HGB Region (March 2020), HGB Serious Classification AD SIP Revision for the 2008 Eight-Hour Ozone NAAQS

Exhibit 21: Exhaust Emission Rates Versus Speeds



Slower speeds may occur due to non-recurring congestion from traffic incidents or recurring congestion due to high corridor demand during morning and afternoon peak period. These slow speed and idle operations often happen in congested urban areas, near locations where trucks may pick up or deliver cargo, and at truck stops and other rest areas. They may also happen in route on IH 45 itself, as this particular Interstate has no continuous frontage roads and a crash or other incident that results in blocked lanes can leave all traffic idling for hours. By contrast, an idling MHD ZEV produces no tailpipe emissions under these conditions.

Air Quality Improvement Potential of ZEV Adoption

The magnitude of NO_X emissions attributable to transportation indicates the magnitude of ozone precursor reductions that are possible if the transportation system were to electrify. While a full fleet transition is not realistic in the short term, moderate levels of electrification can have substantial impact. In a Houston truck electrification case study performed for the Energy Foundation, Xu and Meitiv (2021)[10] found that electrifying 40 percent of MHD trucks (including light commercial truck and motor homes) would reduce 21 tons per day, or about 25 percent, of on-road mobile source NO_X emissions in the H-GAC 8-county area in 2020. As of 2017, there are 109,000 medium-duty and 46,000 heavy-duty trucks in operation in the study area, compared to over five million light-duty vehicles. Therefore, truck electrification provides an actionable opportunity for NO_X reduction. Heavy-duty long-haul trucks represent the highest reduction potential when the technology becomes feasible.

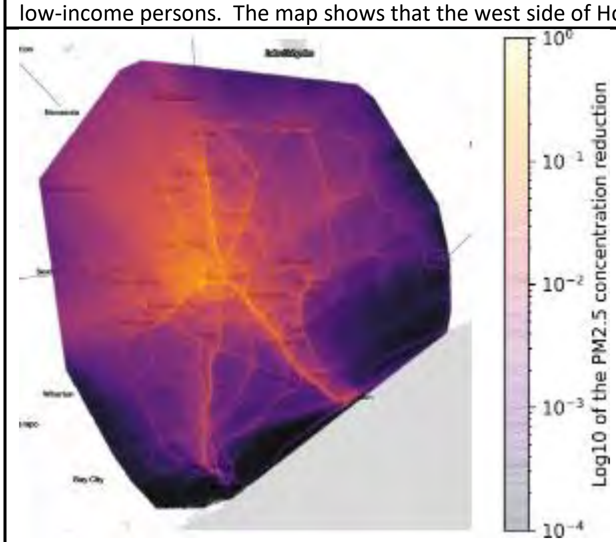
The study also identified co-benefits of vehicle electrification regarding the reduction of fine particulate matter. **Exhibit 22** illustrates the geographic distribution of $PM_{2.5}$ emissions reductions resulting from a scenario in which 40 percent of MHD truck traffic is electrified, with added context of demographic distribution. The comparison indicates that heavy-duty truck electrification, even though more

[10] Xu, Ann; Meitiv, Alexander, 2021, "Tailpipe Emission Benefits of Medium- and Heavy-Duty Truck Electrification in Houston, TX," CARTEEH DATA:HUB, http://carteehdata.org/library/document/tailpipe-emission-benefit-7ea6 (accessed May 20 2022)

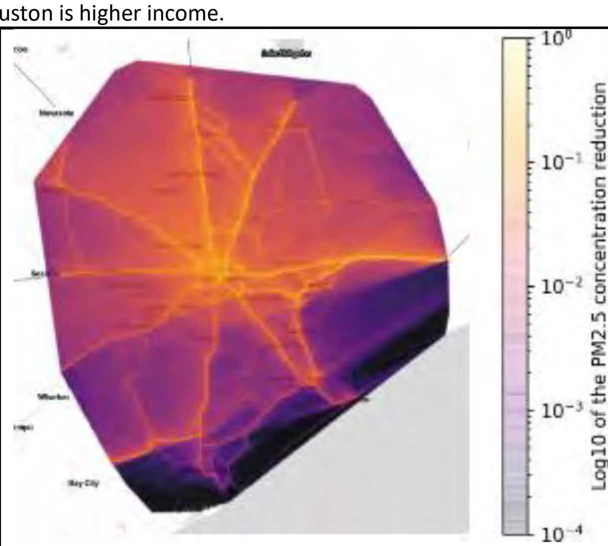
challenging from a technology perspective, will likely benefit more low-income persons. The NO_X and $PM_{2.5}$ emissions reduction is likely to have profound implications on public health and the electric grid. A conservative estimate using an average monetary value of emissions shows that 40 percent electrification would lead to $74 million annual savings in avoided health cost in the 8-county Houston area.

Exhibit 22: Distribution of Environmental Benefits from Battery Electric Vehicle Adoption Across Demographic Groups

Census block group map of percentage of low- and moderate-income persons. Darker color indicates higher percentage of low-income persons. The map shows that the west side of Houston is higher income.



$PM_{2.5}$ concentration reduction from 40% medium-duty truck electrification, showing more reduction on the west side



$PM_{2.5}$ concentration reduction from 40% heavy-duty truck electrification, showing reduction distributed across the region

Because this study was focused on tailpipe emissions, the results are applicable to both battery electric vehicle (BEV) and fuel cell electric vehicle (FCEV) platforms and are indicative of the improvements that could be made through adoption of either ZEV type, as long as the drivetrain is electrified. The use of ZEVs in the two regions and along IH 45, especially in the freight sector, would be instrumental in meeting air quality goals in both the DFW and Houston areas.

Well-to-Wheels Considerations and Impacts

While ZEVs offer clear-cut benefits to local air quality improvement by reducing tailpipe emissions, questions often arise about the well-to-wheel benefits once upstream fuel production – whether electricity or hydrogen – is accounted for. In other words, are emissions just being moved from one sector to another? It is important to remember that both gasoline and diesel fuels also are refined in a manner that produces upstream emissions. When well-to-wheels concerns arise, it is critical to ensure that the well-to-wheels comparison is being done across all fuels – both ZEV and conventional vehicle platforms. It is also important to remember that once a ZEV is deployed, its well-to-wheels impacts improve over time, as both electricity and hydrogen production pathways decarbonize, become more efficient, and integrate higher levels of renewables. In other words, a ZEV can be considered to become more low emissions over time. On the contrary, an internal combustion engine is the lowest emissions it will ever be at the point it is placed in service, as it produces more tailpipe emissions over time due to deterioration of on-board emissions control systems.

While this plan does not delve deeply into details of upstream production or feedstock issues, it is important to acknowledge these concerns. There are substantial differences in the potential for emissions benefits on a well-to-wheels basis, depending on the method by which either electricity or hydrogen is produced. Electricity produced from renewable energy sources (e.g., solar or wind) will have greater emissions benefits than that produced via coal or natural gas-powered generation, as the renewable generation has lower carbon intensity and also lower criteria pollutants on a well-to-wheels basis. Similarly, the production mechanism for hydrogen, whether from renewable sources or fossil fuel sources, has substantial impact on the well-to-wheels benefits.

Since a major motivation for ZEV deployment is air quality improvement, NCTCOG would encourage use of the production pathways that result in the lowest lifecycle emissions but acknowledges that the lowest emission pathways may present higher costs and be less readily available in the near term. However, NCTCOG also notes that upstream fuel production may happen outside of the nonattainment areas, and could be dispersed across broad geographic areas, whereas the tailpipe benefits of a ZEV transition are most strongly felt in the urban cores where high concentrations of vehicles are active. This is most certainly true for electricity generation, where electric generating units are often located outside of the nonattainment areas in more rural areas. Thus, the well-to-wheels emissions benefits of BEV adoption are likely to be enhanced in the urbanized nonattainment areas, with the upstream impacts being felt in other parts of the state. On the other hand, hydrogen production in Texas has typically been concentrated along the Texas Gulf Coast, with a relatively large proportion happening within the Houston nonattainment area boundary.

New federal actions aimed at reducing power plan and major industrial emissions, such as the "Good Neighbor" plan recently proposed by EPA,[11] would further enhance well-to-wheels benefits of BEVs by reducing the emissions generated by upstream activities, including conventional generation methods. Likewise, federal investments from the Bipartisan Infrastructure Law are aimed at reducing upstream emissions impacts of hydrogen production, though they are primarily focused on climate impacts versus criteria pollutants.

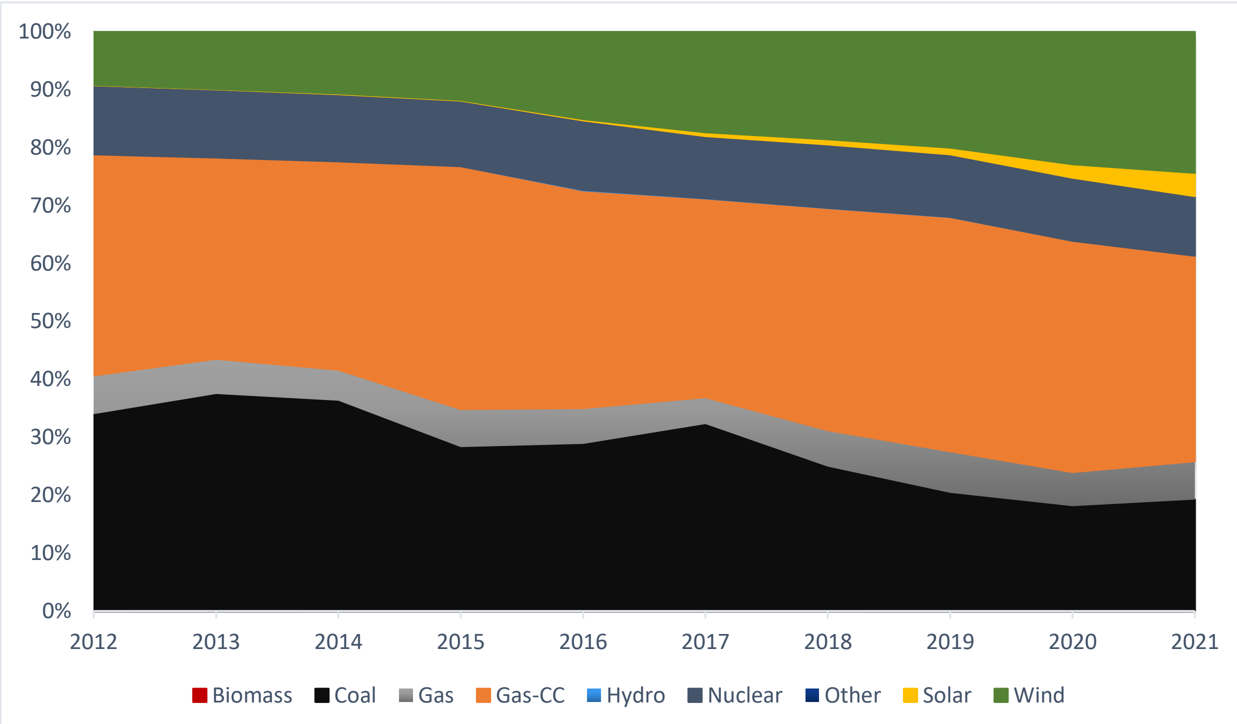
State of Electricity Generation

The IH 45 corridor falls into the Electric Reliability Council of Texas (ERCOT) grid, which is largely isolated from the grids in the rest of the country. Over the past decade, the trend in proportion of electricity generated from renewable sources has been increasing steadily. **Exhibit 23** illustrates the proportion of electricity generation attributed to various fuel sources over the last 10 years, based upon ERCOT Fuel Mix reports.[12] Clean electricity generation from renewables (wind, solar, and hydroelectric) has increased from approximately 9 percent of total annual electricity generation across the ERCOT grid in 2012 to approximately 28 percent in 2021. Combined with nuclear, nearly 40 percent of electricity

[11] EPA Proposes "Good Neighbor" Plan to Cut Smog Across Much of the United States | US EPA
[12] Fuel Mix Reports, Electric Reliability Council of Texas, https://www.ercot.com/gridinfo/generation

generation in the ERCOT grid is now produced from emissions-free sources. This proportion is increasing even in the face of an overall increase in total energy generation across ERCOT, which rose from approximately 324 terawatt-hours in 2012 to over 391 terawatt-hours in 2021. The trend toward increased renewable generation is key to continuing to achieve emissions reductions as transportation electrifies and is relevant to consider when reviewing the well-to-wheels emissions and energy graphs provided in **Exhibits 24** to **28**. Additional information on future generating capacity is provided in Chapter 5.

Exhibit 23: Electricity Generation by Fuel Type in the ERCOT Grid, 2012-2021



State of Hydrogen Production

Texas boasts compelling advantages regarding the supply of hydrogen, as the Houston Gulf Coast area produces nearly one third of the entire nation's hydrogen supply each year.[13] A recent study done by the Center for Houston's Future, along with the University of Houston Energy, and the University of Houston College of Business, found that, currently, a total of 48 hydrogen production plants on the Texas Gulf Coast produce approximately 3.44 million metric tons of hydrogen annually. Most of this production occurs through steam methane reformation (SMR).[14]

The Bipartisan Infrastructure Law (BIL) provides for substantial investment in production of "clean hydrogen," and momentum around lower-emission hydrogen production is gaining. Notably, the BIL included a provision for the Secretary of Energy to create a definition of "clean hydrogen," which has been announced as hydrogen that is produced with a carbon intensity equal to or less than two kilograms of carbon dioxide-equivalent produced (at the site of production) per kilogram of hydrogen

[13] Center for Houston's Future, *Houston Region: Becoming a Global Hydrogen Hub,* https://static1.squarespace.com/static/5bd0cda394d71a3556faeb6c/t/6022ff8c59eed438f73aaeaa/1612906382736/Houston+Hydrogen+Whitepaper+Final.pdf

[14] Center For Houston's Future, "Becoming a global hydrogen hub," (Slide 15), Microsoft PowerPoint - Houston Hydrogen Project_Final Report_DRAFT_12Jan21.pptx (squarespace.com), Accessed June 14, 2022.

produced. This definition, coupled with BIL investment in electrolysis and carbon capture and sequestration (CCS), will likely shift trends in hydrogen production toward lower-emissions pathways. Notably, a recent article published by Engineering News-Record covers Det Nostke Veritas (DNV) group's Hydrogen Forecast 2050, which forecasts hydrogen production by production route. DNV shows that the largest forms of hydrogen production are going to be dedicated renewable electrolysis, and grid-connected electrolysis that take up most of the market share. SMR with CCS is shown to start to have a gradual decline after 2045 whereas the other two options only show continual growth.[15] This transition would reduce upstream emissions associated with hydrogen production and enhance emissions benefits gained by displacing diesel with hydrogen in the transportation system. This is important to keep in mind when reviewing the well-to-wheels emissions and energy graphs provided in **Exhibits 24** to **28**.

Emissions Comparisons

NCTCOG used the Greenhouse gases, Regulated Emissions, and Energy use in Transportation Model (GREET) and Well to Wheels Calculator, developed by Argonne National Laboratory, to compare the well-to-wheels impacts of conventional and ZEV vehicles.[16] Comparisons were completed for key transportation-related criteria pollutants, including both ozone precursors (NO_X and VOCs) and $PM_{2.5}$. Comparisons for overall greenhouse gas emissions impact and total energy consumption were also completed.

Results are provided in **Exhibits 24** to **28**. These graphs illustrate emissions impacts on a well-to-wheels basis of:

- Conventional gasoline internal combustion engine vehicles
- Diesel internal combustion engine vehicles
- BEVs, separated based upon type of electricity generation:
  - US Mix
  - Natural gas combined cycle
  - Renewable
- FCEVs, separated based upon type of hydrogen production:
  - Central SMR using landfill gas
  - Central SMR using North America natural gas without CCS
  - Central SMR using North America natural gas with CCS
  - Central high temperature electrolysis with solid oxide electrolysis cells
  - Distributed electrolysis (using solar)

Note that the GREET model does not provide for an "ERCOT Grid" electricity generation mix. However, the US mix is a similar composition. In 2021, the total generation attributed to nuclear and renewables together totaled approximately 39 percent in both the ERCOT grid and across the US; coal makes up a slightly smaller proportion, and natural gas a higher proportion in the ERCOT grid compared to the US average mix.[17]

Note that neither ZEV platform provides favorable well-to-wheels comparisons for both ozone precursors, regardless of the electricity or hydrogen production pathway. This reinforces the

[15] Engineering News-Record, "Global Upswing Forecast in Hydrogen-Fueled Energy Production," Global Upswing Forecast in Hydrogen-Fueled Energy Production | 2022-06-14 | Engineering News-Record (enr.com), Accessed June 17, 2022.

[16] Argonne National Laboratory, the Greenhouse gases, Regulated Emissions, and Energy use in Transportation Model (GREET), Well to Wheels Calculator, https://greet.es.anl.gov/index.php, Accessed May 23, 2022.

[17] US Energy Information Administration, https://www.eia.gov/energyexplained/electricity/electricity-in-the-us-generation-capacity-and-sales.php#:~:text=In%202020%2C%20about%2060%25%20of%20U.S.%20utility-scale%20electricity,were%20natural%20gas%2040%25%20coal%2019%25%20nuclear%2020%25

opportunities for the ZEV transition to support ozone attainment efforts in both the DFW and Houston areas.

Exhibit 24: Well-to-Wheels NO_X Emissions of Gasoline, Diesel, Battery Electric, and Fuel Cell Electric Vehicle Platforms Based on Fuel Feedstock, in Grams/Mile

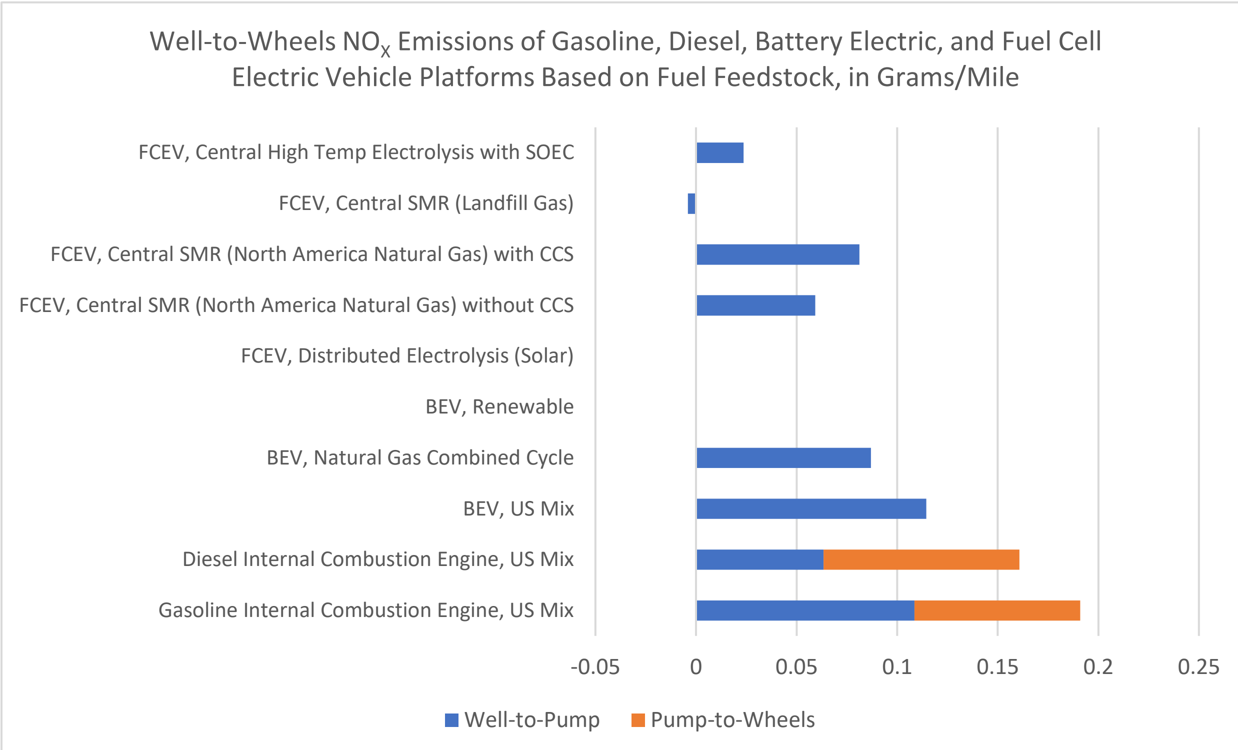
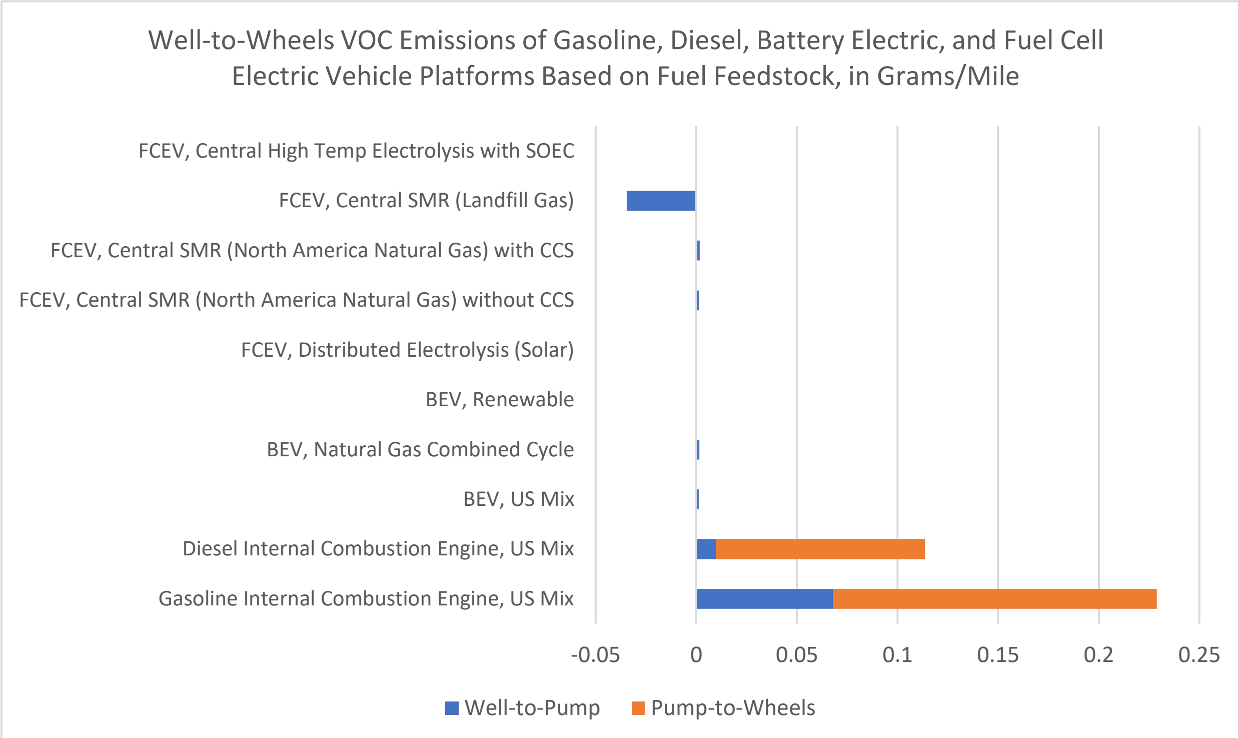
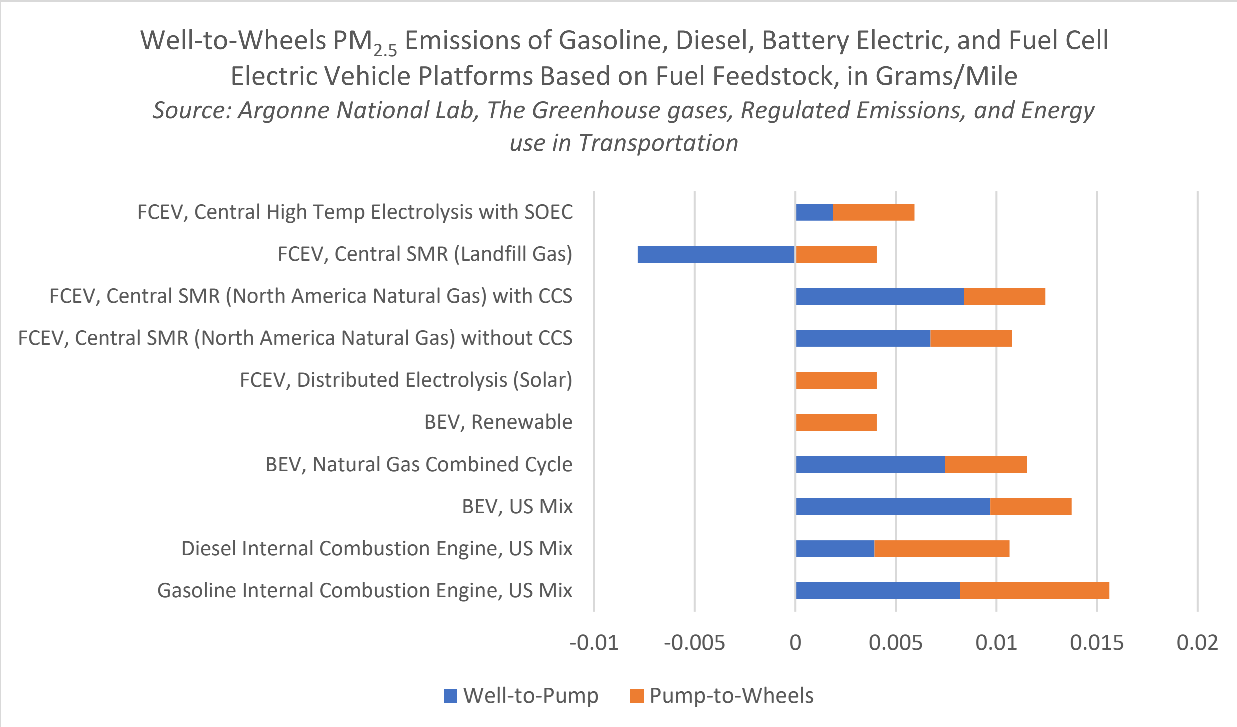


Exhibit 25: Well-to-Wheels VOC Emissions of Gasoline, Diesel, Battery Electric, and Fuel Cell Electric Vehicle Platforms Based on Fuel Feedstock, in Grams/Mile



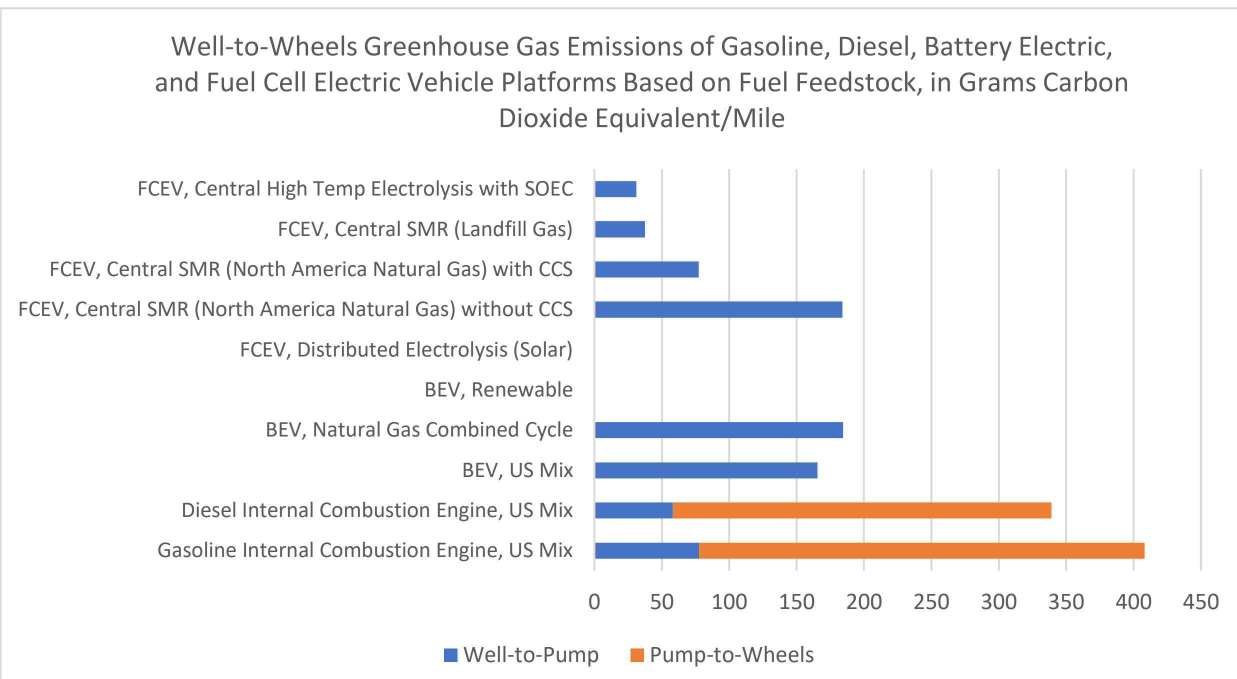
Well-to-wheels impacts on fine particulate emissions are more variable based on upstream processes. As renewables take a larger share of electricity generation, BEV benefits become more pronounced. On the hydrogen side, benefits are greatest with hydrogen produced via electrolysis, or SMR using landfill gas.

Exhibit 26: Well-to-Wheels $PM_{2.5}$ Emissions of Gasoline, Diesel, Battery Electric, and Fuel Cell Electric Vehicle Platforms Based on Fuel Feedstock, in Grams/Mile



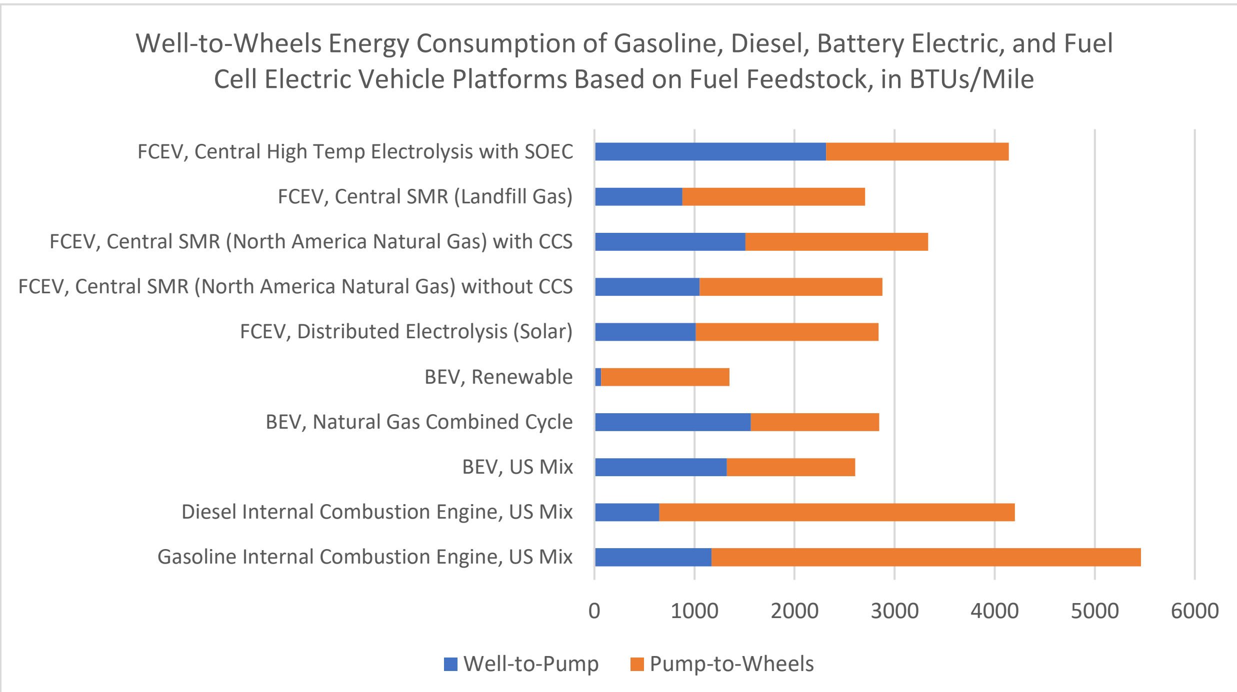
Both ZEV platforms also offer clear benefits in terms of greenhouse gas emissions impact due to the high rate of tailpipe emissions of a conventional internal combustion engine vehicle.

Exhibit 27: Well-to-Wheels Greenhouse Gas Emissions of Gasoline, Diesel, Battery Electric, and Fuel Cell Electric Vehicle Platforms Based on Fuel Feedstock, in Grams/Mile



Overall energy consumption is another impact that varies greatly depending on upstream processes. BEV platforms offer the greatest efficiency overall, regardless of type of electricity generation, based largely on the inherent efficiency of an electric motor. While there is some transmission loss from the point of power generation to the point of electricity consumption, as of 2017, transmission and distribution loss has reduced to 5.1 percent and would be even lower today due to continual improvements in grid efficiency.[18] In the case of FCEVs, efficiency losses are greater. There are efficiency losses associated with both the SMR process and in electrolysis, where electricity is transformed into hydrogen. There are also efficiency losses on board the vehicle itself from converting hydrogen fuel back into electricity to power the drivetrain. Thus, hydrogen can take substantially more energy to go the same distance as BEV due to loss of energy conversion.

Exhibit 28: Well-to-Wheels Energy Consumption of Gasoline, Diesel, Battery Electric, and Fuel Cell Electric Vehicle Platforms Based on Fuel Feedstock, in BTUs/Mile



Zero Emission Vehicle Availability and Outlook for Adoption

BEV adoption is starting to mature as more vehicles are on the market. ERCOT conducts a Long-Term System Assessment, during which they evaluate different scenarios that could result in changes to the load on the grid.[19] In the scenario used for the latest Long-Term System Assessment, key segments electrify as follows:

- Between 15 and 20 percent of light-duty vehicles on the road by 2037
- Over 15 percent of local heavy-duty trucks on the road by 2037

[18] Emissions Impacts of Electrifying Passenger Cars in Texas, July 31, 2019. Slide 16, Accessed 6/30/2022, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjm-veBldb4AhWPC0QIHROXAQ0QFnoECCEQAQ&url=https%3A%2F%2Fwww.epa.gov%2Fsites%2Fdefault%2Ffiles%2F2019-08%2Fdocuments%2F1000am_kite_0.pdf&usg=AOvVaw3tMPB5qCcGGEYs7hIE3DKK

[19] Electric Reliability Council of Texas (ERCOT) Long-Term Systems Assessment, https://www.ercot.com/files/docs/2020/12/23/2020_LTSA_Report.zip

- Approximately 10 percent of heavy-duty trucks on the road by 2037
- Over 70 percent of buses on the road by 2037

While FCEV adoption has not yet begun in Texas, a few transit agencies are planning near-term FCEV pilot projects, and the outlook in the MHD sector is promising as technology matures.

It should be noted there is a greater degree of certainty on the results, impacts, and benefits of BEV adoption due to greater market maturity, which yields a more robust set of observed data and longer-lasting trends from which to project adoption or impacts. This is true across the spectrum of evaluation, from vehicle availability and costs to upstream fuel production impacts discussed previously. Many MHD FCEV developments are still in nascent stages. Expected drops in both vehicle and fuel costs, and transition toward more renewable hydrogen production, are largely predicated on BIL investments that will be coming to fruition over the next several years. Nonetheless, both platforms are likely to play a role in transportation in the coming years.

Light-Duty Vehicles

As of February 2022, there are 28 different electric vehicles (EVs) available in the United States from 18 different manufacturers. According to the 2021 EPA Automotive Trends Report, 3.1 percent production share in 2021 were ZEVs and by 2025, it is estimated that 30 percent of new car sales could be a form of electric, including both ZEV and plug-in hybrid.[20] Additionally, the Biden Administration announced a national goal for 50 percent of all passenger vehicle sales in the United States to be electric by 2030. Anticipating this technology transition, many automobile manufacturers have set various electrification and carbon neutrality goals, which will significantly increase ZEV options and availability on the market, which can be seen in **Exhibit 29** below.

According to EV registration data compiled by NCTCOG/DFWCC, as of June 14, 2022, there were 130,435 registered EVs in Texas, comprising approximately 0.54 percent of all registered vehicles in Texas. Nearly three-fourths of these, or approximately 98,000, are truly ZEV as they are full battery-electric, with the remainder being plug-in hybrid electric (and not in the scope of a ZEV). Comparatively, EVs constitute approximately 0.71 percent of the overall passenger vehicle fleet in the North Texas region and 0.54 percent of vehicles in the Houston-Galveston region. North Texas observed a 32.5 percent average annual growth for EV registration from 2015 to 2020, showing that EV adoption is growing quickly within the region. Current forecasts predict ZEVs could comprise 30 percent of all vehicles on the road by 2040, based on policy and technology assumptions, but the rate of adoption may be substantially impacted by state and local measures.[21]

As noted, light-duty FCEVs are not expected to be available to or adopted by Texans until after MHD FCEVs are deployed.

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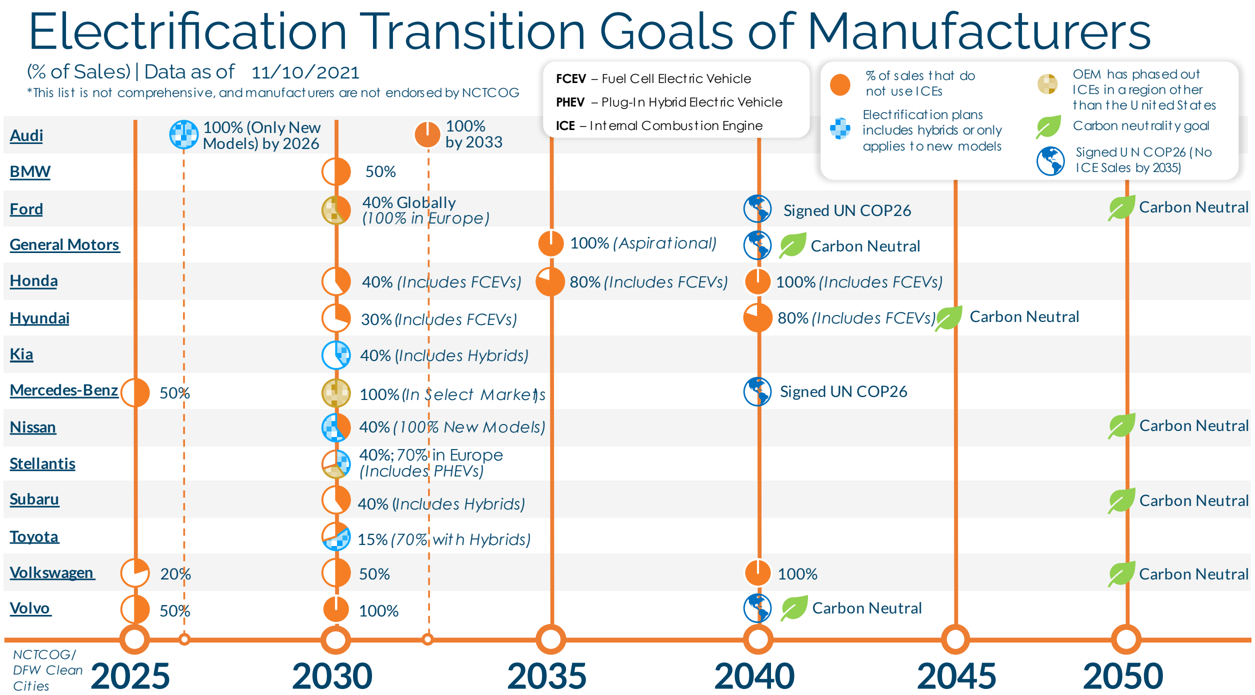
[20] US Environmental Protection Agency 2021 Automotive Trends Report, https://www.epa.gov/automotive-trends/download-automotive-trends-report#Full%20Report

[21] Bloomberg New Energy Finance, Electric Vehicle Outlook 2020, https://about.bnef.com/electric-vehicle-outlook/

Exhibit 29: Electrification Transition Goals of Manufacturers



Medium- and Heavy-Duty Vehicles

ZEV availability in the MHD sector is still in its early years but is accelerating quickly, with quick uptake in demand. With Diesel Class 8 tractor trucks being the staple of the cargo-hauling industry for over 50 years, these trucks can hold over 300 gallons of fuel and run 1800 miles on a single tank. As air quality and sustainability goals drive interest to change, ZEVs must strive to meet the same performance demands with the fewest required changes in operational practices as possible to gain adoption and acceptance. Several reports on decarbonizing or electrifying this sector have been completed recently, including studies by the North American Council on Freight Efficiency (NACFE), the Fuels Institute, and the National Renewable Energy Laboratory. The NACFE Run on Less Report found that for regional haul (defined as trucks staying within 300 miles of their home base), alternative-fuel vehicles, especially BEV trucks, are ideal.[22] Another report by NACFE showed that regional haul trucking for 10 different fleets showed a daily average of 434 miles was achievable and accessible to fleets with current options.[23] Key findings support the premise that ZEV adoption will grow rapidly as technologies mature, driven by two major factors. First, total cost of ownership for ZEVs promises to be more favorable than diesel due to the improved efficiency of an electric drivetrain relative to an internal combustion engine, regardless of whether that electric drivetrain is powered by batteries or a fuel cell. Second, corporate objectives to decarbonize or otherwise reduce their environmental footprint are gaining ground, whether based on regulatory mandates or the economic advantages of being perceived as a "green" company. As advancements in vehicle and fuel technologies continue, ZEVs could reach cost parity with conventional diesel fuels for all MHD vehicle classes by 2035 without incentives, and ZEV sales could reach 42 percent

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[22] North American Council for Freight Efficiency "Run on Less Regional Report Executive Summery," June 2020, Page 7, Accessed June 15, 2022, https://nacfe.org/wp-content/uploads/edd/2020/06/ROLR_NACFE_Report_Executive_Summary.pdf

[23] North American Council for Freight Efficiency "Battery Electric Powertrains for Class 8 Regional Haul Freight Based on NACFE Run-On-Less," June 14-17 2020, Page 11, Accessed 6/21/22, https://nacfe.org/wp-content/uploads/2020/06/EVS33_Mihelic_ID257_NACFE_NREL_PrePub_Download.pdf

of MHD vehicles by 2030 through lower combined vehicle purchase and operating costs.[24] A third factor is the presence of regulatory or policy factors, such as those in California, that are now mandating a certain level of ZEV adoption. While these are less pronounced in Texas, which is not a "ZEV state," there is some indirect level of influence as the regulations force market maturity to advance in other areas, thus increasing technological familiarity and market maturity nationwide. These types of policy and regulatory levers are discussed in more detail in Chapter 6.

Within the two ZEV platforms, there are a few key factors that drive the decision on the best solution for a given truck application. In terms of overall energy efficiency, a BEV will have better performance as there is minimal energy loss, whereas a FCEV presents energy losses during the process of converting hydrogen fuel into electricity. However, there are a few key considerations that may result in a FCEV being a better fit:

- Weight: Batteries are heavy, so trucks and routes that are weight-constrained may find a FCEV to be a better solution to avoid loss of payload.
- Range: To date, batteries have a shorter range, whereas FCEVs are anticipated to be more closely comparable to ranges of diesel trucks for how far one can drive in a single day.
- Fueling Time: Hydrogen fueling can be completed in approximately the same amount of time as diesel fueling, which can help avoid changes in operational patterns that might be needed to accommodate the longer charging times for BEV trucks.

As noted in the Introduction, most of the heavy-duty traffic on the IH 45 corridor falls into the largest weight category, suggesting that FCEVs may be well-suited to trucks hauling freight on this route. However, much traffic may be confined to Texas, indicating a relatively short range, which may lend well to BEVs. Both platforms are likely to be well-suited solutions, depending on individual fleet needs. Recommendations for additional analyses to further evaluate the volume of traffic along this corridor and other major routes in Texas are outlined in Chapter 8.

Battery-Electric Vehicle Trucks

Texas benefits from low costs of energy, especially electricity. The average retail cost of electricity in Texas is 8.36 cents per kilowatt-hour, as reported by the Energy Information Administration, versus the national average of 10.59 cents per kilowatt-hour. [25] Using and maintaining a BEV is drastically less expensive than an internal combustion engine vehicle, largely due to the lower cost of fuel and reduced costs for maintenance and repair. These factors help offset the initial capital cost and are a major factor driving the economic benefits of BEV adoption, where total cost of ownership can already reach parity with diesel in certain applications. A recent study by the National Renewable Energy Laboratory indicates that medium-duty (Class 4-6) BEVs shipping in the 100- to 300-mile range reach cost parity with diesel on a total cost of ownership basis shortly after 2025, with heavy-duty (Class 7-8) BEVs achieving this milestone shortly after 2030.[26] This assumed electricity cost per kilowatt-hour is slightly higher than that seen in Texas, with diesel costs of under $4 per gallon. Current fuel prices, if sustained, would further enhance the costs benefits of choosing a BEV over diesel.

As BEVs grow in popularity, there are currently 18 heavy-duty BEV options from 9 different companies. Two more options will be released in 2022. These options can be seen in **Exhibit 30** below, along with

[24] NREL's "Decarbonizing Medium- & Heavy-Duty On-Road Vehicles: Zero-Emission Vehicles Cost Analysis," March 2022, Accessed April 1, 2022, https://www.nrel.gov/docs/fy22osti/82081.pdf

[25] State Electricity Profiles - Energy Information Administration (eia.gov)

[26] National Renewable Energy Laboratory. Decarbonizing Medium- and Heavy-Duty On-Road Vehicles: Zero-Emission Vehicles Cost Analysis, https://www.nrel.gov/docs/fy22osti/82081.pdf

key details of each model. Both the heavy-duty and light-duty sectors currently utilize the Society of Automotive Engineers CCS connector for Direct Current Fast Charging, allowing for cross-compatibility and standardizing infrastructure options. Even as the industry works toward a megawatt charging system standard for heavy-duty trucks, there seems to be agreement among original equipment manufacturers to ensure interoperability and standardization of connector and infrastructure architecture.[27]

Exhibit 30: Future and Current BEV Heavy-Duty Truck Options[28]

OEM	Model	Weight Class/Size	(Estimated) Payload (lbs)	Battery Size (kW)	(Estimated) Range (miles)	(Estimated) Availability
BYD	8TT	Class 8	78,765	409	125	Available
Freightliner	eCascadia	Class 8	not available	550	250	2022
Freightliner	eM2 106 - Class 7	Class 7	not available	550	250	Available
Kenworth	T680E	Class 8	57,500	396	150	Available
Lion	Lion8	Class 8	30,000	480	180	Available
Mercedes-Benz	eActros	Class 8	40,000	240	124	Available
Nikola	Tre EV	Class 8	40,000	753	350	Available
Peterbilt	520EV	Class 6	not available	420	90	Available
Peterbilt	520EV	Class 7	not available	420	90	Available
Peterbilt	579EV	Class 8	not available	420	200	Available
Roush	Ford F-750	Class 7	not available	not available	not available	Available
SEA Electric	Autocar ACMD Class 7	Class 7	depends	160	150	Available
SEA Electric	Autocar ACMD Class 8	Class 8	depends	160	150	Available
SEA Electric	Freightliner Cascadia	Class 8	depends	216	150	Available
SEA Electric	Freightliner M2 105	Class 8	depends	160	150	Available
SEA Electric	Freightliner M2 106	Class 8	depends	160	150	Available
SEA Electric	Hino GH EV	Class 8	depends	220	125	Available
SEA Electric	Kenworth T370	Class 8	depends	160	150	Available
Tesla	Semi	Class 8	not available	not available	500	2022
Volvo	VNR Electric	Class 8	66,000	565	275	Available

Fuel Cell Electric Vehicle Trucks

Heavy-duty FCEV truck options are growing. Currently, the price for hydrogen ranges between $13.11 to $16.50 per kilogram after tax.[29] However, the Department of Energy Hydrogen Shot initiative has set a goal to reduce the cost of one kilogram to one dollar in one decade. This would represent a reduction in cost of over 90 percent. Interest in FCEVs is already high, and with the expected drops in fuel price, demand is likely to increase, driving expanded production in FCEV Class 8 trucks. The Center for Houston's Future completed an evaluation which found that the total cost of ownership for a heavy-

[27] Megawatt Charging System (MCS) (charin.global)

[28] CALSTART (2022): Drive to Zero's Zero-Emission Technology Inventory (ZETI) Tool, Accessed March 21, 2022, https://globaldrivetozero.org/tools/zero-emission-technology-inventory/

[29] Joint Agency Staff Report of Assembly Bill 8: 2019 Annual Assessment of Time and Cost Needed to attain 100 Hydrogen Refueling Stations in California

duty FCEV falls below that of a heavy-duty diesel truck – with total cost of ownership for a FCEV truck of $0.77 million per truck versus $1 million per truck for diesel – by 2026.[30]

As illustrated in **Exhibit 31**, as of April 2022, the Global Commercial Vehicle Drive to Zero: Zero-Emission Technology Inventory website indicates that two FCEV options are available for purchase: the Hyzon FCET 6 and FCET 8. Both trucks boast a range in excess of 300 miles. However, for the future of the FCEV market, six options will be coming out in 2023 to 2024. The FCEV market is only expected to grow more extensive and more efficient. The Hydrogen Council predicts that approximately 2.5 percent of heavy-duty truck sales will be FCEV in 2030.[31] This seems consistent with rates of adoption of other new vehicle technologies. For reference, passenger EVs just reached 5 percent of new sales in 2021, approximately one decade after the release of modern EVs.

Exhibit 31: Future and Current FCEV Heavy-Duty Truck Options

(Source: Drive To Zero ZETI; data collected on 3/21/2022)[32]

OEM	Model	Weight Class/Size	Estimated Payload (lbs)	Battery Size (kW)*	Estimated range (miles)	Estimated Availability
Hyundai	HDC-6 Neptune	Class 8	not available	not available	800	2023
Hyundai	Xcient	Class 8	not available	not available	249	2023
Hyzon	FCET 6	Class 6	not available	55	350	Available
Hyzon	FCET 8	Class 8	not available	110	500	Available
Kenworth	T680	Class 8	not available	not available	150	2023
Nikola	Tre FCEV	Class 8	40,000	not available	500	2023
Nikola	Two FC	Class 8	40,000	not available	900	2024
Toyota	Beta	Class 8	40 tons	12	300	2023

**Refers to the on-board battery that drives propulsion; the battery receives power from the fuel cell*

30 Center for Houston's Future, *Houston Region: Becoming a Global Hydrogen Hub*, https://static1.squarespace.com/static/5bd0cda394d71a3556faeb6c/t/6022ff8c59eed438f73aaeaa/1612906382736/Houston+Hydrogen+Whitepaper+Final.pdf

31 Challenges remain in path for fuel cell electric trucks - Truck News

32 CALSTART (2022): Drive to Zero's Zero-Emission Technology Inventory (ZETI) Tool, Accessed March 21, 2022, https://globaldrivetozero.org/tools/zero-emission-technology-inventory/

CH 3

Filling the Gap: EV Charging for Light-Duty Passenger Vehicles

Chapter 3

Filling the Gap: EV Charging for Light-Duty Passenger Vehicles

Assessment of Existing Infrastructure

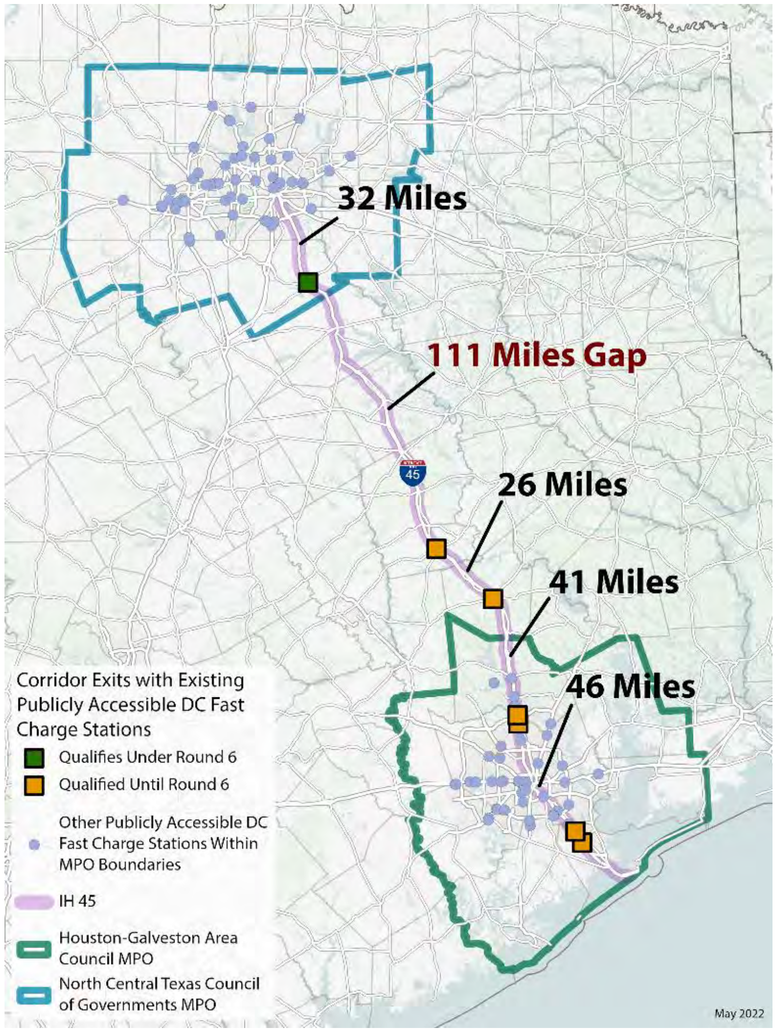
As mentioned in Chapter 1, the Federal Highway Administration (FHWA) has requested nominations for Alternative Fuel Corridors in six 'rounds' since the Alternative Fuel Corridor Program began. Currently, the entire IH 45 corridor is designated "Corridor Ready" for electric except for a 111-mile gap from Ennis to Madisonville. **Exhibit 32** lists details for existing Direct Current (DC) Fast Charge stations along the corridor, along with corridor designation status at that location and the distance to the next "corridor-qualifying" DC Fast Charge stations. These sites are then mapped in **Exhibit 33**. All locations in this table met corridor designation standards through Round 5 of the FHWA Alternative Fuel Corridor nominations/designations. As noted in Chapter 1, FHWA updated the criteria for DC Fast Charge stations to be eligible for corridor consideration during the Round 6 Request for Nominations, which was released in February 2022. As a result of the updated criteria, several of these existing stations no longer meet corridor designation standards. However, FHWA did not "downgrade" corridor designations because of this change. Thus, there was no change to the "pending" segment, which remains limited to the 111-mile gap between Ennis and Madisonville.

Exhibit 32: Existing Electric Vehicle Charging Stations that Met FHWA Corridor Criteria Through Round 5 Designations

Site/Network	Exit #	Address	Connector Details	Distance from Highway	Distance to Next Round 5 Qualifying Station (miles)	Corridor Designation at this Location	Still Qualifies Under Round 6 Criteria?
Walmart/Electrify America	251B	700 East Ennis Avenue, Ennis, TX 75119	Outlets: 4 Connectors: CHAdeMo, CCS	0.5	Northbound: Last qualifying station along corridor Southbound: 111	Point at which Ready and Pending Segments Meet	Yes
Walmart/Electrify America	142	1620 East Main Street, Madisonville, TX 77864	Outlets: 4 Connectors: CHAdeMo, CCS	1.2	Northbound: 111 Southbound: 27	Point at which Ready and Pending Segments Meet	No; 0.2 miles too far from Interstate
Walmart/Electrify America	116	141 IH 45 South, Huntsville, TX 77340	Outlets: 4 Connectors: CHAdeMo, CCS	1.3	Northbound: 27 Southbound: 43	Ready	No; 0.4 miles too far from Interstate
H-E-B/EVgo	73	130 Sawdust Road, Spring, TX 77380	Outlets: 1 Connectors: CHAdeMo, CCS	1.3	Northbound: 43 Southbound: 5	Ready	No; too few connectors
Walgreens/EVgo	68	19710 Holzwarth Road, Spring, TX 77388	Outlets: 1 Connectors: CHAdeMo, CCS	1.6	Northbound: 5 Southbound: 45	Ready	No; too few connectors
Cracker Barrel/ EVgo	23	231 Gulf Freeway South, League City, TX 77573	Outlets: 1 Connectors: CHAdeMo, CCS	0.3	Northbound: 45 Southbound: 3	Ready	No; too few connectors
Walmart/Electrify America	20	1701 West FM 646 Road, League City, TX 77573	Outlets: 3 Connectors: CHAdeMo, CCS	1.5	Northbound: 3 Southbound: Last qualifying station along corridor	Ready	No; too few connectors

CHAdeMo = Charge de Move
CCS = carbon capture and sequestration

Exhibit 33: Existing Publicly Accessible DC Fast Charge Stations Along the IH 45 Corridor



The change in qualifying station criteria impacts the 'readiness' of IH 45, both north and south of the existing "pending" segment. After the change in Round 6 qualifying criteria, the only DC Fast Charging station along the entirety of IH 45 that meets the latest FHWA criteria is the Electrify America site located at a Walmart in Ennis, Texas. Despite this apparent dearth of qualifying stations, the designated "pending" segment remains the most important focus for planning efforts because several new DC Fast Charge stations are planned on both the northern and southern ends of the corridor. Corridor-compliant station availability will be enabled for the northern end of the corridor, as well as the portion of the corridor from Madisonville southward, because of the Texas Volkswagen Environmental Mitigation Program (TxVEMP) funding awarded by the Texas Commission on Environmental Quality in early 2022.[1] The conditions of the TxVEMP awards received by these sites require stations to be publicly available 24 hours a day, 7 days a week; have a minimum power rating of 150 kilowatts (kW); and include at least one Charge de Move (CHAdeMO) and one Society of Automotive Engineers (SAE) carbon capture and sequestration (CCS) connector. The details of the power rating – that is, whether the power level is split among connectors (e.g., whether two electric vehicles charging at the same time will each receive 150

[1] "Projects Awarded" Report, https://www.tceq.texas.gov/agency/trust/dcfch

kW of power or whether the 150 kW would be divided among connectors in the event of simultaneous charging) – is not yet known. However, the sites listed in **Exhibit 34** are within one mile of the Interstate exit and are likely to meet most, if not all, FHWA corridor criteria. Upon completion, these locations will result in substantial availability of DC Fast Charge stations within the required 50-mile interval from Madisonville southward.

Exhibit 34: TxVEMP-Awarded Electric Vehicle Charging Stations that Meet FHWA Round 6 Corridor Criteria

TxVEMP Grant Recipient	Exit #	Address	Expected # Connectors (will include at least 1 each SAE CCS and CHAdeMO)	Distance to Next Potentially Qualifying DC Fast Charging Station	Current Corridor Designation at this Location
B&G Warehouse Services	284A (north of transition from IH 45 to US 75)	496 South Good Latimer Parkway, Dallas TX 75226	4	~35 miles south to Ennis charger	Ready
Landmark Industries, LLC	142	3002 East Main Street, Madisonville, TX 77864	4	~111 miles north to Ennis charger	Point at which ready and pending segments meet
Retail EV Charging Central Texas, LLC	142	205 IH 45, Madisonville, TX 77864	6	~111 miles north to Ennis charger	Point at which ready and pending segments meet
Landmark Industries, LLC	90-91	1200 League Line, Conroe, TX 77303	4	~51 miles north to Madisonville chargers	Ready
Equilon Enterprises, LLC (dba Shell Oil Products US)	68	110 East Louetta, Spring, TX 77373	4	~23 miles north to Conroe charger	Ready
Landmark Industries, LLC	15	1001 FM 1764, LaMarque, TX 77568	4	~53 miles north to Spring charger	Ready

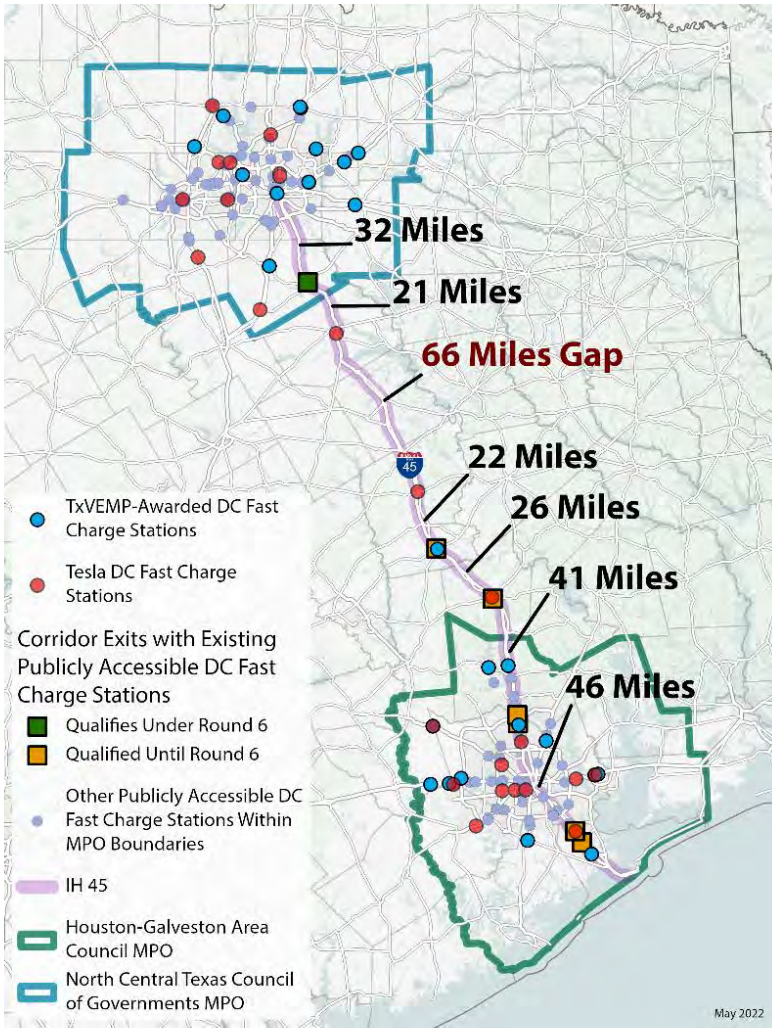
The northern end of the corridor will also benefit from the Zero Emission Vehicle (ZEV) Investment Plan portion of the Volkswagen settlement. The Dallas-Fort Worth metroplex will be the site of at least 8, and as many as 12, new Electrify America stations as a result of the Cycle 3 National ZEV Investment Plan.[2] These stations are also expected to meet FHWA criteria, and there is a high probability of at least one being in close proximity to the IH 45 corridor (which transitions to US 75 near downtown Dallas). This investment will re-establish the availability of corridor-compliant stations on the northern end of IH 45.

In addition to the stations planned through TxVEMP and Electrify America, Tesla has announced plans to open its proprietary charging network to allow charging by other types of electric vehicle (EVs). While this is not a certainty, it does present another scenario in terms of existing infrastructure availability. There are currently five Tesla DC Fast Charge sites along the IH 45 corridor in Corsicana, Centerville, Huntsville, Houston, and Webster. *If* these sites were to be made universally accessible with the addition of (SAE) CCS connectors, they would complete the corridor without the need to build additional sites beyond those already funded.

Exhibit 35 illustrates existing DC Fast Chargers from **Exhibit 32**, combined with those which have been awarded TxVEMP funds as listed in **Exhibit 34**, and Tesla sites. If all the TxVEMP locations come to fruition *and* the Tesla sites were to be made universally compatible, the largest distance between DC Fast Charge stations along the corridor would be 65.8 miles.

[2] Cycle 3 National ZEV Investment Plan, https://www.electrifyamerica.com/our-plan/

Exhibit 35: Existing, TxVEMP-Awarded, and Tesla DC Fast Charge Stations Along the IH 45 Corridor



Approach to Identifying Recommended Exits for New Charging Stations

To evaluate highway exits and develop siting recommendations for new stations, staff first created a spreadsheet that detailed every exit along IH 45 with a variety of key data characteristics. This information was compiled for all exits that led from IH 45 to an intersecting roadway that was designated as part of the National Highway System and/or the Texas Department of Transportation (TxDOT) Highway Freight Network. This spreadsheet is included as Appendix 3. Filters were then used to narrow the focus for siting recommendations:

1. Filter 1: Include only exits that are within the 111-mile “corridor-pending” segment – this is between Exit 142 in Madisonville and Exit 251B in Ennis.
2. Filter 2: Include only exits that lead to a roadway designated as part of the National Highway System (NHS). The intent of this plan is to develop actionable recommendations that result in project deployment, and the availability of incentive funding is a critical element to enabling projects to proceed. Incentive funding to support station development along IH 45 is available through the National Electric Vehicle Infrastructure Formula Program and will likely be leveraged to complete this corridor in the months immediately following publication of this plan. Stations located within one mile of the junction of IH 45, and another NHS roadway can serve to not only complete

the IH 45 corridor, but also set a foundation for future designation of the intersecting NHS roadway. By focusing on stations that serve two different highways, investments are optimized to reach the greatest number of travelers (and enable additional highway designations) with the lowest number of stations (and thus lower cost and potentially better return on investment per station). For example, the existing and awarded stations at Exit 142 serve “double duty” by serving travelers along US 190 and can be factored into a future nomination for that US Highway.

3. Filter 3: Exclude any exit where IH 45 connects to the intersecting roadway via a direct-connect ramp (e.g., Exit 247 at US 287). Direct-connect ramps do not offer opportunity to access facilities along the highway, as the direct-connect lanes take the driver from the main lanes of IH 45 to the main lanes of the “intersecting” roadway without any opportunity to exit the roadway.

After applying these three initial filters, only four exits remained for consideration. These locations are included in **Exhibit 36**, along with estimated distances to the next available existing station. Notably, three of the four exits are located in Corsicana, indicating that the corridor can be completed with only two strategically placed stations – one in Buffalo, near Exit 178, and one in Corsicana.

The final element that the North Central Texas Council of Governments (NCTCOG) considered was availability of amenities such as food, shopping, or entertainment, so that drivers have other services available to them while they wait for the vehicle to charge. NCTCOG compiled a summary of available amenities at each exit to serve as an indicator of development in the area and evaluate which locations offer services that a driver could find valuable. The types of amenities included were automotive services, fuel, bank services, entertainment, food, lodging, medical services, parks, pet services, rest areas, and shopping. Two of the three exits in Corsicana offer plentiful options. Thus, the recommended placement for additional EV chargers is one station at or near Exit 178 in Buffalo and another at or near either Exit 229 or 231 in Corsicana. Deployment of these stations would result in availability of a DC Fast Charge site within the 50-mile intervals required by FHWA, as the resulting intervals would be approximately 36 miles from Exit 142 in Madisonville to the recommended site in Buffalo, approximately 51 to 53 miles from the recommended site in Buffalo to the recommended site in Corsicana, and approximately 20 to 22 miles from the recommended site in Corsicana to the existing site in Ennis. **Exhibit 36** also details the city, county, and utility for each site, as these organizations have roles to play as Authority Having Jurisdictions or utility partners and should be contacted early in the project development phase. The Council of Government is also listed, as that agency could be a potential collaborator or may be able to facilitate coordination with the other relevant organizations.

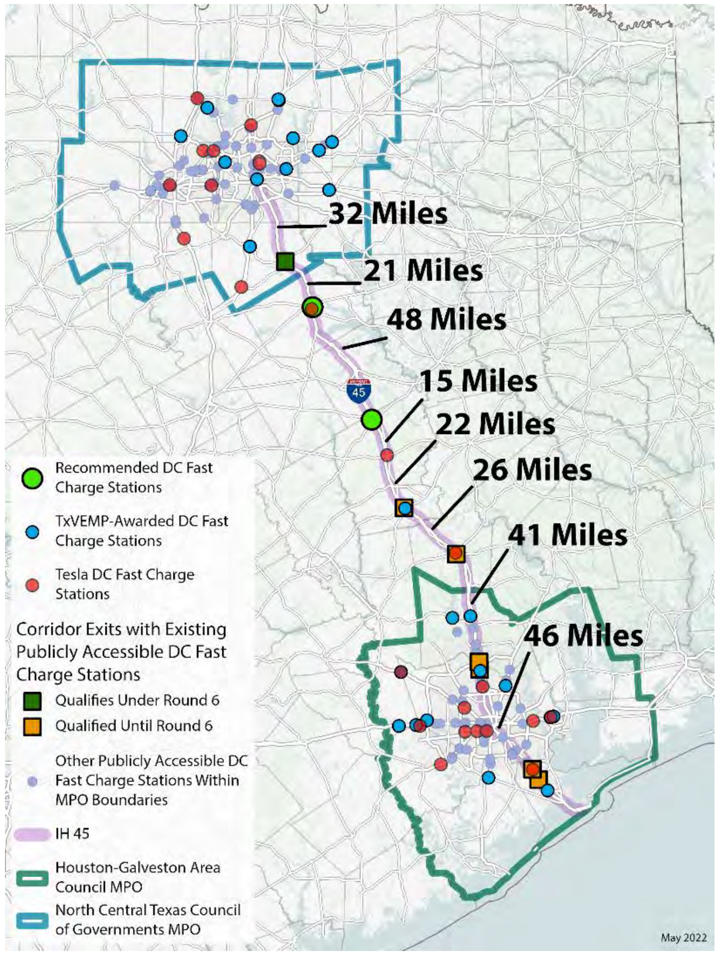
Exhibit 36: Exits Meeting Initial Three Criteria Filters and Siting Recommendations

<table>
<tr><th>Exit</th><th>Exit Name/ Street</th><th>City, County</th><th>COG</th><th>Electric Utility Territory/Utility Structure</th><th>Number of Amenity Types</th><th>Miles to Next Existing DC Fast Charge Station</th><th>Siting Recommendation</th></tr>
<tr><td>178</td><td>US 79</td><td>Buffalo, Leon</td><td>Brazos Valley COG</td><td>Oncor Electric (Deregulated)</td><td>5</td><td>~36 to Madisonville
~73 to Ennis</td><td>Station recommended</td></tr>
<tr><td>227</td><td>TX 31</td><td>Corsicana, Navarro</td><td>NCTCOG</td><td>Oncor Electric (Deregulated)</td><td>0</td><td>~85 to Madisonville
~24 to Ennis</td><td>No station</td></tr>
<tr><td>229</td><td>US 287</td><td>Corsicana, Navarro</td><td>NCTCOG</td><td>Oncor Electric (Deregulated)</td><td>9</td><td>~87 to Madisonville
~22 to Ennis</td><td rowspan="2">Station recommended at/near one of these two exits</td></tr>
<tr><td>231</td><td>Martin Luther King Jr. Blvd./SH 31 West</td><td>Corsicana, Navarro</td><td>NCTCOG</td><td>Oncor Electric (Deregulated)</td><td>9</td><td>~89 to Madisonville
~20 to Ennis</td></tr>
</table>

These locations are consistent with the study areas identified by TxDOT as part of the Texas EV Charging Plan and are expected to be constructed as part of TxDOT's implementation of the National Electric Vehicle Infrastructure Formula Program.[3] The suggested locations and miles to the next station are detailed below in **Exhibit 37**.

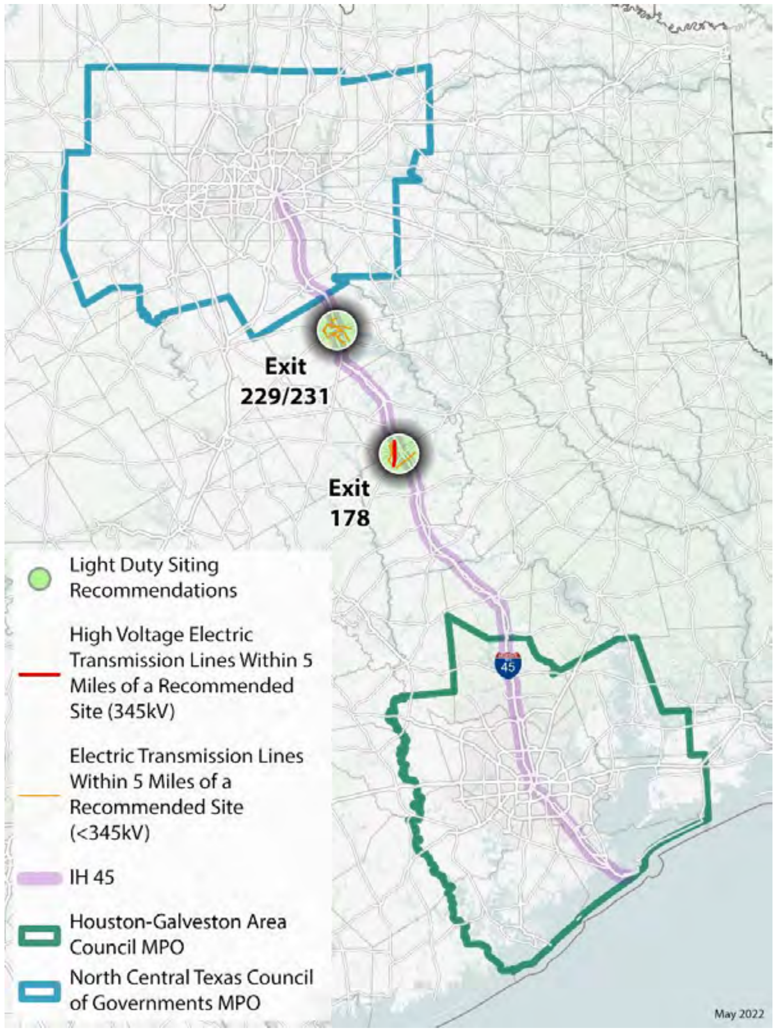
[3] https://txdot.mysocialpinpoint.com/tx_ev_plan

Exhibit 37: Existing, Awarded, and Recommended Electric Vehicle Charging Stations Along the IH 45 Corridor



NCTCOG did not factor in the availability or distance to utility substations or high voltage electrical lines as part of its analysis criteria. Utility stakeholders indicated there would not likely be challenges with providing the minimum 600 kilowatt power capacity needed at an individual charging station to meet FHWA standards for light-duty EV charging stations. However, NCTCOG did review locations of transmission and high voltage lines in proximity to the recommended exits after analysis was complete to review access of the recommended sites to grid infrastructure. As illustrated in **Exhibit 38**, both locations are in close proximity to grid assets.

Exhibit 38: Recommended Electric Vehicle Charging Sites in Relation to Electric Transmission Lines



CH 4

Building a Corridor for Medium- and Heavy-Duty Freight Vehicles

Building a Corridor for Medium- and Heavy-Duty Freight Vehicles

As stated in the Introduction, there are no criteria set forth by the Federal Highway Administration for building out corridors for medium- and heavy-duty (MHD) trucks in the same manner with the establishment of the Alternative Fuel Corridors for light-duty vehicles; however, with the passage of the Bipartisan Infrastructure Law, National Electric Vehicle Charging Corridors for Freight and Goods Movement criteria will be established by November 2022, after this plan is completed. Currently, the aforementioned electric vehicle (EV) charging stations on the corridor are the only zero emission vehicle (ZEV) infrastructure available to MHD vehicles traveling along the corridor, so this plan approaches the corridor as a blank slate for building new ZEV infrastructure designed with MHD vehicle capacities, drivers, and loads in mind as the end users, and that existing EV stations pose challenges for various reasons that are elaborated on below.

Approach to Identifying Recommended Exits for New Stations

In developing siting recommendations for infrastructure that serves MHD trucks, the North Central Texas Council of Governments (NCTCOG) first attempted to collect information from the industry about interest in, and plans for, a ZEV transition. NCTCOG distributed two surveys – one for fleets and shippers and one for fuel providers. This information gathering was largely unsuccessful, with only a few responses received. The results are outlined in Appendix 4 for reference.

Without leading information on industry plans, the overarching principle to approaching infrastructure recommendations was to identify where trucks are currently traveling to align proposed sites with existing travel patterns. This same approach was used for both hydrogen fueling and EV charging infrastructure. Two key data sources were used:

1. The Texas Department of Transportation (TxDOT) Statewide Planning Map:[1] This publicly available map includes data such as highway designations (e.g., on the National Highway System, on the TxDOT Freight Network), traffic data (e.g., traffic counts, truck traffic as a percentage of overall traffic), and other metrics that are useful in assessing where MHD traffic may be most likely to travel.
2. StreetLight Data:[2] StreetLight offers transportation analytics based on location-based data from applications on smartphones and in-vehicle navigation devices, which comprises approximately 40 billion anonymized location records each month. This is a ‘big data’ dataset, with large volumes of unstructured, hard-to-manage data that is incompatible with typical databases. The StreetLight algorithm called “Route Science” transforms these data points into contextualized, aggregated, and normalized travel patterns. The data is then validated against thousands of traffic counters and embedded sensors. Route Science normalizes and aggregates the data into transportation analytics, providing insights into how trucks move on various roadways. The software platform, StreetLight InSight®, is web-accessible and enables the user to analyze and visualize travel patterns. A feature within StreetLight enables the user to analyze travel for commercial trucks, which are tagged as medium-duty trucks (defined as 14,000 to 26,000 pounds gross vehicle weight rating) or heavy-duty

[1] https://www.txdot.gov/apps/statewide_mapping/StatewidePlanningMap.html
[2] https://www.streetlightdata.com/

trucks (defined as anything over 26,000 pounds). For the purposes of this project, both MHD trucks were included in the analysis. The truck type (weight) is an inherent attribute of the source data used by the StreetLight system. Notably, the source data points, or 'pings,' are linked together into anonymous truck 'trips,' and a truck trip ends when the individual truck is stationary for five or more minutes.

TxDOT had a contract to access StreetLight Data's InSight® platform during the drafting of this plan. As Metropolitan Planning Organizations, NCTCOG and the Houston-Galveston Area Council (H-GAC) were able to access the platform through the TxDOT contract. For this project, NCTCOG and H-GAC predominantly used the "top routes" analysis method to evaluate the origins or destinations of trucks coming through defined zones along or across IH 45. This analysis was used to identify major routes and turns taken by trucks traveling IH 45, and enabled staff to evaluate locations along IH 45 where recharging or refueling stations might be best placed to capture the largest volume of passing truck traffic prior to a point at which a noticeable amount of truck traffic turned onto another roadway.

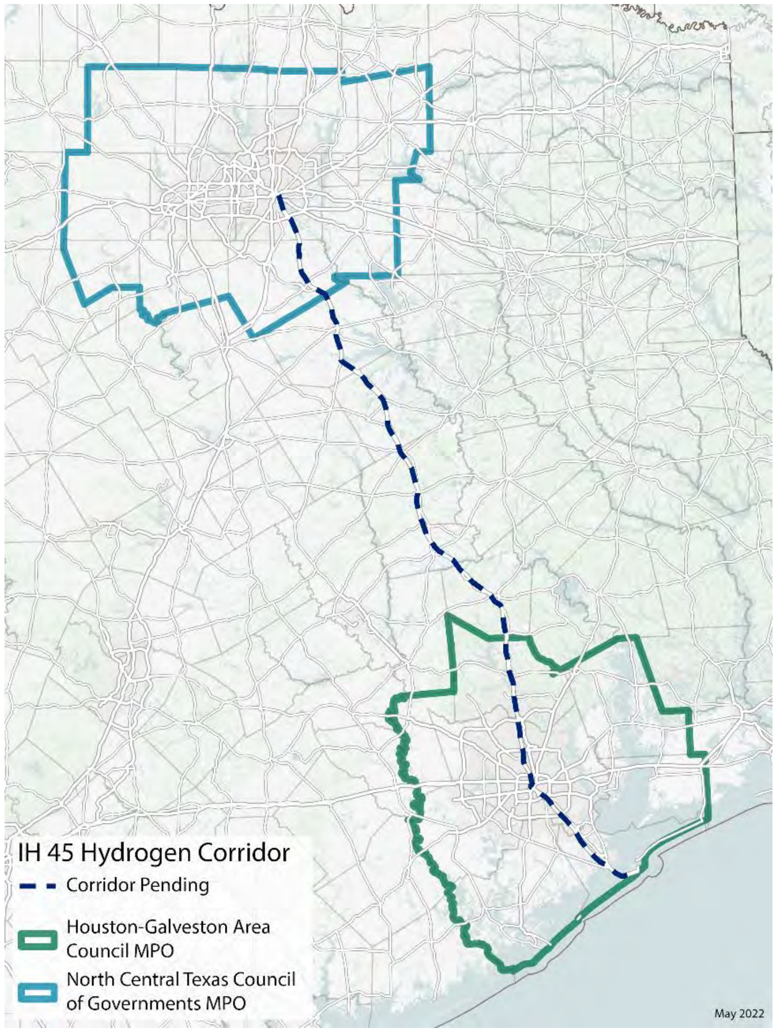
Assessment of Existing Infrastructure

Staff first assessed the degree to which MHD battery electric vehicles (BEVs) or fuel cell electric vehicles (FCEVs) are currently able to fuel:

Hydrogen Fueling: No hydrogen FCEV fueling infrastructure currently exists along IH 45, so the corridor is clearly a "blank slate" in terms of developing siting recommendations for this fuel type, shown in **Exhibit 39** below. The objective is to ensure availability of a hydrogen fueling station every 150 miles. The earliest adoption of hydrogen in the trucking sector has been related to port activity. In keeping with that model, it is likely that one of the first deployments of hydrogen for transportation purposes in Texas will be in conjunction with Port Houston. Analysis completed on behalf of the Center for Houston's Future has honed in on five potential sites for hydrogen fueling sites throughout the Houston area, with the container terminals at Bayport or Barbour's Cut seeming to be the most likely candidates for deployment. Further evaluation on a Port Houston area station is being conducted in conjunction with the Department of Energy sponsored H2@Scale in Texas and Beyond project being coordinated by Frontier Energy, the University of Texas at Austin, and GTI Energy.[3] NCTCOG analysis assumed that a station in the Port Houston vicinity will be deployed above and beyond recommendations along the IH 45 corridor.

[3] https://sites.utexas.edu/h2/h2scale-project-launched-in-texas/

Exhibit 39: Current IH 45 Corridor Designation for Hydrogen Fuel



EV Charging: While existing corridor qualifying Direct Current (DC) Fast Charge stations may technically be compatible with MHD BEVs, the reality is that building a corridor to support MHD BEV trucks is largely a blank slate. MHD BEVs are primarily commercial vehicles, mostly in the freight sector, where the downtime required to charge presents an opportunity cost in terms of business productivity. These vehicles will need high-powered DC Fast Charge stations that are capable of recharging their larger batteries quickly so they can return to work. There may be opportunities for time charging events to coincide with driver rest periods required to meet hours of service regulations, but adoption will likely be limited to short, regional-haul day-cab routes that return to a depot, unless higher-power chargers become more widespread. There is a growing consensus that to meet business operational needs, heavy-duty BEVs will use a Megawatt Charging System based on the carbon capture and sequestration (CCS) standard.[4]

As illustrated in Exhibit 30 in Chapter 2, many MHD BEVs are expected to have a battery capacity near or above 400 kilowatt-hours (kWh), and nearly all use the CCS protocol. The highest powered DC Fast Charge currently available in the United States are 350 kW chargers, and these are still relatively new and rare. There are two locations along the IH 45 corridor that incorporate 350 kW chargers – the Electrify America stations in Ennis and Huntsville. However, charging speed is not just a function of

[4] Megawatt Charging System (MCS) (charin.global)

power, but also the batteries themselves. Higher-powered charging can lead to battery degradation and better batteries are needed to reduce charging times, as well as reduce vehicle gross weight.

While this is a very high-power level, it should be noted that vehicles typically cannot accept power at this rate for a full charge. Most vehicles manage the flow of power into the battery and start to “ramp down” the incoming energy when the battery reaches approximately 50 percent state of charge.[5] Thus, a 350 kW charger would still take approximately 2.5 hours to provide a full charge to a 400 kWh battery, assuming an estimate of 90 percent useable battery capacity,[6] a conservative power efficiency loss estimate of 10 percent,[7] and the charger decreasing the power delivery around 50 percent state of charge. Taking over two hours to fully charge underscores the need for high-powered chargers of at least this level to serve MHD vehicles where the downtime associated with EV charging presents a business challenge. For example, the Nikola TRE BEV takes approximately two hours to charge from a battery state of 10 percent to 80 percent, using a 240 kW charger, which may not be a viable option to serve all routes or business needs.[8] However, technology improvements are expected to become more efficient in the future.

Aside from power constraints, the geometric design of existing EV charging stations is configured primarily to support light-duty BEV use, with the assumption that the vehicle will have a charging port readily accessible based on pulling in or backing into a typical parking space with the charging unit placed at the end of the space. MHD vehicles, in contrast, often cannot connect to these chargers without pulling across the spaces due to the charging cable length and location of the charging port on the vehicle. This can often result in adjacent chargers being blocked. **Exhibit 40** illustrates this challenge.

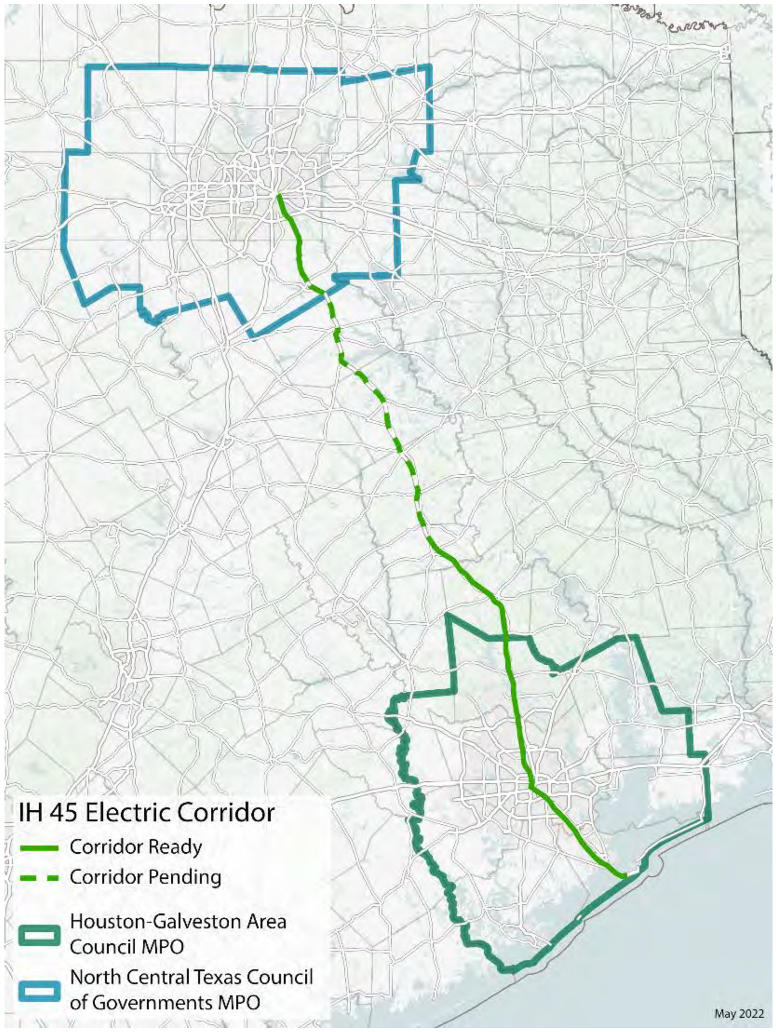
[5] DC Fast Charging - www.ElectrifyAtlanta.com
[6] EVs Explained: Battery Capacity, Gross Versus Net (caranddriver.com)
[7] How much does it cost to charge a Tesla? - Electrek
[8] Nikola Tre: Battery-Electric Daycab Semi-Truck (nikolamotor.com)

Exhibit 40: Examples of MHD BEVs Using Charging Stations Designed for Light-Duty Vehicles

(Photo source: Portland General Electric & Daimler Truck)

Based on these challenges, NCTCOG approached the task of developing recommendations for charging MHD BEVs along the IH 45 corridor from the perspective that no suitable charging stations are currently in place. **Exhibit 41** illustrates the current status of the IH 45 corridor designation from this perspective.

Exhibit 41: Current IH 45 Corridor Designation for Electricity



To meet Federal Highway Administration (FHWA) standards for alternative fuel corridor designation, NCTCOG adhered to the existing criteria for EV charging, which is to ensure availability of a suitable station every 50 miles. While this criterion is geared toward passenger vehicle traffic, and FHWA will soon be developing freight corridor designations as a provision of the Bipartisan Infrastructure Law, freight-oriented criteria are not yet available. Moreover, stakeholder feedback has been mixed – while it is widely acknowledged that MHD BEVs will have a range well in excess of 50 miles, some industry representatives have indicated the 50-mile interval may still be appropriate to provide the redundancy of charger accessibility needed to overcome concerns about charging station availability for freight drivers. For these drivers, the risk of a charging station being occupied and causing delay in deliveries may be less acceptable than for the average consumer, as lost time often represents lost revenue in the freight sector. Additionally, stakeholders have pointed out that because batteries charge quickly up to approximately a half-full charge, then reduce the rate of charging as a function of battery management, there may be interesting behavior patterns that evolve around a strategy to minimize downtime associated with charging events. For example, drivers may try to strategize a plan to charge when the battery is near empty and stop charging when the charging speed drops off rather than wait for a full charge, as the time to fill a battery from half full to full is substantially longer than that to fill from empty to half full. If this type of charger utilization pattern were to develop, the importance of redundancy and frequent spacing of chargers would increase, even if MHD battery range was adequate to allow a much longer interval.

Justification for Public-Access Electric Vehicle Charging to Serve Medium- and Heavy-Duty Trucks

Some may question the need for publicly available EV charging focused on the freight sector. Many fleets who are considering adoption of MHD BEVs are quick to dismiss the need for publicly accessible charging and indicate they intend to charge their trucks at their own fleet depots. EV charging stations are substantially less expensive than hydrogen fueling infrastructure, and thus many companies can justify the expense of building their own private-access facilities where they are able to control utilization and ensure charger availability for their own companies' vehicles. However, research has indicated that many freight operations cannot rely on depot charging alone:

- Idaho National Laboratory conducted a study of the real-world routes of a Texas carrier and determined that depot-only charging was not adequate. The study included real-world data collection on truck routes, combined with simulation of charging activities for three case study scenarios. One case study was of a regional-haul private motor carrier that made 23 stops at regional distribution centers. In this case study, the simulation modeled a scenario in which the fleet would plug in to charge throughout the entire stop at each distribution center but relied only on these locations (no use of public-access charging stations). Based on the modeling, in a scenario where the vehicle had 300 miles of range and used 350 kW charging, only 33 percent of trips would have been able to be completed with the amount of range remaining if the truck relied only on charging at the regional distribution centers. If charging services were available at delivery points, in addition to the distribution centers, the proportion of trips which could be completed improves to 79 percent.[9] This indicates that if companies intend to electrify beyond local pickup and delivery routes, some blend of depot and publicly accessible charging will be critical to supporting more flexible operations. Availability of publicly accessible DC Fast Charge along FHWA-designated corridors will likely be a key element of this infrastructure build-out.
- The Texas A&M Transportation Institute conducted a study on drayage truck electrification feasibility, using Port Houston as a case study (Sharifi et l, 2021[10]). The study showed that, if the trucks can only charge at their depots, only up to 42 percent of their daily mileage can be carried out by an electric truck. Having additional charging opportunities beyond the depots will significantly increase the operational coverage of electric trucks.

Methodology for Siting Recommendations

As explained in Chapter 3, NCTCOG began this evaluation by creating a spreadsheet that detailed every exit along IH 45 with a variety of key data characteristics. This information was compiled for all exits that led from IH 45 to an intersecting roadway that was designated as part of the National Highway System and/or TxDOT Highway Freight Network. Given the emphasis of the FHWA Alternative Fuel Corridors Program on connectivity for long-distance travel, roadways that did not carry one of these designations were considered to be inappropriate for consideration as they likely either do not carry adequate traffic volume or do not adequately connect to other highways. A summary of this spreadsheet is included as Appendix 3.

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[9] Victor Walker, Idaho National Laboratory, Charging Infrastructure Needs for Electrification of Freight Delivery Vehicles, 2020 DOE Vehicle Technologies Office Annual Merit Review, June 3, 2020, EEMS 072.

[10] http://www.carteeh.org/wp-content/uploads/2022/02/TTI-03-23-Drayage-Truck-Electrification-Feasibility-and-Benefit-Analysis-Sharifi.pdf

The first step was to evaluate appropriate 'end points' for the corridor from a freight perspective:

- **Northern Endpoint:** Anecdotally, NCTCOG understands that on the northern end of the corridor, MHD traffic attempts to avoid driving into the Dallas urban core unless necessary, and much northbound traffic turns off onto IH 20. Similarly, much southbound traffic enters the IH 45 corridor from a variety of directions. StreetLight observations support this understanding. For this reason, staff determined the IH 45 and IH 20 interchange (Exits 276A and 276B) represents the northernmost point for evaluation for MHD travel. Notably, Exit 273 (just south of this point) is a hub of intermodal travel for the region due to the presence of the Union Pacific Dallas Intermodal Terminal.
- **Southern Endpoint:** Truck traffic around Houston is largely dispersed around the three loops – Grand Parkway/TX 99, Sam Houston Tollway/Beltway 8, and Loop IH 610, and traffic appears to be trying to circle the urban core as much as possible rather than follow IH 45 through the city. Thus, staff set the IH 45 and Beltway 8 intersection on the northern side of the city (Exit 60B) as the southernmost end point for corridor analysis. This location is the intersection of IH 45 with the Beltway 8 frontage road and has the potential to serve traffic on both highways. While this does leave the southernmost portion of the corridor out of the analysis, data from both StreetLight data and the TxDOT Statewide Planning map suggests that truck traffic avoids traveling down IH 45 through the city center, and skirts downtown Houston by following another route. Evaluating the 2020 Annual Average Daily Traffic and the 24-Hour Percent Truck attributes from the "Future Traffic and Percent Truck" layer from the TxDOT Statewide Planning map,[11] the volume of trucks on IH 45 stays relatively low from the southern terminus of the corridor to Galveston Island, then starts to increase along the segment within Loop 610, before increasing further north of the interchange of Loop 610 and IH 45 on the north side of Houston. StreetLight analysis indicated that the portion of traffic on IH 45 that originated near Port Houston traveled along Interstate 610 to reach IH 45, then turned north (crossing Beltway 8). This is reasonable considering the substantial amount of truck traffic that would divert off of the north-south Interstate to follow other roadway segments to reach Port Houston or the adjacent industrial activities, which lie to the east. Infrastructure located to the east of IH 45, close to Port Houston, would likely be better suited to serve much of this traffic than a station located within a mile of the Interstate.

Once these endpoints were determined, staff set key data characteristics as filters to narrow the list of potential sites for either fuel type:

1. Filter 1: Include only exits that lead to a roadway designated as part of the TxDOT Highway Freight Network. Unlike the more free-form and unpredictable travel of passenger vehicles, freight traffic often follows more prescribed routes. Truck traffic is likely to adhere to the TxDOT Highway Freight Network when traveling onto or off of IH 45.
2. Filter 2: Exclude any exit where IH 45 connects to the intersecting roadway via a direct-connect ramp (e.g., Exits 276A and 276B at IH 45 and IH 20). Direct-connect ramps do not offer opportunity to access facilities along the highway, as the direct-connect lanes take the driver from the main lanes of IH 45 to the main lanes of the "intersecting" roadway without any opportunity to actually exit the roadway.

[11] Statewide Planning Map (txdot.gov)

3. Filter 3: Include only exits where the intersecting roadway (the cross street) is accessible from both northbound and southbound directions of travel, so that a facility located near that exit can serve all drivers traveling that section of roadway.

These three filters resulted in a short list of 20 exits along approximately 216 miles between and including the northern and southern endpoints of the corridor, as illustrated in **Exhibit 42**.

Exhibit 42: Exits Meeting Initial Three Criteria Filters and Key Characteristics

<table>
<tr><th>Exit #</th><th>Exit Name</th><th>Direction of Travel on IH 45</th><th>Is the Cross Street on the TxDOT Highway Freight Network?</th><th>Is the Cross Street Accessible?</th><th>Is the Exit a Direct-Connect Ramp?</th><th>Number of Amenities</th><th>Number of Truck Stops at Exit</th><th>Is this Exit a Turning Point Based on StreetLight Analysis?</th></tr>
<tr><td rowspan="2">60B</td><td rowspan="2">Beltway 8</td><td>NB</td><td rowspan="2">Y</td><td>Y</td><td>N</td><td rowspan="2">9</td><td rowspan="2">0</td><td>N</td></tr>
<tr><td>SB</td><td>Y</td><td>N</td><td>Y</td></tr>
<tr><td>66</td><td rowspan="2">FM 1960</td><td>NB</td><td>Y</td><td>Y</td><td>N</td><td rowspan="2">9</td><td rowspan="2">0</td><td>N</td></tr>
<tr><td>66A</td><td>SB</td><td>Y</td><td>Y</td><td>N</td><td>N</td></tr>
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<tr><td>SB</td><td>Y</td><td>N</td><td>N</td></tr>
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<tr><td>84</td><td>SB</td><td>Y</td><td>N</td><td>N</td></tr>
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<tr><td rowspan="2">116</td><td rowspan="2">TX 30/US 190</td><td>NB</td><td rowspan="2">Y</td><td>Y</td><td>N</td><td rowspan="2">9</td><td rowspan="2">0</td><td>Y</td></tr>
<tr><td>SB</td><td>Y</td><td>N</td><td>N</td></tr>
<tr><td rowspan="2">118</td><td rowspan="2">TX 75/FM 1791</td><td>NB</td><td rowspan="2">Y</td><td>Y</td><td>N</td><td rowspan="2">4</td><td rowspan="2">3</td><td>N</td></tr>
<tr><td>SB</td><td>Y</td><td>N</td><td>Y</td></tr>
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<tr><td>SB</td><td>Y</td><td>N</td><td>Y</td></tr>
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<tr><td>SB</td><td>Y</td><td>N</td><td>Y</td></tr>
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<tr><td>SB</td><td>Y</td><td>N</td><td>Y</td></tr>
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<tr><td>SB</td><td>Y</td><td>N</td><td>N</td></tr>
</table>

Exit #	Exit Name	Direction of Travel on IH 45	Is the Cross Street on the TxDOT Highway Freight Network?	Is the Cross Street Accessible?	Is the Exit a Direct-Connect Ramp?	Number of Amenities	Number of Truck Stops at Exit	Is this Exit a Turning Point Based on StreetLight Analysis?
251B	TX 34	NB	Y	Y	N	6	0	N
		SB	Y		N			**Y**
271	Pleasant Run Road	NB	Y	Y	N	0	0	N
		SB	Y		N			N
273	Wintergreen Road	NB	Y	Y	N	3	1	**Y**
		SB	Y		N			N

To further narrow the list of exits for infrastructure siting, staff evaluated three additional elements:

1. Availability of amenities: In general, stakeholder consensus is that to optimize success of a fuel transition, operational changes should be as minimal as possible. To best serve commercial vehicle drivers, a refueling or recharging site needs to offer something of value in addition to fuel. Availability of restrooms, food, or convenience store services is highly important so the driver can accomplish multiple tasks in a single stop. NCTCOG compiled a summary of available amenities currently existing at each exit to serve as an indicator of development in the area and evaluate which locations offer services a truck driver could utilize while stopped for fuel. The types of amenities included were automotive services, bank services, entertainment, food, lodging, medical services, parks, pet services, rest areas, and shopping.

   Within the scope of available amenities, the presence of a truck stop was considered a key factor and was noted separately. In discussions with stakeholders, the presence of a truck stop was identified as critically important to station success as the services provided are indispensably valuable to drivers. This is especially true in the event a driver is required to adhere to hours-of-service rules, where services associated with long-haul routes (showers, adequate parking for required breaks, etc.) are needed. Large truck stops are also expected to have larger power capacity and may be more feasible from a utility standpoint for the addition of heavy-duty BEV charging.

   As a note, while the availability of amenities is important for all drivers, it is more compelling for BEV trucks, which may need 30 minutes or more to recharge larger batteries. Drivers will need to not only be able to accomplish critical logistical tasks, but also may need access to useful activities or services that can capture their attention for the longer stop. For hydrogen fueling, which can be accomplished in approximately the same amount of time as conventional diesel fueling, the presence of a variety of amenities is an important convenience factor but is less critical.

   Staff limited recommendations to exits where more than two different types of amenities were available, with emphasis on exits which also provided access to existing truck stops. This is not intended to preclude consideration of developing a greenfield or redeveloping an existing property to be a purpose-built ZEV infrastructure location. However, if a greenfield site is developed, success may be linked to availability of other amenities that can serve other commercial driver needs. The presence of development at various exits may be an indicator of location viability due to existing patterns of traffic and economic activity, which could still be relevant to developing a location from the ground up rather than adding to an existing location.

2. StreetLight route analysis: StreetLight Top Routes analysis helped assess points at which a noticeable amount of truck traffic turns off IH 45. This helps assess whether a station is placed appropriately to serve a substantial amount of traffic. For example, because StreetLight indicates that northbound traffic starts dispersing in a variety of directions once IH 45 intersects IH 10, NCTCOG recommends fueling infrastructure be located south of this interchange to optimize opportunity for the smallest number of stations to capture as much passing truck traffic as possible. Details of the StreetLight analysis are included in Appendix 5. In general, once trucks reach SH 99/Grand Parkway in Houston, they are likely traveling all the way to IH 20 in Dallas-Fort Worth. The same is true for trucks headed south on IH 45 just south of IH 20, which largely stay on the Interstate until reaching the Hardy Toll Road or Grand Parkway in Houston (Exits 72 and 71, respectively), at which point trucks start to disperse around the city. Very little truck traffic turns off IH 45 between the metro areas, but the turning points that do appear in the analysis helped narrow focus further.

Staff looked for exits that had more than two different types of amenities, a truck stop, and/or was a turning point based on StreetLight analysis. This narrowed the scope of evaluation to 10 exits, as detailed in **Exhibit 43**.

Exhibit 43: 10 Exits Meeting Initial Criteria and Have More than Two Types of Amenities, a Truck Stop, and/or Indicate a Turning Point Based on StreetLight Analysis

Exit #	Exit Name	Direction of Travel on IH 45	Number of Amenities	Number of Truck Stops at Exit	Is this Exit a Turning Point Based on StreetLight Analysis?	2020 AADT on the Cross Street to the Left of IH 45	% Truck Traffic on Cross Street	2020 AADT on the Cross Street to the Right of IH 45	% Truck Traffic on Cross Street
60B	Beltway 8	**NB**	9	0	N	7,715	7.9	12,402	6.7
		SB			**Y**	14,171	6.3	8,210	7.6
116	TX 30/US 190	**NB**	9	0	**Y**	18,396	6.4	23,037	4.5
		SB			N	23,037	4.5	18,396	6.4
118	TX 75/ FM 1791	**NB**	4	3	N	5,534	27.9	10,507	18.8
		SB			**Y**	10,507	18.8	5,534	27.9
142	TX 21/US 190 West	**NB**	8	0	N	11,111	9	4,991	16.3
		SB			**Y**	4,991	16.3	11,111	9
178	US 79	**NB**	5	1	**Y**	11,799	19.5	9,496	21.1
		SB			**Y**	9,496	21.1	11,799	19.5
197	US 84	**NB**	6	1	**Y**	5,897	18.9	12,058	15.8
		SB			**Y**	12,058	15.8	5,897	18.9
198	FM 27	**NB**	7	1	**Y**	3,523	7.4	4,738	8
		SB			**Y**	4,738	8	3,523	7.4
229	US 287 South	**NB**	9	0	N	10,700	3.1	12,921	8.2
		SB			**Y**	12,921	8.2	10,700	3.1
251B	TX 34	**NB**	6	0	N	16,288	2.7	8,821	20.5
		SB			**Y**	8,821	20.5	16,288	2.7
273	Wintergreen Road	**NB**	3	1	**Y**	9,144	3.2	9,144	3.2
		SB			N	9,144	3.2	9,144	3.2

AADT = annual average daily traffic

Staff further narrowed the scope of recommended locations based on the principle that infrastructure should be sited to meet FHWA Alternative Fuel Corridors distance interval criteria, which require availability of a BEV charger within one mile of the Interstate exit every 50 miles, and hydrogen fueling every 150 miles. The objective to meet these intervals was balanced with a desire to complete station availability along the corridor with as few stations as possible (and therefore, the least expensive investment) to enable heavy-duty ZEV travel. Ultimately, NCTCOG recommends installation of EV infrastructure at or near five exits, and hydrogen infrastructure at or near three exits. The siting recommendations, along with other key considerations, is outlined in **Exhibit 44**. Additionally, **Exhibit 45** shows those recommendations on a map.

Exhibit 44: Siting Recommendations with Key Considerations

Exit #	Exit Name	Infrastructure Recommendation	Key Considerations	Miles to Next Recommended Exit
60B	Beltway 8	Install EV Charging and Hydrogen Fueling	Southern "end point" of corridor; high percentage of truck traffic at this point and captures southbound trucks turning off onto Beltway 8	For EV: ~58 miles north to Exit 118 For H2: ~118 miles north to Exit 178
116	TX 30/US 190	None	Relative to Exit 118, less preferred as it does not have a truck stop and has less truck traffic on the cross street	N/A
118	TX 75/FM 1791	Install EV Charging Only	Presence of 3 truck stops indicates strong market potential for freight-oriented infrastructure; high percentage of truck traffic along IH 45 and the cross street	For EV: ~58 miles south to Exit 60B; ~60 miles north to Exit 178
142	TX 21/US 190 West	None	Exit highly congested with passenger vehicle traffic	N/A
178	US 79	Install EV Charging and Hydrogen Fueling	Closest location to Exit 118 that closely meets mileage criteria and has suitable characteristics	For EV: ~60 miles south to Exit 118; ~51 miles north to Exit 229 For H2: ~118 miles south to Exit 60B; ~95 miles north to Exit 273
197	US 84	None	Unnecessary if infrastructure located at Exit 178	N/A
198	FM 27	None	Unnecessary if infrastructure located at Exit 178	N/A
229	US 287 South	Install EV Charging Only	Good location to meet distance interval requirements; well located to capture southbound truck traffic before turning off of IH 45	For EV: ~51 miles south to Exit 178; ~44 miles north to Exit 273

Exit #	Exit Name	Infrastructure Recommendation	Key Considerations	Miles to Next Recommended Exit
273	Wintergreen Road	Install EV Charging and Hydrogen Fueling	Northern "end point" of corridor; high volume of truck traffic and well located to capture all northbound traffic before dispersing around the metroplex, or after converging onto Interstate headed south	For EV: ~44 miles south to Exit 229 For H2: ~95 miles south to Exit 178

Exhibit 45: Corridor Exits that Met Amenity Criteria and Siting Recommendations

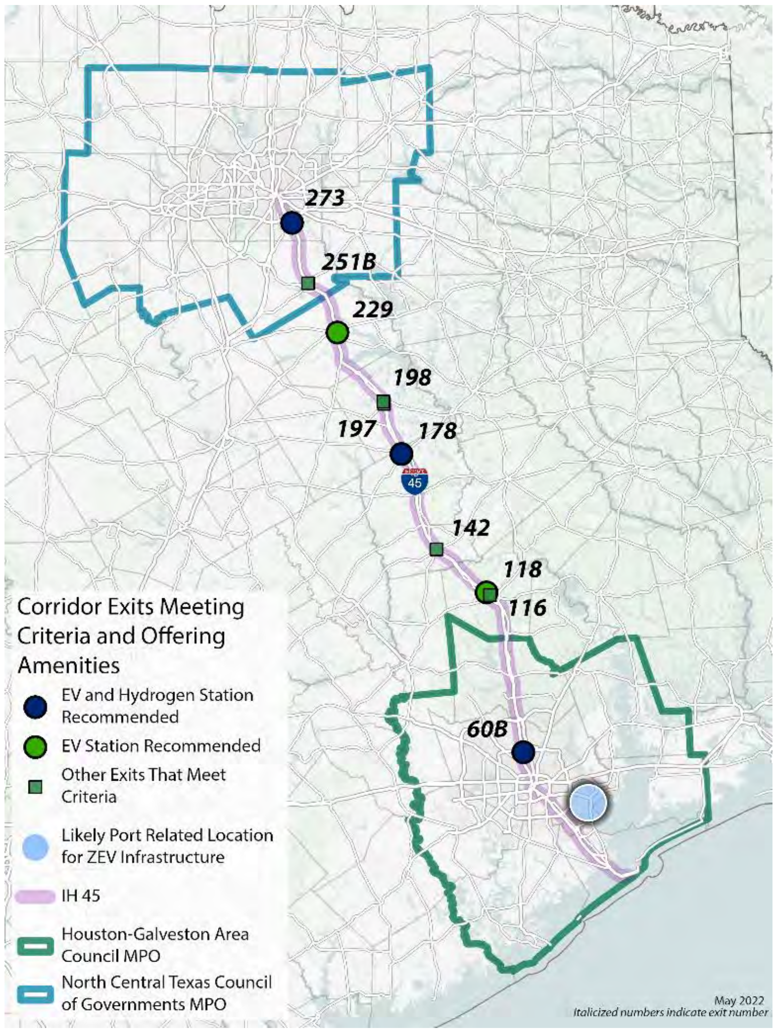


Exhibit 46 summarizes the five exits at which infrastructure is recommended, along with the city, county, electric utility, and regional agency that may have a collaborative role to play in station development. Note that the electric utility structure can be impactful due to the differing roles that regulated or deregulated utilities are able to play in supporting EV charging station deployment. This is further discussed in Chapter 6.

Exhibit 46: Exits Recommended for ZEV Infrastructure Investment

Exit #	Exit Name	City, County*	Electric Utility Territory/Utility Structure	COG/MPO	Siting Recommendation
60B	Beltway 8	Houston, Harris*	CenterPoint (Deregulated)	H-GAC	Install EV Charging and Hydrogen Fueling
118	TX 75/FM 1791	Huntsville, Walker	Mid-South Synergy (Regulated)	H-GAC	Install EV Charging Only
178	US 79	Buffalo, Leon	Navasota Valley Electric Co-Op (Regulated) Houston County Electric Co-Op (Regulated)	BVCOG	Install EV Charging and Hydrogen Fueling
229	US 287 South	Corsicana, Navarro	Navarro County Electric Co-Op (Regulated)	NCTCOG	Install EV Charging Only
273	Wintergreen Road	Hutchins, Dallas*	Oncor (Deregulated)	NCTCOG	Install EV Charging and Hydrogen Fueling

** Locations in a county designated as nonattainment for the pollutant ozone may have access to more funding incentive programs than others. These locations are marked with an asterisk.*

Exhibits 47 and **48** map these recommended exits, along with the distance intervals that would be left between sites if deployed as recommended. Note that the recommendations result in distances between locations that are within or very close to existing FHWA corridor criteria, indicating that IH 45 would likely be able to be designated as corridor-ready to serve MHD vehicles.

Exhibit 47: IH 45 MHD EV Station Recommendations and Distance Intervals

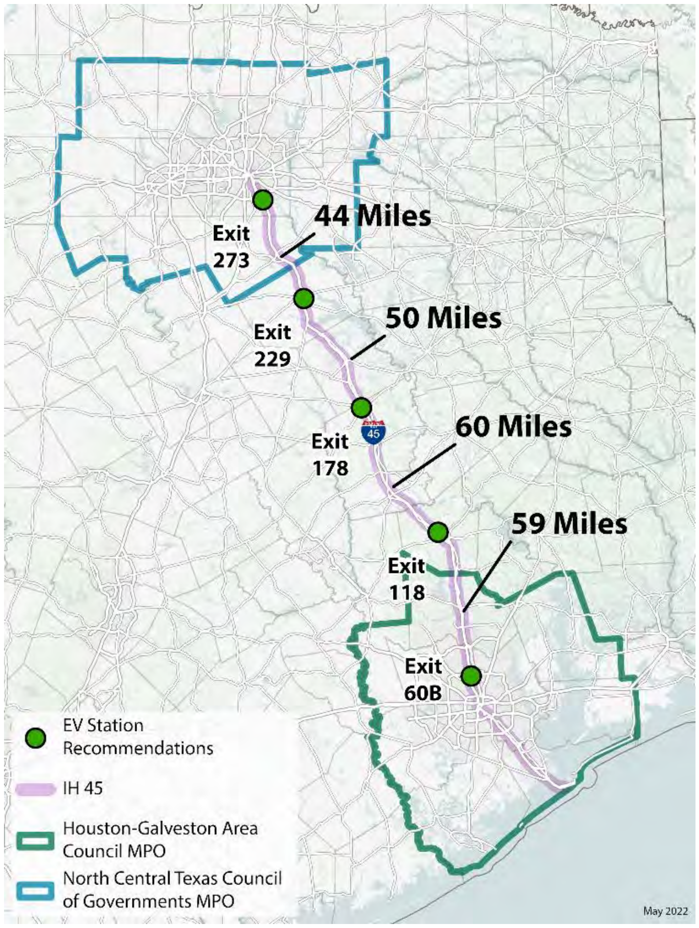
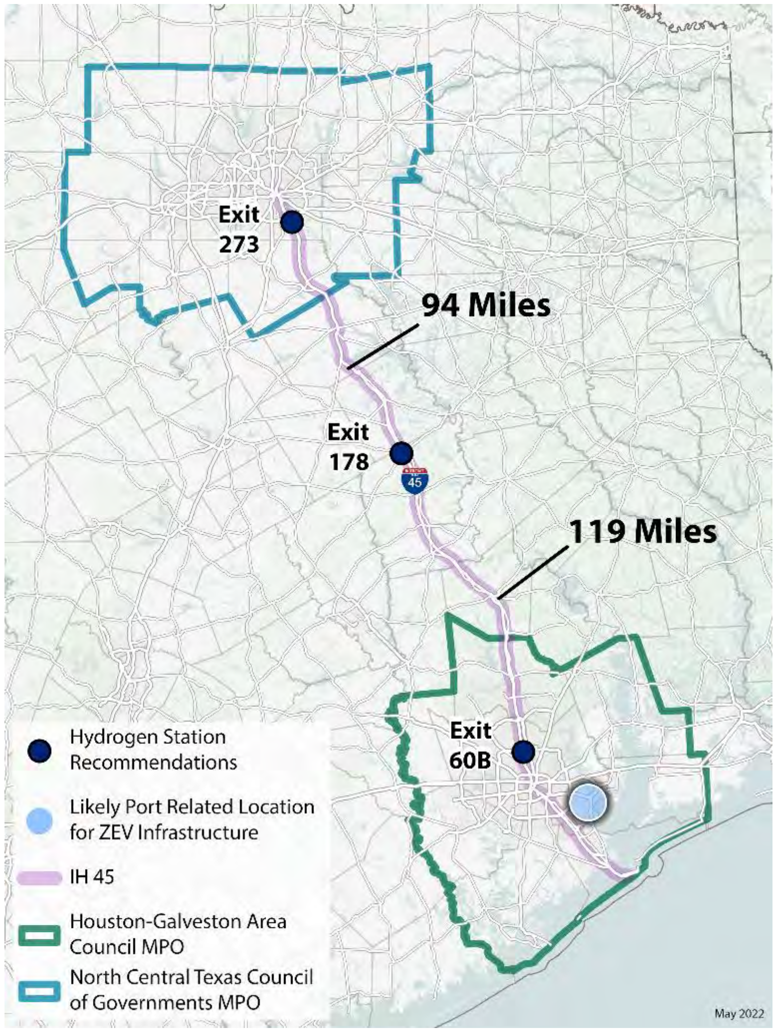
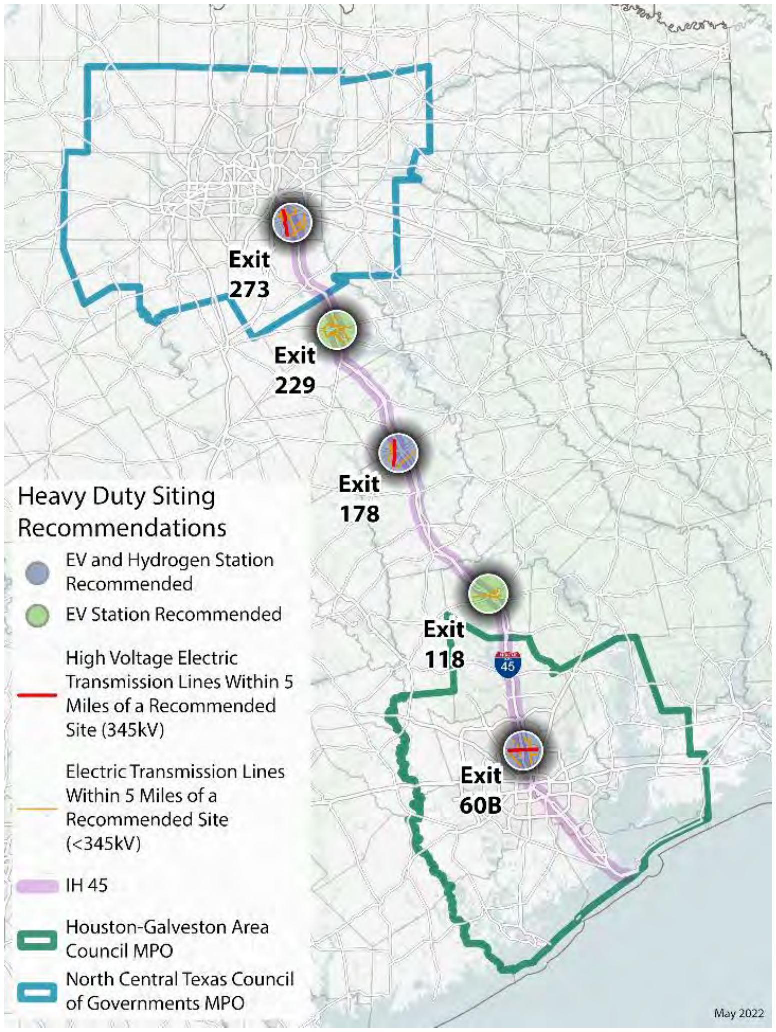


Exhibit 48: IH 45 MHD Hydrogen Fueling Station Recommendations and Distance Intervals



Access to robust electric grid infrastructure is a more important factor for development of EV charging that serves MHD vehicles than for sites serving light-duty vehicles only. While electric utility stakeholders have not indicated concern over the ability to provide power to a site that may serve multiple MHD vehicles with high-speed chargers, NCTCOG did review the location of transmission and high voltage lines in proximity to the recommended exits. As illustrated in **Exhibit 49**, the five proposed MHD EV charging locations do have grid assets nearby, with three of five locations in close proximity to high-voltage lines.

Exhibit 49: Location of Recommended MHD EV Charging Sites Relative to Electric Transmission Lines



Alternate Siting Approaches

Mimicking Compressed Natural Gas for Hydrogen Fueling

Some stakeholders indicated that a good approach to building hydrogen fueling infrastructure could be to follow the pattern of development of compressed natural gas (CNG) refueling sites. FHWA criteria for allowed distance intervals between stations is the same for both CNG and hydrogen, at 150 miles. Fleets operating CNG trucks may be some of the most likely to be early adopters of hydrogen fuel cell trucks, as their operators are already acclimated to gaseous fueling and the habit of locating alternative fueling stations. Some industry representatives have even suggested the CNG stations could be readily expanded to add hydrogen fueling or retrofitted to accommodate the fuel. If this approach were to be taken, the hydrogen corridor could be built out by adding or co-locating hydrogen fuel at or near three existing CNG sites, as illustrated in **Exhibit 50**.

Exhibit 50: Corridor-Compliant CNG Refueling Sites Along IH 45 and Potential Hydrogen Co-Location

Nearest Exit	Station Name/ Address	County*	COG/MPO	Electric Utilities	Miles to Next CNG Station	H2 Co-Location Would Meet 150-Mile Interval?
284A (north of the transition from IH 45 to US 75)	Clean Energy Dallas Service Center, 1616 Baylor Street, Dallas, TX 75226	Dallas*	NCTCOG	Oncor	~134 miles south to Centerville	Yes; ~134 miles south to Centerville
164	GAIN Clean Fuel Centerville, 350 North Freeway Service Road, Centerville, TX 75833	Leon	BVCOG	Navasota Valley Electric Co-Op and Houston County Electric Co-Op	~134 miles north to Dallas; ~65 miles south to Willis	Yes; ~134 miles north to Centerville and ~136 miles south to south Houston site
95	Love's Travel Stop #468, 9600 Longstreet Road, Willis, TX 77378	Montgomery	H-GAC	Just Energy	~65 miles north to Centerville; ~36 miles to north Houston site	
60B	Freedom CNG, 303 Fallbrook Drive, Houston, TX 77038	Harris*	H-GAC	CenterPoint	~36 miles north to Willis; ~29 miles to south Houston site	
32	Freedom CNG, 6000 Debbielou Gardens Drive, Houston, TX 77034	Harris*	H-GAC	CenterPoint	~29 miles to north Houston site	Yes; ~136 miles north to Centerville

** Locations in a county designated as nonattainment for the pollutant ozone may have access to more funding incentive programs than others. These locations are marked with an asterisk.*

Leveraging Texas Department of Transportation Rest Areas

As do all state Departments of Transportation, TxDOT owns and operates rest areas along the Interstates. These rest areas have become important stopping points for heavy-duty trucks, especially as a shortage of safe truck parking for hours-of-service rest periods has become more pressing. These facilities also provide important services for passenger vehicles, especially as IH 45 is an evacuation corridor in the event of a hurricane. Many stakeholders perceive these locations to be ideal candidates for placement of infrastructure – and in the event of evacuations, they could become critically strategic sites. However, a federal provision that prohibits addition of services that would typically be provided by commercial entities, including fueling, precludes use of these sites for EV charging or hydrogen fueling.

Since the passage of the Bipartisan Infrastructure Law, there has been renewed interest in removing this barrier at the federal level, since state DOTs are now charged with implementation of EV charging stations under the National Electric Vehicle Infrastructure Program. In the event this issue was resolved, placement of infrastructure could be as follows. Note that these stops are not connected by a cross street and, therefore, do not allow for ease of connection from one side of the Interstate to the other nor to the frontage roads that run along IH 45, so infrastructure would likely need to be located on both sides of the Interstate to be easily accessible. **Exhibit 51** lists the rest areas along the corridor and potential infrastructure that could be co-located.

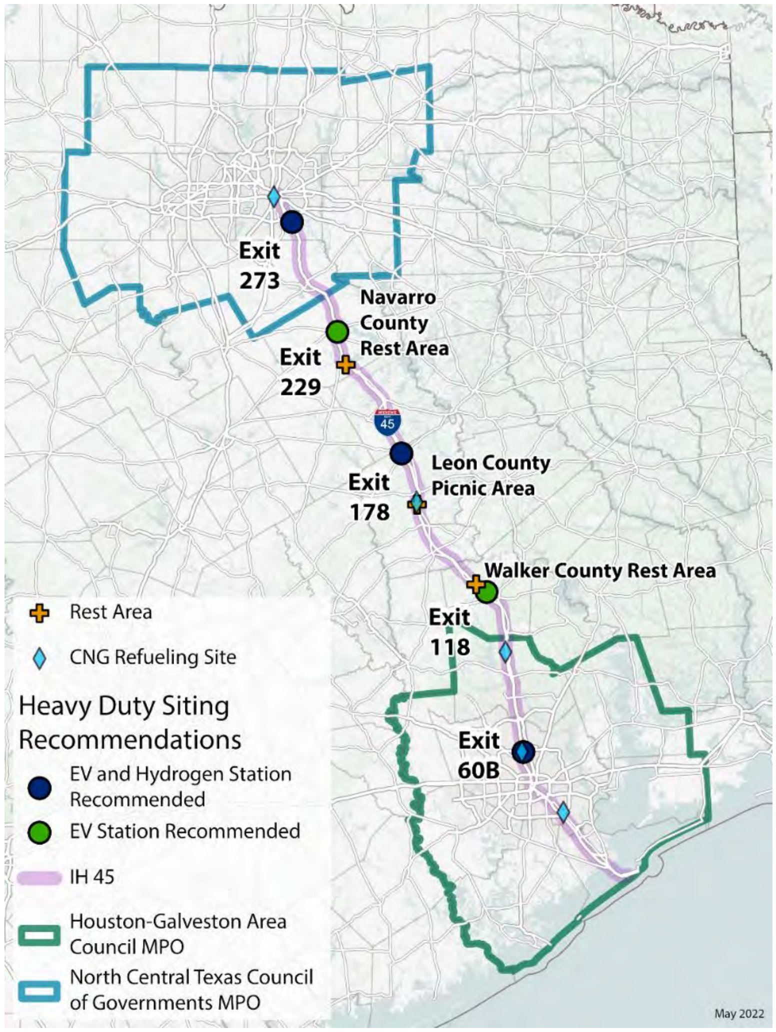
As a note, the prohibition on commercial activities at rest areas applies only to Interstates such as the IH 45 corridor. There is opportunity for TxDOT right-of-way or rest areas along a US Highway or State Highway to be leveraged as sites for infrastructure development.

Exhibit 51: TxDOT Rest Areas Along IH 45 and Potential ZEV Infrastructure Co-Location

Nearest Exit	Rest Area	County*	COG/MPO	Electric Utilities	Siting Recommendation	Miles to Next Recommended Location
123	Walker County Rest Area northbound	Walker	H-GAC	Mid-South Synergy	Install EV Charging and Hydrogen Fueling	EV: ~33 miles to Exit 123 H2: ~95 miles to Exit 218
123	Walker County Rest Area southbound	Walker	H-GAC	Mid-South Synergy	Install EV Charging and Hydrogen Fueling	EV: ~33 miles to Exit 123 H2: ~95 miles to Exit 218
156	Leon County Picnic Area northbound	Leon	BVCOG	Navasota Valley Electric Co-Op, Houston County Electric Co-Op	Install EV Charging	EV: ~33 miles to Exit 123; 62 miles to Exit 218
156	Leon County Picnic Area southbound	Leon	BVCOG	Navasota Valley Electric Co-Op, Houston County Electric Co-Op	Install EV Charging	EV: ~33 miles to Exit 123; 62 miles to Exit 218
218	Navarro County Rest Area northbound	Navarro	NCTCOG	Navarro County Electric Co-Op	Install EV Charging and Hydrogen Fueling	EV: ~62 miles to Exit 156 H2: ~95 miles to Exit 123
218	Navarro County Rest Area southbound	Navarro	NCTCOG	Navarro County Electric Co-Op	Install EV Charging and Hydrogen Fueling	EV: ~62 miles to Exit 156 H2: ~95 miles to Exit 123

Exhibit 52 illustrates the location of these other infrastructure facilities – existing CNG refueling and TxDOT rest areas – with the ZEV infrastructure placement recommended by this plan. Note that there is relatively close alignment between the three locations at which this plan recommends both hydrogen and EV charging and existing CNG sites. The TxDOT rest areas are relatively close to the additional two sites at which only EV charging is recommended.

Exhibit 52: Location of Existing CNG Refueling Sites and TxDOT Rest Areas Relative to Recommended ZEV Infrastructure Site



CH 5

Implementation Resources

Chapter 5

Implementation Resources

Fuel Availability

As zero emission vehicle (ZEV) adoption grows, questions arise regarding fuel availability – is there enough electricity and hydrogen to sustain a new market in the transportation sector? This is particularly high profile on the battery electric vehicle (BEV) side of ZEV discussions, especially in the aftermath of weather events, such as Winter Storm Uri, that exposed vulnerabilities of the electric grid. Many people wonder if the grid can sustain the increased load of BEVs. Hydrogen is a relative newcomer to transportation fuel discussions and has primarily been used for industrial purposes to date. A new market for hydrogen in the transportation sector would necessitate increased supply.

Electricity

Except for the segment that passes through Walker County, the IH 45 corridor falls into the Electric Reliability Council of Texas (ERCOT) grid, which is largely isolated from other electrical grids in the United States. New grid load and new generating capacity is added constantly as Texas' population continues to grow and economic activity triggers new commercial facilities. Summer peak load is typically higher than winter peak load. During 2023, ERCOT has forecasted generating capacity in excess of 100 gigawatts of power, while summer peak demand is forecasted to reach approximately 76 gigawatts, providing for over 25 gigawatts reserve capacity.[1] In the May 2022 ERCOT Capacity Demand and Reserves Report, ERCOT indicates that an additional 13 gigawatts in new generating capacity is planned in 2023. Overall, planned additions of new generating capacity keep pace with forecasted load increase. It should be noted that ERCOT has issued a Request for Proposals for the purpose of forecasting electric vehicle (EV) adoption to integrate EV load better into its Long-Term System Assessment planning, which is conducted every two years.

This plan recommends the addition of two charging stations for passenger vehicles and five charging stations for heavy-duty trucks. To meet Federal Highway Administration (FHWA) standards for EV charging along designated corridors, the two stations for passenger vehicles each must have at least 600 kilowatts of capacity, totaling 1.2 megawatts. FHWA has not yet laid out expectations for stations designed to supply power to heavy-duty trucks, but some estimates could be made based upon National Electric Vehicle Infrastructure Formula Program design standards. Assume that an EV charging site purpose-built for heavy-duty trucks requires the same minimum four carbon capture and sequestration connectors, but minimum power supply increases to the anticipated megawatt charging standard. Each site would require 4 megawatts of power, for a total of 20-megawatt capacity. If all additional chargers were used along IH 45 at maximum power rating *at the same time*, this would reflect an additional 21.2 megawatt load distributed across the corridor. This is a relatively small fraction of the additional generating capacity anticipated to be added to the ERCOT grid in 2023 alone.

The latest ERCOT Long-Term System Assessment does include a scenario for potential charging load of BEVs and anticipates that most charging load would occur in overnight hours, outside of the hours which currently represent peak load on a daily basis.[2] Additional analysis is needed to better understand how transportation and grid infrastructure can best manage EV charging to optimize performance and benefits, but the grid does appear to offer adequate capacity. Managed charging balances the energy

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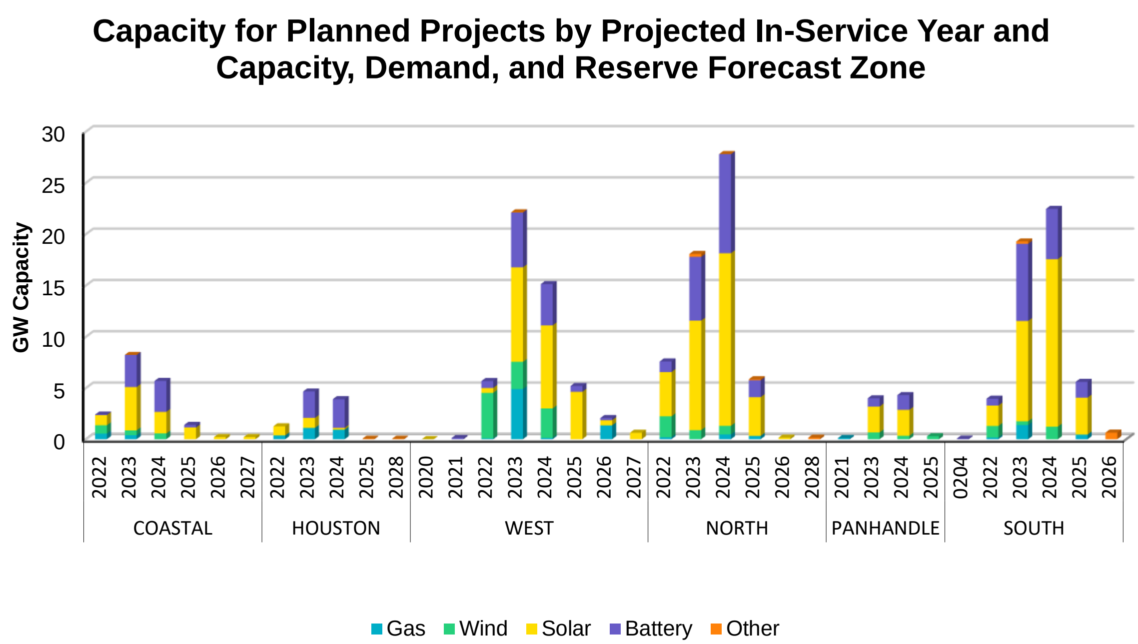
[1] Capacity Demand and Reserves Report, May 2022, Electric Reliability Council of Texas, https://www.ercot.com/gridinfo/resource
[2] https://www.ercot.com/gridinfo/planning

needs of the vehicles with site management objectives, which can include reducing grid strain or maintaining a certain level of power.[3] Moreover, certain BEVs and EV chargers have the capability of sending power back to the grid, which can enable the use of EVs as a grid asset and source of power. Some chargers have features such as integrated battery storage or solar panels that help more evenly distribute power load or minimize peaks in power demand. The amount of charging load represented by travel along corridors, which represents short-term opportunity charging events for BEV, will be a small portion of the overall demand for power that BEVs will introduce.

Short-term ERCOT predictions show that wind and solar growth are expected to continue rapidly. The newest electricity "source" on the ERCOT grid is battery storage, which broke 500 megawatts of capacity in 2021 and is forecasted to reach nearly 5 gigawatts in 2023. Battery storage is a key tool to enhancing grid stability, reducing variability, and capturing the value of intermittent renewable generation. This storage will be essential to Texas' ability to sustain rapid population and economic growth and absorb new electricity demand from BEVs. **Exhibit 53** illustrates additional planned capacity by fuel type for the next several years and illustrates the large proportion of new generation that will come from batteries, wind, and solar. Notably, a substantial proportion of this generation is planned to occur in the "North" Capacity, Demand, and Reserve Zone. Six of the 10 counties through which IH 45 travels fall into this "North" Zone. Overall, over 90 percent of new capacity is anticipated to be generated by wind, solar, and battery storage.

Exhibit 53: Planned Electric Generation Capacity in the ERCOT Grid[4]



At most, an individual EV charging station requires a few megawatts of electricity capacity. The quantity of additional load associated with powering EV chargers is no different from an electric utility perspective adding power load needed to support a small factory or data center or any other end user of electricity. These types of facilities are added to the Texas grid almost daily. In most cases, this is accommodated at no consumer expense. Corridor charging, in particular, represents a marginal increase

[3] Managed Electric Vehicle Charging | Department of Energy
[4] Electric Reliability Council of Texas, May 2022 Monthly Generator Interconnection Status Report, https://www.ercot.com/gridinfo/resource.

in load because it does not facilitate a large concentration of BEV charging in a single place for an extended period of time, but distributes charging demand along the route.

What is notable about EV chargers is the variability of the load, which can ramp up and down quickly. This is often considered to be a liability for the grid, but that is not necessarily the case. While many consider BEVs to trigger a requirement for additional grid generation, it should be acknowledged that BEVs themselves have the potential to become a source of electricity. In many senses, BEVs are essentially energy storage (batteries) on wheels. An increasing proportion of BEVs are being manufactured with the potential to not only charge from the grid, but also push energy from the on-board battery back from the vehicle to the building (vehicle-to-building) or grid (vehicle-to-grid). This is already happening on a small scale, with some BEV owners using their vehicles to provide power to key appliances or to their own homes in the event of a power outage. The Texas Electric Transportation Resources Alliance has estimated that 125,000 BEVs (approximately the number currently registered), at an average of 75 kilowatt-hour storage per vehicle, represent nearly 10,000 megawatt-hour of electricity storage.[5] The Bipartisan Infrastructure Law provides funding for additional study and demonstration of how BEVs can be utilized as a grid asset to more evenly distribute electricity load throughout that day and further capitalize on intermittent renewable generation.

Hydrogen

There is substantial opportunity for the hydrogen supply to expand, especially given the emphasis on developing new pathways for decarbonized hydrogen production under the Bipartisan Infrastructure Law programs, ranging from electrolysis to carbon capture, utilization, and storage. The Houston area, with a high concentration of petrochemical activity, is likely to be a proving ground for many of these new technologies, as evidenced by recent headlines announcing major carbon capture, utilization, and storage investments in the area.[6] Texas contains the workforce, expertise, and hard infrastructure necessary to expand the hydrogen supply to create capacity for fueling in the transportation system. Total demand for blue/green hydrogen in Texas' heavy-duty trucking sector is estimated to reach two Million Tonnes Per Annum by 2050, with around 25 percent of that demand occurring by 2035.[7]

The Center for Houston's Future identified heavy-duty trucking as an initial priority application for end use of an expanded hydrogen industry based on two key factors. First, a limited amount of new infrastructure is needed to supply hydrogen as a trucking fuel, especially considering the density of trucking activity centered around the Houston area ports and connecting to Dallas-Fort Worth area inland ports via IH 45. The second factor is the cost-competitiveness of hydrogen compared to diesel.

This plan recommends the addition of three hydrogen fueling stations along IH 45, with the assumption that a fourth facility will be located near Port Houston. Since hydrogen fueling is an emerging concept in Texas, much stakeholder discussion revolved around how hydrogen fuel cell electric vehicles may be adopted and how an infrastructure network may grow over time. Based on these discussions, the North Central Texas Council of Governments (NCTCOG) anticipates deployment of hydrogen fuel cell trucking along the IH 45 corridor to follow a four-phased approach, as outlined in **Exhibit 54**. The siting recommendations contained in this plan align with an intent to move this corridor from a ZEV launch phase to scale up on the path toward full deployment.

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[5] Comments Submitted by the Texas Electric Transportation resources Alliance to Public Utility Commission Project 51603, Review of Wholesale Electric Market Design, https://interchange.puc.texas.gov/Documents/51603_18_1215531.PDF

[6] Exxon's $100 Billion Carbon Capture Plan: Big, Challenging And Needed (forbes.com)

[7] H2Houston Hub Clean Hydrogen Roadmap (pg. 23), https://www.centerforhoustonsfuture.org/h2houstonhub, Accessed 6/13/2022

Exhibit 54: Potential Scale Up of Hydrogen Fueling Along IH 45

Phase	ZEV Pilot	ZEV Launch	ZEV Scale Up	ZEV Deployment
Intent/Purpose	Demonstrate Feasibility with Controlled Expenses	Demonstrate Business Case in Texas	Engage Early Adopters	Expand Fleet Adoption
Hydrogen Stations	-1 Modular Site in Dallas-Fort Worth -1 Modular Site in Houston	-1 Permanent Site in Dallas-Fort Worth -1 Permanent Site in Houston	-2 Permanent Sites in Dallas-Fort Worth -2 Permanent Sites in Houston -1 Mid-Corridor Site	-Station Cluster in Dallas-Fort Worth -Station Cluster in Houston -2 Mid-Corridor Sites
Vehicle Deployment Size	2-3 Trucks	10 Trucks	Up to 50 Trucks	Over 50 Trucks

Unlike EV charging, FHWA has not established fueling volume or rate requirements for hydrogen stations as part of the Alternative Fuel Corridors Program. Thus, NCTCOG looked to a recent study by the International Council on Clean Transportation to determine appropriate throughput for a station designed to fuel medium- and heavy-duty (MHD) trucks. Depending on application, throughput per dispenser could range from 570 kilograms per day for drayage applications to 1,000 kilograms per day for long-haul trucking.[8] To support the three proposed stations with two dispensers per station, the volume of hydrogen fuel needed to support these stations would range from 3,420 to 6,000 kilograms per day. For perspective, the Texas Gulf Coast currently produces approximately 3.4 million metric tons of hydrogen per year,[9] which is more than 9 million kilograms per day. The quantity of hydrogen needed to support the recommended stations represents less than one-tenth of one percent of existing Gulf Coast hydrogen production.

Proposed Plan Implementation Costs

Exhibit 55 illustrates the potential cost of implementing the recommendations outlined in Chapters 3 and 4, assuming no incentive funding. Estimated station costs for light-duty BEV charging are based on the draft Texas EV Infrastructure Plan published by the Texas Department of Transportation as part of National Electric Vehicle Infrastructure Formula Program (NEVI) planning.[10] Costs for infrastructure serving MHD vehicles was based on a report from the International Council on Clean Transportation,[11] using the "low volume" scenario of 100 trucks served, as MHD ZEV travel along IH 45 is in its infancy.

[8] Estimating the infrastructure needs and costs for the launch of zero-emission trucks (theicct.org)
[9] University of Houston and Center for Houston's Future, Becoming a global hydrogen hub, September 2020, https://static1.squarespace.com/static/5bd0cda394d71a3556faeb6c/t/6023019a01041730583e0fd1/1612906908395/Hydrogen+Final+presentation.pdf
[10] Texas Electric Vehicle Charging Plan | Social Pinpoint (mysocialpinpoint.com)
[11] International Council on Clean Transportation, Infrastructure Needs and Costs for Zero-Emission Trucks, https://theicct.org/wp-content/uploads/2021/06/ICCT_EV_HDVs_Infrastructure_20190809.pdf

Exhibit 55: Estimated Costs to Implement IH 45 ZEV Plan Recommended Sites

Infrastructure Type	Sector Served	Number of Sites Recommended	Estimated Cost Per Site	Total Cost to Implement Plan
Light-Duty BEV Charging	2	2	$600,000	$1.2 Million
MHD BEV Charging (Long-Haul Class 8 Sector)	Long-Haul Class 8 Sector	5	$18 Million	$30-$90 Million
	Delivery Sector		$8 Million	
	Drayage Sector		$6 Million	
MHD Hydrogen Fueling (Long-Haul Class 8 Sector)	Long-Haul Class 8 Sector	3	$26 Million	$18-$78 Million
	Delivery Sector		$11 Million	
	Drayage Sector		$6 Million	

The light-duty BEV charging sites recommended in this plan, or alternative sites that serve the same purpose in filling the "pending" gap on IH 45, are expected to be implemented through NEVI funding during year one of Texas Department of Transportation NEVI implementation, if not built through other incentive programs or market forces prior to that point. Thus, these stations should be deployed in 2023 to 2024, if not sooner.

Chapter 7 outlines a variety of incentive programs that could be leveraged to support implementation of the MHD infrastructure recommendations. Given the status of IH 45 as a FHWA-designated alternative fuel corridor, the $2.5 billion "Grants for Charging and Fueling Infrastructure" created through Section 11401 of the Bipartisan Infrastructure Law is a key opportunity.

Future-Proofing Recommendations

Standardization

Standardization of infrastructure is a critical step in ensuring a site can be used by the largest possible number of vehicles, and in maintaining a simple refueling or recharging process that avoids driver frustration. If early adopters find inconsistencies between sites that result in unnecessary complications, there could be a cooling effect on ZEV adoption as dissatisfied drivers – both citizens and fleets – relay negative experiences. Standardization is important both in technical equipment specifications and configurations, and in payment schemes.

In June 2022, FHWA released a Notice of Proposed Rulemaking under NEVI that includes several standardization recommendations.[12] Among the elements included in the proposal are standard requirements for:

- Minimum quantity of ports, type of charging port, and power rating for all NEVI-funded sites
- Payment systems and customer support services
- Stations to be capable of communicating and operating on the same platform from one state to another
- On-premise signage
- Provision of data about location, real-time availability, price, and accessibility of sites to be provided at no cost to third-party mapping applications

This type of standardization will be impactful in creating a seamless and predictable end user experience and can help the market grow in a consistent manner. While the standards finalized through the

[12] https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/

rulemaking will only apply to NEVI-funded sites, and the requirements for quantity and type of charging ports may not be appropriate for all sites, standards for interoperability of communications, payment systems, and signage would be best practices for all EV charging sites to employ.

While this level of standardization detail is not yet present for stations designed for MHD EVs or hydrogen fueling, industry groups such as CharIN are working to promote interoperability among MHD BEV equipment, which is an important foundational element. Other industry members have banded together to evaluate potential MHD hydrogen fueling protocols, as fuel cell electric vehicle trucks currently use the light-duty hydrogen fueling protocol (which has been standardized[13]) and would benefit from a faster fueling process. Existing safety standards and codes also provide a consistent foundation from which infrastructure can be built. All infrastructure developers should ensure they are following the latest published standards, as well as staying apprised of developments from organizations such as the Department of Energy Hydrogen and Fuel Cells Technology Office, the Joint Office of Energy and Transportation, and CharIN.

Autonomous Vehicle Considerations

The IH 45 corridor has become one of the leading test grounds for real-world demonstration, pilot, and use of autonomous trucking. Waymo, Via, Kodiak, TuSimple, Aurora, and Embark are all currently operating trucks along this corridor. The prevalence of AV operations is driven by many of the national industry challenges, such as driver shortages, but also by favorable state regulations in Senate Bill 2205. Infrastructure sites should be developed with this in mind and should be designed in a way to accommodate, and even attract, AV trucks in the future to ensure relevance through the AV truck transition.

There is some debate over which refueling technology platform will ultimately be preferred by autonomous truck companies, especially as the industry looks forward to the point that drivers and engineers finally exit the truck and truly autonomous transport begins, with no humans aboard. Key considerations in this debate are:

Mechanics of Refueling: Without human intervention, how would a truck refuel? Some have suggested that human operators at designated fueling points would intervene to help connect and disconnect the autonomous truck to the fueling infrastructure, like the full-service gas stations of past decades. Others have suggested that robotic autonomous systems would be able to communicate with the truck to provide the connect/disconnect, and still others have suggested that wireless charging for BEV trucks would offer solutions. The potential for wireless inductive charging seems interesting, as an automated system could easily navigate a truck over an inductive pad in the pavement for recharging with no need for a human or robotic operator to intervene to enable a hard connection for conventional charging. However, inductive charging is still in nascent stages with relatively low power output, so much research and development in this technology is likely necessary for it to become a feasible solution for freight.

Range and Duty Cycle Implications: There is often an assumption that electric and autonomous platforms will evolve in conjunction with one another, to the point that all autonomous vehicles will be electrified. However, one of the greatest benefits of the autonomous transition is the ability to travel long distances without the need for a government-mandated rest period for human drivers. In the freight sector, where time is money, the ability for cargo to continue traveling nearly nonstop is a substantial economic benefit. The substantial power needs of autonomous systems may drain BEV

[13] https://www.energy.gov/eere/fuelcells/articles/10-questions-regarding-sae-hydrogen-fueling-standards

truck batteries and reduce range. Range limitations of BEV technology, which may become even more constrained by power-hungry AV systems, could be a barrier to BEV transition in the AV industry. On the contrary, the longer-distance-fewer-stops duty cycle of AV trucks may be well-matched to fuel cell electric vehicle platforms, which are promising substantially longer range with little additional weight.

Regardless of the fuel platform, stakeholders have indicated that the most important element for smooth AV operation at refueling sites is the ability for the AV truck to avoid interaction with human drivers. “Mixed traffic” refueling sites, where AV trucks and human-driven trucks both operate within the same space, is a high-liability environment that AV operators wish to avoid. With this in mind, infrastructure developers wishing to future-proof their investments and attract AV trucks in the future may wish to design their sites in a way that can be segregated in the future, with one portion of the site reserved for human-operated trucks and another side reserved for AV trucks. Clear and simple signage and striping is also key to AV operation and is an important design element to incorporate into plans.

Resiliency

As new infrastructure is built, it will be critical to integrate resiliency features into location design from the outset. Just as many critical infrastructure sites, including some conventional gas stations, have backup power generation, EV charging and hydrogen fueling should be designed in a way that provides for redundancy and on-site backup power sources to ensure the fuel supply is readily available even in unforeseen emergency situations. If the electrical grid fails, power outages affect fueling facilities of all types, including conventional gasoline and diesel pumps that rely on electricity to operate. Resilience is especially critical for the IH 45 corridor, which serves as a hurricane evacuation route for the Houston area. However, Winter Storm Uri also provided a sober reminder that hurricanes are not the only extreme weather event that can threaten Texans, and the extended lack of electricity left many people wondering about the ramifications of a similar storm in a scenario where a substantial portion of transportation is electrified.

Resilience can be designed into EV charging and hydrogen fueling in a variety of ways. One key strategy could be to co-locate both fuels and developing sites that include both BEV charging and hydrogen fueling at a single location. Notably, the recommendations in Chapter 4 for MHD sites suggest deployment of both fuels at three locations. The availability of hydrogen can serve as a source of electricity storage for EV charging locations, enabling a more stable grid load and hardening the site against grid outages. A recent study by the National Renewable Energy Laboratory also found that co-locating Direct Current Fast Charging and hydrogen fueling can reduce total lifecycle costs.[14] As infrastructure developers attempt to predict how the different ZEV platforms will be adopted in the transportation sector, designing a site to provide both fuels can ensure value to a wider variety of end users and shield against risk of becoming a stranded asset in the event technology adoption shifts in one direction or the other.

Other options to integrate resilient features include generators, which could run off of a variety of low or no-emission fuels, and/or batteries. On-site generation could be supported by micro-grids, which could integrate solar and/or wind.

[14] National Renewable Energy Laboratory, DCFC + Hydrogen Station Design Optimization, September 3, 2020, https://www.nrel.gov/docs/fy21osti/77799.pdf

Development Outside the IH 45 Corridor

For ZEV adoption to be successful, supporting infrastructure must be developed along additional major corridors so that trucks traveling IH 45 have the flexibility to travel beyond this highway. This is critical to ensuring that fleets are willing to make investments, as they must have the flexibility to move fleet assets from route to route, depot to depot, or to sell or trade assets as business demands warrant. Trucks must, therefore, be capable of operating along IH 45 or other routes. A key initial step would be development of a network of infrastructure that serves the entire Texas Triangle, which encompasses 66 counties throughout Texas and is expected to be home to an estimated 70 percent of Texas' population by 2050.[15] Without this broader network, ZEV vehicle adoption would likely stay in pilot stages, and lack of growth in customer base could lead to stranded infrastructure assets over time.

[15] Texas Freight Mobility Plan 2018: https://ftp.txdot.gov/pub/txdot/move-texas-freight/studies/freight-mobility/2018/plan.pdf

CH 6

Policy and Regulatory Landscape

Chapter 6

Policy And Regulatory Landscape

Policies and regulations can have substantial impact on the advancement of zero emission vehicle (ZEV) projects aside from the use of incentives. These measures can either help or hinder ZEV deployments, either intentionally or unintentionally. This section highlights key areas where policies and regulations are – or could be – impactful, outside the universe of ZEV-related financial incentives.

Federal Policy Landscape

Federal Initiatives Supporting ZEV Adoption

Aspirational Goals

While not binding, aspirational objectives set by the federal administration can enhance momentum surrounding ZEV adoption and serve as an example for other levels of government, and for the private sector, to emulate. Several of these goals have been set recently by the Biden Administration. The Federal Sustainability Plan sets goals for 100 percent of all light-duty vehicles acquired by the federal government to be ZEV by 2027 and 50 percent of all vehicles to be ZEV by 2030.[1] It also sets an objective for 100 percent carbon-free electricity by 2030, enhancing ZEV benefits on a well-to-wheels basis. Similarly, the August 2021 Executive Order on Strengthening American Leadership in Clean Cars and Trucks[2] set a policy goal that 50 percent of all new light-duty vehicles sold in 2030 be ZEV. This Executive Order ushered in a series of major automaker announcements and commitment to the ZEV transition, as illustrated in Exhibit 29 in Chapter 2.

New Environmental Protection Agency Regulatory Actions

The Executive Order on Strengthening American Leadership in Clean Cars and Trucks[3] also called for regulatory activities on the part of the Environmental Protection Agency (EPA) that have resulted in key rulemakings:

- Light-Duty Greenhouse Gas Emissions Standards[4]
  The EPA finalized revised national standards for greenhouse gas emissions for model year 2023-2026 light-duty vehicles in December 2021. While the standards do not require the purchase or sale of ZEVs, the EPA has indicated their evaluation of industry compliance projected 7 percent ZEV penetration by 2023, jumping to 17 percent by 2026. While other technologies are available to vehicle manufacturers to comply with the new regulations, they are sure to accelerate ZEV adoption in the light-duty sector.
- Proposed Rule and Related Materials for Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards[5]
  As part of the EPA Clean Trucks Plan,[6] the EPA published a proposed rule on March 28, 2022 to further reduce both criteria and greenhouse gas emissions from heavy-duty engines.[7] While the EPA indicated it was not establishing a ZEV mandate, the options proposed for nitrogen oxides (NO_X) standards ranged from 20 to 40 micrograms per horsepower-hour (mg/hp-hr) under Option

[1] Federal Sustainability Plan: Catalyzing America's Clean Energy Industries and Jobs | Office of the Federal Chief Sustainability Officer
[2] Executive Order on Strengthening American Leadership in Clean Cars and Trucks | The White House
[3] Executive Order on Strengthening American Leadership in Clean Cars and Trucks | The White House
[4] Regulations for Greenhouse Gas Emissions from Passenger Cars and Trucks | US EPA
[5] Proposed Rule and Related Materials for Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards | US EPA
[6] Clean Trucks Plan | US EPA
[7] https://www.epa.gov/regulations-emissions-vehicles-and-engines/proposed-rule-and-related-materials-control-air-1#rule-summary

1, or 50 mg/hp-hr under Option 2. Either of these scenarios present standards that are orders of magnitude more stringent than the existing 0.2 grams per hp-hr NO_X standards. Based on current diesel technology and emissions controls, it is unlikely that diesel engines could achieve and maintain these standards, given literature suggesting diesel vehicles operating in real-world environments (low speeds, idle time) are still unable to meet existing 0.2 grams/hp-hr NO_X standards. Thus, the proposed standards for NO_X emissions appear to be set so low that, if adopted, the practical impact of the regulations would likely force further adoption of ZEV platforms.

Updated Federal Fuel Economy Standards

The same Executive Order that triggered the EPA rulemakings established requirements for the Secretary of Transportation to develop a rulemaking for updated fuel efficiency standards. New standards for passenger cars and light trucks are to begin with model year 2027, heavy-duty pickup trucks and vans are to begin in model year 2028, and medium- and heavy-duty engines and vehicles are to begin in model year 2030. While fuel economy standards do not dictate use of specific technologies to achieve compliance, these regulations have been a driving factor in the increased levels of hybridization and electrification in vehicles thus far, as electrification has been one of the most effective strategies to increase fuel economy.

Bipartisan Infrastructure Law

The policy landscape for ZEV adoption has changed substantially in recent years, most notably with the passage of the Bipartisan Infrastructure Law (BIL) in November 2021. This legislation provides substantial investment, not only in terms of the incentives discussed in Chapter 7, but also by making investments in research and other programs that may either enhance or lead directly to deployment projects. Highlights include:[8]

- <u>Measures that Primarily Support Battery Electric Vehicles</u>:
    - BIL Section 11129 sets requirements to modify the Manual of Uniform Traffic Control Devices (MUTCD), which sets guidance at the federal level for elements of the transportation system, by adding standards for electric vehicle (EV) charging stations. The simple addition of EV charging stations to the MUTCD is notable, as the formal recognition of EV chargers as elements of the transportation system reinforces the permanence of the transition toward electrified transportation. The substance of the standards is also important. They require non-proprietary charging connectors and open access payment. Such standards improve the customer experience when using charging stations and can result in greater utilization of infrastructure, which may support faster ZEV adoption and improved return on investment. They are also a critically important foundational element in the face of fast technological, service, and market changes, serving as a future-proofing element.
    - BIL Section 25006 establishes an Electric Vehicle Working Group as a collaboration between the US Department of Transportation (DOT), US Department of Energy (DOE), US EPA, White House Council on Environmental Quality, and General Services Administration, along with utilities and manufacturers to develop three separate reports on barriers to greater EV adoption. Part of the significance of this measure is the cross-agency collaboration created by the provision, which has often been lacking in the past as different federal agencies have created electrification or efficiency initiatives that seem disconnected or disjointed. Simply

[8] https://www.congress.gov/117/plaws/publ58/PLAW-117publ58.pdf

by requiring different agencies to collaborate and engage with utilities and the private sector, this provision could help create more cohesion among federal efforts which may then lead to more effective messaging and implementation of programs to advance electrification.

- BIL Section 40431 modifies the Public Utility Regulatory Policies Act of 1978 by adding language that requires each state to consider measures to promote greater electrification of the transportation sector, including access to charging, an improved customer experience, greater third-party investment in EV charging, and cost recovery. While this section falls short of requiring specific activities beyond developing a "consideration," it does formally establish that state utility regulators and utilities have a role to play in supporting transportation electrification.
- The BIL also provides for substantial investment in the electrical grid, much of which is specific to integration of battery electric vehicles (BEVs). Elements include:
    - Section 40107, which funds methods to enhance grid flexibility, including vehicle-to-grid technologies
    - Section 40112, which establishes a project to demonstrate second-life applications of EV batteries as energy storage to service the electric grid
    - Section 40414, which expands data collection on EV and grid integration
    - Section 40431, which requires state public utility commissions to amend rates to promote greater electrification of the transportation sector
- Sections 40207, 40208, 40209, and 40210 tackle manufacturing and supply chain elements related to BEVs to address concerns about reliance on foreign sources of EV and battery components, as well as environmental concerns associated with battery manufacturing and disposal. Initiatives include programs to support a domestic supply chain for battery production; to develop and demonstrate second-life EV battery applications; to develop processes for final recycling and disposal; for development of manufacturing facilities; and advancement of critical minerals mining, recycling, and reclamation.

• <u>Measures that Primarily Support Fuel Cell Electric Vehicle</u>:

- BIL Section 40314 creates a variety of additional initiatives related to clean hydrogen within Title VIII of the Energy Policy Act of 2005. Key efforts are directed to the Secretary of Energy to establish a definition of "clean hydrogen" and develop a national clean hydrogen strategy and roadmap and substantial investment in clean hydrogen manufacturing and advancement of electrolysis. Perhaps the most notable element is the initiative to fund and establish at least four regional clean hydrogen hubs. At least one of the hubs must demonstrate the end use of clean hydrogen in the transportation sector, which ensures fuel cell electric vehicle (FCEV) deployment projects will be completed in conjunction with hydrogen hubs. Substantial competition for selection as a regional clean hydrogen hub is expected. The US DOE is expected to release the solicitation in summer 2022 and will likely make selections in the months immediately following publication of this plan.

• <u>Measures that Support all ZEVs (Both BEV and FCEV)</u>:

- BIL Section 11403 requires DOTs to establish carbon reduction programs to reduce transportation emissions. ZEV projects certainly fit into the scope of carbon reduction, especially if upstream production of electricity or hydrogen is accomplished through renewable or other low-carbon mechanisms. This program may be part incentive, as some funds could be used for project implementation, but is potentially more impactful in requiring the development of carbon reduction programs that can set a long-term framework for ZEV project support within DOTs.

Federal Barriers to ZEV Adoption

Allowance for Heavier Truck Weight

One constraint to ZEV adoption at the federal level is the limitation on allowable truck weight. This is more problematic for BEV trucks because the battery weight is heavier than additional fuel cell weight on FCEV trucks, but this could be impactful to both types of electric drivetrains. Currently, the Consolidated Appropriations Act allows both natural gas and electric trucks to weigh up to an extra 2,000 pounds, for a total gross vehicle weight rating (GVWR) not to exceed 82,000 pounds, on Interstates and roadways providing reasonable access to Interstates.[9] Industry representatives have indicated the 2,000 pound allowance is not adequate to cover the full weight of additional batteries on a battery-electric truck, and results in loss of payload for end users who carry cargo, which results in reaching full GVWR weight limitations. Some have proposed an exemption in the range of 5,000 to 7,000 pounds, or an amount equivalent to the weight of the battery pack, would be needed to ensure customers can acquire BEV trucks without loss of payload.

A second challenge associated with the heavier weight of ZEV trucks is that requirements for commercial driver's licenses may be triggered if a truck crosses into a higher weight category due to the added weight of the battery or fuel cell systems.[10] This would require additional driver training and could create a disincentive for ZEV adoption.

Research may be needed on safety and road wear implications of this heavier weight rating to evaluate the appropriate level at which to set weight exemptions and require commercial driver's license training.

Federal Prohibition on Commercial Activities at Interstate Rest Areas

Federal law prohibits commercial activities at Interstate rest areas, with limited exceptions for vending services and tourism-related media.[11] Many state DOT rest areas, including those in Texas, are considered to be prime candidates for siting ZEV infrastructure. In Texas, Interstate rest areas have been expanded to include small museum exhibits, along with basic restroom and vending services, and some include walking trails and playgrounds. They often have space for truck parking as well. Rest areas along IH 45, in particular, are heavily trafficked by both light-duty and heavy-duty traffic, suggesting they could be well-suited for ZEV infrastructure. The federal prohibition against commercial activity precludes addition of charging or fueling services, unless they were to be provided at no cost, which would be financially unsustainable for the state. After passage of the BIL, renewed efforts were focused on amending this statute, but no changes have been made to date.

State Policy Landscape

Texas presents a mixed policy landscape for ZEV adoption. Texas lacks many of the lucrative incentives present in California, and certainly lacks the state-level mandates that have driven much of the ZEV adoption on the west coast. On the other hand, Texas offers a business-friendly climate with low costs of doing business, and particularly low energy costs. These latter factors can sometimes provide enough momentum for adoption of ZEV even without certain changes in regulatory structures.

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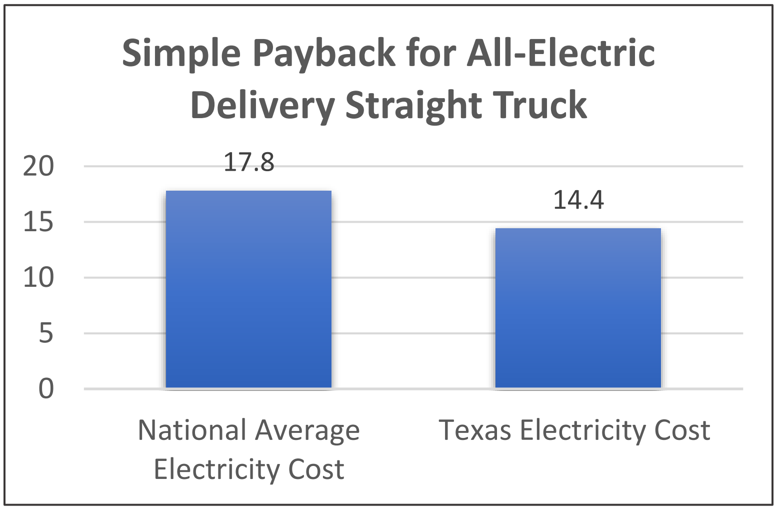
[9] https://ops.fhwa.dot.gov/freight/pol_plng_finance/policy/fastact/tswprovisions2019/index.htm
[10] https://www.fmcsa.dot.gov/registration/commercial-drivers-license/drivers
[11] https://codes.findlaw.com/us/title-23-highways/23-usc-sect-111.html

Factors Supporting ZEV Adoption in Texas

Cost of Ownership

Lower electricity costs in Texas result in a faster return on investment for battery electric vehicles through lower operational costs associated with fuel consumption. Nationwide, the average commercial retail electricity rate was 11.2 cents per kilowatt-hour in November 2021, compared to 8.38 cents per kilowatt-hour in Texas.[12,13] Holding all other factors constant, the North Central Texas Council of Governments (NCTCOG) compared the return on investment of a battery-electric delivery straight truck to a diesel delivery straight truck using the Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) tool developed by Argonne National Laboratory.[14] The difference in price shortened the simple payback by 3.4 years, as illustrated in **Exhibit 56**.

Exhibit 56: AFLEET Results for Simple Payback on a BEV Delivery Truck, Texas Versus National Average



Definition of an Electric Utility

One key policy factor that supports BEV adoption is to provide clarity that electric vehicle supply equipment (EVSE) providers are not regulated as utilities simply because they 'sell electricity' to fuel a vehicle. This policy has been found to be one of the most important policy measures that influences BEV market development.[15] Typically, language is incorporated into a specific regulatory or statutory definition that divorces the sale of electricity for fueling a vehicle from the usual "retail sale" of electricity, creating a "carve-out" in utility regulations. This often also enables EVSE providers to charge for the quantity of electricity consumed (charge by kilowatt) rather than charge for amount of time spent charging. In Texas, Senate Bill 1202 by the 87th Texas Legislature, which became effective on September 1, 2020, exempts entities that sell electricity for the purpose of providing power to a mode of transportation from the definition of a "retail electric utility."[16]

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[12] https://www.eia.gov/electricity/data/browser/#/topic/7?agg=2,0,1&geo=g&freq=M
[13] https://www.eia.gov/state/data.php?sid=TX#Prices
[14] https://greet.es.anl.gov/afleet
[15] https://www.fuelsinstitute.org/Research/Reports/Evaluation-of-Policies-for-Electric-Vehicle-Chargi
[16] https://capitol.texas.gov/BillLookup/Text.aspx?LegSess=87R&Bill=SB1202

Authorization for Texas Department of Transportation to Operate Fueling Stations (Specific to FCEVs)

Section 201.618 of the Texas Transportation Code authorizes the Texas Department of Transportation (TxDOT) to seek funding to acquire hydrogen-fueled vehicles, as well as acquire and operate at least five hydrogen refueling stations along major State Highways in urbanized areas.[17] Notably, these stations would be required to be open to the public. The federal prohibition on commercial activities in rest areas, discussed on page 6-4, is specific to Interstates. Thus, this provision of the state statute provides a pathway for TxDOT to create a hydrogen refueling network that could connect major urban areas and serve as a foundation for freight transition to hydrogen fuel cells.

Barriers to ZEV Adoption in Texas

Lack of State-Level ZEV Goals or Mandates

Several states across the country have enacted ZEV initiatives of various forms, ranging from aspirational goals to formal regulations. California is the best-known example, with a ZEV program for light-duty vehicles and an Advanced Clean Trucks regulation for heavy-duty vehicles, both of which set requirements for the sale of ZEVs in the state.[18,19] Notably, 15 other states have adopted the ZEV light-duty regulation, resulting in 35.9 percent of US new vehicle sales being subject to ZEV standards by 2026.[20] The Advanced Clean Trucks regulation has been adopted by five states other than California.[21] Aside from regulatory steps, other states have set aspirational goals toward ZEV adoption or have developed cooperative compact with neighboring jurisdictions, such as the Multi-State Medium- and Heavy-Duty Zero Emission Vehicle Memorandum of Understanding, among 15 states and the District of Columbia.

Texas is not among the states that have adopted regulations or opted into non-binding agreements. While market forces in Texas support ZEV adoption based on economics, the presence of regulations certainly accelerates market penetration. Moreover, original equipment manufacturers that have limited ZEV supply are compelled to send the few ZEVs that may be available for sale to the states where regulations drive demand and often compensate manufacturers for ZEV sales. This creates a supply chain disadvantage for potential ZEV buyers in Texas, leaving Texas with less ZEV availability until production capacity expands. While the light-duty market has matured substantially, there are still challenges in Texas with car dealers struggling to obtain BEV supply from the manufacturers, and consumers have reported instances where the dealer has said the BEV they were looking for is "not sold in Texas." As the heavy-duty ZEV market grows, and deadlines to comply with the Advanced Clean Trucks regulation force fleets in adoption states to move toward ZEVs, the limited supply of ZEV trucks may become harder for Texas fleets to obtain.

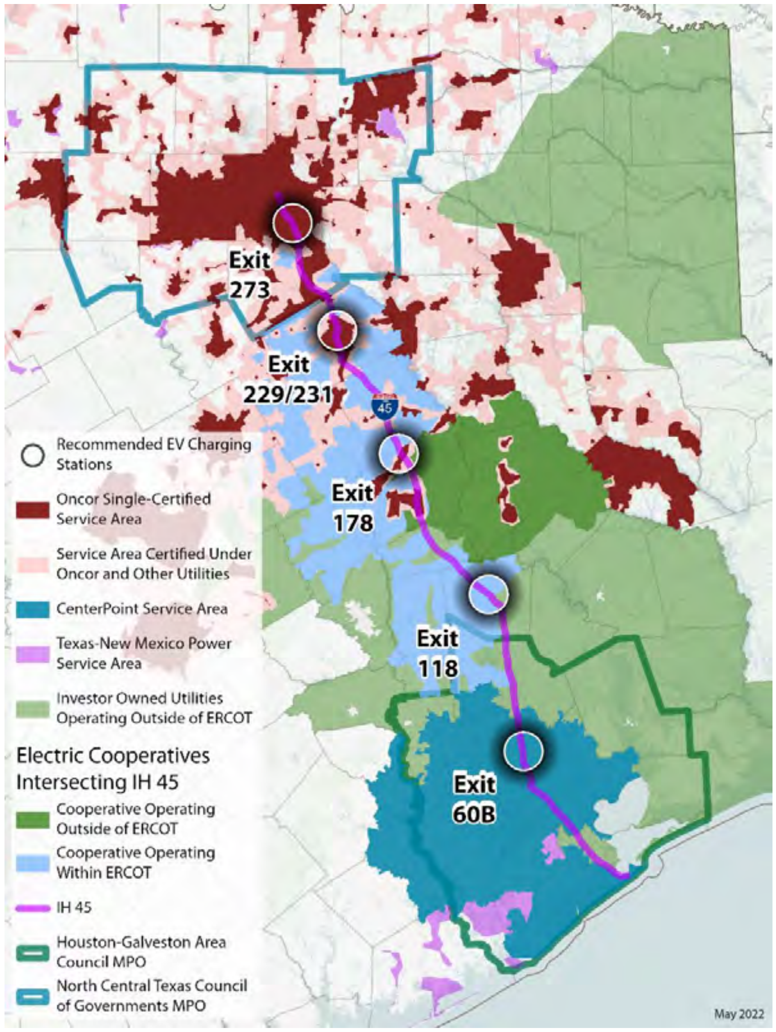
Complications of the Deregulated Electricity Market (Specific to Battery Electric Vehicles)

Texas' deregulated electricity market poses unique challenges, as many of the utility policies and incentives that are widely cited as supporting EV market development in other parts of the country do not translate to the areas where deregulated transmission and distribution service providers (TDSPs) provide service. **Exhibit 57** illustrates electric utility boundaries along the IH 45 corridor. Note that a

[17] https://statutes.capitol.texas.gov/Docs/TN/htm/TN.201.htm#201.618
[18] https://ww2.arb.ca.gov/our-work/programs/zero-emission-vehicle-program
[19] https://ww2.arb.ca.gov/our-work/programs/advanced-clean-trucks
[20] https://ww2.arb.ca.gov/sites/default/files/2022-05/%C2%A7177_states_05132022_NADA_sales_r2_ac.pdf
[21] https://www.truckinginfo.com/10158758/six-states-now-committed-to-zero-emission-truck-rules

good portion of the IH 45 corridor falls within Oncor or Centerpoint TDSP territories, which are deregulated.

Exhibit 57: Electric Utility Territories Along IH 45, Along with Recommended EV Charging Locations



In these deregulated areas, the TDSP has responsibility solely for delivering electricity. Responsibility for electricity generation falls to generating utilities, and responsibility for selling electricity to the end user falls to retail electric providers (REPs). Each of the three types of utilities (TDSP, generating utility, or REP) is disallowed under Public Utility Commission of Texas rules from participating in other segments of the electricity market – for example, an electricity generating utility is not allowed to deliver electricity or sell directly to the customer. The REP is the only one of the three utilities that has a direct relationship with the electricity end user, and customers are able to choose which REP they wish to use. The TDSP assesses fees for use of the transmission lines they manage, but these fees are assessed to the electricity customer through the customer's choice of REP.

This complicated dynamic presents particular challenges to the effective implementation of EV incentives or policies around time-of-use rates or demand charges.

EVSE providers often cite high demand charges as a barrier to building more charging stations in Texas. This issue requires regulatory or statutory intervention to provide clarity for the TDSP utilities, which are currently unable to alleviate demand charges for purposes of EV charging projects.

Time-of-use rates or EV-specific rates are often cited as a key incentive to encourage EV charging at off-peak times when electricity is more affordable for the end customer and the additional load from EV demand would add load during times with latent generating capacity. In the deregulated Electric Reliability Council of Texas market, the REP would be the entity to offer a time-of-use pricing program, but the REP is divorced from electricity generation activities and thus may lack the insight or motivation to offer such a program. To the contrary, a TDSP utility is unable to offer time-of-use rates associated with transmission and distribution chargers. In general, TDSPs are limited to providing incentives solely for energy efficiency or other activities that reduce grid load. Because EVs and EV charging represents additional grid load, they cannot be incentivized under current Public Utility Commission rules governing the deregulated market.

Even if a REP were to offer a special pricing program for EVs, building consumer awareness of these types of programs is a daunting task. Electricity customers in the deregulated market can choose from hundreds of REPs. As an example, 176 different electricity plans are available the 76011 zip code, which is the home address for NCTCOG offices.[22] This includes flat rate plans, variable rate plans, plans that include renewable generation, buy-back for on-site solar generation, and various other features. With this magnitude of choice, it is impractical to inventory EV-specific features, much less publicize or promote them to achieve consumer awareness. Consumers are often overwhelmed by the variety of choices just to choose a basic electricity rate that is best suited for their circumstance.

It should be noted that these challenges are present only in the deregulated portions of the state. There are substantial areas of Texas that do fall within regulated municipally owned utilities or electricity cooperatives, where there is ability to offer many incentives and programs. This includes the following Electric Cooperatives which are located along IH 45:

- Mid-South Synergy
- Navasota Valley Electric Co-Op
- Houston County Electric Co-Op
- Navarro County Electric Co-Op

There may be opportunity to seek implementation of utility policies and programs to grow EV adoption, either by facilitating development of EV charging stations or crafting deployment projects among end users, especially fleets, within these territories.

Lack of Exemption for Heavier Truck Weight

While the Consolidated Appropriations Act provides for additional BEV truck weight, it is applicable only to Interstates and facilities providing reasonable access to Interstates. This leaves a gap where heavier trucks may not be allowed on all public highways in Texas without additional policy provisions provided by state law and may create uncertainty or hesitation for fleet end users who operate on routes that divert from the Interstate system. Given that BEV trucks are most well-suited to shorter-haul routes, which may stay within Texas and frequently follow US Highways or State Highways, this may be particularly problematic. Texas Transportation Code Section 621.101 (b-1) allows an additional 2,000 pounds GVWR (an amount consistent with the federal provision) for trucks powered by natural gas but

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[22] http://www.powertochoose.org/

does not currently extend this allowance to any other fuel type.[23] This provision could be expanded to encompass electric drive trucks in addition to natural gas.

In the event the state does not increase allowable weight, trucks as heavy as 88,000 pounds GVWR are allowed to operate in Texas as long as they possess a valid oversize-overweigh permit. However, a need has been flagged for weight up to 91,000 pounds GVWR to accommodate weight-limited BEV trucks – specifically, terminal tractors – that haul freight short distances over public roadways.

Lack of a Low-Carbon Fuel Standard

The Low-Carbon Fuel Standard creates an economic incentive for companies to produce low-carbon fuel. The fuel producer can pass a portion of the incentive on through reduced fuel costs, thus providing a benefit also to the end user. This policy has helped drive decarbonization of natural gas and biofuels and has the potential to have the same impact on hydrogen fuel by shifting production methods away from conventional fossil-fueled steam methane reformation. Texas currently realizes partial benefits of this policy by producing low-carbon fuel that is ultimately sold in other states. Establishment of a low-carbon fuel standard in Texas, either at the state level or as a result of the policy being set in place nationally, would enable realization of additional economic benefits and support further market development within the state.

Local Policy Landscape

Several local initiatives along the IH 45 corridor should provide a favorable framework for project development.

Local Initiatives Supporting ZEV Adoption

Dallas Comprehensive Environmental and Climate Action Plan

Projects located along IH 45 north of the interchange with Interstate 20 stand to benefit from local policy support at the city of Dallas. The city of Dallas adopted a Comprehensive Environmental and Climate Action Plan (CECAP) in May 2020, which includes 97 specific actions for the city of Dallas to take as part of its efforts to improve quality of life and address climate change.[24] The CECAP is organized into eight goals, including "Goal 3: Dallas' Communities Have Access to Sustainable, Affordable Transportation Options." Within this goal, a key objective is to "Shift the surface transportation system to move people and goods in fuel-efficient vehicles," and the following two action items are relevant to the IH 45 ZEV Deployment Plan:

- Action T4: Establish a comprehensive incentives package to help accelerate electric vehicle use
- Action T19: Encourage businesses, commercial entities, and institutions to electrify fleet, including, but not limited to, local and regional delivery trucks and other heavier vehicles

Both of these actions can underpin collaboration between city of Dallas staff and fleets or station developers looking for develop ZEV projects. These local policy statements could be the foundation for development of public-private partnerships or enactment of more specific updates to local regulatory structure to help streamline processes for ZEV deployments. For example, action T4 references potential for the city to address EV charging in zoning or new construction requirements. Action T19 calls on city staff, as well as the Dallas Regional Chamber, to engage with local fleets through education and partnerships to support fleet electrification and assist with securing funding support.

[23] https://statutes.capitol.texas.gov/Docs/TN/htm/TN.621.htm
[24] https://www.dallasclimateaction.com/

While the actions and local policy support expressed in the Dallas CECAP are limited to ZEV deployments that would be based in the city of Dallas, this plan provides an example of supportive local measures that other cities along the IH 45 corridor could emulate.

Houston Climate Action Plan and Resilient Houston Plans

Local policy activities being undertaken by the city of Houston along the southern end of the corridor also seem likely to benefit from this ZEV corridor plan. In September 2020, the city of Houston finalized the Houston Climate Action Plan (CAP).[25] The CAP is a science-based community-driven strategy to guide the city of Houston's activities towards making its transportation networks, building operations, and waste systems to be as clean and efficient as possible. Additionally, this plan will work to adopt, honor, and uphold the goals of the Paris Climate Agreement and undertake actions to help the city of Houston become carbon neutral by 2050.

Houston's CAP is organized into four main sections, with each section being comprised of three goals and a varying number of targets for each goal. Most applicable to the IH 45 ZEV Deployment Plan is Goal 1: "Shift Regional Fleet to Electric and Low-Emission Vehicles." This goal includes individual strategies to encourage increases in the amount of commercial private sector infrastructure and incentives for ZEV and low-emission vehicles, as well as a commitment to convert 100 percent of the city's non-emergency, light-duty municipal fleet to EV technologies.

In addition to the CAP, the city of Houston also developed and published the Resilient Houston[26] plan in 2020. This plan was developed as a framework for how to move forward to help people, places, and systems within the city to be safer, stronger, and more resilient in the face of disasters. While the 18 goals and 62 actions included in this plan do not directly impact this IH 45 ZEV Deployment Plan, actions focused on implementing the CAP, as well as assisting city neighborhoods with developing their own climate action plans, will help provide additional support for this deployment plan.

Emphasis on Local Economic Growth

The northern end of the IH 45 corridor is in an area that is eager to see additional economic growth. Southern Dallas County is currently one of the less-developed parts of the NCTCOG urban core, and substantial local efforts are focused on promoting additional development. The Dallas Regional Chamber recently launched a website at southerndallascounty.com/ that integrates key information such as available parcels of land, traffic counts, recent development projects, and other key information. These data points are useful for potential station developers looking for potential recharging or refueling locations, and the integration of this data into a single website is a helpful tool that can support infrastructure development efforts. This type of website could be a best practice for other corridor areas to follow.

Local Barriers to ZEV Adoption

"Soft Costs" Created by Local Regulations and Processes

A recent study by the Rocky Mountain Institute found that "soft costs" – expenses associated with permitting delays, local regulatory processes, etc. – present the greatest opportunity for cost reduction in the expansion of EV charging, similar to trends in the solar industry.[27] Reduction of soft cost barriers can not only reduce infrastructure expenses, but also reduce delays and installation time. Municipalities may inadvertently hinder development of ZEV infrastructure projects when they employ strict parking or

[25] http://greenhoustontx.gov/climateactionplan/
[26] https://www.houstontx.gov/mayor/chief-resilience-officer.html
[27] Chris Nelder and Emily Rogers, Reducing EV Charging Infrastructure Costs, Rocky Mountain Institute, 2019, https://rmi.org/ev-charging-costs

permitting requirements for EV charging or hydrogen fueling stations. To date, real-world examples are limited to EV charging station development, and NCTCOG has received reports of long delays in development of Direct Current (DC) Fast Charge stations in communities along the IH 45 corridor due to permitting requirements. At issue is a requirement for both building and electrical permits and, in some cases, there have been reports of parking studies being required because the ancillary equipment to support a DC Fast Charge station (transformers and electrical cabinets, often placed on a cement pad) displaces a few parking spaces.

These challenges can be resolved through adoption of permitting best practices. The Fuels Institute EV Market Regulatory Report gives insight on how streamlined permitting can have a large impact on the effectiveness of installation processes.[28] The report highlights how expedited and streamlined permitting laws, such as those adopted in California, can significantly lessen costs associated with site redesigns and administrative delays, both of which may result in less site investment.

Real-world examples of these same challenges have not yet arisen in Texas for hydrogen fueling stations, but there is a risk of similar complications due to lack of experience in permitting or processing hydrogen sites among authorities having jurisdiction in Texas. These risks can be reduced by adhering to existing codes and standards for hydrogen safety and site development. Resources are available through:

- The Department of Energy Hydrogen and Fuel Cell Technologies Office: https://www.energy.gov/eere/fuelcells/regulations-guidelines-and-codes-and-standards.
- The National Renewable Energy Laboratory's *Guide to Permitting Hydrogen Motor Fuel Dispensing Facilities*: https://h2tools.org/sites/default/files/Motor%20Fueling%20Station%20Permit%20Guide%20Final%20March2016.pdf
- The California Fuel Cell Partnership's *Hydrogen Station Buyers Guide*: https://cafcp.org/system/files/cafcp_members/Hydrogen_Station_Buyers_Guide.pdf

[28] Fuels Institute EV Market Regulatory Report, https://www.fuelsinstitute.org/Research/Reports/EV-Market-Regulatory-Report

CH 7

Federal and State Incentives to Support Zero Emission Vehicle Deployment

Federal and State Incentives to Support Zero Emission Vehicles Deployment

This chapter summarizes current incentives available to zero emission vehicles (ZEVs) in Texas from both federal and state sources. Because the scope of this plan is *deployment* of ZEV vehicles and infrastructure, the scope of incentives discussion is limited to programs relevant to deployment projects. There may be many other opportunities for ZEV-related research and development or business development funding that are not included here as those are outside the scope of this plan. In addition, as the scope of this plan is limited to on-road freight, this narrative excludes funding opportunities that are solely focused on non-road sectors (e.g., the Electric or Low-Emission Ferries Program or the Rail Vehicle Replacement Program).

This chapter is intended to not only inventory opportunities that can assist deployments, but also highlight areas where programs could be modified to better support ZEV projects. For example, Texas benefits from a relatively large number of incentive programs that have the potential to assist with ZEV deployment, courtesy of the Texas Emissions Reduction Plan (TERP) Program. However, in practice, few ZEV vehicle projects have materialized under TERP. This narrative identifies some of the key constraints that limit advancement of ZEV projects, in addition to identifying "gaps" where certain project types lack incentive opportunities. In highlighting these limitations, the North Central Texas Council of Governments (NCTCOG) hopes this will be a resource both for end users wishing to take advantage of existing programs, and stakeholders wishing to improve upon existing programs through rulemaking or legislative actions.

The scope of this chapter includes both federal and state incentives, but not local funding sources, as local funding sources are not common in Texas. However, there can be limited opportunities for projects of substantial regional significance in the Dallas-Fort Worth area to receive local funding from NCTCOG in the form of Regional Transportation Council Local or Regional Toll Revenue funding. Potential/proposed funding that is contingent upon legislative action is also highlighted.

Stakeholders interested in pursuing projects in either the NCTCOG or Houston-Galveston Area Council (H-GAC) regions should coordinate with staff from those agencies to discuss process and potential collaboration opportunities. As ZEV projects are relevant to the Clean Cities mission, and both agencies house the respective Clean Cities Coalitions, contact information can be gathered from https://cleancities.energy.gov/coalitions/locations/.

Overview of Federal Funding Initiatives

Incentive funding from federal programs to support ZEV projects can be available from formula programs (where a set amount of money is directed to specific entities based on an allocation formula, which often includes population), discretionary programs (where applicants compete for funding via competitive proposals or grant applications), or tax credits. Some federal programs, especially those from the Environmental Protection Agency or Department of Energy, have funded ZEV projects for a long time. However, the availability of federal funding to support ZEV deployments expanded substantially with passage of the Infrastructure Investments and Jobs Act (IIJA), also known as the Bipartisan Infrastructure Law (BIL), in November 2021. This legislation put increased emphasis on transportation electrification and ZEV infrastructure in many existing federal transportation funding programs and also established a variety of new funding programs. Key resources to review available funding include:

- The White House established a website at www.build.gov to inventory funding programs authorized under the IIJA/BIL. This website includes both a listing and a guidebook to funding programs that includes a high-level summary of scope.
- The US Department of Transportation (DOT) has created an information resource called "Federal Funding is Available For Electric Vehicle Charging Infrastructure On the National Highway System," which details programs administered by US DOT and applicability to vehicles, infrastructure, planning, and other elements.[1]

Notably, the US DOT resource identifies several programs which are very large, well-funded programs, such as Rebuilding American Infrastructure with Sustainability and Equity, and Infrastructure for Rebuilding America. These are often thought of as funding traditional transportation road or bridge infrastructure, but ZEV projects can fit into the scope of eligible activities. Notably, the most recent funding cycles included a specific reference to ZEV infrastructure in scoring criteria related to climate, resilience, and equity. These are important opportunities that are often overlooked.

It should be noted that as of the time of plan drafting, details of project eligibility under several new funding programs established by the BIL – especially discretionary programs – were still unknown. Thus, it is possible there could be ZEV deployment eligibility in some federal programs that are not listed in this chapter.

Administration of US DOT Formula Funding in Texas

Some federal funding is actually administered and awarded at the local level. Substantial amounts of US DOT funding are available from the Federal Highway Administration (FHWA) Congestion Mitigation and Air Quality Improvement Program (CMAQ) and the FHWA Surface Transportation Block Grant Program (STBG). Funding from both federal programs flows to the Texas Department of Transportation (TxDOT), which administers some funding at the state level. As Metropolitan Planning Organizations (MPOs), NCTCOG and H-GAC receive formula allocations of these funds from TxDOT, and the MPO policy boards make recommendations about which projects should receive funding. Those projects then are allocated dollars either through a contract with the MPO or with TxDOT directly.

The **CMAQ Program** provides a funding source for projects and programs that yield air quality benefits in areas that face nonattainment or maintenance requirements for transportation-related criteria pollutants (ozone, carbon monoxide, or particulate matter). For the IH 45 corridor, this means that CMAQ could fund projects located in 5 of the 10 counties through which the IH 45 corridor passes. This includes Dallas and Ellis counties on the northern end of the corridor, and Montgomery, Harris, and Galveston counties on the southern end. CMAQ eligibility is very broad and can range from conventional transportation infrastructure, such as grade separations and traffic signal projects, to vehicle replacement projects. A wide range of ZEV deployment projects fall within the scope of CMAQ eligibility. However, those projects must compete with a wide range of other CMAQ-eligible projects to receive a limited number of CMAQ dollars. For Fiscal Years 2022 through 2031, NCTCOG and H-GAC are slated to receive approximately $1 billion and $968 million in CMAQ funds, respectively.[2] Interested parties should reference CMAQ guidance for additional details regarding eligibility, but the most recent

[1] Federal Funding is Available For Electric Vehicle Charging Infrastructure On the National Highway System (dot.gov), updated April 2022.
[2] Tables 23 and 25 of the 2022 Unified Transportation Program; 2022 Unified Transportation Program (txdot.gov)

guidance suggests that ZEV deployment could be accomplished within the following eligible project types:[3]

- Diesel engine retrofits and other advanced truck technologies (note: eligibility may include certain non-road equipment, and guidance calls out locomotive projects in particular)
- Freight/intermodal projects (note: eligibility may include both on-road vehicles and non-road equipment)
- Transit improvement projects
- Alternative fuels and vehicle projects

The **STBG Program**, formerly referred to as the Surface Transportation Program, provides flexible funding to best address state and local transportation needs. STBG funding is largely used on traditional transportation infrastructure such as construction of roads and bridges. The Unified Transportation Program outlines the allocation of $1.7 billion to NCTCOG and $1.6 billion to H-GAC over the course of Fiscal Years 2022 through 2031. However, the latest guidance, issued March 2016, provides for eligibility of certain ZEV deployment projects, including:

- Electric vehicle charging infrastructure
- Capital costs of transit vehicles

The **National Electric Vehicle Infrastructure Program** is a new formula program established by the BIL, which is designed specifically to fund battery electric vehicle (BEV) charging infrastructure. At the time of plan drafting, TxDOT had published the draft Texas EV Infrastructure Plan as a first step toward implementation of the National Electric Vehicle Infrastructure Program.[4] The draft plan outlines the following implementation structure:

- Year 1: Install Direct Current Fast Chargers Along Alternative Fuel Corridors (estimated 48 stations statewide; $42.84M federal)
- Years 2 to 5:
  - Work with Counties and Small Urban Areas to Install Direct Current Fast Charge Sites In/Near County Seats (estimated 190 Locations, $159.65M federal)
  - Work with MPOs to Identify Locations and Types of Charge Sites (estimated $203.75M federal)

The collaboration proposed between TxDOT and MPOs, coupled with the allocations set aside for chargers within MPO boundaries, not along FHWA-designated corridors, provides for a significant role for both NCTCOG and H-GAC in guiding implementation locally. The draft plan proposes an allocation of approximately $51.8 million for charger installation in the NCTCOG 12-county MPO boundary, and approximately $41.7 million for charger installation in the H-GAC area.

The **Carbon Reduction Program** is another new formula funding program established by the BIL that includes electrification and ZEV projects within the scope of eligible activities. While little is known to date, authorizing language reads similarly to STBG funding. Thus, NCTCOG expects there to be a role for MPOs in receiving an allocation and/or directing use of funds on specific projects, similar to other formula programs.

[3] https://www.fhwa.dot.gov/environment/air_quality/cmaq/policy_and_guidance/2013_guidance/index.cfm
[4] https://txdot.mysocialpinpoint.com/tx_ev_plan

Overview of State Funding Initiatives

Texas is blessed with extensive state incentives for 'clean vehicle' type projects through the TERP Program, which was created by the Texas Legislature in 2001 to reduce emissions in Texas' ozone nonattainment and near nonattainment areas. TERP is governed by statutes laid out primarily in Texas Health and Safety Code Section 386. The TERP Program provides financial incentives to eligible individuals, businesses, or local governments to reduce emissions from high-polluting vehicles and equipment. The Texas Commission on Environmental Quality (TCEQ) administers the program through a variety of individual grant initiatives, which have been outlined by the legislature and are laid out in various statutes. The program has been modified over the years in various ways, with additional programs created and funds set aside for certain research purposes, but the overall intent is still focused on reducing emissions of ozone-forming nitrogen oxides in affected counties.

Until Fiscal Year 2022, TERP was subject to legislative appropriation. In many years, the legislature failed to appropriate all revenues collected for TERP purposes, resulting in a balance of nearly $2 billion in revenues collected for TERP purposes which have not been appropriated.[5] During the 86th Texas Legislative Session, House Bill 3745 created the TERP Trust Fund, which divorced incoming TERP revenues from the legislative appropriation process and instead directed them into a trust fund managed by TCEQ. This bill has the overall impact of nearly doubling the total amount of funding available through TERP programs during the Fiscal Year 2022-2023 biennium.

In addition, the State of Texas received nearly $209 million from the Volkswagen settlement and designated TCEQ as the agency responsible for administering the funding. TCEQ outlined plans for distributing this money through the Texas Volkswagen Environmental Mitigation Program (TxVEMP). While most funds from TxVEMP have been expended, a few programs were undersubscribed in certain parts of the state. These funds will be made available in a future opportunity.

Inventory of Available Funding Programs

Exhibit 58 summarizes key aspects of federal and state programs, and more discussion of the various constraints identified in the far-right column is provided in the following section.

[5] Appendix 1, Texas Emissions Reduction Plan Biennial Report (2019-2020): Report to the 87th Texas Legislature, December 2020. https://www.tceq.texas.gov/downloads/air-quality/terp/publications/sfr/79-20.pdf

Exhibit 58: Funding Programs Available to Support ZEV Deployment Projects

Administering or Awarding Agency	Program	Eligible Applicants/End Users[1,2]	Project Scope	Eligible Deployment Activities		Geographic Applicability to IH 45 Corridor[3]	Key Constraints[4]
				Light-Duty/Medium-Duty/ Heavy-Duty Vehicles	Infrastructure		
Formula Programs							
Administered by TxDOT; Projects Recommended by NCTCOG and H-GAC	Congestion Mitigation and Air Quality Improvement Program	Public Sector, PPP	Funds projects that achieve air quality benefits in areas with nonattainment or maintenance requirements for transportation-related criteria pollutants.	Light-Duty/Medium-Duty/ Heavy-Duty EV and FCEV	X	Nonattainment Counties	Buy America; broad scope/highly competitive
Administered by TxDOT; Projects Recommended by NCTCOG and H-GAC	Surface Transportation Block Grants	Public Sector,[1] PPP[2]	Provides flexible funding to best address state and local transportation needs.	Light-Duty/Medium-Duty/ Heavy-Duty EV and FCEV	X	Nonattainment Counties	Buy America; broad scope/highly competitive
Administered by TxDOT	National EV Infrastructure Formula Program	Public Sector,[1] PPP[2]	Funds EV charging infrastructure along FHWA-designated alternative fuel corridors; hydrogen ineligible.		X (EV Only)	Entire Corridor	Unknown as this is a new program; however, Buy America requirements are expected
Administered by TxDOT	Carbon Reduction Program	Unknown	Funds a wide range of projects designed to reduce carbon dioxide emissions from on-road highway sources.	Unknown	X	Entire Corridor	Unknown as this is a new program
Discretionary/Competitive Programs – Federal							
DOE VTO	Various Programs; Focuses Update Year-to-Year	Public or Private Sector	Wide variety; varies from year to year. ZEV generally can fit into at least one program.	Light-Duty/Medium-Duty/ Heavy-Duty EV and FCEV	X	Entire Corridor	Broad scope/highly competitive; Buy America; unreliable funding availability
DOE Hydrogen & Fuel Cells Technology Office	H2@Scale	Public or Private Sector	Funds projects to advance affordable hydrogen production, transport, storage, and utilization to enable decarbonization across multiple sectors.	Light-Duty/Medium-Duty/ Heavy-Duty EV and FCEV	X	Entire Corridor	Broad scope/highly competitive
DOE Bioenergy Technologies Office	Various Programs; Focuses Update Year-to-Year	Public or Private Sector	May be able to fund ZEV projects if fueled through bioenergy-generated electricity or hydrogen.	Light-Duty/Medium-Duty/ Heavy-Duty EV and FCEV	X	Entire Corridor	Broad scope/highly competitive
USDA	Rural Business Development Grants	Private Sector	Funds projects that support economic development in rural communities; can include infrastructure sites.	Light-Duty/Medium-Duty/ Heavy-Duty EV and FCEV	X	Rural Areas along Corridor	Unknown

Administering or Awarding Agency	Program	Eligible Applicants/End Users[1,2]	Project Scope	Eligible Deployment Activities		Geographic Applicability to IH 45 Corridor[3]	Key Constraints[4]
				Light-Duty/Medium-Duty/ Heavy-Duty Vehicles	Infrastructure		
EPA	Diesel Emissions Reductions Act (DERA) National Grants Program	Public Sector,[1] PPP[2]	Provides funds to replace older, diesel vehicles with newer, lower-emitting vehicles. Provides funds for infrastructure as well.	Medium-Duty/Heavy-Duty EV and Select FCEV	X	Entire Corridor; Nonattainment Counties Prioritized	Requires scrappage; arbitrary limits on projects
Federal Transit Administration	Low or No-Emission Vehicle Program	Public Sector	Funds the purchase or lease of low- or no- emission buses.	Medium-Duty/Heavy-Duty EV and FCEV	X	Entire Corridor; Nonattainment Counties Prioritized	Broad scope/highly competitive; Buy America
U.S. DOT	Various Programs	Various Eligible Entities	Varies by program; see US DOT brochure titled "Federal Funding is Available For Electric Vehicle Charging Infrastructure On the National Highway System." Many programs can encompass FCEV as well. Go HERE for information on the DOT funding programs.	Light-Duty/Medium-Duty/ Heavy-Duty EV and FCEV	X	Entire Corridor	Broad scope/highly competitive; Buy America
Discretionary/Competitive Programs – State							
TCEQ	TERP Light-Duty Motor Vehicle Purchase or Lease Incentive Program	Public or Private Sector	Provide rebates for the purchase/lease of light-duty natural gas and ZEV vehicles.	Light-Duty EV and FCEV		Entire Corridor	Inadequate funding level for ZEV*; first-come, first-served awards; arbitrary limits on projects
	TERP Texas Clean Fleet Program	Public or Private Sector	Provide funds to replace older diesel vehicles with alternative fuel medium-duty/heavy-duty vehicles.	Light-Duty/Medium-Duty/ Heavy-Duty EV and FCEV		Entire Corridor	Requires scrappage; overly narrow selection criteria; historically underfunded; cannot be combined with federal funds; does not include infrastructure
	TERP Rebate Grants Program	Public or Private Sector	Provide funds to replace older vehicles with newer, conventional and alternative fuel medium-duty/heavy-duty vehicles.	Medium-Duty/Heavy-Duty EV and FCEV		Nonattainment Counties	Requires scrappage; first-come, first- served awards; cannot be combined with federal funds; overly narrow selection criteria; does not include infrastructure
	TERP Emissions Reduction Incentive Grants	Public or Private Sector	Provide funds to replace older diesel vehicles with newer, conventional and alternative fuel medium-duty/heavy-duty vehicles.	Medium-Duty/Heavy-Duty EV and FCEV	X	Nonattainment Counties	Requires scrappage; overly narrow selection criteria; cannot be combined with federal funds; highly competitive; overly narrow selection criteria

Administering or Awarding Agency	Program	Eligible Applicants/End Users[1,2]	Project Scope	Eligible Deployment Activities		Geographic Applicability to IH 45 Corridor[3]	Key Constraints[4]
				Light-Duty/Medium-Duty/ Heavy-Duty Vehicles	Infrastructure		
	TERP Governmental Alternative Fuel Fleet Grant Program	Public Sector	Provide funds for the purchase or lease light-duty/medium-duty/heavy-duty alternative fuel vehicles.	Light-Duty/Medium-Duty/ Heavy-Duty EV and FCEV	X	Entire Corridor: Nonattainment Counties Prioritized	Inadequate funding level for ZEV; cannot be combined with federal funds
	TERP Seaport and Rail Yard Areas Emissions Reduction Program	Public or Private Sector	Provide financial incentives to replace older drayage and cargo handling equipment with newer lower-emitting equipment.	Medium-Duty/Heavy-Duty EV and FCEV		Specific Facilities in Nonattainment Counties	Requires scrappage; does not encompass required infrastructure; overly narrow selection criteria; cannot be combined with federal funds; first-come, first-served
	TERP Alternative Fueling Facilities Program	Public or Private Sector	Provide funds for the installation of alternative fuel infrastructure, with priority given to projects that are publicly accessible.		X	Entire Corridor	Broad scope/highly competitive; cannot be combined with federal funds; inadequate funding level for ZEV (H2 specific)
TCEQ	Texas Volkswagen Environmental Mitigation Program	Public or Private Sector	Provides funding to replace diesel vehicles with newer, lower emitting vehicles. - School Bus - Freight Trucks - Refuse Trucks - Various Equipment	Medium-Duty/Heavy-Duty EV and FCEV	X	Nonattainment Counties	Unreliable funding availability; first-come, first- served awards

[1] (e.g., state Departments of Transportation, MPOs, and local governments)

[2] PPP = Public-Private Partnerships possible; usually requires public State Agency (such as MPOs, DOTs, etc.) to apply and redistribute funds or partner with private entities. Both NCTCOG and H-GAC have taken advantage of this through Diesel Emissions Reduction Act, CMAQ, and STBG funding.

[3] Nonattainment counties along IH 45 include Dallas, Ellis, Montgomery, Harris, and Galveston counties

Key Constraints

Buy America

Buy America has become a major barrier across a variety of federal programs. Section 165 (49 USC § 5323(j)) of the Surface Transportation Act of 1982 (commonly known as the Buy America Act), was originally established to ensure the use of domestic iron and steel for road and bridge projects. As the scope of eligible projects evolved to include elements such as vehicle purchases, the application of the same domestic content requirements to manufactured goods, including vehicles and more recently, charging stations, has posed challenges. In recent years, this challenge has surfaced most substantially for the CMAQ Program, where current FHWA CMAQ guidance emphasizes funding for cost-effective emissions reductions, and highlights diesel retrofits as a program priority. Despite this prioritization, because the supply chain to manufacture vehicles and many infrastructure components is global in nature, vehicles and infrastructure generally cannot meet this standard. In fact, FHWA has acknowledged that no commercially available vehicle on the market has been identified that can meet FHWA Buy America standards. The consequence of this has been that ZEV projects are eligible on paper but cannot be implemented in practice unless a waiver for Buy America requirements can be obtained by the project. FHWA had initiated a standard quarterly waiver process for vehicle projects but stopped processing these waivers in 2017, following the Presidential Executive Order on Buy American and Hire American issued April 18, 2017.[6] This resulted in the suspension of many CMAQ-funded clean vehicle related projects nationwide. Some ZEV infrastructure may comply, but availability is limited. This has created a disconnect between the stated priorities of the legislation and practical application of regulatory requirements.

Challenges also exist for ZEV infrastructure. While a limited number of charging stations have been able to document Buy America compliance, there is not a sufficient supply of these stations to fulfill the nationwide demand for electric vehicle chargers to fully implement the National Electric Vehicle Infrastructure Formula Program, let alone other US DOT funding programs. On the hydrogen front, there have long been challenges in documenting compliance of the tanks needed to provide compression at a refueling infrastructure site. Again, increased emphasis on ZEV deployments from the BIL will likely exacerbate limited supplies of Buy America compliance equipment and components.

Potential Solutions: A variety of solutions to this disconnect have been proposed, including reinstatement of a routine waiver process for vehicles. Updated Buy America guidance was released in early May 2022.[7] The full impact of this guidance is unknown; however, it directs federal agencies to avoid unnecessary disruption and provides direction with regard to the issuance of waivers. The new guidance allows for flexibility to maintain current policies where appropriate to avoid unnecessary disruption to program, or elements of programs, that already meet or exceed Build America, Buy America requirements. Given the challenges presented above, this may present continued compliance issues and disconnects between legislation and practical application of regulatory requirements. However, if agencies like FHWA take time to re-evaluate legislative priorities and make updates to their policies and procedures, and implement Buy America waivers consistent with the Act, or implement thresholds (e.g., percentage) for domestic content, there may be progress towards streamlining previous Buy America compliance challenges.

[6] https://www.federalregister.gov/documents/2018/04/16/2018-07901/buy-america-waiver-notification
[7] https://www.whitehouse.gov/wp-content/uploads/2022/04/M-22-11.pdf

Broad Scope/Highly Competitive

Many federal programs are very broad in scope. While they may accommodate funding for ZEV deployment activities, they may also accommodate a variety of disparate other activities that ZEV deployment projects must compete against (e.g., US DOT programs like the Infrastructure for Rebuilding America Program and the Rebuilding American Infrastructure with Sustainability and Equity Program may fund traditional transportation infrastructure like bridges that impact more system users; US Department of Energy (DOE) funding may fund outreach and engagement activities that are lower-cost). It can sometimes be hard for ZEV deployment projects to garner prioritization over other projects.

TERP programs are also highly competitive, with several programs consistently having more funds requested than available. With the creation of the TERP Trust Fund and the associated increase of funds, programs which are allocated a percentage of the overall budget, such as TERP's Texas Clean Fleet Program and Governmental Alternative Fuel Fleet Grant Program (GAFF), will be able to take advantage of the additional funds now available and may no longer be underfunded. However, the Alternative Fueling Facilities Program (AFFP) is not allocated a percentage of the overall budget, but rather the maximum amount of funds for this program is set at $6 million by Texas Health and Safety Code (THSC) Section 386.252. For the AFFP to gain additional funds, a change in statute would be needed. Other TERP programs will need to be revisited to evaluate whether the changes in the TERP Trust Fund resulted in these programs no longer being underfunded.

Potential Solutions: Prospective project partners could start coordinating project scope and design well in advance of the potential funding opportunity. Review selection criterion closely and review past project awards to get a sense of project characteristics that are successful and ensure prospective project design is responsive to criteria.

In addition, funding agencies could ensure that to the degree they are allowed flexibility, dollars be prioritized toward the incentive programs that have shown the greatest demand. In the case of TERP, statute dictates how staff can allocate funds at the outset of the biennium. TCEQ does have flexibility to adjust dollars between programs after all incentive programs are competed, if there are "leftover" dollars from a program that has been undersubscribed. This may result in some projects receiving funds simply because they have no competition, even though those projects are not particularly impactful. However, if statute provided this flexibility to TCEQ at the outset of each biennium, the agency would be able to direct funds to programs that are the most oversubscribed, which may increase the proportion of highly meritable projects that are able to be awarded from the high-demand programs. This change would require legislative action.

Unreliable Funding Availability

Some funding opportunities are "one-off" programs such as the TCEQ TxVEMP. Others, such as programs from the DOE Vehicle Technologies Office, are made available every year but with substantially different topic areas that may be unrelated to the priorities released the prior year. Still others, such as the Environmental Protection Agency (EPA) Diesel Emissions Reduction Act (DERA) or TCEQ TERP, are issued repeatedly and with consistent objectives, but do not adhere to a predictable schedule. In all cases, these characteristics prevent potential applicants from being able to conduct long-term planning and project development.

Potential Solutions: Funding agencies could publish a long-range schedule of funding cycles within each incentive program that includes multiple Fiscal Years at a time. A published schedule or set frequency of funding cycles would enable longer-range planning and coordination among the public and private sector to optimize investments. Ideally, the schedule could include expected application windows, timing of award notices, and timeframes for required project completion. This would also enhance the ability of applicants to leverage federal and state programs together, as the long-range schedule could enable state and local funding agencies to time their incentive programs in a manner that enables leveraging with federal dollars.

Requires Scrappage

Many programs require scrappage of older diesel vehicles, which is a constraint in several ways. First, the fleets most likely to be early adopters of ZEV vehicles are unlikely to have old diesel vehicles in their fleet which meet replacement criteria, as they typically sell vehicles after only a few years of operation to maintain a new, high-performing fleet. By the same token, early ZEV adopters may have already transitioned away from diesel trucks and are using alternative fuel vehicles already. Additionally, the requirement to scrap vehicles requires fleets to forfeit resale value, which can make the project economically unviable.

Potential Solutions: Prospective project partners could start coordinating project scope and design well in advance of the opening of funding opportunities to identify eligible vehicles to scrap. Creating a fleet inventory with a fleet vehicle's engine model year, daily and annual vehicle mileage, fuel type, gross vehicle weight rating, and an identifying number (such as vehicle identification number or license plate number), may be beneficial to the grant application process.

Cannot be Combined with Federal Funds

TCEQ has stated that funds from various TERP state incentive programs cannot be combined with any other incentive funds that are based on emissions reductions, including EPA DERA funds, to eliminate the risk of double-counting emissions benefits to two different programs. Similar issues may occur in other states. This requires the applicant to secure "matching fund," or the cost of the project that the grant does not cover, from out-of-pocket sources. For ZEV projects that are likely to be expensive and/or require additional infrastructure investment, this can make a project economically unviable.

Potential Solutions: The awarding agency could issue clear statements that awarded funding is not claiming emissions reductions for State Implementation Plan or other purposes, and that any emissions reductions resulting from the funding programs may be credited to other grant programs.

First-Come, First-Served Awards

Occasionally, when projects are awarded through a lottery or a first-come, first-served basis, projects with the greatest merit or emissions reductions are not chosen. This can be especially true of first-come, first-served projects. As an example, the TxVEMP Direct Current (DC) Fast Charge funding round awarded programs on a first-come, first-serve basis, and was immensely popular. Funding was fully subscribed less than two minutes after the program began accepting applications. Notably, over 94 percent of the funds awarded were to support addition of DC Fast Chargers at conventional fueling stations – namely, Buccee's, Racetrac, and Shell locations. Because the program limited each eligible applicant to five sites, potential applicants created subsidiary companies so they could submit more locations. While this was technically legal, it was not in the spirit of the program, which had limited the number of applications allowed per entity in an effort to broadly distribute awards. Additionally, the first-come, first-served approach may cause an applicant to rush the project planning process which could undermine implementation efforts.

A first-come first-served program can also deter future applications. Entities that are interested in funding but have tried and failed to apply in past funding cycles are unlikely to continue to put effort into future applications due to the perception that it is a 'waste of time.' This discourages potentially strong and impactful projects from being pursued by many entities.

Potential Solutions: Funding programs could pursue awards based on merit. If the awarding agency is concerned about delays in project implementation due to the time and effort required to score and select projects, they could set a recurring deadline. For example, a program could open with deadlines every month, or every other month, and all projects received within that given timeframe could be evaluated and awarded on a competitive basis, with a minimum score required. The lowest ranking projects would then be left to be funded at the end of the program after the final deadline if more meritorious projects were not received.

Inadequate Funding Level for ZEVs

Several programs have funding levels that are set too low to encourage the acquisition of ZEV and infrastructure, as they still bear the highest incremental cost relative to other fuel types. Often, project applicants prefer funding programs to cover the incremental cost of purchasing a ZEV instead of a conventional diesel or gasoline vehicle to help reach cost "parity." In Texas, NCTCOG has identified several TERP programs as having inadequate funding levels to cover the incremental cost of ZEV:

The Governmental Alternative Fueling Facilities Program: THSC Section 395.007 (a) states the commission may establish standardized grant amounts for the GAFF Program based on the incremental costs associated with the purchase or lease of different categories of motor vehicles, including the type of fuel used, vehicle class, and other categories the commission considers appropriate. Currently, the funding levels are as follows:

- Class 1 vehicles: $15,000
- Class 2-3 vehicles: $20,000
- Class 4-6 vehicles: $35,000
- Class 7-8 vehicles: $70,000

After using the 2020 Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) tool,[8] the average costs of medium- and heavy-duty vehicles can be seen below in **Exhibit 59**.

Exhibit 59: The Average Cost of Medium- and Heavy-Duty Vehicles

Vehicle Type	Cost of Diesel Vehicle	Cost of Electric Vehicle	Incremental Cost for EV
Class 6 Delivery Straight Truck	$75,000	$185,000	$110,000
Class 7-8 Refuse Truck	$300,000	$500,000	$200,000
Class 7-8 School Bus	$100,000	$300,000	$200,000
Class 7-8 Dump Truck	$170,000	$370,000	$200,000

As seen above, the current funding levels of GAFF are not adequate to cover the incremental cost of medium- and heavy-duty electric vehicles (EVs). Funding levels for hydrogen fuel cell vehicles are not listed, as there are currently not enough medium- and heavy-duty fuel cell electric vehicles (FCEVs) on the market for AFLEET to provide an average cost. However, stakeholders have indicated that heavy-duty FCEVs may cost as much as $1 million per truck.

[8] https://greet.es.anl.gov/afleet

The Light-Duty Motor Vehicle Purchase or Lease Incentive Program: Under THSC Section 386.154, the Light-Duty Motor Vehicle Purchase or Lease Incentive Program (LDPLIP) provides rebates for purchasers of light-duty cars or trucks. Currently, the rebate for the purchase or lease of an electric drive (including plug-in hybrids, BEVs, and FCEVs) is up to $2,500. However, according to AFLEET, the incremental cost of light-duty ZEVs is $17,500 for BEVs and $30,000 for FCEVs.

The Alternative Fueling Facilities Program: The AFFP funds new construction or the expansion of existing alternative fueling facilities for public or private entities or individuals within the Clean Transportation Zone. The AFFP funding levels are set in THSC Section 393.006, and funds up to 50 percent, or a maximum of $600,000, for eligible projects, which can include both electric charging equipment and hydrogen fueling facilities. While 50 percent is a workable funding threshold, the $600,000 maximum may be inadequate on charging stations designed for larger vehicles, which are likely to be much more expensive than the EV charging stations built to date. Hydrogen fueling stations cost even more, with a station capable of dispensing 770 kilograms per day through gaseous tube trailers delivery, costing approximately $1.4 million.[9] The cost will increase more, depending on the method of delivery of the hydrogen and the amount of hydrogen dispensed per day. Removing the $600,000 maximum award, and instead setting the maximum funding per project at 50 percent, could help incentivize ZEV infrastructure.

Potential Solutions: Maintaining funding levels based on a percentage of cost, without specific dollar caps, may be a streamlined way to ensure adequate funding levels. The percentage could be set to a level that is adequate to cover, or nearly cover, the incremental cost. If cost surveys are used to set incentive amounts, they could be refreshed on an annual basis to ensure the latest and greatest data is used to inform funding amounts. The Clean Cities Program collects information on vehicle and station costs annually and can be a source of this information. As a note, applicants have responded favorably to funding levels offered by the EPA DERA, which provides for 45 percent of the total cost of a ZEV and (in the case of a BEV) an accompanying charging station, so this provides some sense of what an "adequate" funding level might be.

Revisiting funding levels under TERP programs may be timely. As previously discussed, the total amount of funding available under TERP should increase substantially due to the change in statute that directs revenues to the TERP Trust Fund rather than leaving them subject to legislative appropriation. The increased revenue may be able to support increased incentive amounts without reducing the total number of projects able to be funded. While GAFF incentive levels are set by TCEQ, funding amounts under the LDPLIP and AFFP are set in statute and can only be increased through legislative action.

Does Not Include Infrastructure

Several funding programs which can support ZEV replacements do not include infrastructure funding as an eligible cost. To adequately charge a medium-duty/heavy-duty electric vehicle, most fleets will need a high-powered DC Fast Charge. **Exhibit 60** below summarizes estimated costs for DC Fast Charge equipment but does not include additional costs associated with transformers or other utility upgrades.[10]

[9] https://www.hydrogen.energy.gov/pdfs/21002-hydrogen-fueling-station-cost.pdf

[10] Chris Nelder and Emily Rogers, Reducing EV Charging Infrastructure Costs, Rocky Mountain Institute, 2019, https://rmi.org/ev-charging-costs

Exhibit 60: Estimated Costs for DC Fast Charge (Not Including Utility Upgrades)

Charger Type	Cost Range Estimate
DC Fast Charge (50 kilowatts)	$20,000 - $35,800
DC Fast Charge (150 kilowatts)	$75,600 - $100,000
DC Fast Charge (350 kilowatts)	$128,000 - $150,000

Hydrogen refueling stations cost substantially more than EV charging stations. Estimates from the International Council for Clean Transportation range from approximately $3.2 million for a single-dispenser hydrogen station serving delivery trucks to approximately $5 million for a single-dispenser hydrogen station serving long-haul tractor-trailers.[11] These costs make the barriers to hydrogen fuel cell projects through these funding programs even higher. Use of the vehicles depends on availability of the infrastructure. If the program does not encompass infrastructure as an eligible cost, then the end user must also apply and be successful in receiving funds from an infrastructure incentive program. The need to receive two separate awards from two separate funding programs is a substantial complication. In addition, the timing of the different incentive programs is often ill-aligned so that, even if an applicant were successful under both programs, the first project to be awarded likely cannot proceed until the second award is known, which causes project delays.

Potential Solutions: Funding programs that incentivize ZEV equipment projects could allow supporting infrastructure to be included as part of the total eligible project costs so that a single project can be scoped wholistically, including all necessary elements for feasible implementation.

Overly Narrow Selection Criteria

During the project selection process, the majority of TERP programs, including the largest TERP program, the Emissions Reduction Incentive Grant Program, choose projects based on cost per ton of nitrogen oxides (NO_X) reduced. This selection process puts ZEVs at a disadvantage, as they are much more expensive than replacing with a diesel vehicle. It also ignores important co-benefits in other pollutants. Additionally, it is important to consider that TERP programs only look at the NO_X reduced during the timeframe in which the grant awardee is obligated to operate the vehicle – typically only a five-to-seven-year window – and not the entire lifetime of the vehicle. TERP also uses EPA-certified engine emissions rates in its calculations, which underestimate the emissions of new diesel vehicles/equipment that have been shown to emit far more NO_X than the certified rate, especially at low speeds.

Notably, the focus solely on cost per ton also precludes consideration of equity impacts, which must be considered based on project location. Project location is often considered in TERP with regard to whether the project is located in a nonattainment area, but in a more granular evaluation.

Potential Solutions: Programs could consider comprehensive air quality benefits. Prioritizing the local pollutant of concern is important but should not preclude consideration of reductions in emissions of NO_X, particulate matter, carbon monoxide, hydrocarbons, and greenhouse gases, as well as reductions in gallons of diesel fuel consumed or overall energy efficiency (as measured in British thermal units) to optimize the use of funds from one program to achieve benefits that may meet other objectives. This also can pre-empt other air quality issues from arising – for example, particulate matter may become a nonattainment concern in some parts of Texas if the EPA lowers the National Ambient Air Quality Standard for particulate matter in summer 2022, as is widely expected. If particulate matter reductions had been considered in selecting TERP awards since the inception of

[11] International Council of Clean Transportation. *Estimating the Infrastructure Needs and Costs for the Launch of Zero-Emission Trucks.* August 2019. https://theicct.org/publication/estimating-the-infrastructure-needs-and-costs-for-the-launch-of-zero-emission-trucks/

the program, more reductions of this pollutant could have been made, mitigating nonattainment risk. To update the TERP Program, legislative change may be required, as existing statutory language emphasized NO_X reductions. This emphasis has been interpreted to limit the ability to evaluate multipollutant benefits.

Another improvement in methodology could be to use a quantification approach that encompasses well-to-wheel benefits, and that reflects the latest research in terms of real-world emission factors for various fuels. Nationally recognized quantification tools, such as the Greenhouse gases, Regulated Emissions, and Energy use in Transportation model or AFLEET tool, both from the Argonne National Laboratory, can accomplish this work.

To incorporate equity, funding programs can use mapping tools such as the EV Charging Justice40 Map tool,[12] developed by the Argonne National Laboratory, to overlay the location of ZEV projects with Justice40 communities.

Arbitrary Limitations on Projects

Some programs set specific limits on various program elements that arbitrarily scope out otherwise eligible projects. For example, the EPA DERA requires a vehicle to have traveled a minimum of 7,000 miles each year for the past two years to be eligible. The TCEQ TERP programs generally all require that a vehicle be continuously registered for the preceding two years, which can be problematic for public sector entities that are not required to renew registration annually but can document vehicle activity through maintenance records and other evidence of utilization. Another example is the limiting of funds to certain fuel types. As mentioned above, the LDPLIP limits the number of rebates provided each biennium to 1,000 for EVs and 2,000 for propane or natural gas vehicles. The TERP Biennial Report (2019-2020) Report to the 87th Texas Legislature,[13] indicated that since 2014, TCEQ awarded 4,607 rebates for EVs and only 265 for propane or natural gas vehicles. Given the low demand for rebates in the propane or natural gas category, the program may be more effective if there was flexibility in the number of rebates awarded by fuel type. This is especially true given the expected increase in funds available due to the changes in the TERP Trust Fund mentioned above. However, this would require a change in statute, as the number of rebates available under the LDPLIP are set by Texas Health and Safety Code Section 386.154.

Potential Solutions: Overly specific language in authorizing statutes can lead to unintended consequences in preventing project eligibility based on technicalities. Removing specific details or adding language that expressly authorized the implementing agency to modify certain requirements if they become problematic, could enable flexibility needed to optimize all programs' benefits.

[12] Electric Vehicle Charging Equity Considerations | Argonne National Laboratory (anl.gov)
[13] https://www.tceq.texas.gov/downloads/air-quality/terp/publications/sfr/79-20.pdf

Funding Gaps in Texas

Utility Rebates

One common way to incentivize ZEVs at the local level is through utility rebates. In Texas, municipally owned utilities and cooperatives can provide rebates for EVs. One example is Denton Municipal Energy, who currently offers a $300 rebate to residential customers who adopt EV through their GreenSense Incentive Program. However, much of the territory along the IH 45 corridor, and much of the State of Texas, falls into the deregulated portion of the Electric Reliability Council of Texas market and is served by transmission and distribution service providers (TDSPs). These parts of the state have freedom of choice for a retail electric provider, which may be able to offer incentives such as time-of-use pricing. However, TDSPs typically cannot provide incentives under current regulatory structures to avoid the perception of "creating market conditions." Further discussion on utility complications in Texas is provided in Chapter 6.

New Purchase Incentives for Heavy-Duty ZEVs

Currently, grant programs are primarily focused on incentivizing ZEVs as replacements for existing, dirtier vehicles (often diesel). As previously described, there are several constraints with this approach, and the fleets who are most likely to be early adopters of ZEV technology are likely to benefit the most from a simple incentive on a new purchase. This could be in the form of a new purchase rebate or a tax credit or tax deduction. To be most impactful, however, many stakeholders have indicated the ZEV incentive should be applied at the point of sale.

ZEV Incentives at the Point of Sale

Currently, all TERP and TxVEMP incentives are structured to be claimed after a transaction has already been completed. This is also true for many of the federal programs, which are structured as grants or rebates. This means that the fleet or consumer claiming the incentive has to 'front' the entire cost of the ZEV project and wait to be reimbursed after the fact. Other mechanisms for applying the incentive, such as applying the funds at the point of sale, or advancing funds based on documentation of a purchase order, can be very attractive as it reduces the amount of funding the end user must provide out-of-pocket. This can also expand the pool of potential applicants by reducing the 'barrier to entry' in terms of how much funding an end user must have available or be able to finance, making purchase of a ZEV more affordable. This is impactful for both consumers looking to acquire a personal vehicle, and for fleets, as many small business fleets or less wealthy government fleets face affordability challenges similar to low- and moderate-income individuals. In order to allow this, an incentive program would need to specify that it does NOT have to comply with Texas Grant Management Standards. Examples of programs that use these types of approaches include **Hybrid and Zero-Emission Truck, Bus Voucher Incentive Program** and the **EPA's 2022 Clean School Bus Rebate**.

Incentives Provided to the ZEV Dealer/Vendor Instead of the End User

The wide range of incentive programs available for ZEV projects can be very confusing to fleets or consumers as each program has its own set of requirements, eligibility, schedule, and process. This can deter prospective applicants from taking advantage of the programs, especially among smaller organizations that may not have staff dedicated to grant writing or grant processing. This barrier could be alleviated by allowing incentives to be claimed by a ZEV dealer or vendor, who likely has more institutional resources or is able to dedicate a person to becoming an expert in each incentive program and achieve economy of scale. The dealer or vendor could then pass the incentive through to the end user as a discount on the sale, greatly simplifying the process from the fleet or consumer perspective.

Examples of programs that use this approach include **Hybrid and Zero-Emission Truck and Bus Voucher Incentive Program** and the **Oregon Clean Vehicle Rebate Program.** Several TERP programs had, at one point, allowed this via an arrangement called a third-party assignment.

Local Success in Leveraging Funding for ZEV Deployments

Fleets and stakeholders throughout the NCTCOG and H-GAC areas have been successful in leveraging the funding programs described in this chapter for ZEV deployments. The following list highlights some of these projects and is provided to help inspire ideas among potential project developers, as these projects can be sources of best practices or lessons learned in navigating the funding initiatives to enable ZEV projects. To connect with specific project contacts to learn more, contact cleancities@nctcog.org.

US DOT CMAQ: Using CMAQ funding, NCTCOG approved $2.72 million in Fiscal Year 2015 and $4.6 million in Fiscal Year 2018 to implement circulator electric buses and charging stations for Trinity Metro in the Fort Worth 7th Street District. Through coordination with community members and local partners, Trinity Metro started this service in September 2019 and encouraged the public to use this service at their launch event in Downtown Fort Worth. More information can be found on their website, Dash and Discover - Trinity Metro (https://ridetrinitymetro.org). In the Houston area, H-GAC has used US DOT CMAQ to fund the purchase of all-electric school buses.

US DOT Rebuilding American Infrastructure with Sustainability and Equity Funding: NCTCOG was awarded a Rebuilding American Infrastructure with Sustainability and Equity grant for the “Enhancing Mobility within the Southern Dallas Inland Port” project. This project includes a variety of transportation enhancements, including construction of pedestrian infrastructure, improvements to traffic signals, and on-demand transit. The on-demand transit element incorporates a ZEV deployment, including acquisition of eight small BEV buses and installation of five charging stations.

Federal Transit Administration Lo-No: In 2015, Dallas Area Rapid Transit (DART) was awarded funding for electric buses through the Federal Transit Administration’s Low or No Emissions Vehicle Program. Through this funding, DART was able to deploy seven Proterra battery electric buses in 2018. The buses served the D-Link route in Downtown Dallas. In January 2021, the DART Board approved using the remaining funds from the program to purchase an additional battery electric bus.

EPA DERA National Grants Program: Both NCTCOG and H-GAC are eligible applicants for EPA DERA National Grants, and both agencies have been successful in applying for funds and subawarding or providing rebate awards to other fleets. This has enabled private sector fleets to take advantage of EPA funding, as they are not eligible to apply directly to the EPA. Highlights of awards that have led to ZEV deployments are:

> *North Texas Freight Terminal Electrification:* NCTCOG was awarded EPA DERA grant funding to award rebates for idle reduction technology and eligible equipment at freight distribution centers and terminals. The funding is for installation of EPA SmartWay verified electrified parking spaces to reduce idling from transport refrigeration units (TRUs) of heavy-duty diesel trucks and trailers. This project will implement 135 electrified parking spaces for TRU trailers at a Dallas-Fort Worth freight terminal.
>
> *North Texas Emissions Reduction Project:* NCTCOG was awarded EPA DERA grant funding to award rebates for vehicle and equipment replacement, including electrification equipment and rail idle reduction technology. This project will replace 6 heavy-duty diesel on-road trucks with all-electric

on-road trucks and replace 10 heavy-duty non-road equipment with 10 all-electric nonroad equipment. Programs like EPA's DERA, which allow for any model year of diesel vehicle to be scrapped if replacing with ZEVs, have resulted in the successful deployment of ZEVs in the North Texas region. This is especially notable as the funding was made available for projects of any fuel type, but all funds were awarded to BEV replacements.

North Texas Clean Diesel Project: NCTCOG was awarded EPA DERA grant funding to award rebates for replacing diesel vehicles, equipment, or engines; diesel TRUs with electric zero-emission TRUs; installing electric recharging infrastructure, if necessary; and/or installing idle-reduction technology. NCTCOG has opened a competitive call for projects and continues to promote and award funds.

Clean Freight Houston Project and Houston Freight Distribution Electrification Project: H-GAC was awarded EPA DERA grant funding on two separate projects to provide supplemental funding to work with local freight operations to replace existing diesel terminal tractors with new all-electric models. Additionally, these projects assisted with the purchase of electric vehicle supply equipment to support these new vehicle purchases.

US DOE H2@Scale: The University of Texas at Austin is hosting a Department of Energy H2@Scale project entitled "Demonstration and Framework for H2@Scale in Texas and Beyond." The project aims to demonstrate a hydrogen proto hub with multiple forms of renewable hydrogen generation – renewable natural gas, wind, and solar power – with multiple end users, including vehicles and power generation for the Texas Advanced Computing Center. The project is led by Frontier Energy and includes GTI Energy as a key research partner, along with several industrial partners. The industrial partners include Air Liquide, CenterPoint Energy, Chart Industries, Chevron, ConocoPhillips, Low-Carbon Resources Initiative, McDermott International, Mitsubishi Heavy Industries America, OneH2, ONE Gas, ONEOK, Shell, SoCalGas, Toyota, and WM. This project also includes support from TCEQ as discussed below.

TERP Alternative Fueling Facilities Program:

Hydrogen Station**:** Since 2006, the University of Texas at Austin has hosted a hydrogen fueling station at the Pickle Research Campus under the direction of the Center for Electromechanics and in partnership with GTI Energy. As part of the H2@Scale project mentioned above, this fueling station will be upgraded with additional hydrogen generation capacity and an additional hydrogen dispenser at 700 bar. The Alternative Fueling Facilities Program from TCEQ's Texas Emissions Reduction Program is supporting this project with funding for one of the station's dispensers and electrolyzers.

Electrification: Dallas Fort Worth International Airport (DFWIA) installed a total of 20 single-port Level 2 chargers in Terminals A and E through Fiscal Year 2017 TERP AFFP grants. The next year, an additional four dual-port Level 2 stations and one DC Fast Charge were installed at the airport headquarters through a Fiscal Year 2018 TERP AFFP grant. DFWIA was awarded the Fiscal Year 2020 TERP AFFP grant, but with the COVID-19 pandemic, the charging installation has been delayed.

TxVEMP:

School Buses: In 2020, Everman Independent School District received $969,295 to fund three electric school buses, the first in Texas, as well as accompanying infrastructure and associated installation costs. These buses were delivered in October 2020 and have been on route in Texas for the entire 2021 calendar year.

Refuse Vehicles: Community Waste Disposal was awarded approximately $1.6 million to replace 10 diesel refuse haulers with all-electric refuse vehicles. Six of these refuse vehicles will be located in the NCTCOG region.

Level 2 Charging Station Rebates: Over 4,000 charging stations were awarded under the TxVEMP Level 2 Rebate Program, which offered up to $2,500 per charger. At least one location was awarded in every county along the IH 45 corridor.

DC Fast Charge Stations: Nearly $21 million was awarded for 170 DC Fast Charge station locations. Most are near Interstates, including five locations along the IH 45 corridor. These locations did not fill the gap in the "EV-pending" section of IH 45, but the additional charging sites do help provide redundancy and additional charging station availability on the southern portion of the IH 45 corridor. A map illustrating the location of these sites is available in Exhibit 10 in Chapter 1. Notably, over 94 percent of the funds awarded were to support the addition of DC Fast Chargers at conventional fueling stations – namely, Buccee's, Racetrac, and Shell locations.

Proposed or Potential Funding Programs

Federal Measures

Several funding programs and incentives that could support ZEV deployments – especially tax incentives – have been proposed in legislation at the federal level but are not currently in effect. These initiatives include:

Expanded or Renewed Federal Tax Credits

In addition to the funding programs mentioned above, there are also several federal tax credits which can assist in the deployment of ZEVs.[14] The draft Build Back Better would expand or renew several ZEV tax credits such as:

- Clean Hydrogen Production Credit
- Fuel Cell and Energy Storage Investment Tax Credit
- Carbon Oxide Sequestration Credit
- Advanced Manufacturing Investment Credit
- Qualified Fuel Cell Motor Vehicles Credit
- Alternative Fuel Refueling Property Credit
- Advanced Energy Project Credit
- Qualified Plug-In Electric Vehicle Tax Credit

Many of these tax credits have existed in some form in the past. The greatest barrier to tax incentives being useful in advancing ZEV deployments is the uncertainty of availability, as they often expire and are then extended for only a few years at a time. For example, the Alternative Fuel Refueling Property Credit has expired several times, only to be reinstated and applied retroactively. While it is nice to "reward" organizations that already invested in ZEV infrastructure, it does not help organizations develop a long-term plan for ZEV projects with the certainty of tax credit availability. However, long-term enablers that are sustainable, such as the intangible drilling costs tax deduction that has incentivized investments in the oil and gas industry since 1913, could be utilized for the renewables industries.

[14] https://transportationenergypartners.org/webinars/

The Qualified Plug-In Electric Vehicle Tax Credit has been a useful tax credit. The credit may be up to $7,500, based on each vehicle's battery capacity and the gross vehicle weight rating. The credit begins to be phased out for each manufacturer in the second quarter following the calendar quarter in which a minimum of 200,000 qualified plug-in electric vehicles have been sold by that manufacturer for use in the United States. As of the time of plan drafting, incentives for both General Motors and Tesla have fully phased out. Several proposals have been made with regard to expansion of this credit, whether by removing the manufacturer cap, shifting the structure from a tax credit to a tax deduction to better benefit lower income purchasers, creating an incentive for used vehicle purchases, or other adjustments.

While the Qualified Plug-In Electric Vehicle Tax Credit has supported adoption of light-duty BEVs, a tax credit for the purchase of heavy-duty BEVs or FCEVs is still lacking. Given the gap in incremental cost in the heavy-duty sector, which is much greater than the incremental cost for BEVs in the light-duty sector, an incentive for heavy-duty purchases may be particularly helpful. In addition to an incentive on the purchase price, some stakeholders have advocated for a federal excise tax exemption. Because ZEVs currently carry a higher capital cost than their conventional gasoline or diesel counterparts, a fleet making a ZEV purchase is burdened not only with increased capital outlay, but is also then taxed on that higher cost, resulting in an even greater out-of-pocket expense. Some stakeholders have recommended capping the taxable amount based on the equivalent cost of a gasoline or diesel version of the ZEV being purchased to alleviate the perceived financial penalty associated with taxing the full vehicle price.

The Hydrogen for Trucks Act[15]

This legislation would establish a grant program to fund the purchase of hydrogen fuel cell trucks over 26,000 pounds gross vehicle weight rating, as well as associated infrastructure (including hydrogen refueling stations). Eligible applicants would include both public and private fleets or owner-operators and private sector station developers, either individually or in partnership with one another. The legislation specifies that an individual grant award cannot exceed $20 million and requires a minimum 20 percent non-federal match. Eligible expenses could include capital costs of acquiring trucks or building infrastructure, as well as operating, fueling, and training costs. Grant awards for capital costs are limited to 50 percent of the incremental cost of a fuel cell hydrogen truck relative to a conventional gasoline or diesel truck, not to exceed $500,000 per truck. Notably, Senator John Cornyn of Texas is a bill sponsor.

State or Local Measures

"Left Over" TxVEMP Funding

At the time of plan drafting, funding rounds had not yet been made available for electric forklifts and port cargo handling equipment or for electric airport ground support equipment. These funding rounds will award a total of $33.6 million for ZEV equipment, $14.3 million of which is reserved for projects in the Dallas-Fort Worth or Houston areas. In addition, a balance of approximately $47,739,893 is "left over" from the bus, refuse, and local freight funding cycles completed previously. TCEQ has not yet announced detailed plans but has indicated this funding will be made available for additional projects in the future, through another funding round. Many stakeholders, including NCTCOG, have submitted comments to TCEQ requesting the funds be reserved for ZEV deployments. Fleets deploying BEVs are able to apply for funding for a charging station to support the vehicle as part of the overall project.

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[15] https://www.congress.gov/bill/117th-congress/house-bill/7064/text/ih

State or Local Tax Policy

At the state or local level, tax incentives through reduced or exempted property or sales tax burdens could be applied to ZEV infrastructure projects or vehicle purchases.

CH 8

Accomplishments and Recommended Next Steps

Chapter 8

Accomplishments and Recommended Next Steps

Beyond the identification of recommended sites for infrastructure development, this planning project has achieved several key accomplishments consistent with the overall goals of the Federal Highway Administration (FHWA) Alternative Fuels Corridor Program and the grant award itself. Chief among these is development of stakeholder networks associated with the use of zero emission vehicles (ZEVs), especially fuel cell electric vehicle (FCEVs). At the outset of the project, relatively little discussion of hydrogen use in the transportation sector was occurring. Through this project, the North Central Texas Council of Governments (NCTCOG)/Dallas-Fort Worth Clean Cities (DFWCC) has gained an extensive network of additional stakeholders, many of whom hear about the project from other contacts and approached NCTCOG to set up introductory meetings and learn more. NCTCOG perceives these points of contact as evidence of stakeholder collaboration at work, advancing and raising the profile of these technologies for deployment along the IH 45 corridor and throughout Texas.

Several specific initiatives either grew out of, or were enhanced by, the IH 45 stakeholder planning efforts:

ElectroTempo – Department of Energy Project

The infrastructure planning for the IH 45 corridor has already moved to the next phase with a deep dive into charging demand and associated grid infrastructure underway through a research project being conducted by ElectroTempo, Inc. This work is being funded by the US Department of Energy's Vehicle Technologies Office and was launched in quarter four of 2021. The objectives of the project are to 1) develop a truck charging demand model for large urban areas and along highway corridors, temporally resolved to the hour and spatially resolved to the street block/mile level, and 2) demonstrate cost-optimization strategies for placing and sizing charging infrastructure that balance grid upgrade costs and greenhouse gas and air pollutants costs. ElectroTempo is focusing on the IH 45 corridor, specifically, in developing and testing the analytics, with a goal of providing an infrastructure strategy that is optimized to minimize electrification cost and transportation emissions for the corridor by the project's end. This model will be designed to be highly transferable to other regions beyond IH 45 as needed, and highly efficient in terms of processing power and time to deploy.

Round 6 Hydrogen Corridor Nominations

While the Texas Department of Transportation (TxDOT) and NCTCOG have participated in every nomination cycle under the FHWA Alternative Fuels Corridor Program, no hydrogen nominations had been discussed since IH 45 was designated during the inaugural nomination cycle in 2016. Due to the extensive industry involvement in the IH 45 Plan, NCTCOG received numerous inquiries from stakeholders asking how to get involved in nominating additional highways for hydrogen designation in advance of the Round 6 nomination cycle. Interest certainly has been helped by the potential availability of funding from the Discretionary Grant Program for Charging and Fueling Infrastructure, as well as the promise of the Department of Energy (DOE) investment in hydrogen hubs, both of which were established under the Bipartisan Infrastructure Law (BIL). The hydrogen hub initiative, in particular, prompted major announcements from states bordering Texas.[1] Texas leveraged these announcements to underpin TxDOT nominations for additional hydrogen corridors throughout Texas to enable fueling infrastructure development, not only along IH 45, but through the entire "Texas Triangle" and key connecting highways. As a result, TxDOT nominations for hydrogen corridors during Round 6 were the following highway segments:

- IH 10 – From Kendall/Bexar County Line to Louisiana
- IH 20 – From Parker/Tarrant County Line to Louisiana
- IH 30 – From Parker/Tarrant County Line to Arkansas
- IH 35 – Entirety of Route
- IH 35W – Entirety of Route
- IH 35E – Entirety of Route
- IH 37 – Entirety of Route
- IH 40 – Entirety of Route
- US 69 – From US 75/US 69 Intersection to the Oklahoma Border
- US 75 – Entirety of Route

It should be noted that TxDOT also nominated other highway segments for other fuel types, including electricity, but the hydrogen nominations were notable due to the lack of activity on this fuel for the past several years.

Texas Hydrogen Alliance

The Texas Hydrogen Alliance was created in fall 2021 as a nonprofit 501(c)(6) organization focused on providing education and public policy advocacy to further opportunities for hydrogen in Texas and its neighboring states. It has a broad and diverse membership from industry and academia, both national and international in scope. The Alliance was spawned out of dialog associated with the IH 45 project, with initial focus on funding and incentives opportunities with the Texas Commission on Environmental Quality, but soon expanded into much broader activities. These activities include facilitating heavy-duty transportation and supporting infrastructure, hydrogen production, distribution and storage, public policy in support of hydrogen, and participation in the development of hydrogen hubs. NCTCOG is a non-voting, non-paying member of the Alliance's Advisory Board.

Recommended Next Steps

Upon release of this plan, NCTCOG anticipates that stakeholders and other industry participants will leverage these recommendations into action and begin project development along the corridor. To accomplish this, key action items that NCTCOG recommends are:

Complete the Light-Duty Corridor Using National Electric Vehicle Infrastructure Formula Program Funds

In the immediate aftermath of plan publication, TxDOT will be completing the statewide electric vehicle (EV) infrastructure plan required by National Electric Vehicle Infrastructure Formula Program guidance,[2] including study areas for deployment of additional EV charging stations. The locations recommended for light-duty EV charging stations in this plan have been submitted as study areas and are part of the collection of study areas prioritized by TxDOT for first-year implementation.

[1] https://gov.louisiana.gov/index.cfm/newsroom/detail/3587
[2] Texas Electric Vehicle Planning (txdot.gov)

Leverage the IH 45 Stakeholder Network and Federal Investments to Network for Project Planning

Several project ideas have been triggered by the stakeholder network developed as part of the IH 45 plan process, and ongoing federal investments through the BIL, and other DOE initiatives provide opportunities to leverage this momentum into more specific project plans. Specific opportunities and networking strategies are:

Begin Building Public-Private Partnerships to Compete for Incentive Funding

With the increased emphasis on ZEV infrastructure across large US Department of Transportation (DOT) funding programs discussed in Chapter 7 (e.g., RAISE, INFRA, MEGA), combined with the competitive $2.5 billion authorized for the Discretionary Grant Program for Charging and Fueling Infrastructure under the BIL, federal funding opportunities for publicly accessible charging or fueling sites that support ZEV freight are abundant. While these US DOT-funded federal programs are often restricted to public sector applicants, projects can be accomplished through formation of public-private partnerships (also known as P3s) – for example, a project team could leverage publicly-owned land with private-sector capital to build charging and fueling sites. However, the public sector agencies who are eligible to apply for this funding often have procedural rules and constraints around engagement with the private sector, so it is critical to build relationships and begin coordinating ideas on potential projects well in advance of a funding opportunity being released to ensure adequate time is allowed for procedural steps to be accomplished. To start this process, potential industry partners (including potential fleet end users, station developers, and fuel producers/providers) should begin networking with the various public entities with jurisdiction over sites that may be of interest. The municipality, county, utility, Council of Government, Metropolitan Planning Organization, and Clean Cities Coalition are all organizations that could have a stake in project development and could be part of building a project team (and could be a potential grant applicant). The local economic development district and chamber of commerce may also be a good source of networking and support. Many of the key organizations along the IH 45 corridor are listed in tables throughout this plan. Most importantly, industry partners should notify NCTCOG/DFWCC and Houston-Galveston Area Council/Houston-Galveston Clean Cities of project interests. Staff at these two organizations can assist with identifying appropriate contacts at other jurisdictions to begin laying the groundwork for a network of project partners. Industry partners can help advance these conversations quickly by having a clearly scoped vision of what project team members/elements they have secured already, as well as a clearly defined area where assistance is needed, or gaps need to be filled.

While P3s may not be necessary for other incentive programs where the private sector is eligible to apply directly (e.g., Texas Emissions Reduction Plan Alternative Fueling Facilities Program or DOE Vehicle Technologies Office funding), they can still be beneficial. A P3 can bring more resources together to help offset low incentive amounts in the event a funding program offers less generous funding levels. It can also make a project more competitive by showing a high level of support and cooperation that indicates likelihood of successful implementation. Notably, the DOE Vehicle Technologies Office's Notice of Intent for the Fiscal Year 2022 Funding Opportunity Announcement outlined an area of interest for Innovative Medium- and Heavy-Duty EV Charging and Hydrogen Fueling Infrastructure Regional Plans.

Engage in Hydrogen Hub Activities

Through BIL funding, DOE will be funding at least four hydrogen hubs nationwide. At least one of these hubs must demonstrate use of hydrogen fuel in the transportation sector as an end use. Thus, these hydrogen hub projects could become a key center for ZEV transportation project development. The

Center for Houston's Future is coordinating work related to development of hydrogen hubs in Texas. Potential FCEV project collaborators should ensure they are connecting with the Center for Houston's Future to discuss interests and opportunities. Information is available at the H2Houston Hub website at https://www.centerforhoustonsfuture.org/h2houstonhub.

Register in DOE H2 Matchmaker Tool

DOE developed a "Hydrogen Matchmaker" tool to help various stakeholders and players in the hydrogen ecosystem, such as producers and potential end users, identify and connect with each other by self-identifying their hydrogen role and interests. This tool is a useful way for fleets traveling the IH 45 corridor to communicate their interest in using hydrogen fuel, and for potential station developers and hydrogen producers to convey their interest in providing fuel along the corridor. NCTCOG recommends stakeholders leverage this tool, which would assist in the development of public-private partnerships and collaboration on hydrogen hubs previously discussed. See https://www.energy.gov/eere/fuelcells/h2-matchmaker.

Leverage Traditional Transportation Planning Tools to Develop Project Plans

Many private sector stakeholders, especially in the hydrogen arena where attention is just recently turning to the transportation sector as a potential market, have been unfamiliar with key transportation planning tools that can be leveraged for key information such as traffic volumes, freight activity, commodity flow details, etc. These tools can provide useful information about the prospective customer base, which is especially relevant for the medium- and heavy-duty sector. Specifically, station developers and vehicle manufacturers should:

Utilize the TxDOT Statewide Planning Map to Further Refine Project Development Plans

TxDOT provides a wealth of information on the Statewide Planning Map that can be useful for project development. In addition to traffic volume and truck traffic percentage, which were used to develop the recommendations in this plan, the map includes data about planned construction projects within the next 10 or 20 years. Potential site developers should reference this information to identify properties which could be at risk for displacement due to a future construction project, such as a highway widening project that may already be planned, to ensure that investments are made in areas with a potential to remain operational long term.

Engage with TxDOT Freight Planning Efforts

TxDOT is currently developing a new statewide freight plan, and also develops corridor-specific plans on a regular basis. These plans have a wealth of information about current and future levels of activity either across the freight network as a whole, or along a specific highway. This level of detail can be valuable, and TxDOT stakeholder engagement processes can be a helpful way to further understand the types of data that may be available to industry partners, and to share information about industry trends and plans that may be useful for TxDOT planning efforts. For more information, see https://www.txdot.gov/government/partnerships/freight-planning.html.

Become Familiar with the Alternative Fuel Corridor Program

The BIL raised the importance of FHWA Alternative Fuel Corridor designation in two ways: 1) funding eligibility under several incentive programs is now tied to this designation, and 2) FHWA will be required to designate a network of freight corridors "at strategic locations, along major national highways, the National Highway Freight Network established under section 167 of title 23, United States Code, and goods movement locations including ports, intermodal centers, and warehousing locations" by no later than November 15, 2022.[3] Fleets, station developers, and fuel providers should ensure that they are familiar with existing designations, as these are the highways along which funding will be more readily available. For example, station developers should evaluate areas near the exits at which this plan recommends new infrastructure to identify land available for purchase or future development.

Share Infrastructure Development Plans with TxDOT to Inform Future Corridor Designations

The industry can also enable future funding availability for locations that do not fall along existing FHWA-designated corridors by informing TxDOT of specific station development plans along other highways. TxDOT can then consider this information when evaluating whether additional highway segments can or should be nominated under the FHWA Corridor Program, since FHWA requests supporting documentation for nominations, including information on current and planned stations. For example, TxDOT could use information from a company that has specific plans to build a hydrogen refueling station in west Texas to justify designating all of Interstate 10 as a hydrogen corridor, without there being a station there currently. This designation would then unlock the potential for the project to compete for the $2.5 billion in competitive funding made available through the Discretionary Grant Program for Charging and Fueling Infrastructure. Without the corridor designation, that segment of highway would be unable to compete for that portion of federal funding.

Leverage Transportation Datasets for Additional Analysis to Refine Siting Recommendations

Several additional analyses would be helpful to assess which technology – battery electric vehicle (BEV) or FCEV – may be best suited to traffic along IH 45. While time and resources did not permit all of these elements to be evaluated as part of this plan, additional analyses could refine plan recommendations, as the volume of medium- and heavy-duty vehicles using each platform could impact the appropriate number and placement of ZEV sites as the infrastructure scales up.

Key factors that impact suitability of BEV versus FCEV platforms include:

- Trip length: BEVs are likely best-suited to regional-haul routes, whereas true long-haul routes in sleeper cabs may be best served by FCEVs. Location-based datasets such as StreetLight, or other similar platforms, can be leveraged to determine typical trip length associated with travel originating, terminating, or traversing the corridor. This may require combining multiple datasets and platforms.
- Cargo weight: FCEVs may be better served in applications where payload is particularly heavy, so evaluation of specific commodity flows may be helpful in better assessing which ZEV technology may take primary market share. TxDOT is currently developing a new statewide freight plan that incorporates additional supply chain information, and new data coming from the conclusion of that process may shed light on opportunities to analyze more detailed cargo-related information.

In addition, other analyses that impact ideal location of infrastructure could include:

- Full extent of routes that intersect, but travel beyond, IH 45: As noted in Chapter 1, IH 45 is just one leg of the "Texas Triangle," and intersects several major east-west routes, in addition to serving travel that is captive to the Dallas-Fort Worth-Houston routes. To adequately serve all traffic on the corridor and optimize placement of stations to serve intersecting routes, additional analysis could be done. This could be completed using StreetLight or other location-based datasets that offer insights on origin-destination pairs and/or other route data.

[3] FHWA 2022 Round 6 Request for Nominations. Pg. 8 Note: National EV Charging Corridors for Freight and Goods Movement, https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/nominations/2022_request_for_nominations_r6.pdf.

- The share of day cab versus sleeper trucks traveling the corridor: Day cabs and sleeper trucks operate on very different duty cycles and may benefit from different types of amenities. For example, day cabs have less need for amenities, such as hotels, long-term parking, or shower facilities, associated with government-mandated rest periods. Those types of facilities would be less important, but availability of higher-speed chargers may be more important. Conversely, a sleeper cab may find slower speed charging stations to be adequate for a recharge if driving a BEV. A deeper understanding the truck configurations traveling the corridor would help refine recommendations.
- An inventory of potential customer fleets: A listing of companies with substantial presence along the corridor could be useful in identifying potential customer fleets that could become anchor fleets for site investment. Both the Dallas-Fort Worth and Houston areas have extensive freight-oriented developments, including the International Inland Port of Dallas that lies along IH 45 on the northern end of the corridor. These developments are ideal partners in forging fleet relationships and establishing a potential customer base. They can help network, not only with the companies with a warehouse or distribution center, but also with their contracted third-party logistics providers. Economic development districts can be additional sources of networking.

Raise Awareness of Infrastructure Sites

One of the initial objectives of the Alternative Fuel Corridor Program was to raise awareness of alternative fuel infrastructure sites, including development of alternative fuel corridor signage. Placement of highway signage and other traffic control devices is traditionally the responsibility of transportation agencies. All parties have a role to play in ensuring that the presence of new infrastructure is communicated to the Clean Cities network, which can then feed information into platforms that are widely utilized by industry and other drivers.

Post Signage

One key element of increasing ZEV deployment is to increase driver awareness of station availability, and highway signage can be an important element of raising this awareness. A driver who is already operating an alternative fuel vehicle has likely already done research to learn where appropriate fueling is located to ensure they were not at risk of becoming stranded prior to investing in an alternative fuel or ZEV vehicle. However, in order to increase adoption and shift more drivers into ZEVs, it is important to build awareness among those who are NOT already doing this research, to build familiarity and comfort that infrastructure serving these vehicles is readily available. Three categories of highway signage that can be used to convey presence of alternative fuel infrastructure are outlined in the FHWA Manual of Uniform Traffic Control Devices (MUTCD) or interim MUTCD memos: general services signage, specific services signage, and corridor signage. Examples of these types of signs are illustrated in **Exhibit 61**. TxDOT adopted a policy governing placement of general services signs in June 2018. To date, signage has been placed for natural gas stations, but few stations of other fuel types. To qualify for signage, a station must:

- Be immediately adjacent to the signed highway or lie on a roadway intersected by the signed highway
- Be open to the public at least 12 hours a day, 7 days a week
- Have an on-premise sign visible to motorists that identifies types of fuels available
- Be located within the following maximum distances:
    - One-half mile if in a city with a population over 250,000
    - One mile if in an area with populations between 15,000 and 250,000

- Two miles if in an area with population less than 15,000
- EV charging stations are limited to Direct Current Fast Charge stations and must also:
  - Contain a cluster with two or more charging posts
  - Be illuminated
  - Include regulatory signs that clearly identify dedicated parking for EV charging

Exhibit 61: Types of Highway Signage for Alternative Fuel Stations

Signage Type	Example	Recommended Action
General Services		Site Owners: Request placement of signage if facility meets TxDOT policy requirements by emailing TRF_signs@txdot.gov
Specific Services (also known in Texas as the “Logo Signs”[4])		FHWA and TxDOT: Update the MUTCD and Texas MUTCD to ensure alternative fuel infrastructure is allowable
Corridor Signage		FHWA: Formalize guidance related to corridor signage in MUTCD TxDOT: Upon clarification by FHWA, place corridor signage along corridors designated as “ready” to convey availability of fuel

FHWA issued a memo related to placement of alternative fuel corridor signage in December 2016,[5] but proposed changes to MUTCD released in 2021 appeared to conflict, and MUTCD revisions have not yet

[4] Logo and Directional Signs (txdot.gov)
[5] Signing for Designated Alternative Fuels Corridors - FHWA MUTCD (dot.gov)

been finalized. Until clarification is provided with regard to corridor signage, many state DOTs are reluctant to proceed with posting the signage.

Leverage Global Positioning System Application-Based Systems

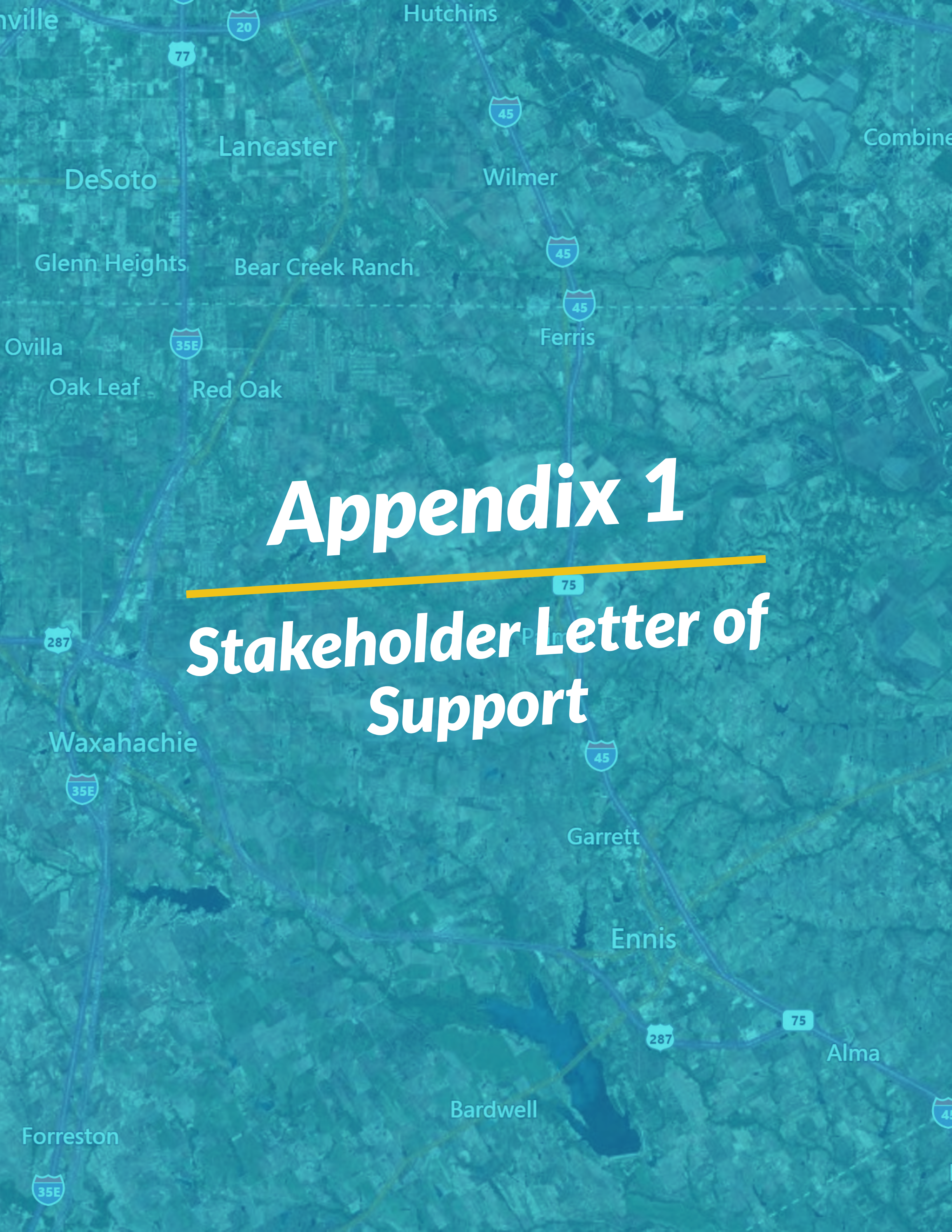
Above and beyond traditional highway signage, many drivers become aware of recharging and refueling sites through mobile smartphone applications. This is especially true for EV charging that serves the general public. Additional exposure through these platforms can be ensured by notifying the local Clean Cities Coalitions when a new station is brought online to ensure visibility through the Alternative Fuels Data Center Station Locator, which is a data source for a variety of other systems. In the case of EV charging, ensuring that stations are networked is a key best practice to ensure that smartphone applications have visibility into the presence and real-time status of that station to the greatest extent possible.

Leverage Information and Recommendations from Other Corridor Deployment Plans

Finally, other plans funded by FHWA under the Alternative Fuels Corridor Deployment Plans initiative include content that is highly relevant to successful implementation of the siting recommendations in this plan. NCTCOG did not attempt to duplicate this content but recommends these plans as complementary resources and reference.[6] Notably, prospective project developers are encouraged to review:

- The *I-40 Alternative Fuel Corridor Deployment Plan*, especially Chapter 2, which includes useful siting considerations for various stakeholder entities (e.g., property owner, utility, governing authority, business owner, etc.)
- The *Alternative Fuels Deployment Plan for I-81 and I-78 in Pennsylvania*, especially the Introduction, which describes important baseline information about potential business models for compressed natural gas and EV charging sites, and the Outreach & Implementation chapter, which describes a useful outreach process for facilitating station deployment

[6] https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/deployment_plan/



Appendix 1

Stakeholder Letter of Support

Stakeholders that Provided Letters of Support

Air Liquide

June 29, 2022

Mrs. Lori Clark
Program Manager and DFW Clean Cities Coordinator
Air Quality Management and Operations
North Central Texas Council of Governments
PO Box 5888
Arlington, TX 76005-5888

Dear Mrs. Clark:

RE: Letter of Support for NCTCOG Interstate 45 Zero Emission Vehicle Corridor Deployment Plan

Air Liquide has reviewed and supports the Interstate 45 Zero Emission Vehicle (ZEV) Corridor Infrastructure Deployment Plan developed by the North Central Texas Council of Governments (NCTCOG). We understand that this plan was drafted under an award from the Federal Highway Administration *Alternative Fuels Corridor Deployment Plans* initiative, and that the objective is to develop actionable recommendations to spur infrastructure development and enable the entire corridor to be designated as "ready" for both electric vehicle charging and hydrogen fueling.

As a stakeholder in this project, Air Liquide is excited to see the results of this long and thoughtful process, and the timing could not be better. Released just as the Production Tax Credit has been included in proposed legislation, and as the DOE begins to solicit proposals under the Bipartisan Infrastructure Law, we expect that this plan will provide insights that will inform the rollout of zero emission infrastructure that will keep Texas on the forefront of American energy.

Air Liquide believes that the plan provides a useful framework for additional deployment activities and looks forward to continued collaboration with NCTCOG and the Dallas-Fort Worth Clean Cities Coalition, hosted within NCTCOG.

Sincerely,

Jeffrey K Harrington, Business Development
Air Liquide Hydrogen Energy U.S. LLC

CENTER FOR HOUSTON'S FUTURE

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Suite 900
Houston, Texas 77010
Phone: 713-844-9325
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July 27, 2022

Mrs. Lori Clark
Program Manager and DFW Clean Cities Coordinator
Air Quality Management and Operations
North Central Texas Council of Governments
PO Box 5888
Arlington, TX 76005-5888

Dear Mrs. Clark:

RE: Letter of Support for NCTCOG Interstate 45 Zero Emission Vehicle Corridor Deployment Plan

Center for Houston's Future has reviewed and supports the Interstate 45 Zero Emission Vehicle (ZEV) Corridor Infrastructure Deployment Plan developed by the North Central Texas Council of Governments (NCTCOG). We understand that this plan was drafted under an award from the Federal Highway Administration *Alternative Fuels Corridor Deployment Plans* initiative, and that the objective is to develop actionable recommendations to spur infrastructure development and enable the entire corridor to be designated as "ready" for both electric vehicle charging and hydrogen fueling.

Center for Houston's Future is a nonprofit organization that works to make our region a top global community in which to work and live. We bring business, government, and community stakeholders together to engage in fact-based strategic planning, collaboration and action on long-term issues of great importance to the region. We are an affiliate of the Greater Houston Partnership, the region's main economic development organization.

One of our key strategic initiatives is focused on the energy transition, with a specific goal of turning Greater Houston and Texas into a clean hydrogen hub. Our roadmap sets out a variety of projects addressing supply, demand, and infrastructure spreading across the region, with concentrations in areas around Greater Houston and extending to Dallas and the Texas Triangle. Scaling hydrogen requires developing infrastructure, including hydrogen transport and storage and fueling stations.

Our work clearly meshes with the plan developed by NCTCOG and as such we are a key stakeholder in the Interstate 45 Zero Emission Vehicle Corridor Deployment Plan and excited by the opportunity to help make it a reality.

Center for Houston's Future believes that the plan provides a useful framework for additional deployment activities and looks forward to continued collaboration with NCTCOG and the Dallas-Fort Worth Clean Cities Coalition, hosted within NCTCOG.

Sincerely,

Brett Perlman
President and CEO
Center for Houston's Future

A 501(c)(3) organization, affiliated with the Greater Houston Partnership
Austin · Brazoria · Chambers · Fort Bend · Galveston · Harris · Liberty · Montgomery · Walker · Waller

CenterPoint Energy

CenterPoint Energy

PO Box 1700
Houston, Texas
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CenterPointEnergy.com

July 25, 2022

Mrs. Lori Clark
Program Manager and DFW Clean Cities Coordinator
Air Quality Management and Operations
North Central Texas Council of Governments
PO Box 5888
Arlington, TX 76005-5888

Dear Mrs. Clark:

RE: Letter of Support for NCTCOG Interstate 45 Zero Emission Vehicle Corridor Deployment Plan

CenterPoint Energy has reviewed and supports the Interstate 45 Zero Emission Vehicle (ZEV) Corridor Infrastructure Deployment Plan developed by the North Central Texas Council of Governments (NCTCOG). We understand that this plan was drafted under an award from the Federal Highway Administration *Alternative Fuels Corridor Deployment Plans* initiative, and that the objective is to develop actionable recommendations to spur infrastructure development and enable the entire corridor to be designated as "ready" for both electric vehicle charging and hydrogen fueling.

As a stakeholder in this project, CenterPoint Energy is committed to be an active participant in advancing this plan. CenterPoint Energy is responsible for the transmission and distribution of electricity across our 5,000-square-mile service territory in the Houston metropolitan area. We strongly support the project objectives outlined in the plan as complimentary to our mission of reducing emissions within the Texas Gulf Coast region through the advancement of electrification technologies. The mission of the plan is consistent with CenterPoint Energy's interests and overall goal of advancing the electrification of the goods and people movement.

CenterPoint Energy believes that the plan provides a useful framework for additional deployment activities and looks forward to continued collaboration with NCTCOG and the Dallas-Fort Worth Clean Cities Coalition, hosted within NCTCOG.

Sincerely,

David M. Owen
Manager, Clean Air Technologies
CenterPoint Energy

Joseph B. Powell
ChemePD LLC
8610 Longpath Ct.
Richmond, TX 77406 (USA)
www.ChemePD.com

19 May 2022

Mrs. Lori Clark
Program Manager and DFW Clean Cities Coordinator
Air Quality Management and Operations
North Central Texas Council of Governments
PO Box 5888
Arlington, TX 76005-5888

Dear Mrs. Clark:

RE: Letter of Support for NCTCOG Interstate 45 Zero Emission Vehicle Corridor Deployment Plan

ChemePD LLC has reviewed and supports the Interstate 45 Zero Emission Vehicle (ZEV) Corridor Infrastructure Deployment Plan developed by the North Central Texas Council of Governments (NCTCOG). As Principal, I understand that this plan was drafted under an award from the Federal Highway Administration *Alternative Fuels Corridor Deployment Plans* initiative, and that the objective is to develop actionable recommendations to spur infrastructure development and enable the entire corridor to be designated as "ready" for both electric vehicle charging and hydrogen fueling.

As a former chair of the U.S. DOE's Hydrogen and Fuel Cell Technical Advisory Committee, Chief Scientist for Shell with principal responsibilities in clean hydrogen opportunity development, and currently serving as consultant to multiple parties across the U.S. involved in Hydrogen Hub opportunity framing including the Center for Houston's Future, as well as advisor to University of Houston Energy and Stanford Energy, and executive board member for the U.S. Business Council for Sustainable Development (based in Austin, TX), I believe that the plan provides a useful framework for additional deployment activities and look forward to continued collaboration and voluntary cost-share contribution with NCTCOG and the Dallas-Fort Worth Clean Cities Coalition, hosted within NCTCOG.

Sincerely,

Joe Powell

Joe Powell (Joseph B. Powell, PhD)
Principal, ChemePD LLC
NAE, Fellow AIChE
JBP@ChemePD.com
JBPChE@Outlook.com

City of Dallas

May 19, 2022

Ms. Lori Clark
Program Manager and DFW Clean Cities Coordinator
Air Quality Management and Operations
North Central Texas Council of Governments
PO Box 5888
Arlington, TX 76005-5888

Dear Ms. Clark:

RE: Letter of Support for NCTCOG Interstate 45 Zero Emission Vehicle Corridor Deployment Plan

The City of Dallas has reviewed and supports the Interstate 45 Zero Emission Vehicle (ZEV) Corridor Infrastructure Deployment Plan developed by the North Central Texas Council of Governments (NCTCOG). We understand that this plan was drafted under an award from the Federal Highway Administration *Alternative Fuels Corridor Deployment Plans* initiative, and that the objective is to develop actionable recommendations to spur infrastructure development and enable the entire corridor to be designated as "ready" for both electric vehicle charging and hydrogen fueling.

As a stakeholder in this project, we recognize the synergy this project allows to coordinate, augment and expand related efforts by the City of Dallas. The City is actively working to expand local charging infrastructure, key to electrifying our fleet, encouraging community vehicle electrification, reducing local transportation emissions, and meeting our related goals from the Comprehensive Environmental and Climate Action Plan (CECAP).

We look forward to working with our partners at the NCTCOG towards timely implementation of the efforts within this project proposal. The City of Dallas believes that the plan provides a useful framework for additional deployment activities and looks forward to continued collaboration with NCTCOG and the Dallas-Fort Worth Clean Cities Coalition, hosted within NCTCOG.

Sincerely,

Susan Alvarez, P.E. CFM, Assistant Director
City of Dallas, Office of Environmental Quality & Sustainability

CITY OF DALLAS - 1500 MARILLA STREET - ROOM 7AN - DALLAS TEXAS 75201

May 31, 2022

Mrs. Lori Clark
Program Manager and DFW Clean Cities Coordinator
Air Quality Management and Operations
North Central Texas Council of Governments
PO Box 5888
Arlington, TX 76005-5888

Dear Mrs. Clark:

RE: Letter of Support for NCTCOG Interstate 45 Zero Emission Vehicle Corridor Deployment Plan

H2 Ranch, LLC has reviewed and supports the Interstate 45 Zero Emission Vehicle (ZEV) Corridor Infrastructure Deployment Plan developed by the North Central Texas Council of Governments (NCTCOG). We understand that this plan was drafted under an award from the Federal Highway Administration *Alternative Fuels Corridor Deployment Plans* initiative, and that the objective is to develop actionable recommendations to spur infrastructure development and enable the entire corridor to be designated as "ready" for both electric vehicle charging and hydrogen fueling.

As a stakeholder in this project, and a Texas based green hydrogen production company, we are interested in any activity that advances the hydrogen industry.

H2 Ranch, LLC believes that the plan provides a useful framework for additional deployment activities and looks forward to continued collaboration with NCTCOG and the Dallas-Fort Worth Clean Cities Coalition, hosted within NCTCOG.

Sincerely,

Michael Martinez

Mike Martinez, Manager
H2 Ranch, LLC
4388 W. Vickery Blvd. #100
Fort Worth, Texas 76107
817-881-4645

June 1, 2022

Ms. Lori Clark
Program Manager and DFW Clean Cities Coordinator
Air Quality Management and Operations
North Central Texas Council of Governments
P.O. Box 5888
Arlington, TX 76005-5888

Subject: Letter of Support for the Interstate 45 Zero Emission Vehicle Corridor Deployment Plan

Dear Ms. Clark:

The Houston-Galveston Clean Cities Coalition (HGCCC) has reviewed and supports the Interstate 45 Zero Emission Vehicle (ZEV) Corridor Infrastructure Deployment Plan developed by the North Central Texas Council of Governments (NCTCOG). We understand that this plan was drafted under an award from the Federal Highway Administration *Alternative Fuels Corridor Deployment Plans* initiative, and that the objective was to develop actionable recommendations to spur infrastructure development and enable the entire corridor to be designated as "ready" for both electric vehicle charging and hydrogen fueling.

As a project stakeholder working to increase the use of alternative fuels within our region on the southern end of the corridor represented in this deployment plan, HGCCC strongly supports this work. As a Clean Cities Coalition, this plan will be a valuable tool for organizations such as ours to help improve the availability of ZEV infrastructure and encourage the use of zero emission technologies within our region and beyond.

The Houston-Galveston Clean Cities Coalition believes that the final plan provides a useful framework for additional deployment activities and looks forward to continued collaboration with NCTCOG and the Dallas-Fort Worth Clean Cities Coalition, hosted within NCTCOG.

Sincerely,

Andrew J. DeCandis
Clean Cities Co-Coordinator
Houston-Galveston Clean Cities Coalition

Ben Finley
Clean Cities Co-Coordinator
Houston-Galveston Clean Cities Coalition

June 10, 2022

Ms. Lori Clark
Program Manager and DFW Clean Cities Coordinator
Air Quality Management and Operations
North Central Texas Council of Governments
P.O. Box 5888
Arlington, TX 76005-5888

Subject: Letter of Support for the Interstate 45 Zero Emission Vehicle Corridor Deployment Plan

Dear Ms. Clark:

The Houston-Galveston Area Council (H-GAC) has reviewed and supports the Interstate 45 Zero Emission Vehicle (ZEV) Corridor Infrastructure Deployment Plan developed by the North Central Texas Council of Governments (NCTCOG). We understand that this plan was drafted under an award from the Federal Highway Administration *Alternative Fuels Corridor Deployment Plans* initiative, and that the objective was to develop actionable recommendations to spur infrastructure development and enable the entire corridor to be designated as "ready" for both electric vehicle charging and hydrogen fueling.

As a project stakeholder representing the region anchoring the southern terminus of the corridor represented in this deployment plan, H-GAC strongly supports this work. Because our region is in nonattainment for Federal ozone standards, much of our transportation planning is focused on identifying and implementing projects and strategies to improve air quality. The development of this corridor plan and our participation in the related stakeholder events has helped H-GAC better understand the regional interest and demand for these technologies. Additionally, we anticipate that the final plan will be instrumental in guiding upcoming infrastructure planning and funding efforts for ZEVs in our region.

H-GAC believes that the final plan provides a useful framework for additional deployment activities and looks forward to continued collaboration with NCTCOG and the Dallas-Fort Worth Clean Cities Coalition, hosted within NCTCOG.

Sincerely,

Craig Raborn
E-signed 2022-06-10 05:55PM CDT
craig.raborn@h-gac.com
Houston-Galveston Area Council

Craig Raborn, AICP
MPO Director

May 20, 2022

Mrs. Lori Clark
Program Manager and DFW Clean Cities Coordinator
Air Quality Management and Operations
North Central Texas Council of Governments
PO Box 5888
Arlington, TX 76005-5888

Dear Mrs. Clark:

RE: Letter of Support for NCTCOG Interstate 45 Zero Emission Vehicle Corridor Deployment Plan

Kaizen Clean Energy (KCE) has reviewed and supports the Interstate 45 Zero Emission Vehicle (ZEV) Corridor Infrastructure Deployment Plan developed by the North Central Texas Council of Governments (NCTCOG). We understand that this plan was drafted under an award from the Federal Highway Administration Alternative Fuels Corridor Deployment Plans initiative, and that the objective is to develop actionable recommendations to spur infrastructure development and enable the entire corridor to be designated as "ready" for both electric vehicle charging and hydrogen fueling.

As a stakeholder in this project, KCE believes strongly in the immediate reduction of localized emissions, reduced cost of hydrogen, and resiliency that is required for EV charging along evacuation routes.

Below is an example of KCE's industry first microgrid capable of providing EV Charging, Hydrogen Fueling, or Microgrid Power for the ZEV Corridor plan. Our technology was designed in Texas and is being deployed globally to support wider EV and Hydrogen adoption.

Kaizen Clean Energy believes that the plan provides a useful framework for additional deployment activities and looks forward to continued collaboration

Kaizen Clean Energy, LLC
Eric Smith, Co-Founder
eric.smith@kaizencleanenergy.com

with NCTCOG and the Dallas-Fort Worth Clean Cities Coalition, hosted within NCTCOG.

Sincerely,
Robert P. Meaney
Co-Founder
Kaizen Clean Energy
www.kaizencleanenergy.com
robert.meaney@kaizencleanenergy.com

ONCOR

Randy M. Boys
Manager, Strategy & Technology

Oncor Electric Delivery
1616 Woodall Rodgers Freeway
Dallas, Texas 75202

214-486-4934
randy.boys@oncor.com

May 31, 2022

Mrs. Lori Clark
Program Manager and DFW Clean Cities Coordinator
Air Quality Management and Operations
North Central Texas Council of Governments
PO Box 5888
Arlington, TX 76005-5888

RE: Letter of Support for NCTCOG Interstate 45 Zero Emission Vehicle Corridor Deployment Plan

Oncor has reviewed and supports the Interstate 45 (I-45) Zero Emission Vehicle (ZEV) Corridor Infrastructure Deployment Plan (the Plan) developed by the North Central Texas Council of Governments (NCTCOG). We understand that the Plan was drafted under an award from the Federal Highway Administration Alternative Fuels Corridor Deployment Plans initiative, and that the objective is to develop actionable recommendations to spur infrastructure development and enable the entire corridor to be designated as "ready" for both electric vehicle charging and hydrogen fueling.

Oncor is the largest electric utility in Texas and serves over 3.7 million points of common coupling, representing over 11 million Texans. Our interests and concerns regarding transportation electrification, including all-electric or hydrogen fuel cell vehicles, have been solicited in a full partnership manner by the NCTCOG, and we believe these to be well-represented in the Plan. The Oncor service territory includes approximately half of the proposed I-45 corridor, and we are confident in our readiness to meet any requests made on behalf of the Plan, or of the more complete transportation electrification that will follow. As a stakeholder in this project, we look forward to our continued engagement.

Best regards,

Randy Boys

Shell USA, Inc.

150 N Dairy Ashford
Houston, TX 77079
USA
www.shell.com

Mrs. Lori Clark
Program Manager and DFW Clean Cities Coordinator
Air Quality Management and Operations
North Central Texas Council of Governments
PO Box 5888
Arlington, TX 76005-5888

Dear Mrs. Clark:

RE: Letter of Support for NCTCOG Interstate 45 Zero Emission Vehicle Corridor Deployment Plan

Shell USA has reviewed and support the Interstate 45 Zero Emission Vehicle (ZEV) Corridor Infrastructure Deployment Plan developed by the North Central Texas Council of Governments (NCTCOG). We understand that this plan was drafted under an award from the Federal Highway Administration *Alternative Fuels Corridor Deployment Plans* initiative, and that the objective is to develop actionable recommendations to spur infrastructure development and enable the entire corridor to be designated as "ready" for both electric vehicle charging and hydrogen fuelling.

As stakeholders in this project, Shell USA would like to emphasize that we advocate for an "All -of-the-Above-That's-Clean" approach when it comes to transitioning the transportation sector to lower carbon fuel options for customers. Shell has demonstrated successes in advancing E-mobility, DC fast charging, Hydrogen, and negative lifecycle emissions Renewable Compressed Natural Gas for transport.

The Alternative Fuels Corridor Deployment Plans are critical to accelerating uptake in investment of infrastructure that will eventually lead to uptake of drivers and fleet owners choosing to transition and creating a lower carbon future.

Specifically on electric vehicle infrastructure expansion, our EV charging division, Shell Recharge Solutions, is actively working with stakeholders in multiple areas of Texas to ready policies and plans to take advantage of additional governmental funding. Options like equipment swap public charging and fleet management will be four parts of the federal infrastructure spending plan around EVs.

We also see CNG & H2 are similar technologies in terms of the infrastructure requirements. Stations built for the fuel solutions today can be repurposed for the fuel solutions of tomorrow (i.e. R-CNG to H2).

In our view, progressing the energy transition and achieving societal net zero emissions can only be realized through an "All -of-the-Above-That's-Clean" and technology neutral approach as different types of transport (light, medium, heavy) and different geographies will find different benefits to one fuel or another. Including a broad range of solutions such as hydrogen and Ultra-Low NOx natural gas vehicles alongside EVs as a part of a comprehensive solution helps to stretch the impact of every dollar as far as possible in our economy and gives customers more options for decarbonizing.

Shell USA believes that the plan provides a useful framework for additional deployment activities and looks forward to continued collaboration with NCTCOG and the Dallas-Fort Worth Clean Cities Coalition, hosted within NCTCOG.

Sincerely,

Chris Angelides, BScME, MBA, PMP

Head of US Energy Transition Integration

Shell USA

David W. Raney
Executive Director
Texas Hydrogen Alliance
2220 Canton Street, Suite 208
Dallas, Texas. 75201

Texas Hydrogen Alliance

July 21, 2022

Mrs. Lori Clark
Program Manager and DFW Clean Cities Coordinator Air Quality Management and Operations
North Central Texas Council of Governments
PO Box 5888
Arlington, TX 76005-5888

Dear Mrs. Clark:

RE: Letter of Support - NCTCOG Interstate 45 Zero Emission Vehicle Corridor Deployment Plan

The Texas Hydrogen Alliance (THA), an industry-based non-profit organization focused on moving forward multiple hydrogen opportunities in Texas, has reviewed and supports the Interstate 45 Zero Emission Vehicle (ZEV) Corridor Infrastructure Deployment Plan developed by the North Central Texas Council of Governments (NCTCOG). We understand that this plan was drafted under an award from the Federal Highway Administration *Alternative Fuels Corridor Deployment Plans* initiative, and that the objective is to develop actionable recommendations to spur infrastructure development and enable the entire corridor to be designated as "ready" for both electric vehicle charging and hydrogen fueling primarily focused on heavy trucks. We hope this activity is also supportive of hydrogen fueling infrastructure in the longer term for heavy truck operation throughout the State and locomotives and urban transit buses.

As a stakeholder in this project, our members are pleased that this Plan will serve as an important model for future studies as needed to support infrastructure development along other Corridors in Texas including I-35 and I-10. It will also be constructive in developing a better understanding of the needs of the major ports in Texas, i.e., Port Houston and Port of Corpus Christi, and other areas including Dallas-Fort Worth metro.

THA believes that the Plan provides a useful framework for additional deployment activities and looks forward to continued collaboration with NCTCOG and the Dallas-Fort Worth Clean Cities Coalition, hosted within NCTCOG. We are thankful for the continued support from FHWA of this important work.

Sincerely,

David W. Raney

David W. Raney, Executive Director

CENTER FOR ELECTROMECHANICS
THE UNIVERSITY OF TEXAS AT AUSTIN
J.J. Pickle Research Campus, Building 133 · 10100 Burnet Rd. Austin, Texas 78758 · (512) 471-4496 · FAX (512) 471-0781

May 19, 2022

Mrs. Lori Clark
Program Manager and DFW Clean Cities Coordinator
Air Quality Management and Operations
North Central Texas Council of Governments
PO Box 5888
Arlington, TX 76005-5888

Dear Mrs. Clark:

RE: Letter of Support for NCTCOG Interstate 45 Zero Emission Vehicle Corridor Deployment Plan

The Center for Electromechanics (CEM) at The University of Texas at Austin has reviewed and supports the Interstate 45 Zero Emission Vehicle (ZEV) Corridor Infrastructure Deployment Plan developed by the North Central Texas Council of Governments (NCTCOG). We understand that this plan was drafted under an award from the Federal Highway Administration Alternative Fuels Corridor Deployment Plans initiative, and that the objective is to develop actionable recommendations to spur infrastructure development and enable the entire corridor to be designated as "ready" for both electric vehicle charging and hydrogen fueling.

As a stakeholder in this project, CEM runs one of the leading academic research institutions in the U.S. focused on hydrogen and fuel cell technologies. Our engagement with the NCTCOG on this project was mutually beneficial to our research as we also look to identify barriers to hydrogen and fuel cell adoption.

CEM believes that the plan provides a useful framework for additional deployment activities and looks forward to continued collaboration with NCTCOG and the Dallas-Fort Worth Clean Cities Coalition, hosted within NCTCOG.

Sincerely,

Michael C. Lewis
Senior Engineering Scientist
The University of Texas at Austin
Center for Electromechanics
mclewis@cem.utexas.edu
(512) 232 - 5715

U.S. Department of Transportation
Office of Small and Disadvantaged Business Utilization

May 19, 2022

Mrs. Lori Clark
Program Manager and DFW Clean Cities Coordinator
Air Quality Management and Operations
North Central Texas Council of Governments
PO Box 5888
Arlington, TX 76005-5888

Dear Mrs. Clark:

RE: Letter of Support for NCTCOG Interstate 45 Zero Emission Vehicle Corridor Deployment Plan

The U.S. DOT Gulf Region Small Business Transportation Resource Center (GRSBTRC) has reviewed and supports the Interstate 45 Zero Emission Vehicle (ZEV) Corridor Infrastructure Deployment Plan developed by the North Central Texas Council of Governments (NCTCOG). We understand that this plan was drafted under an award from the Federal Highway Administration *Alternative Fuels Corridor Deployment Plans* initiative, and that the objective is to develop actionable recommendations to spur infrastructure development and enable the entire corridor to be designated as "ready" for both electric vehicle charging and hydrogen fueling.

The Gulf Region SBTRC believe that the plan provides a useful framework for additional deployment activities and looks forward to continued collaboration with NCTCOG and the Dallas-Fort Worth Clean Cities Coalition, hosted within NCTCOG.

Sincerely,
Tony Arps, Project Director
Gulf Region SBTRC

Volta
155 De Haro Street
San Francisco, CA 94103
T: (888) 264-2208

Mrs. Lori Clark
Program Manager and DFW Clean Cities Coordinator
Air Quality Management and Operations
North Central Texas Council of Governments
PO Box 5888
Arlington, TX 76005-5888

Dear Mrs. Clark:

RE: Letter of Support for NCTCOG Interstate 45 Zero Emission Vehicle Corridor Deployment Plan

Volta Charging has reviewed and supports the Interstate 45 Zero Emission Vehicle (ZEV) Corridor Infrastructure Deployment Plan developed by the North Central Texas Council of Governments (NCTCOG). We understand that this plan was drafted under an award from the Federal Highway Administration *Alternative Fuels Corridor Deployment Plans* initiative, and that the objective is to develop actionable recommendations to spur infrastructure development and enable the entire corridor to be designated as "ready" for both electric vehicle charging and hydrogen fueling.

As a stakeholder in this project, Volta charging is interested in helping accelerate EV charging deployment along I45 and throughout Texas.

Volta Charging believes that the plan provides a useful framework for additional deployment activities and looks forward to continued collaboration with NCTCOG and the Dallas-Fort Worth Clean Cities Coalition, hosted within NCTCOG.

Sincerely,

Gerald Mann, General Manager DFW
Volta Charging

volta

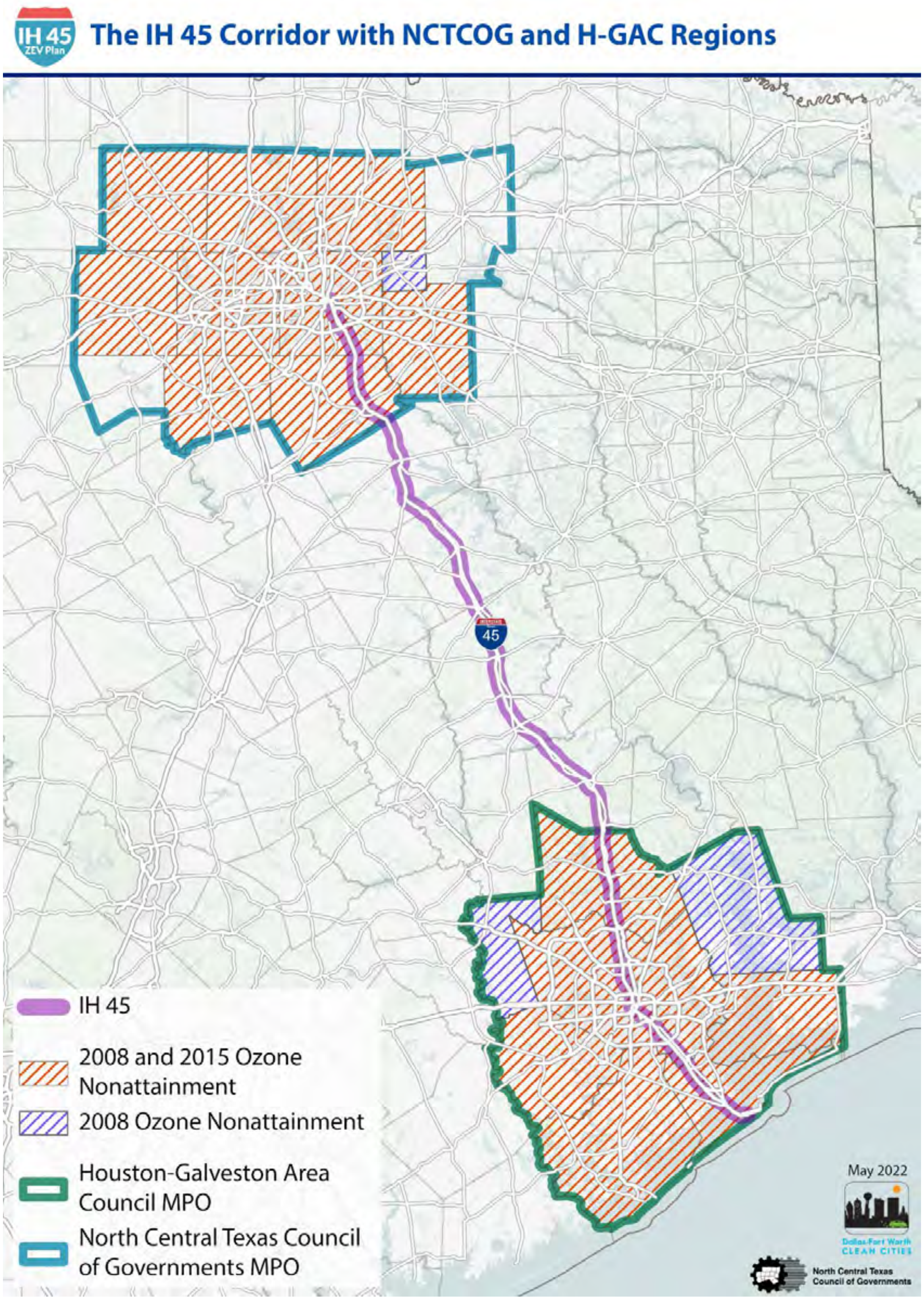
Appendix 2

Select Maps Created for the IH 45 Corridor Plan

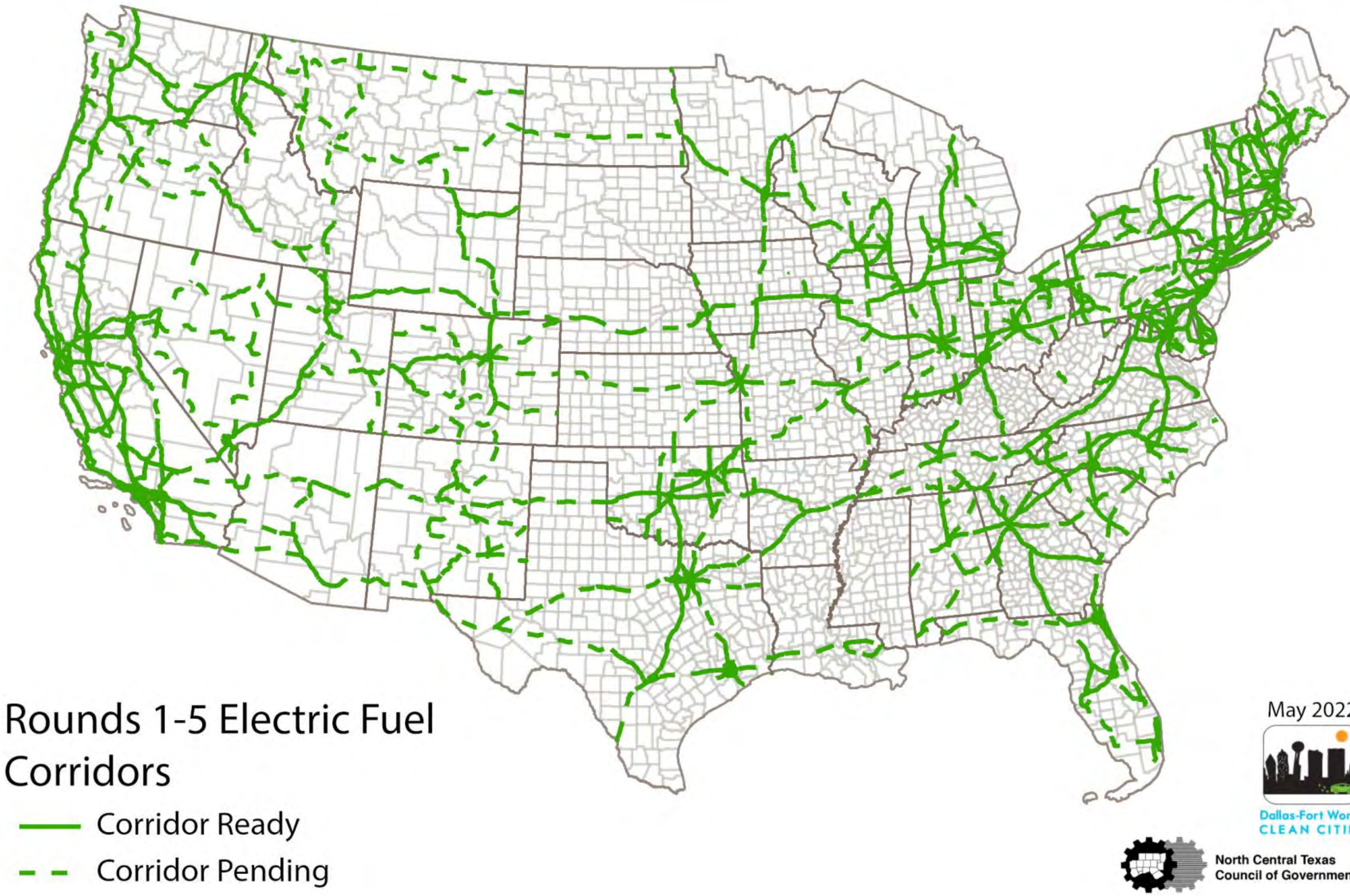
Appendix 2

Select Maps Created for the IH 45 Corridor Plan

Chapter 1 - Introduction



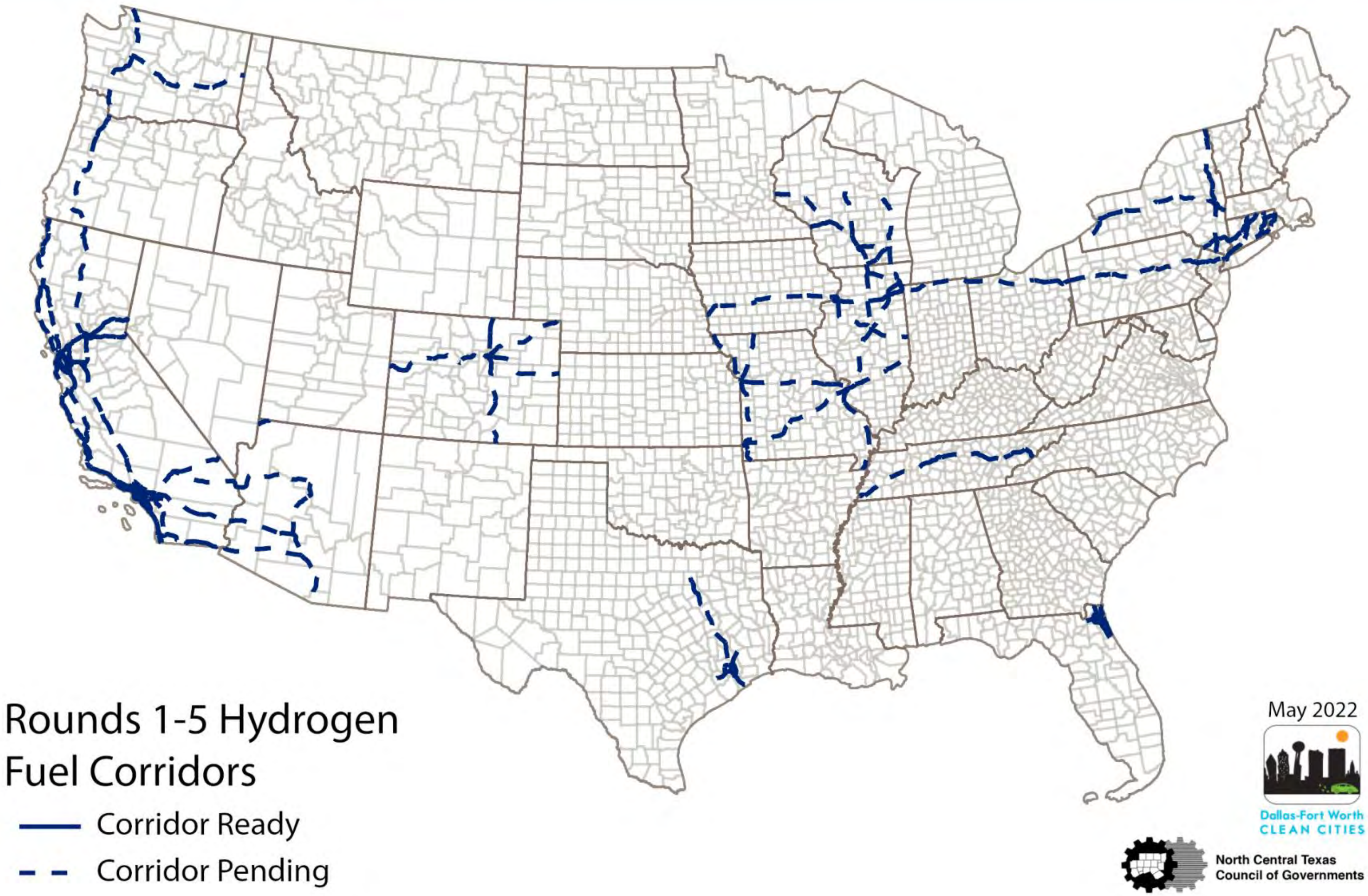
FHWA-Designated Electric Corridors, Round 1 Through Round 5 Designations



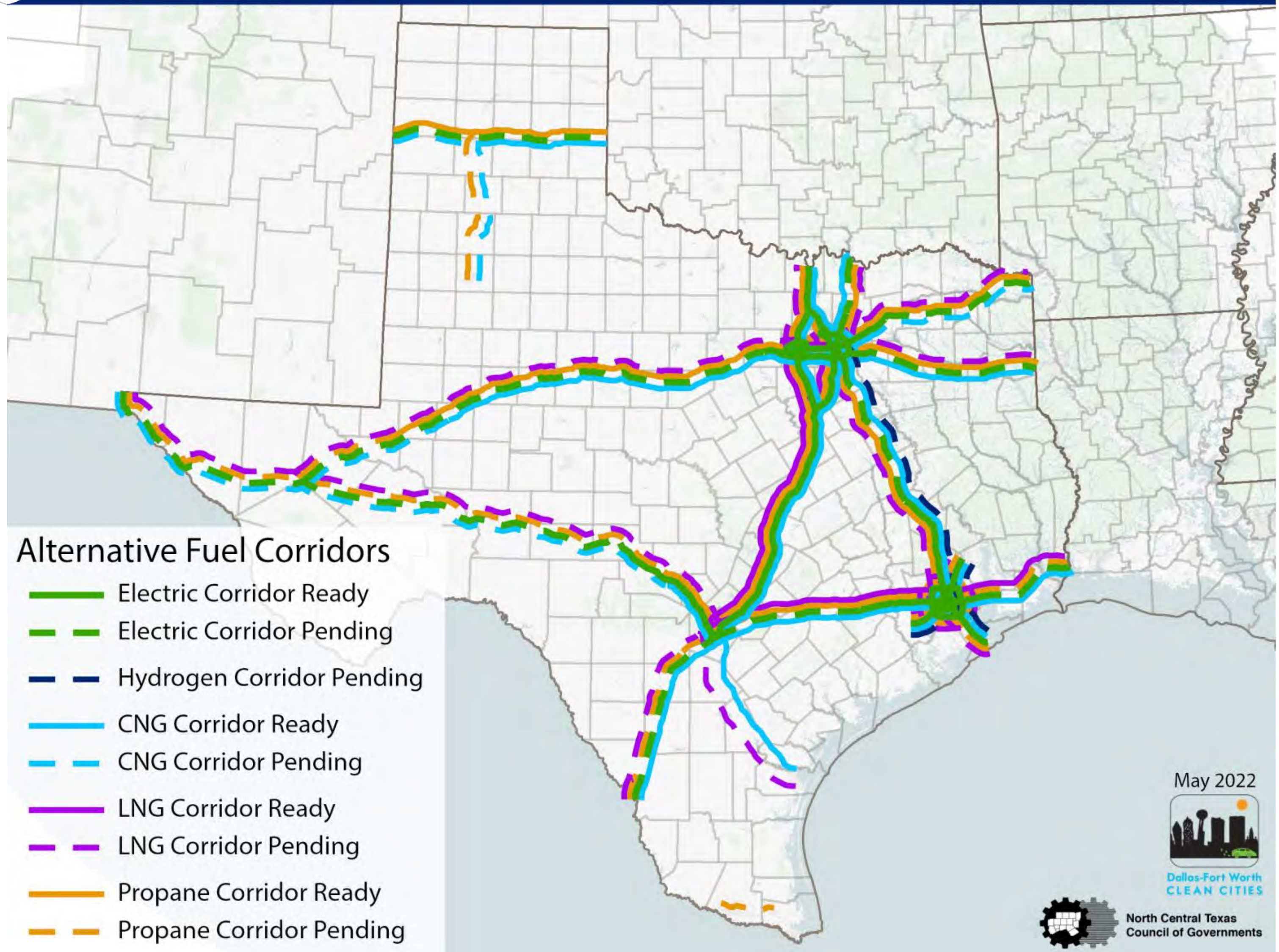
Dallas-Fort Worth CLEAN CITIES

North Central Texas Council of Governments

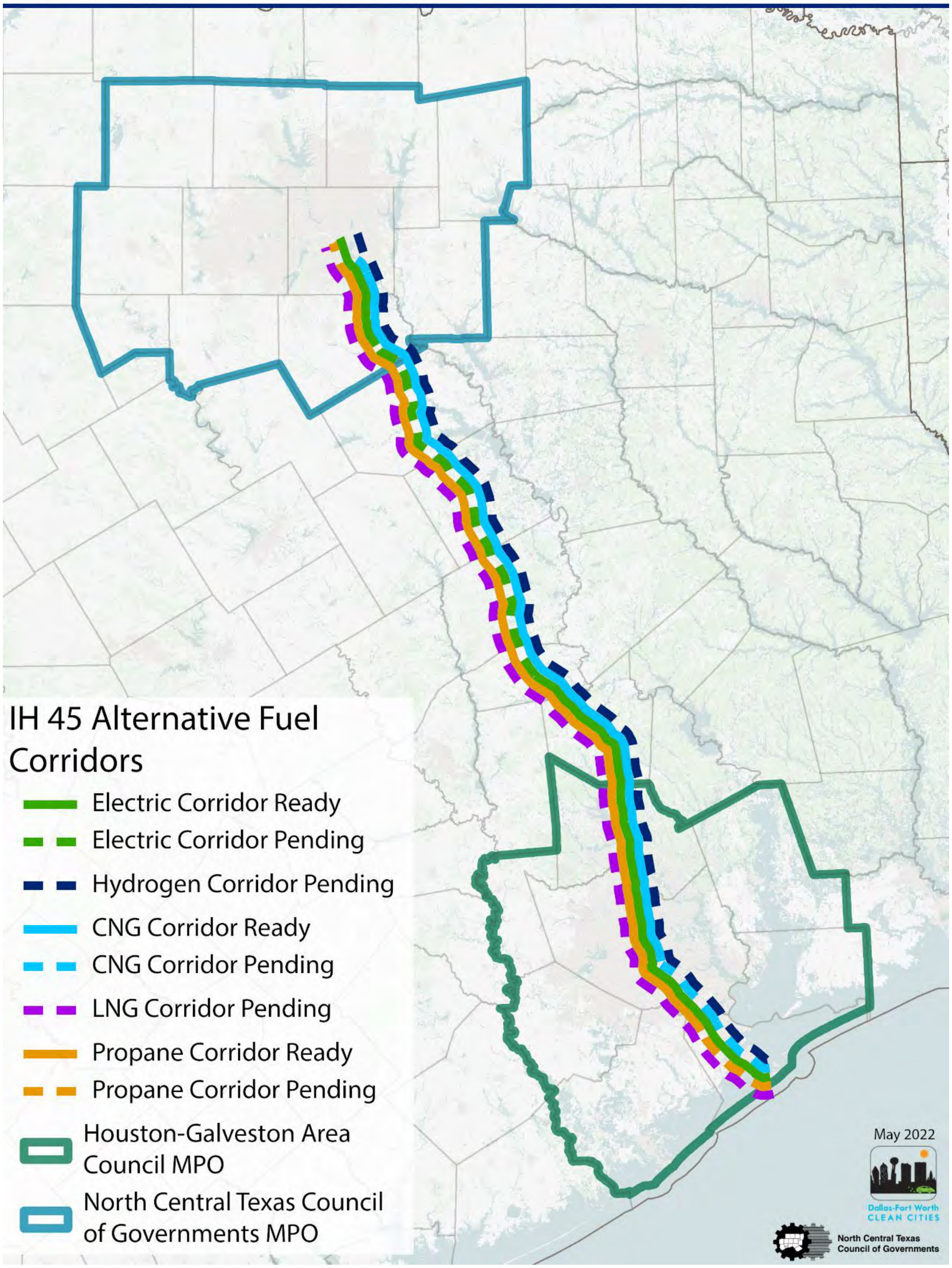
FHWA-Designated Hydrogen Corridors, Round 1 Through Round 5 Designations



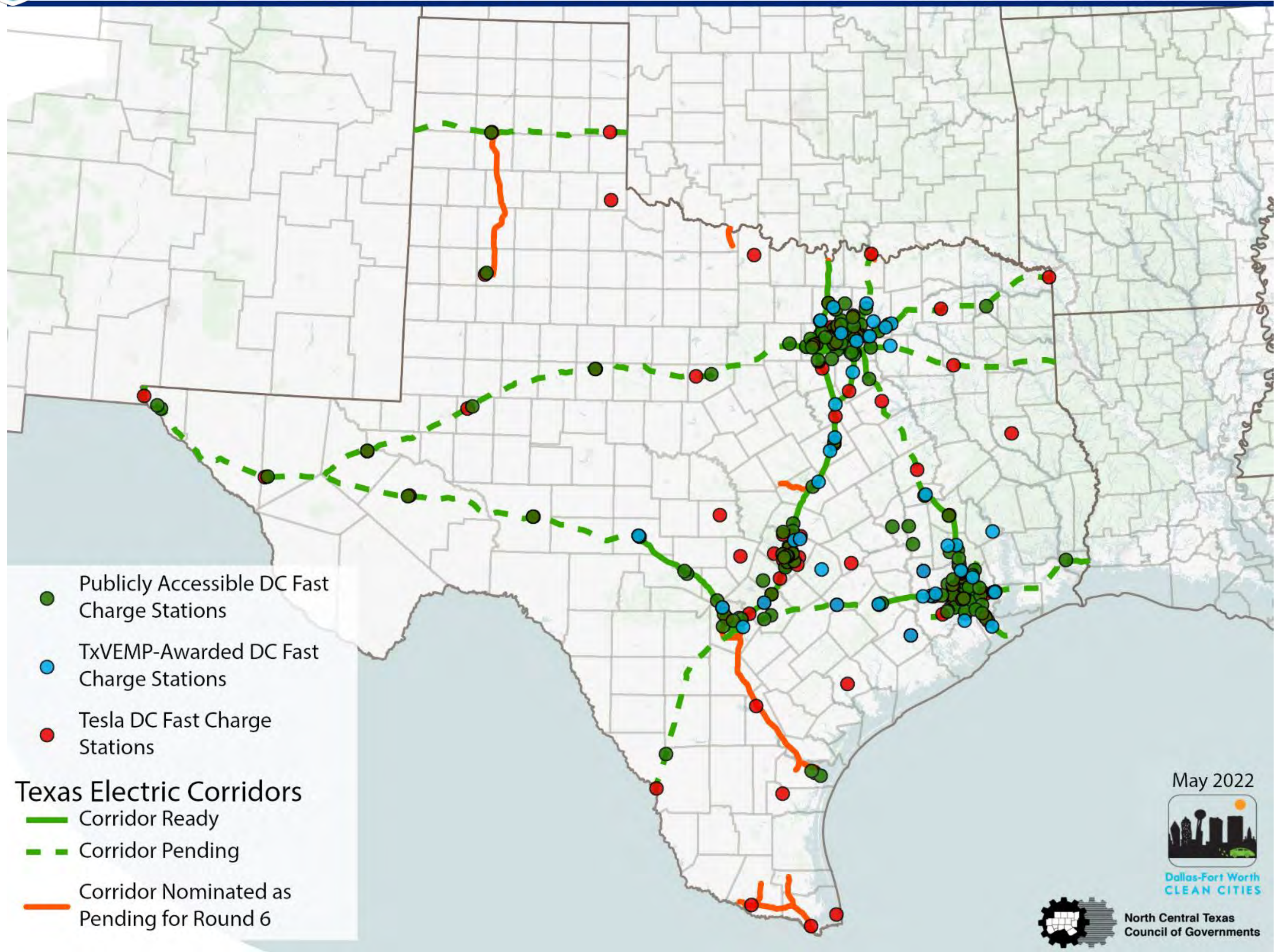
FHWA-Designated Alternative Fuels Corridors in Texas, Round 1 to Round 5



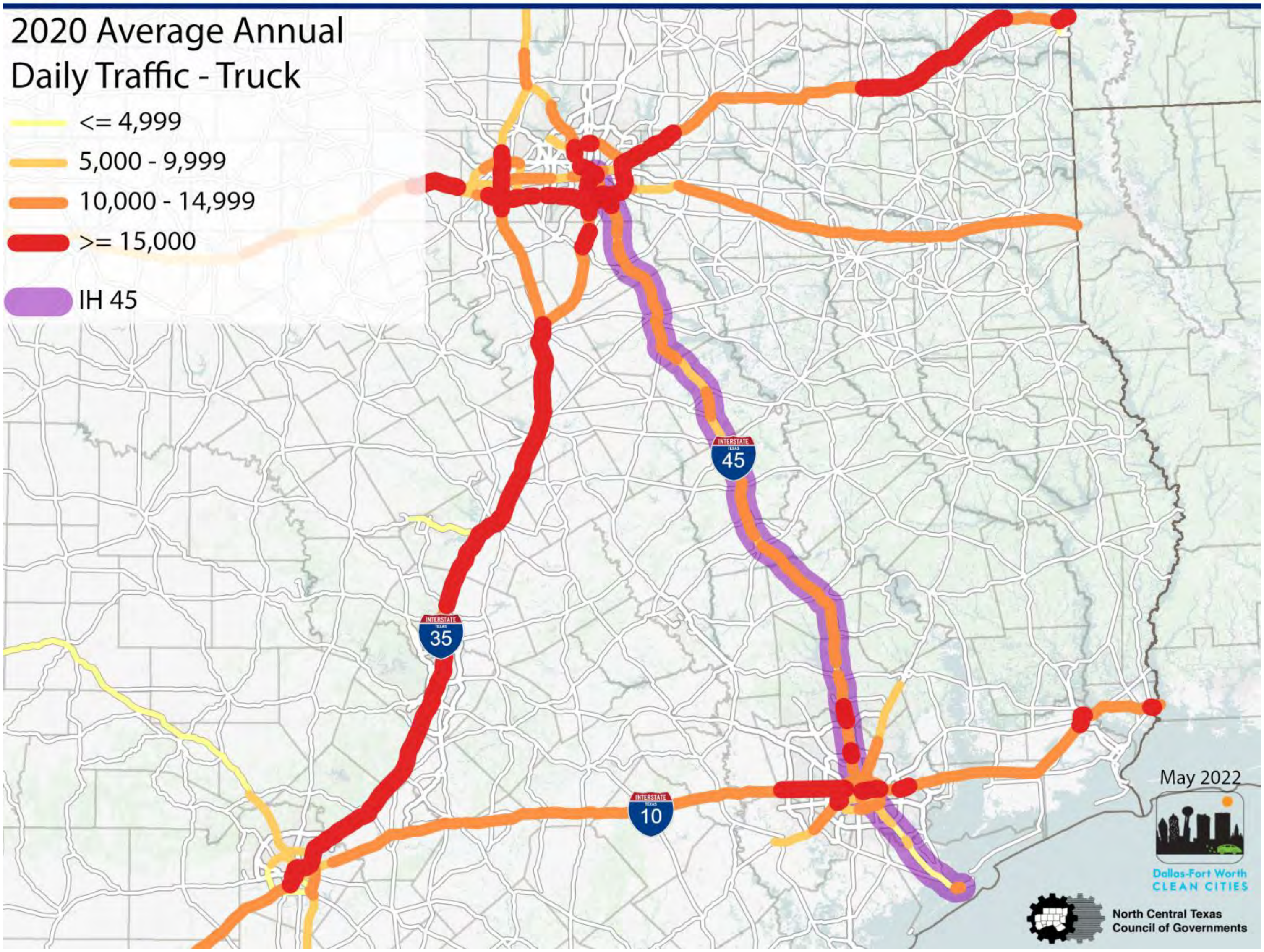
Corridor Designation Status of IH 45

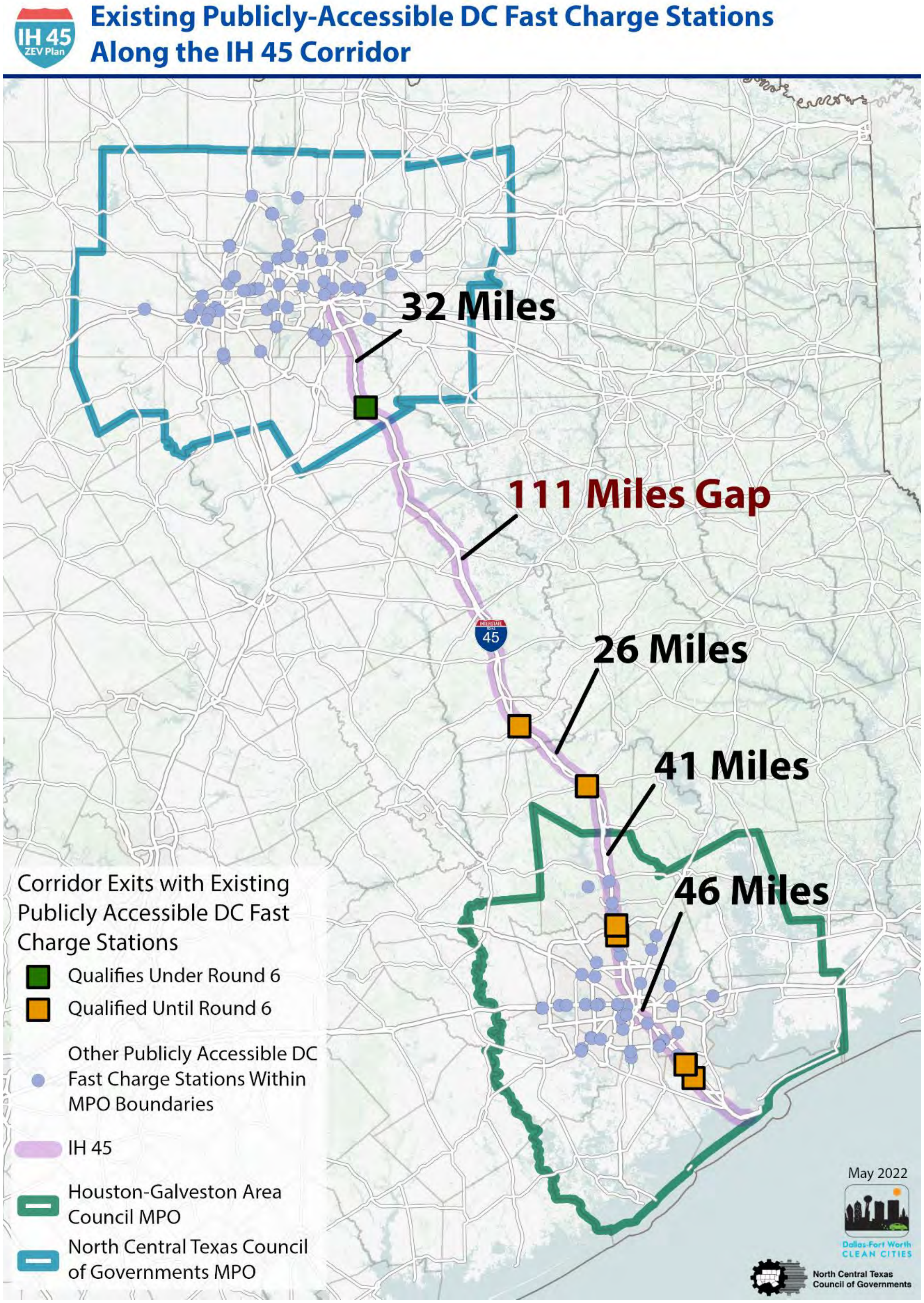


Electric Corridor Designations and Locations of DC Fast Charge Stations Across Texas

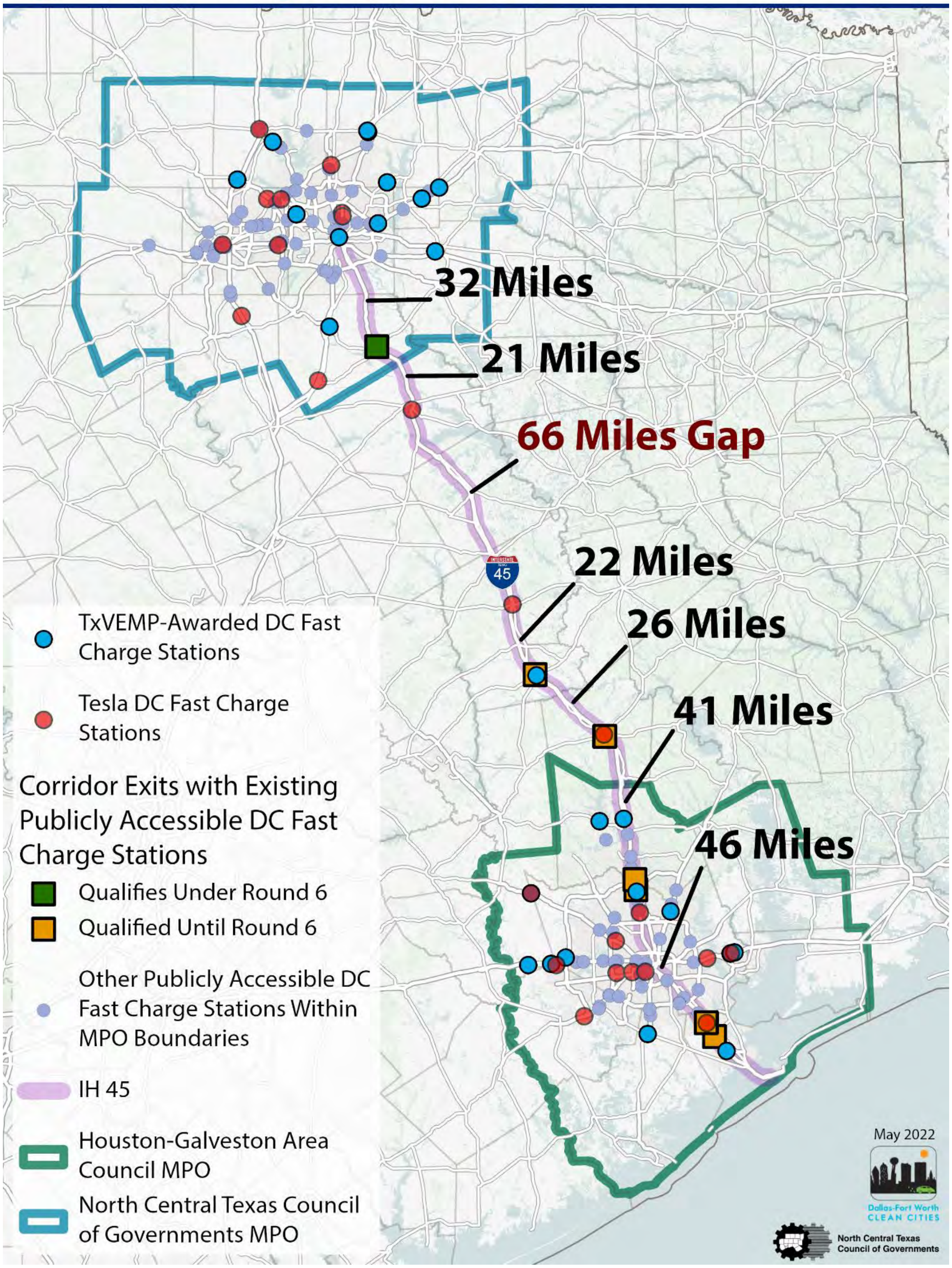


2020 Average Annual Daily Truck Traffic Along IH 45 and Other Interstates

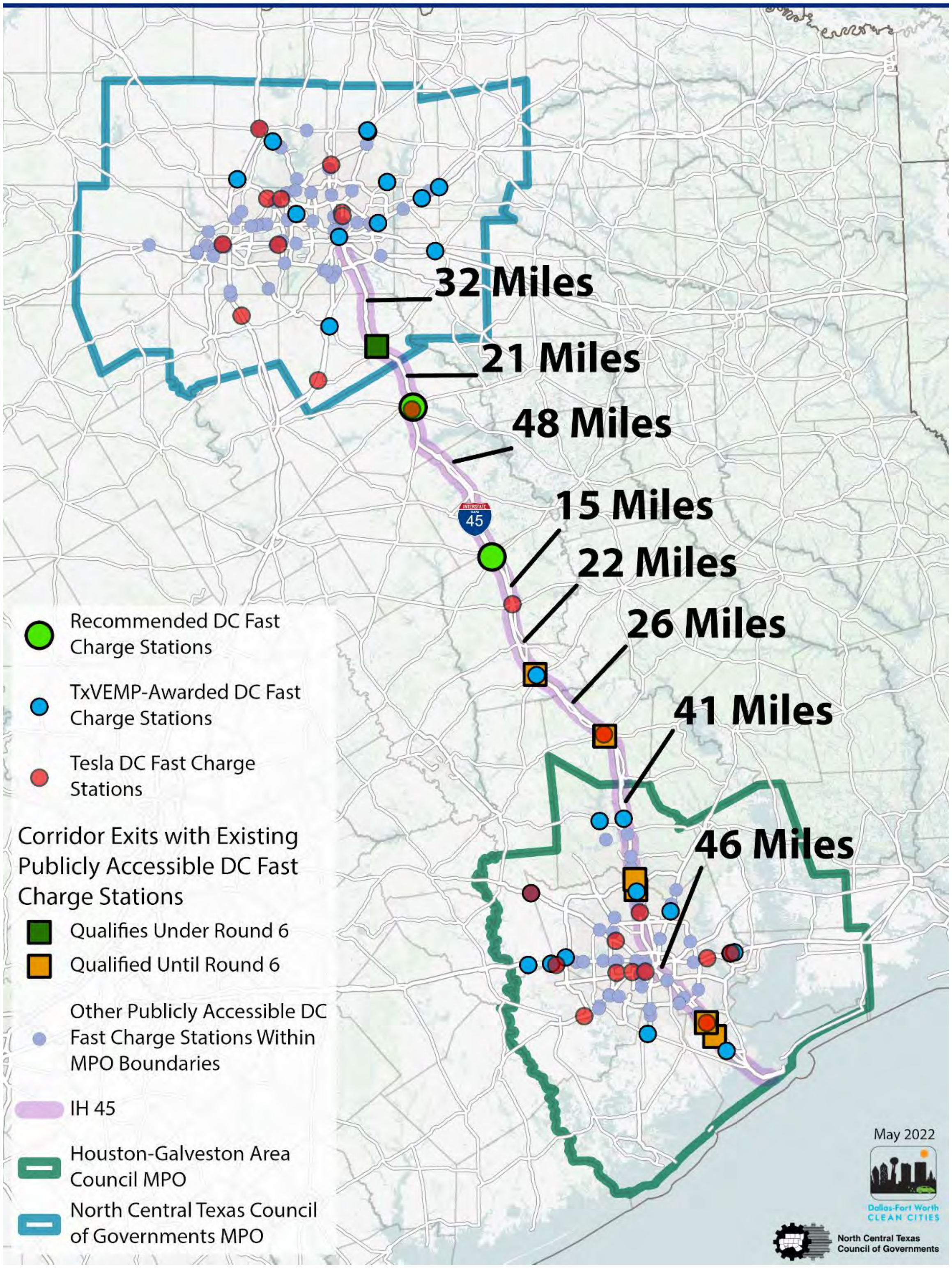



IH 45
ZEV Plan
Existing Publicly-Accessible DC Fast Charge Stations
Along the IH 45 Corridor
32 Miles
111 Miles Gap
45
26 Miles
41 Miles
46 Miles
Corridor Exits with Existing
Publicly Accessible DC Fast
Charge Stations
Qualifies Under Round 6
Qualified Until Round 6
Other Publicly Accessible DC
Fast Charge Stations Within
MPO Boundaries
IH 45
Houston-Galveston Area
Council MPO
North Central Texas Council
of Governments MPO
May 2022
Dallas-Fort Worth
CLEAN CITIES
North Central Texas
Council of Governments

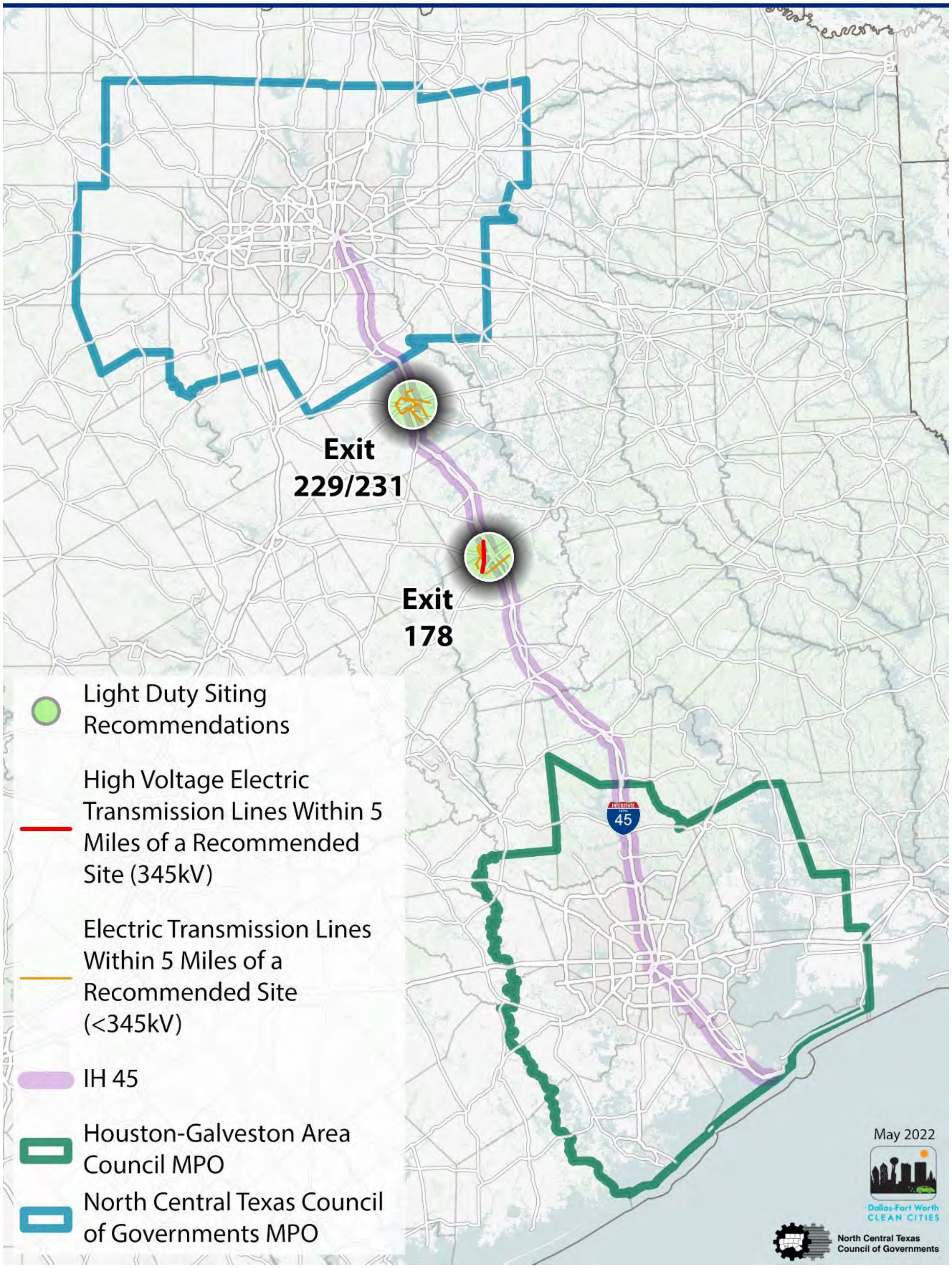
Existing, TxVEMP-Awarded, and Tesla DC Fast Charge Stations Along the IH 45 Corridor



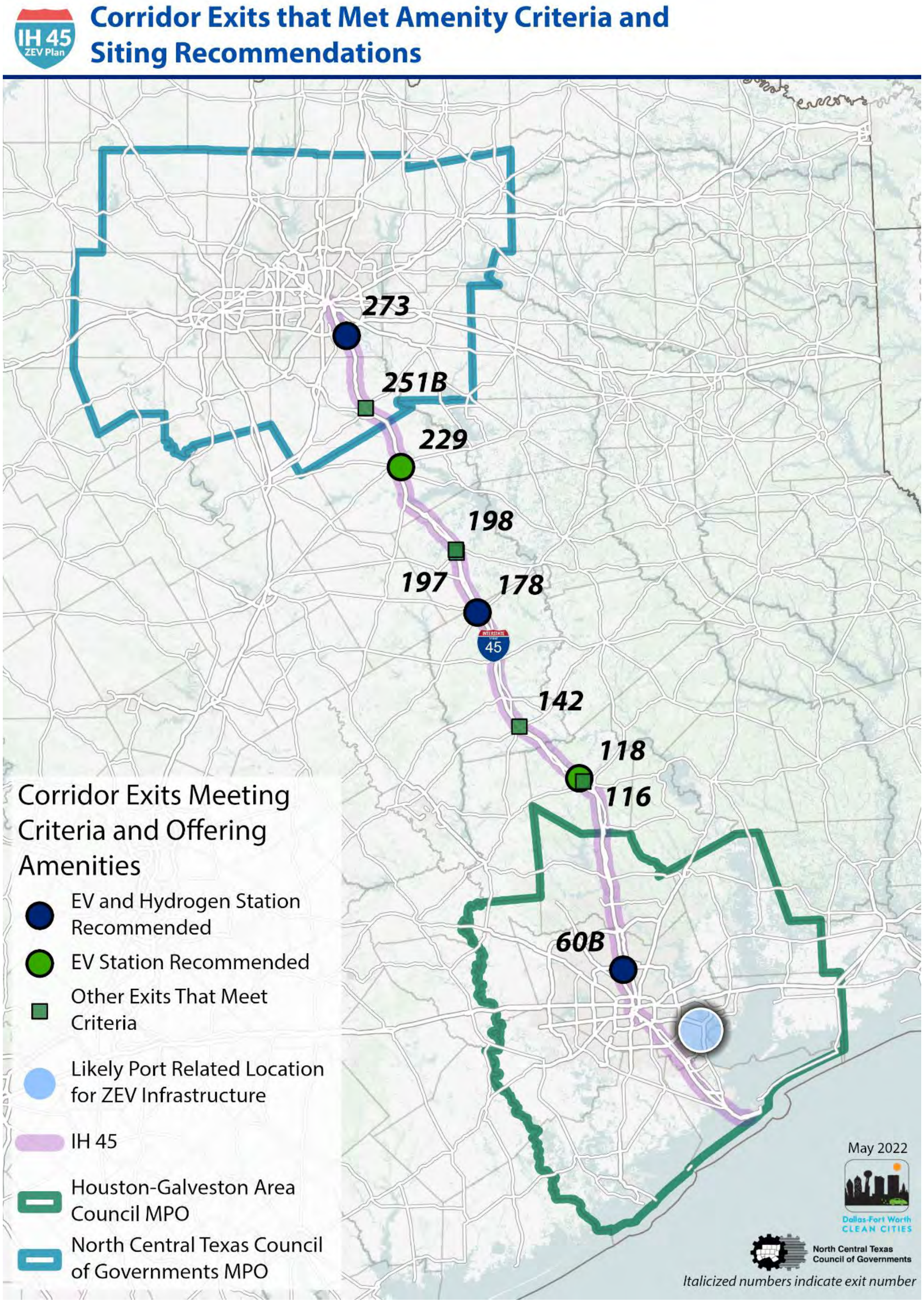
Existing, Awarded, and Recommended EV Charging Stations Along the IH 45 Corridor



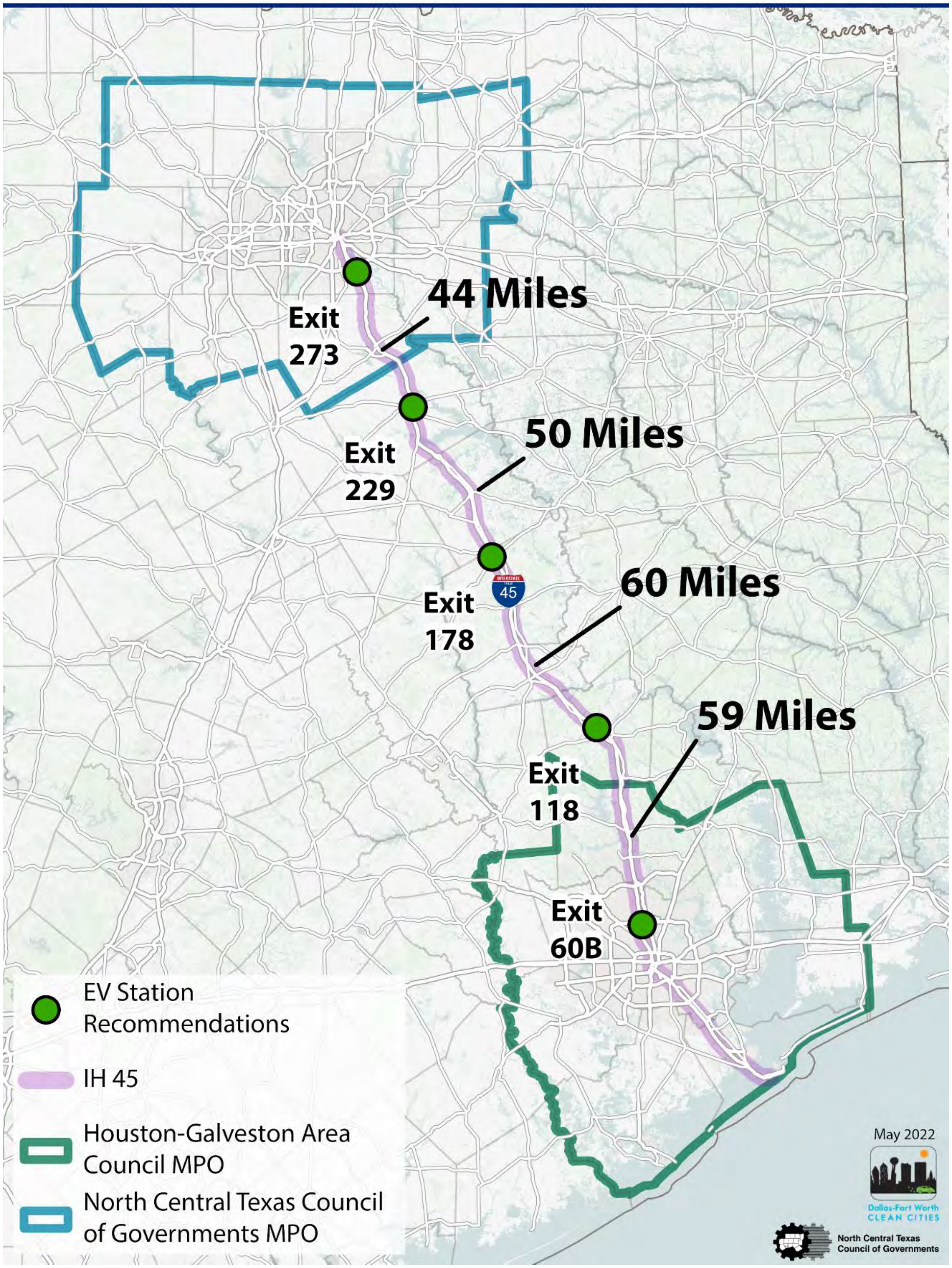
Recommended EV Charging Sites in Relation to Electric Transmission Lines



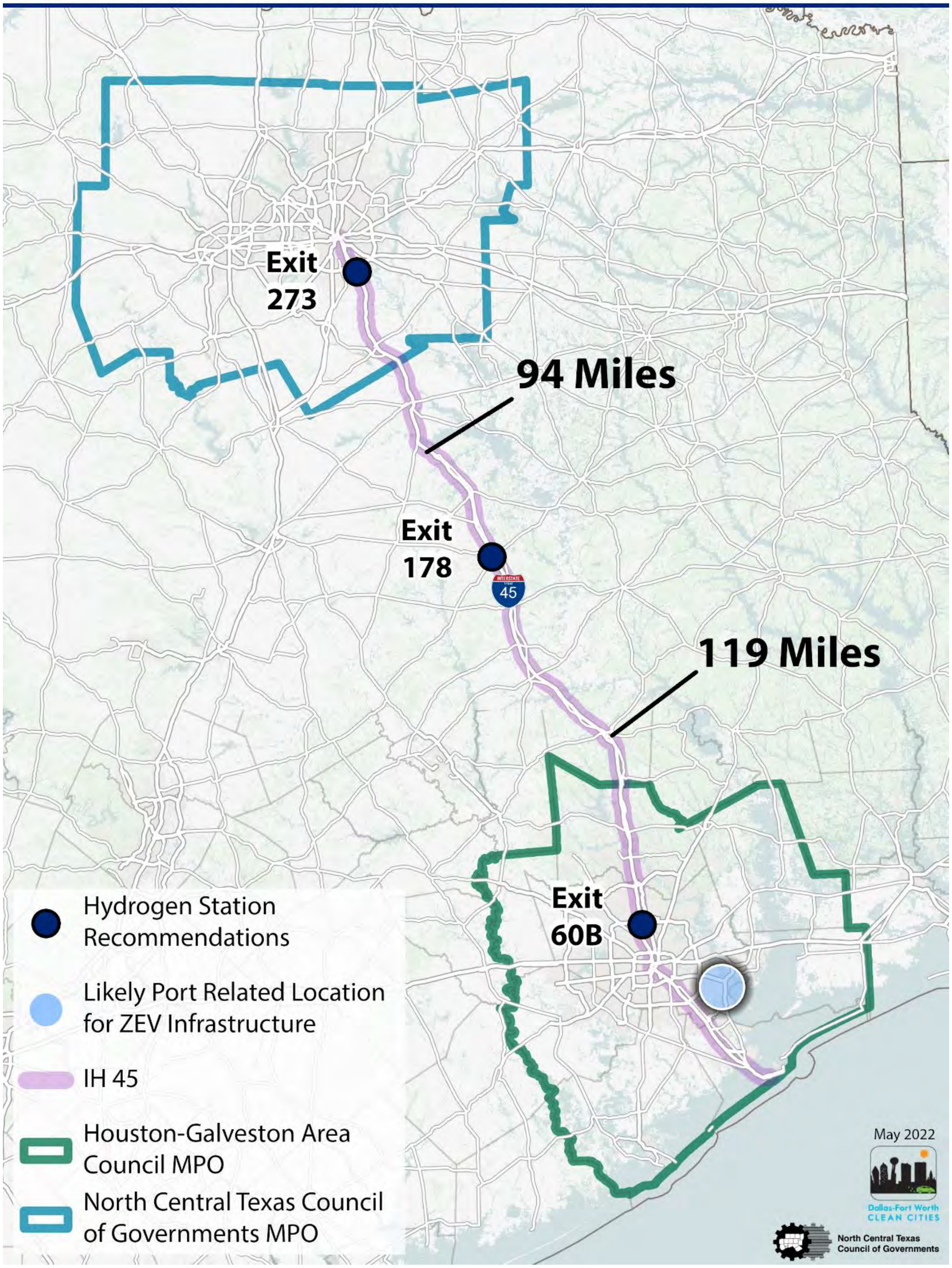
Chapter 4 - Building a Corridor for Medium- and Heavy-Duty Freight Vehicles



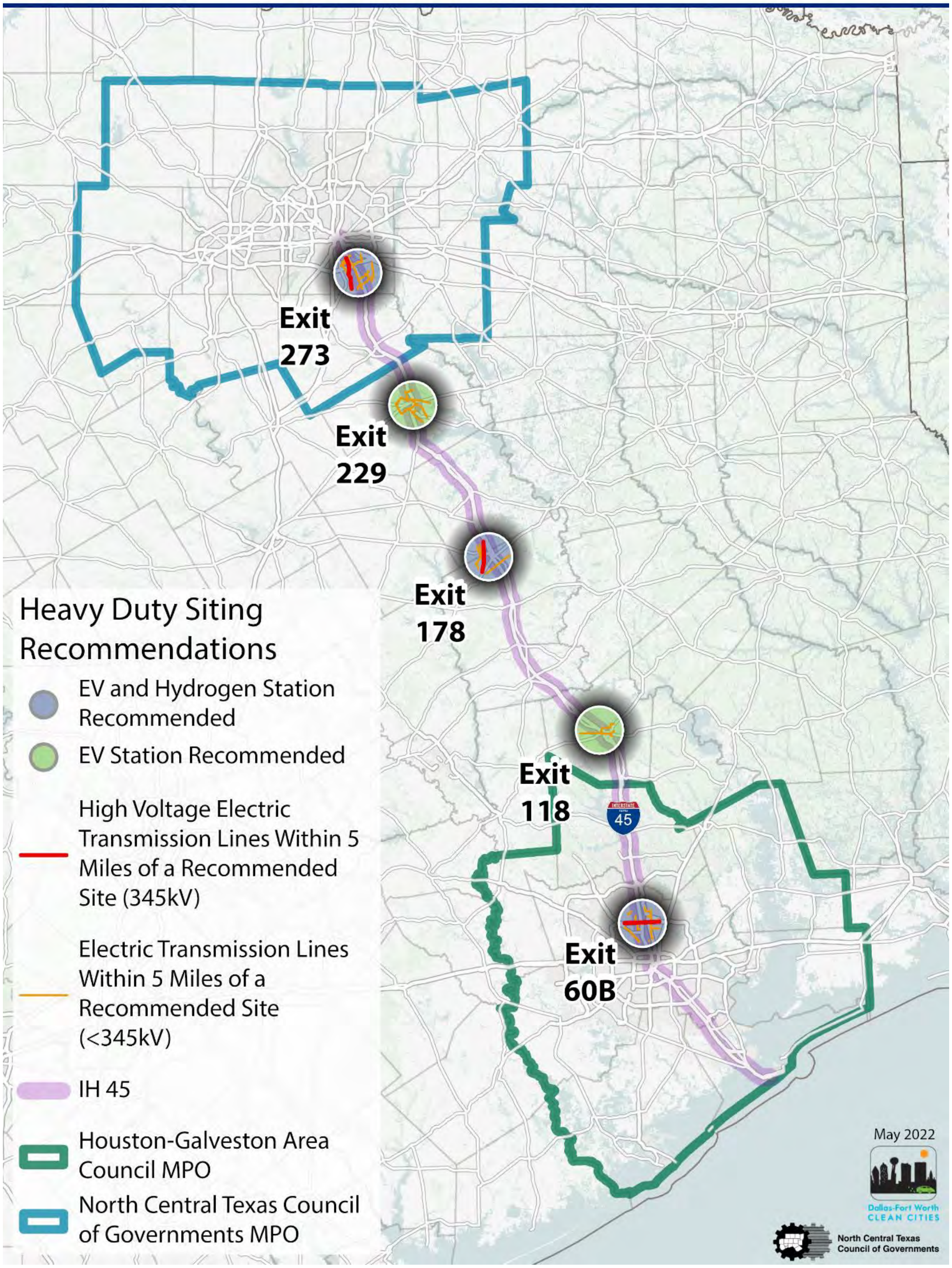
IH 45 MHD EV Station Recommendations and Distance Intervals



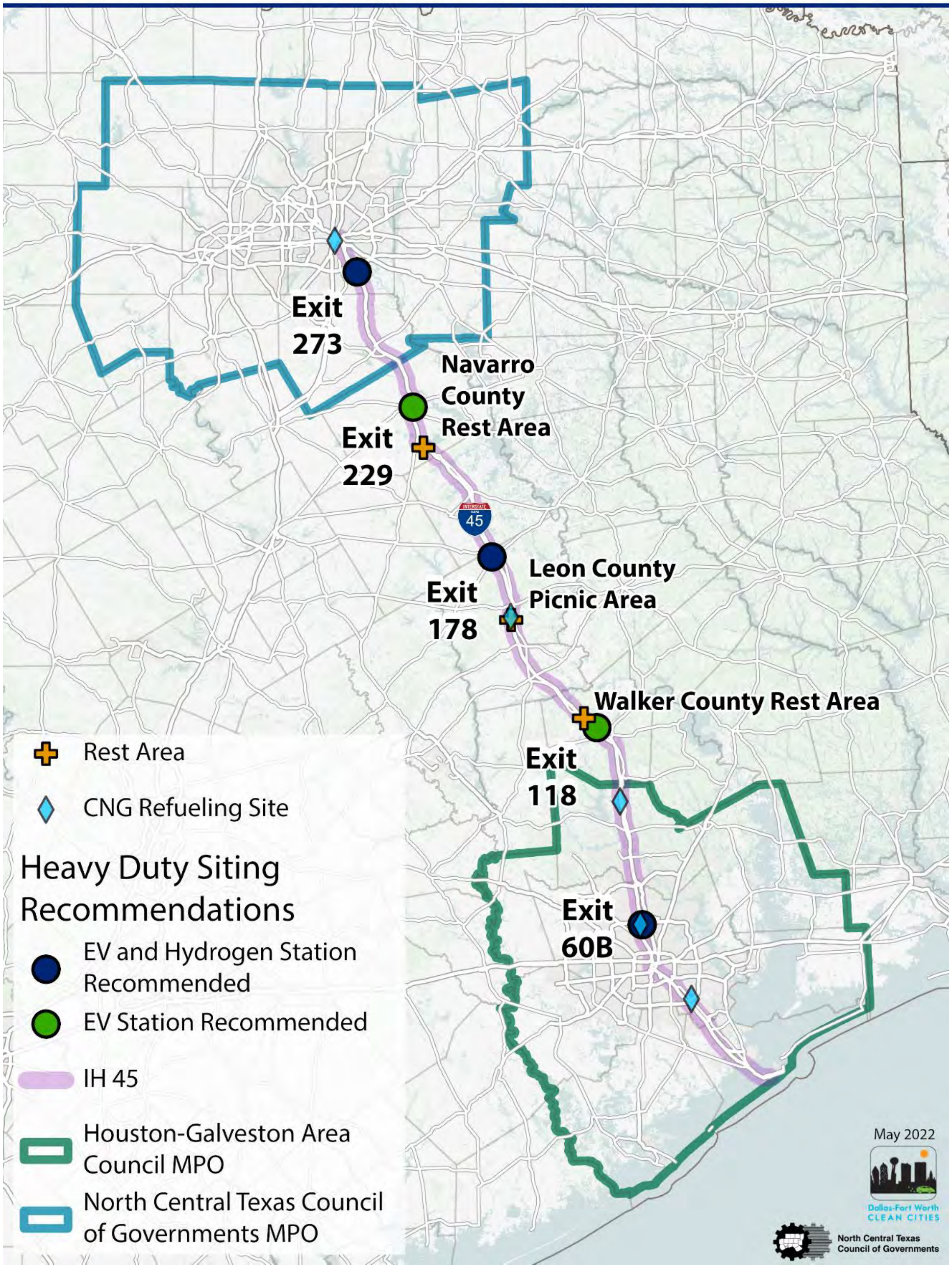
IH 45 MHD Hydrogen Fueling Station Recommendations and Distance Intervals



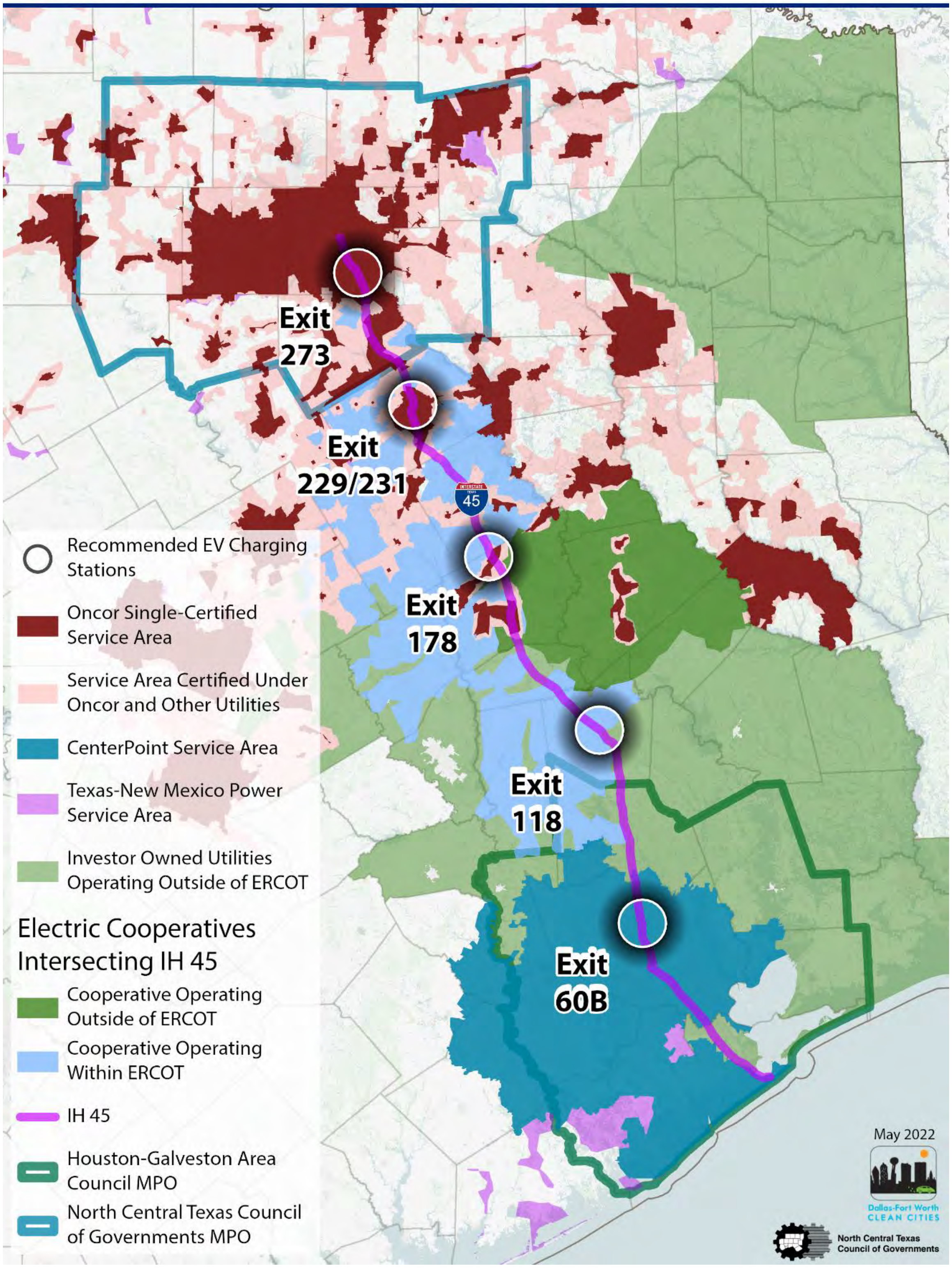
Location of Recommended MHD EV Charging Sites Relative to Electric Transmission Lines



Location of Existing CNG Refueling Sites and TxDOT Rest Areas Relative to Recommended ZEV Infrastructure Sites



Electric Utility Territories Along IH 45 Along with Recommended EV Charging Locations



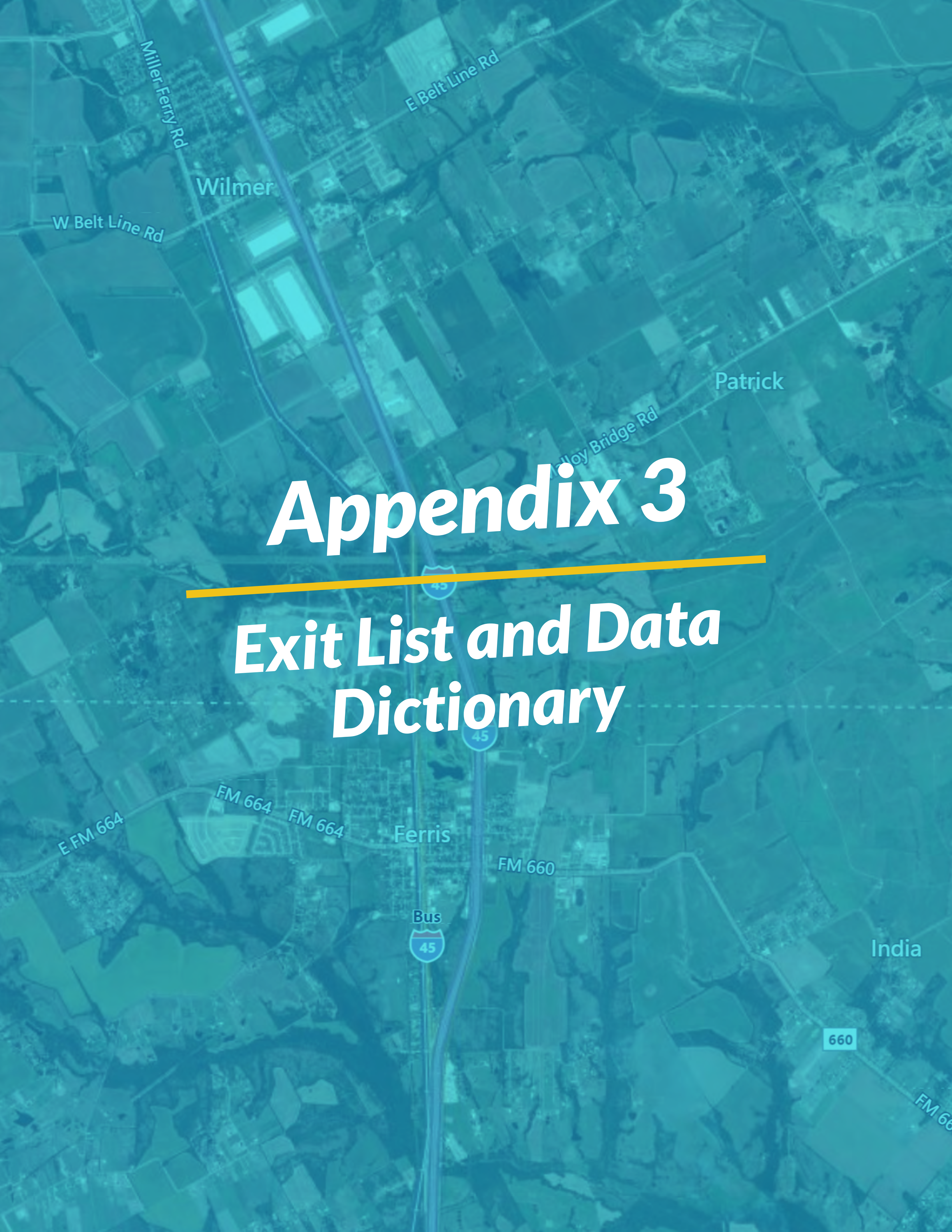
IH 45 Maps Data Dictionary

Name	Definition	Data Source
Background Features		
US County Boundaries	Boundary of all counties within the contiguous United States	U.S. Census Bureau
U.S. State Boundaries	Boundary of all states within the contiguous United States	U.S. Census Bureau
NCTCOG and H-GAC MPO Boundaries	Boundary of the North Central Texas Council of Governments and Houston-Galveston Area Council Metropolitan Planning Organization	TxDOT Open Data Portal
TxDOT Roadways	Texas roadways that are either Interstate Highways, State Highways, US highways, off-system toll roads, or other freeways/expressways as defined by the Texas Department of Transportation	TxDOT Roadway Inventory
IH 45	Interstate Highway 45 as defined by the Texas Department of Transportation	TxDOT Roadway Inventory
NLCD Basemap	Basemap created using the National Land Cover Database combining all classifications into either urban, forestry, grassland, or water/wetland	NLCD 2019 Land Cover (CONUS)
Chapter 1 Features		
Ozone Nonattainment Areas	Texas counties under 2008 and/or 2015 ozone nonattainment	TxDOT Statewide Planning Map
Alternative Fuel Corridors	Alternative fuel corridors designated by the Federal Highway Administration for Rounds 1-5	FHWA Alternative Fuel Corridors (Rounds 1-5)
Texas Electric Fuel Corridor Nominations	Corridors nominated by the Texas Department of Transportation as electric fuel pending for Round 6	TxDOT Texas Electric Vehicle Infrastructure Plan
Existing DC Fast Charging Stations	Currently existing (as of May 2022) electric vehicle Direct Current Fast Charging stations	Alternative Fueling Station Locator
TxVEMP Awarded DC Fast Charging Stations	Locations where funds were awarded for the purchase and installation of Direct Current Fast Charging infrastructure as part of the Texas Volkswagen Environmental Mitigation Program	Texas Volkswagen Environmental Mitigation Program Funded Sites
2020 AADT - Truck	Average annual daily traffic of trucks in 2020	TxDOT Roadway Inventory
Chapter 3 Features		
IH 45 Corridor Exits	Location of exits along Interstate Highway 45	OpenStreetMap; Overpass Turbo Query
Existing DC Fast Charging Stations	Currently existing (as of May 2022) electric vehicle Direct Current Fast Charging stations	Alternative Fueling Station Locator
TxVEMP Awarded DC Fast Charging Stations	Locations where funds were awarded for the purchase and installation of Direct Current Fast Charging infrastructure as part of the Texas Volkswagen Environmental Mitigation Program	Texas Volkswagen Environmental Mitigation Program Funded Sites
Electric Power Transmission Lines	Electric power transmission lines within the United States	HIFLD Electric Power Transmission Lines

Name	Definition	Data Source
Chapter 4 Features		
IH 45 Corridor Exits	Location of exits along Interstate Highway 45	OpenStreetMap; Overpass Turbo Query
Port Related Location for ZEV Infrastructure	Probable location of early ZEV infrastructure deployment based on analysis conducted by the Center for Houston's Future	Center for Houston's Future
Electric Power Transmission Lines	Electric power transmission lines within the United States	HIFLD Electric Power Transmission Lines
TxDOT Rest Areas	Texas rest areas as defined by the Texas Department of Transportation	TxDOT Statewide Truck Parking Study
Existing CNG Fueling Stations	Currently existing (as of May 2022) compressed natural gas fueling stations	Alternative Fueling Station Locator
Chapter 6 Features		
Oncor Service Area	Service territory of Oncor Electric Delivery both single- and multi-certified	Provided by Oncor
CenterPoint Service Area	Service territory of CenterPoint Energy	Provided by CenterPoint
Texas-New Mexico Power Service Area	Service territory of Texas-New Mexico Power	HIFLD Electric Retail Service Territories
Investor-Owned Utilities Service Area	Service territory of other investor-owned utilities	HIFLD Electric Retail Service Territories
Electric Cooperatives	Electric cooperatives within the State of Texas	Texas Electric Cooperatives

Appendix 3

Exit List and Data Dictionary



Exits are marked by a color key that aligns with key evaluation criteria, as follows:

White: Intersects both NHS (National Highway System) and HFN (Highway Freight Network)	Gray: Does not Intersect Either NHS or HFN Network	Blue: Intersects HFN Only	Peach: Intersects NHS Only	Green: No Exit/Non Accessible Road	Gold: Rest Area/Picnic Area

Some rows have incomplete data. If initial criteria screens (described in Chapters 3 and 4) eliminated an exit from consideration early in the evaluation process, NCTCOG did not continue gathering all data points for that exit location.

Exit Features												Truck Traffic Data					Statewide Planning Map Data													Amenities At Exit											
																	I-45 Interstate Data						Cross Street Data																		
Exit #	Exit Mile Marker	Exit Name	Direction	City	Part of Existing EV Pending Gap	Cross Street Access-ible both sides	NHS (TxDOT)	HFN (TxDOT)	Direct-Connect Ramps	Distance to Nearest Existing Public Non-Tesla DCFC Station (Miles)	Has an Existing Non-Tesla DCFC Station	Truck Stops (Y/N)	# of Truck Stops at Exit	Funding under AFFP	Funding under VW DCFC	Street-light Exits	Station Flag	AADT 2019	AADT 2020	AADT 2040	24HR % Truck	24HR Truck Count	Name of Cross Street	Cross Street Left AADT 2020	Cross Street Left AADT 2040	Cross Street Left % Truck	Cross Street Right AADT 2020	Cross Street Right AADT 2040	Cross Street Right % Truck	Auto-motive	Bank	Entertain-ment	Food	Fuel	Lodging	Medical	Parks	Pets	Rest Area	Shop-ping	# of Amenity Types
1A	1	TX 342 Spur South	**NB**	Galveston	N	Y	Y	Y	N	21	N	N	0	N	N	N	N/A	N/A	31080	62160	**25%**	**7770**	Texas Spur 342	30471	42659	1.8	3251	4551	6.1	Y	Y	Y	Y	Y	Y	N	Y	N	N	Y	8
1A	1	TX 342 Spur South	**SB**	Galveston	N	Y	Y	Y	N	21.2	N	N	0	N	N	N	85H21	65247	50270	100540	**28%**	**14126**	Texas Spur 342	3251	4551	6.1	30471	42659	1.8	Y	Y	Y	Y	Y	Y	N	Y	N	N	Y	8
1B	1	71st Street	N/A	Galveston	N	N/A	N	N	N/A		N	N	0	N	N	N	84H21	65247	50270	100540	**28%**	**14126**	77th Street	1044	1462	3.2	N/A	N/A	N/A												
1C	1	TX 275	**NB**	Galveston	N	Y	Y	Y	N	19.9	N	N	0	N	N	N	N/A	N/A	50270	100540	**28%**	**14126**		N/A	N/A	N/A	1044	1462	3.2	Y	Y	N	Y	Y	Y	N	Y	N	N	Y	7
1C	1	TX 275	**SB**	Galveston	N	Y	Y	Y	N	20.1	N	N	0	N	N	N	85SP204	73010	61328	85859	**4%**	**2453**	FM 188	10950	18886	10.1	1242	1739	11.9	N	N	N	N	N	N	N	N	N	N	N	7
4	4	Village of Tiki Island	N/A	Galveston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
5	5	Gulf Freeway Frontage Road	N/A	Hitchcock	N	N/A	N	N	N/A		N	N	0	N	N	N																									
7A	7	TX 3/TX 146	**NB**	Hitchcock	N	Y	Y	Y	Y	14.2	N	N	0	N	N	N	85H69	55230	61328	85859	**4%**	**2453**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	N	N	N	Y	N	N	N	N	N	N	N	1
7	7	TX 3/TX 146	**SB**	Hitchcock	N	Y	Y	Y	Y	20.9	N	N	0	N	N	N																									
7B	7	TX 67	**NB**	Hitchcock	N	Y	Y	Y	Y	14	N	N	0	N	N	N	85H69	55230	61328	85859	**4%**	**2453**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	Y	N	N	Y	Y	N	N	N	N	N	N	3
7	7	TX 67	**SB**	Hitchcock	N	Y	Y	Y	Y	20.9	N	N	0	N	N	N																									
7C	7	Frontage Road	N/A	La Marque	N	N/A	N	N	N/A		N	N	0	N	N	N																									
8	8	Frontage Road	N/A	La Marque	N	N/A	N	N	N/A		N	N	0	N	N	N																									
9	9	Frontage Road	N/A	La Marque	N	N/A	N	N	N/A		N	N	0	N	N	N																									
10	10	FM 519	N/A	La Marque	N	N/A	N	N	N/A		N	N	0	N	N	N																									
11	11	Vauthier Road	N/A	La Marque	N	N/A	N	N	N/A		N	N	0	N	N	N																									
12	12	Texas Avenue	**NB**	La Marque	N	Y	Y	Y	N	8.8	N	N	0	N	N	N														Y	N	N	Y	Y	Y	N	N	N	N	Y	5
12	12	Texas Avenue	**SB**	La Marque	N	Y	Y	Y	N	9.1	N	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	5
13	13	Century Blvd	N/A	La Marque	N	N/A	N	N	N/A		N	N	0	N	N	N																									
15	15	FM 1764	**NB**	La Marque	N	Y	N	Y	N	6.3	N	N	0	N	**Y**	N														Y	Y	Y	Y	Y	Y	N	N	N	N	Y	7
15	15	FM 1764	**SB**	La Marque	N	Y	N	Y	N	6.3	N	N	0	N	**Y**	N														N	N	N	N	N	N	N	N	N	N	N	7
16	16	FM 1764	N/A	Dickson	N	N/A	N	N	N/A		N	N	0	N	N	N																									
17	17	Gulf Freeway Frontage Road	N/A	Dickson	N	N/A	N	N	N/A		N	N	0	N	N	N																									
19	19	FM 517	N/A	Dickson	N	N/A	N	N	N/A		N	N	0	N	N	N																									
20	20	FM 646	**NB**	Dickinson	N	Y	Y	Y	N	1.4	**Y**	N	0	N	N	N														N	Y	N	N	N	N	N	N	N	N	N	1
20	20	FM 646	**SB**	Dickinson	N	Y	Y	Y	N	1.6	N	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	1
22	22	TX 96	**NB**	League City	N	Y	Y	N	N	0.8	N	N	0	N	N	N	85H59	118113	82309	164618	**5%**	**4198**	TX 96	27751	38851	3.2	23860	33404	2.1	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	9
22	22	TX 96	**SB**	League City	N	Y	Y	N	N	2.8	N	N	0	N	N	N																									
23	23	FM 518	**NB**	League City	N	Y	Y	Y	N	95.3	N	N	0	N	N	N														N	N	N	Y	N	N	N	N	N	N	Y	2
23	23	FM 518	**SB**	League City	N	Y	Y	Y	N	N/A	**Y**	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	2
24	24	NASA 1	**SB**	Webster	N	N	Y	Y	Y		N	N	0	N	N	N																									
25	25	FM 528	**NB**	Webster	N	Y	Y	Y	N	93.2	N	N	0	N	N	N														Y	N	Y	Y	Y	Y	Y	Y	N	N	Y	8
25	25	FM 528	**SB**	Webster	N	Y	Y	Y	N	N/A	N	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	8
26	26	W Bay Area Blvd	**NB**	Webster	N	Y	Y	N	N		N	N	0	N	N	N																									
26	26	W Bay Area Blvd	**SB**	Webster	N	Y	Y	N	N		**Y**	N	0	N	N	N																									
27	27	Gulf Freeway Frontage Road	N/A	Friendswood	N	N/A	N	N	N/A		N	N	0	N	N	N																									
29	29	FM 2351	**NB**	Friendswood	N	Y	N	Y	N		N	N	0	N	N	N														Y	Y	N	Y	Y	N	Y	Y	Y	N	N	7
29	29	FM 2351	**SB**	Friendswood	N	Y	N	Y	N		**Y**	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	7
30	30	FM 1959	N/A	Friendswood	N	N/A	N	N	N/A		N	N	0	N	N	N																									
31	31	Scarsdale Blvd	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
32	32	Beltway 8	**NB**	Houston	N	Y	Y	Y	N	85.2	**Y**	N	0	N	N	N	**N/A**	**N/A**	111334	222668	**4%**	**4899**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	N	N	N	N	N	N	N	N	N	N	N	0
32	32	Beltway 8	**SB**	Houston	N	Y	Y	Y	N	N/A	**Y**	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	0
33	33	Texas 8 Beltway	**NB**	Houston	N	Y	Y	Y	N	84.6	N	N	0	N	N	N	102H216A	200879	133023	266046	**6%**	**7316**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	9

Exit Features												Truck Traffic Data					Statewide Planning Map Data: I-45 Interstate Data						Statewide Planning Map Data: Cross Street Data							Amenities At Exit											
Exit #	Exit Mile Marker	Exit Name	Direction	City	Part of Existing EV Pending Gap	Cross Street Accessible both sides	NHS (TxDOT)	HFN (TxDOT)	Direct-Connect Ramps	Distance to Nearest Existing Public Non-Tesla DCFC Station (Miles)	Has an Existing Non-Tesla DCFC Station	Truck Stops (Y/N)	# of Truck Stops at Exit	Funding under AFFP	Funding under VW DCFC	Street-light Exits	Station Flag	AADT 2019	AADT 2020	AADT 2040	24HR % Truck	24HR Truck Count	Name of Cross Street	Cross Street Left AADT 2020	Cross Street Left AADT 2040	Cross Street Left % Truck	Cross Street Right AADT 2020	Cross Street Right AADT 2040	Cross Street Right % Truck	Auto-motive	Bank	Entertain-ment	Food	Fuel	Lodging	Medical	Parks	Pets	Rest Area	Shop-ping	# of Amenity Types
33	33	Texas 8 Beltway	SB	Houston	N	Y	Y	Y	N	N/A	N	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	9
34	34	S Shaver Road	NB	Houston	N	Y	Y	N	N		Y	N	0	N	N	N																									
34	34	S Shaver Road	SB	Houston	N	Y	Y	N	N		N	N	0	N	N	N																									
35	35	Edgebrook	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
36	36	College Avenue	NB	Houston	N	Y	Y	N	N		N	N	0	N	N	N																									
36	36	College Avenue	SB	Houston	N	Y	Y	N	N		N	N	0	N	N	N																									
38A	38	TX 3	NB	Houston	N	Y	Y	Y	N	79.2	N	N	0	N	N	N														Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	8
38A	38	TX 3	SB	Houston	N	Y	Y	Y	N	N/A	N	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	8
38B	38	Howard Drive	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
39	39	Broadway Street	NB	Houston	N	Y	Y	N	N		N	N	0	N	N	N																									
39	39	Broadway Street	SB	Houston	N	Y	Y	N	N		N	N	0	N	N	N																									
40A	40	Gulf Freeway	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N	102H197A	255202	208346	416692	5%	9792	IH 610	137439	274878	7.5	137439	274878	7.7	Y	N	N	Y	Y	N	N	N	N	N	Y	4
40B	40	IH 45 N/610 W	NB	Houston	N	Y	Y	Y	Y	77	N	N	0	N	N	N	102H197A	255202	208346	416692	5%	9792	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	N	N	N	N	N	0
40B	40	IH 45 N/610 W	SB	Houston	N	Y	Y	Y	Y	N/A	N	N	0	N	N	Y																									
40C	40	610 E	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N	102H197A	255202	208346	416692	5%	9792	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	N	N	N	N	N	0
41A	41	Woodridge Drive	N/A	Houston	N	N/A	N	N	N/A		Y	N	0	N	N	N																									
41B	41	US 90 Alt	NB	Houston	N	Y	Y	Y	N	75.6	N	N	0	N	N	N	102H129A	230168	156215	312430	4%	6092	US 90	5580	7812	3.2	5580	7812	3.2	Y	Y	N	Y	Y	Y	N	Y	N	N	Y	7
41B	41	US 90 Alt	SB	Houston	N	Y	Y	Y	N	N/A	N	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	7
42	42	US 90 Alt	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N	N/A	N/A	173504	347008	4%	6420	US 90	28726	40216	2.4	12178	17049	3.6	Y	Y	Y	Y	Y	Y	N	Y	N	N	Y	8
43A	43	Telephone Road	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
44A	44	Elgin-Lockwood Cullen Blvd	NB	Houston	N	Y	Y	N	N		N	N	0	N	N	N																									
44C	44	Cullen Blvd Lockwood-Elgin	SB	Houston	N	Y	Y	N	N		N	N	0	N	N	N																									
44B	44	Spur 5	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N	102H129D	34300	173504	347008	4%	6420	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	N	N	N	N	N	0
45A	45	Scott Street	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
46	46	US 69	NB	Houston	N	Y	Y	Y	Y	71.7	N	N	0	Y	N	N	N/A	N/A	198000	277200	4%	6930	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	N	N	N	N	N	0
46A	46	US 69	SB	Houston	N	Y	Y	Y	Y	N/A	N	N	0	Y	N	N																									
46	46	US 69; TX 288	NB	Houston	N	Y	Y	Y	Y	71.7	N	N	0	N	N	N	N/A	N/A	198000	277200	4%	6930	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	N	N	N	N	N	0
46B	46	US 69; TX 288	SB	Houston	N	Y	Y	Y	Y	N/A	N	N	0	N	N	N																									
47A	47	Allen Parkway	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
47B	47	Houston Avenue	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
47C	47	McKinney Street	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
47D	47	Dallas Street	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
48A	48	IH 10 E/W	NB	Houston	N	Y	Y	Y	Y	69	N	N	0	N	N	N	102D5	125804	105675	147945	8%	8665	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	Y	Y	Y	Y	Y	N	Y	N	N	Y	8
48A	48	IH 10 E/W	SB	Houston	N	Y	Y	Y	Y	N/A	N	N	0	N	N	N																									
48B	48	IH 45 N/W	NB	Houston	N	Y	Y	Y	Y	68.6	N	N	0	N	N	N	102S146	230232	198000	277200	4%	6930	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	N	N	N	N	N	0
48B	48	IH 45 N/W	SB	Houston	N	Y	Y	Y	Y	N/A	N	N	0	N	N	N																									
49A	49	Quitman Street	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
49B	49	N Main Street	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
50	50	Cavalcade Street	NB	Houston	N	Y	N	N	N		N	Y	1	Y	N	N	N/A	N/A	179357	358714	5%	8250	Cavalcade Street	19325	27055	3.2	17193	24070	3,2	Y	N	Y	Y	Y	Y	Y	N	N	N	Y	7
50	50	Cavalcade Street	SB	Houston	N	Y	N	N	N		N	Y	1	Y	N	N	102H77C	211847	179357	358714	5%	8250	Cavalcade Street	17193	24070	3,2	19325	27055	3.2	Y	N	Y	Y	Y	Y	Y	N	N	N	Y	7

Exit Features												Truck Traffic Data					Statewide Planning Map Data													Amenities At Exit											
																	I-45 Interstate Data						Cross Street Data																		
Exit #	Exit Mile Marker	Exit Name	Direction	City	Part of Existing EV Pending Gap	Cross Street Accessible both sides	NHS (TxDOT)	HFN (TxDOT)	Direct-Connect Ramps	Distance to Nearest Existing Public Non-Tesla DCFC Station (Miles)	Has an Existing Non-Tesla DCFC Station	Truck Stops (Y/N)	# of Truck Stops at Exit	Funding under AFFP	Funding under VW DCFC	Streetlight Exits	Station Flag	AADT 2019	AADT 2020	AADT 2040	24HR % Truck	24HR Truck Count	Name of Cross Street	Cross Street Left AADT 2020	Cross Street Left AADT 2040	Cross Street Left % Truck	Cross Street Right AADT 2020	Cross Street Right AADT 2040	Cross Street Right % Truck	Automotive	Bank	Entertainment	Food	Fuel	Lodging	Medical	Parks	Pets	Rest Area	Shopping	# of Amenity Types
51	51	IH 610 E/W	NB	Houston	N	Y	Y	Y	Y	65.9	N	N	0	N	N	N	N/A	N/A	215192	430384	6%	12696	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	N	Y	Y	Y	Y	N	N	Y	N	Y	7
51	51	IH 610 E/W	SB	Houston	N	Y	Y	Y	Y	N/A	N	N	0	N	N	Y																									
52A	52	North Freeway Frontage Road	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
52B	52	Crosstimbers Road	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
53	53	Airline Drive	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
54	54	Tidwell Road	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
55A	55	Parker Road	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
55B	55	Little York Road	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
56A	56	N Shepherd Drive	SB	Houston	N	N	N	Y	N		N	N	0	N	N	N																									
56B	56	Texas 261	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N	N/A	N/A	220370	440740	6%	12781	Gulf Bank	16660	23324	5.2	16660	23324	5.2	Y	N	Y	Y	Y	N	Y	N	N	N	Y	6
57A	57	Gulf Bank Road	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
57B	57	TX 249	NB	Houston	N	Y	Y	Y	N	59.3	N	N	0	N	N	N	N/A	N/A	220370	440740	6%	12781	Texas 249	40570	56798	6	330	330	3.2	Y	Y	Y	Y	Y	N	N	N	N	N	Y	6
57B	57	TX 249	SB	Houston	N	Y	Y	Y	N	N/A	N	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	6
59	59	West Road	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N																									
60A	60	TX 525	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N	N/A	N/A	221319	442638	6%	12837	TX 525	9566	13392	3.2	26327	36858	3	Y	Y	N	Y	Y	Y	N	Y	Y	N	Y	8
60B	60	Beltway 8	NB	Houston	N	Y	Y	Y	N	58.1	N	N	0	N	N	N	102H81	305353	221319	442638	6%	13279	Beltway 8	7715	10801	7.9	12402	17363	6.7	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	9
60B	60	Beltway 8	SB	Houston	N	Y	Y	Y	N	N/A	N	N	0	N	N	Y	N/A	N/A	239279	478558	7%	16271	Beltway 8	14171	19839	6.3	8210	11494	7.6	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	9
60C	60	Beltway 8	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N	102H81	305353	221319	442638	6%	12837	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	N	N	N	N	N	0
60D	60	Beltway 8	N/A	Houston	N	N/A	N	N	N/A		N	N	0	N	N	N	102H81	305353	221319	442638	6%	12837	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	N	N	N	N	N	0
61	61	Greens Road	N/A	Houston	N	N/A	N	N	N/A		N	N	0	Y	N	N																									
62	62	Rankin Road	NB	Houston	N	Y	Y	N	N		N	N	0	N	N	N																									
62	62	Rankin Road	SB	Houston	N	Y	Y	N	N		N	N	0	N	N	N																									
63	63	Airtex Drive	NB	Houston	N	Y	N	N	N		N	Y	1	N	N	N	N/A	N/A	193601	387202	8%	14520	Airtex Drive	16509	23113	3.2	330	330	3.2	Y	Y	N	Y	Y	Y	N	N	N	N	Y	6
63	63	Airtex Drive	SB	Houston	N	Y	N	N	N		N	Y	1	N	N	N	N/A	N/A	193601	387202	8%	14520	Airtex Drive	330	330	3.2	16509	23113	3.2	Y	Y	N	Y	Y	Y	N	N	N	N	Y	6
64	64	Richey Road	NB	Houston	N	Y	N	N	N		Y	Y	1	N	N	N	N/A	N/A	193601	387202	8%	14520	Richey Road	16654	23316	3.2	32174	45044	3.2	Y	N	Y	Y	Y	Y	N	Y	N	N	Y	7
64	64	Richey Road	SB	Houston	N	Y	N	N	N		Y	Y	1	N	N	Y	102H34	287321	193601	387202	8%	15101	Richey Road	32174	45044	3.2	16654	23316	3.2	Y	N	Y	Y	Y	Y	N	Y	N	N	Y	7
66	66	FM 1960	NB	Spring	N	Y	N	Y	N		N	N	0	N	N	N														Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y	9
66A	66	FM 1960	SB	Spring	N	Y	N	Y	N		Y	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	9
68	68	Louetta Road	N/A	Spring	N	N/A	N	N	N/A		Y	N	0	N	Y	N																									
70A	70	North Freeway Frontage Road	N/A	Spring	N	N/A	N	N	N/A		N	N	0	N	N	N																									
70B	70	North Freeway Frontage Road	N/A	Spring	N	N/A	N	N	N/A		N	N	0	N	N	N																									
71A	71	Grand Parkway/ Texas 99	N/A	Spring	N	N	Y	N	N/A		N	N	0	N	N	Y																									
72A	72	Pruitt Road	N/A	Spring	N	Y	Y	N	N		N	Y	1	N	N	N	N/A	N/A	214087	428174	8%	16485	Pruit Road	N/A	N/A	N/A	6460	9044	3.2												
72	72	HTR	NB	Spring	N	Y	Y	Y	Y	45.5	N	N	0	N	N	N														Y	Y	Y	Y	Y	Y	N	N	Y	N	Y	8
72B	72	HTR	SB	Spring	N	Y	Y	Y	Y	N/A	N	N	0	N	N	Y	170E3067	278288	214087	428174	8%	16485	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	N	N	N	N	N	0
73	73	Rayford Road	N/A	Spring	N	Y	N	N	N		Y	Y	1	N	N	N	170E3067	278228	214087	428174	8%	16485	Rayford	43314	60640	4.4	32849	45989	5												
76A	76	Robinson Road	N/A	Spring	N	N/A	N	N	N/A		N	N	0	N	N	N																									
76B	76	Woodlands Parkway	NB	Spring	N	Y	Y	N	Y		N	N	0	N	N	N																									
76B	76	Woodlands Parkway	SB	Spring	N	Y	Y	N	Y		N	N	0	N	N	N																									
77	77	Tamina Road	NB	Conroe	N	Y	Y	Y	N	39.7	N	N	0	N	N	N														Y	N	Y	Y	Y	Y	Y	Y	N	N	Y	8
77	77	Tamina Road	SB	Conroe	N	Y	Y	Y	N	N/A	Y	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	8
79	79	Texas 242	N/A	Conroe	N	N/A	N	N	N/A		Y	N	0	N	N	N																									
81	81	FM 1488	N/A	Conroe	N	N/A	N	N	N/A		N	N	0	N	N	N																									

Exit Features												Truck Traffic Data					Statewide Planning Map Data: I-45 Interstate Data						Statewide Planning Map Data: Cross Street Data							Amenities At Exit											
Exit #	Exit Mile Marker	Exit Name	Direction	City	Part of Existing EV Pending Gap	Cross Street Access-ible both sides	NHS (TxDOT)	HFN (TxDOT)	Direct-Connect Ramps	Distance to Nearest Existing Public Non-Tesla DCFC Station (Miles)	Has an Existing Non-Tesla DCFC Station	Truck Stops (Y/N)	# of Truck Stops at Exit	Funding under AFFP	Funding under VW DCFC	Street-light Exits	Station Flag	AADT 2019	AADT 2020	AADT 2040	24HR % Truck	24HR Truck Count	Name of Cross Street	Cross Street Left AADT 2020	Cross Street Left AADT 2040	Cross Street Left % Truck	Cross Street Right AADT 2020	Cross Street Right AADT 2040	Cross Street Right % Truck	Auto-motive	Bank	Entertain-ment	Food	Fuel	Lodging	Medical	Parks	Pets	Rest Area	Shop-ping	# of Amenity Types
82	82	River Plantation Drive	N/A	Conroe	N	N/A	N	N	N/A		N	N	0	N	N	N																									
83	83	Crighton Road	N/A	Conroe	N	N/A	N	N	N/A		N	N	0	N	N	N																									
84B	84	Fraizer Street	NB	Conroe	N	Y	N	Y	N		N	N	0	N	N	N														Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	8
84	84	Frazier Street	SB	Conroe	N	Y	N	Y	N		N	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	8
85	85	Gladstell Street	N/A	Conroe	N	N/A	N	N	N/A		N	N	0	N	N	N																									
87A	87	Conroe/TX 105/FM 2854	NB	Conroe	N	Y	Y	Y	N	30.1	Y	N	0	N	N	N														Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	9
87	87	Conroe/TX 105/FM 2854	SB	Conroe	N	Y	Y	Y	N	N/A	N	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	9
88	88	Texas 336 Loop	NB	Conroe	N	Y	Y	Y	N	28.7	N	N	0	N	N	N	170H88	163958	103003	206006	11%	11021	TX 336 Loop	17127	20552	5.3	25939	36315	4.1	Y	N	Y	Y	Y	Y	N	Y	Y	N	Y	8
88	88	Texas 336 Loop	SB	Conroe	N	Y	Y	Y	N	N/A	N	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	8
89	89	N FM 3083 W	NB	Conroe	N	Y	Y	Y	N	27.5	N	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	0
89	89	N FM 3083 W	SB	Conroe	N	Y	Y	Y	N	N/A	N	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	0
90	90	League Line Road	N/A	Conroe	N	N/A	N	N	N/A		N	N	0	N	Y	N																									
91	91	League Line Road	N/A	Conroe	N	N/A	N	N	N/A		N	N	0	N	Y	N																									
92	92	FM 830	N/A	Conroe	N	N/A	N	N	N/A		N	N	0	N	N	N																									
94	94	FM 1097	N/A	Willis	N	N/A	N	N	N/A		N	N	0	N	N	N																									
95	95	Longstreet Road	NB	Willis	N	Y	N	N	N		N	Y	1	N	N	N	170H38	73310	51876	103752	2%	1152	Longstreet Road	3378	4729	3.2	3314	4640	3.4	N	N	Y	Y	Y	N	N	N	N	N	N	3
95	95	Longstreet Road	SB	Willis	N	Y	N	N	N		N	Y	1	N	N	Y	N/A	N/A	51876	103752	22%	11516	Longstreet Road	3314	4640	3.4	3378	4729	3.2	N	N	Y	Y	Y	N	N	N	N	N	N	3
97	97	Calvary Road	N/A	Willis	N	N/A	N	N	N/A		N	N	0	N	N	N																									
98	98	TX 75	NB	Willis	N	Y	N	N	N		N	Y	1	N	N	N	N/A	N/A	51876	103752	22%	11516	TX 75	4247	5946	32	4247	5946	32	Y	N	N	Y	Y	Y	N	N	N	N	N	4
98	98	TX 75	SB	Willis	N	Y	N	N	N		N	Y	1	N	N	N	N/A	N/A	51876	103752	22%	11516	TX 75	4247	5946	32	4247	5946	32	Y	N	N	Y	Y	Y	N	N	N	N	N	4
102	102	FM 1375	N/A	New Waverly	N	N/A	N	N	N/A		N	N	0	N	N	N																									
103	103	TX 150	N/A	New Waverly	N	N/A	N	N	N/A		N	N	0	N	N	N	236H49	53719	44811	89622	24%	10755	Texas 150	3612	5057	6.9	3612	5057	6.9	Y	N	N	Y	Y	Y	N	N	N	N	Y	5
109	109	Texas 40	N/A	Huntsville	N	N/A	N	N	N/A		N	N	0	N	N	Y	236SP244	52226	44811	89622	24%	10755	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	Y	N	N	N	N	N	N	N	1
113	113	TX 19	NB	Huntsville	N	N	Y	Y	Y		N	N	0	N	N	Y	N/A	N/A	44811	89622	24%	10755	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	Y	Y	N	N	N	N	N	N	2
112	112	TX 19	SB	Huntsville	N	N	Y	Y	Y		N	N	0	N	N	Y	N/A	N/A	44811	89622	24%	10755	TX 75	4719	6607	4.2	5101	7141	4.2	N	N	N	Y	Y	N	N	N	N	Y	N	3
114	114	FM 1374	N/A	Huntsville	N	N/A	N	N	N/A		N	N	0	N	N	Y																									
115	115	IH 45 South	N/A	Huntsville	N	N/A	N	N	N/A		N	N	0	N	N	Y																									
116	116	TX 30/US 190	NB	Huntsville	N	Y	Y	Y	N	1.2	N	N	0	N	N	Y	236H75	63074	33249	66498	28%	9443	TX 30/US 190 E	18396	25754	6.4	23037	32252	4.5	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	9
116	116	TX 30/US 190	SB	Huntsville	N	Y	Y	Y	N	1.4	Y	N	0	N	N	N	N/A	N/A	32729	65458	31%	10081	TX 30/US 190 E	23037	32252	4.5	18396	25754	6.4	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	9
118	118	TX 75/ FM 1791	NB	Huntsville	N	Y	Y	Y	N	25.5	N	Y	3	N	N	N	236H77	48987	32729	65458	31%	10081	TX 75	5534	7748	27.9	10507	14710	18.8	Y	N	N	N	Y	Y	N	N	N	N	Y	4
118	118	TX 75/ FM 1791	SB	Huntsville	N	Y	Y	Y	N	2.8	N	Y	3	N	N	Y	236H81	41059	34771	69542	30%	10397	TX 75	10507	14710	18.8	5534	7748	27.9	Y	N	N	N	Y	Y	N	N	N	N	Y	4
123	123	FM 1696	NB	Huntsville	N	Y	N	N	N		N	Y	2	N	N	N	N/A	N/A	34771	69542	30%	10397	FM 1696	825	1155	8.7	262	367	3.4	N	N	Y	N	N	N	N	N	N	N	Y	2
123	123	FM 1696	SB	Huntsville	N	Y	N	N	N		N	Y	2	N	N	N	N/A	N/A	32507	65014	31%	10045	FM 1696	262	367	3.4	825	1155	8.7	N	N	Y	N	N	N	N	N	N	N	Y	2
Rest Area	Rest Area	Walker County Rest Area	NB	Huntsville	N	Y	N	N	N		N	N	2	N	N	Y	N/A	N/A	32507	65014	31%	10045	Walker County Rest Area	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	Y	N	N	N	Y	N	2
Rest Area	Rest Area	Walker County Rest Area	SB	Huntsville	N	Y	N	N	N		N	N	2	N	N	Y	N/A	N/A	32507	65014	31%	10045	Walker County Rest Area	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	Y	N	N	N	Y	N	2
132	132	FM 2989	N/A	Huntsville	N	N/A	N	N	N/A		N	N	0	N	N	N																									
136	136	TX 67	N/A	Madisonville	N	N/A	N	N	N/A		N	N	0	N	N	Y	154SP200	37618	32507	65014	31%	10045	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	N	N	N	N	N	0

Exit Features												Truck Traffic Data					Statewide Planning Map Data													Amenities At Exit											
																	I-45 Interstate Data						Cross Street Data																		
Exit #	Exit Mile Marker	Exit Name	Direction	City	Part of Existing EV Pending Gap	Cross Street Accessible both sides	NHS (TxDOT)	HFN (TxDOT)	Direct-Connect Ramps	Distance to Nearest Existing Public Non-Tesla DCFC Station (Miles)	Has an Existing Non-Tesla DCFC Station	Truck Stops (Y/N)	# of Truck Stops at Exit	Funding under AFFP	Funding under VW DCFC	Street-light Exits	Station Flag	AADT 2019	AADT 2020	AADT 2040	24HR % Truck	24HR Truck Count	Name of Cross Street	Cross Street Left AADT 2020	Cross Street Left AADT 2040	Cross Street Left % Truck	Cross Street Right AADT 2020	Cross Street Right AADT 2040	Cross Street Right % Truck	Auto-motive	Bank	Entertain-ment	Food	Fuel	Lodging	Medical	Parks	Pets	Rest Area	Shop-ping	# of Amenity Types
142	142	TX 21/US 190 W	NB	Madisonville	N	Y	Y	Y	N	1.1	N	N	0	N	Y	N	154H9A	34917	32507	65014	31%	10045	TX 21	11111	15555	9	4991	6987	16.3	Y	Y	N	Y	Y	Y	Y	N	Y	N	Y	8
142	142	TX 21/US 190W	SB	Madisonville	N	Y	Y	Y	N	1.3	Y	N	0	N	Y	Y	154H9A	36389	31115	62230	32%	9832	TX 21	4991	6987	16.3	11111	15555	9	Y	Y	N	Y	Y	Y	Y	N	Y	N	Y	8
146	146	TX 75	NB	Madisonville	Y	Y	N	Y	N		N	N	0	N	N	N	154H6	35704	31115	62230	32%	9832	TX 75	4304	5251	21.7	1443	2020	7.3	Y	N	N	N	N	N	N	N	N	N	N	1
146	146	TX 75	SB	Madisonville	Y	Y	N	Y	N		N	N	0	N	N	Y	154H62	36988	32619	65238	31%	10079	TX 75	1443	2020	7.3	4304	5251	21.7	Y	N	N	N	N	N	N	N	N	N	N	1
152	152	Texas OSR	NB	Madisonville	Y	Y	N	Y	N		N	Y	1	N	N	N	N/A	N/A	32619	65238	31%	10079	OSR	971	1364	18.4	351	491	8.5	N	N	N	Y	Y	N	N	N	N	N	N	2
152	152	Texas OSR	SB	Madisonville	Y	Y	N	Y	N		N	Y	1	N	N	Y	145H38	37031	33632	67264	30%	10224	OSR	351	491	8.5	971	1364	18.4	N	N	N	Y	Y	N	N	N	N	N	N	2
Picnic Area	Rest Area	Leon County Picnic Area	NB	Leona	Y	Y	N	N	N		N	N	2	N	N	Y	145H38	37031	33632	67264	30%	10224	Leon County Picnic Area	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	Y	N	N	N	Y	N	2
156	156	FM 977	N/A	Leona	Y	N/A	N	N	N/A		N	N	0	N	N	Y																									
Picnic Area	Rest Area	Leon County Picnic Area	SB	Leona	Y	Y	N	N	N		N	N	2	N	N	Y	N/A	N/A	33082	66164	31%	10123	Leon County Picnic Area	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	Y	N	N	N	Y	N	2
164	164	TX 7	NB	Centerville	Y	Y	N	N	N		N	Y	1	N	N	N	N/A	N/A	33082	66164	31%	10123	TX 7	3836	5370	16.9	6750	9720	12.9	Y	N	N	Y	Y	N	N	Y	N	N	N	4
164	164	TX 7	SB	Centerville	Y	Y	N	N	N		N	Y	1	N	N	Y	145H87	35324	32548	65096	31%	10057	TX 7	6750	9720	12.9	3836	5370	16.9	Y	N	N	Y	Y	N	N	Y	N	N	N	4
178	178	US 79	NB	Buffalo	Y	Y	Y	Y	N	37.9	N	Y	1	N	N	Y	145H86	37908	32548	65096	31%	10057	US 79	11799	16519	19.5	9496	13294	21.1	Y	N	N	Y	Y	Y	N	N	N	N	Y	5
178	178	US 79	SB	Buffalo	Y	Y	Y	Y	N	38.2	N	Y	1	N	N	Y	145T7A	37109	32504	65008	31%	10044	US 79	9496	13294	21.1	11799	16519	19.5	Y	N	N	Y	Y	Y	N	N	N	N	Y	5
180	180	TX 164	N/A	Buffalo	Y	N/A	N	N	N/A		N	N	0	N	N	Y	145T7A	37109	32504	65008	31%	10044	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	N	N	N	N	N	0
189	189	TX 179	NB	Teague	Y	Y	N	N	N		N	Y	2	N	N	Y	82H34	34011	32130	64260	31%	9992	TX 179	2018	2825	14.9	1429	2001	14.2	N	N	N	Y	Y	N	N	N	N	N	N	2
189	189	TX 179	SB	Teague	Y	Y	N	N	N		N	Y	2	N	N	Y	N/A	N/A	32229	64458	31%	10023	TX 179	1429	2001	14.2	2018	2825	14.9	N	N	N	Y	Y	N	N	N	N	N	N	2
197	197	US 84	NB	Fairfield	Y	Y	N	Y	N		N	Y	1	N	N	Y	82H33	33434	32229	64458	31%	10023	US 84	5897	8256	18.9	12058	16881	15.8	Y	N	Y	Y	Y	Y	N	N	Y	N	N	6
197	197	US 84	SB	Fairfield	Y	Y	N	Y	N		N	Y	1	N	N	Y	82H32	34055	31102	62204	32%	9828	US 84	12058	16881	15.8	5897	8256	18.9	Y	N	Y	Y	Y	Y	N	N	Y	N	N	6
198	198	FM 27	NB	Fairfield	Y	Y	N	Y	N		N	Y	1	N	N	Y	82H32	34055	31102	62204	32%	9828	FM 29	3523	4932	7.4	4738	6633	8	Y	N	Y	Y	Y	Y	N	N	Y	N	Y	7
198	198	FM 27	SB	Fairfield	Y	Y	N	Y	N		N	Y	1	N	N	Y	82H82	32414	31532	63064	31%	9901	FM 29	4738	6633	8	3523	4932	7.4	Y	N	Y	Y	Y	Y	N	N	Y	N	Y	7
206	206	FM 833	N/A	Fairfield	Y	N/A	N	N	N/A		N	N	0	N	N	N																									
211	211	Spur 114	N/A	Streetman	Y	N/A	N	N	N/A		N	N	0	N	N	N	N/A	N/A	31678	63356	31%	9852	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	Y	N	N	N	N	N	N	1
213	213	US 75	N/A	Streetman	Y	N/A	N	N	N/A		N	N	0	N	N	N	N/A	N/A	34143	47800	32%	10994	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	Y	N	N	N	N	N	N	1
Rest Area	Rest Area	Navarro County Rest Area	NB	Richland	Y	Y	N	N	N		N	N	2	N	N	Y	N/A	N/A	34143	47800	32%	10994	Navarro County Rest Area	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	Y	N	N	N	Y	N	2
Rest Area	Rest Area	Navarro County Rest Area	SB	Richland	Y	Y	N	N	N		N	N	2	N	N	Y	175H54	34488	34143	47800	32%	10994	Navarro County Rest Area	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	Y	N	N	N	Y	N	2
218	218	TX 1394	N/A	Richland	Y	N/A	N	N	N/A		N	N	0	N	N	N	175H54	34488	34143	47800	32%	10994	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	Y	N	N	N	N	N	N	1
219A	219	TX 14	N/A	Richland	Y	N/A	N	N	N/A		N	N	0	N	N	Y	175H53	39511	39098	78196	29%	11378	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	Y	N	N	N	N	N	N	1
219B	219	Frontage Road	N/A	Richland	Y	N/A	N	N	N/A		N	N	0	N	N	N																									
220	220	Frontage Road	N/A	Richland	Y	N/A	N	N	N/A		N	N	0	N	N	N																									
221	221	Frontage Road	N/A	Corsicana	Y	N/A	N	N	N/A		N	N	0	N	N	Y																									
225	225	TX 739	NB	Corsicana	Y	Y	N	N	N		N	Y	1	N	N	N	N/A	N/A	39098	78196	29%	11378	TX 739	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	Y	N	N	N	N	N	Y	2
225	225	TX 739	SB	Corsicana	Y	Y	N	N	N		N	Y	1	N	N	N	175SP40	41624	39494	78988	29%	11453	Bonner Avenue	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	Y	N	N	N	N	N	Y	2
227	227	TX 31	NB	Corsicana	Y	Y	Y	N	N	25.9	N	N	0	N	N	N	175SP40	41624	39494	78988	29%	11453	TX 31	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	N	N	N	N	N	0
227	227	TX 31	SB	Corsicana	Y	Y	Y	N	N	30.8	N	N	0	N	N	N			39494	78988	29%	11453	TX 31	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	N	N	N	N	N	0
228A	228	15th Street	N/A	Corsicana	Y	N/A	N	N	N/A		N	N	0	N	N	Y																									
228B	228	S Business 45	NB	Corsicana	Y	Y	N	Y	Y		N	N	0	N	N	N																									
228B	228	S Business 45	SB	Corsicana	Y	Y	N	Y	Y		N	N	0	N	N	Y																									
229	229	US 287 South	NB	Corsicana	Y	Y	Y	Y	N	23.5	N	N	0	Y	N	N	N/A	N/A	39494	78988	29%	11453	US 287	10700	14980	3.1	12921	18089	8.2	Y	Y	Y	Y	Y	Y	N	Y	N	N	Y	9
229	229	US 287 South	SB	Corsicana	Y	Y	Y	Y	N	23.2	N	N	0	Y	N	Y	N/A	N/A	41907	83814	27%	11105	US 287	12921	18089	8.2	10700	14980	3.1	Y	Y	Y	Y	Y	Y	N	Y	N	N	Y	9
231	231	Martin Luther King Jr Blvd/ State Hwy 31 W	NB	Corsicana	Y	Y	Y	N	N	21.4	N	N	0	N	N	N	175H35	42820	41907	83814	27%	11105	SH 31 W	13064	18290	10.8	12032	16845	11.2	Y	Y	N	Y	Y	Y	N	Y	N	Y	Y	8

Exit Features												Truck Traffic Data					Statewide Planning Map Data: I-45 Interstate Data						Statewide Planning Map Data: Cross Street Data							Amenities At Exit											
Exit #	Exit Mile Marker	Exit Name	Direction	City	Part of Existing EV Pending Gap	Cross Street Accessible both sides	NHS (TxDOT)	HFN (TxDOT)	Direct-Connect Ramps	Distance to Nearest Existing Public Non-Tesla DCFC Station (Miles)	Has an Existing Non-Tesla DCFC Station	Truck Stops (Y/N)	# of Truck Stops at Exit	Funding under AFFP	Funding under VW DCFC	Streetlight Exits	Station Flag	AADT 2019	AADT 2020	AADT 2040	24HR % Truck	24HR Truck Count	Name of Cross Street	Cross Street Left AADT 2020	Cross Street Left AADT 2040	Cross Street Left % Truck	Cross Street Right AADT 2020	Cross Street Right AADT 2040	Cross Street Right % Truck	Auto-motive	Bank	Entertain-ment	Food	Fuel	Lodging	Medical	Parks	Pets	Rest Area	Shop-ping	# of Amenity Types
231	231	Martin Luther King Jr Blvd/ State Hwy 31 W	SB	Corsicana	Y	Y	Y	N	N	21.7	N	N	0	N	N	Y			38993	77986	28%	10762	SH 31 W	12032	16845	11.2	13064	18290	10.8	Y	Y	N	Y	Y	Y	N	Y	N	Y	Y	8
232	232	Roane Road	N/A	Corsicana	Y	N/A	N	N	N/A		N	N	0	N	N	N																									
235A	235	Frontage Road	N/A	Corsicana	Y	N/A	N	N	N/A		N	N	0	N	N	N																									
235B	235	Business 45	SB	Corsicana	Y	N	N	Y	Y		N	N	0	N	N	Y																									
237	237	Frontage Road	N/A	Rice	Y	N/A	N	N	N/A		N	N	0	N	N	N																									
238	238	FM 1603	NB	Rice	Y	Y	N	N	N		N	Y	1	N	N	N	N/A	N/A	48460	96920	25%	11921	FM 1603	38	53	5.3	2608	4509	28.5	N	N	N	Y	Y	N	N	N	N	N	N	2
238	238	FM 1603	SB	Rice	Y	Y	N	N	N		N	Y	1	N	N	Y	N/A	N/A	48911	97822	25%	11983	FM 1603	2608	4509	28.5	38	53	5.3	N	N	N	Y	Y	N	N	N	N	N	N	2
239	239	Frontage Road	N/A	Rice	Y	N/A	N	N	N/A		N	N	0	N	N	N																									
242	242	Calhoun Street	N/A	Rice	Y	N/A	N	N	N/A		N	N	0	N	N	N																									
243	243	Frontage Road	N/A	Rice	Y	N/A	N	N	N/A		N	N	0	N	N	Y																									
244	244	FM 1182	N/A	Ennis	Y	N/A	N	N	N/A		N	N	0	N	N	Y																									
246	246	FM 1183	NB	Ennis	Y	Y	N	N	N		N	Y	1	Y	N	N	N/A	N/A	49013	98026	25%	12008	FM 1183	1084	1518	5.5	66	66	3.2	N	N	N	Y	Y	N	N	N	N	N	N	2
246	246	FM 1183	SB	Ennis	Y	Y	N	N	N		N	Y	1	Y	N	Y	71E16D	53620	51459	102918	24%	12299	FM 1183	66	66	3.2	1084	1518	5.5	N	N	N	Y	Y	N	N	N	N	N	N	2
247	247	US 287 N	NB	Ennis	Y	Y	Y	Y	Y	5.1	N	N	0	N	N	Y	71E16D	53620	51459	102918	24%	12299	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	N	N	N	N	N	0
247	247	US 287 N	SB	Ennis	Y	Y	Y	Y	Y	107	N	N	0	N	N	Y	71H61B	41686	51459	102918	24%	12299								N	N	N	N	N	N	N	N	N	N	N	0
249	249	Buisness IH 45	NB	Ennis	N	Y	Y	Y	N	3.4	N	N	0	N	N	N														Y	N	Y	Y	Y	N	N	N	N	N	Y	5
249	249	Buisness IH 45	SB	Ennis	N	Y	Y	Y	N	109	N	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	5
251A	251	Creechville Road	N/A	Ennis	N	N/A	N	N	N/A		N	N	0	N	N	Y																									
251B	251	TX 34	NB	Ennis	N	Y	Y	Y	N	0.7	N	N	0	Y	N	N	71H37A	45280	44051	88102	23%	10220	TX 34	16288	27038	2.7	8821	12349	20.5	Y	N	N	Y	Y	Y	Y	N	N	N	Y	6
251B	251	TX 34	SB	Ennis	N	Y	Y	Y	N	0.8	Y	N	0	Y	N	Y	N/A	N/A	40791	81582	24%	9831	TX 34	8821	12349	20.5	16288	27038	2.7	Y	N	N	Y	Y	Y	Y	N	N	N	Y	6
253	253	IH 45 Bus	N/A	Ennis	N	N/A	N	N	N/A		N	N	0	N	N	Y																									
255	255	FM 879	N/A	Ennis	N	N/A	N	N	N/A		N	N	0	N	N	Y																									
258	258	Parker Hill Road	NB	Palmer	N	Y	N	N	N		N	Y	1	N	N	Y	71H39	45714	44580	89160	23%	10253	Parker Hill Road	2193	3070	4.3	66	66	3.2	N	N	Y	Y	Y	N	N	N	N	N	N	3
258	258	Parker Hill Road	SB	Palmer	N	Y	N	N	N		N	Y	1	N	N	Y	N/A	N/A	44580	89160	23%	10253	Parker Hill Road	66	66	3.2	2193	3070	4.3	N	N	Y	Y	Y	N	N	N	N	N	N	3
259	259	FM 813	N/A	Palmer	N	N/A	N	N	N/A		N	N	0	N	N	N																									
260	260	IH 45 Bus	N/A	Palmer	N	N/A	N	N	N/A		N	N	0	N	N	Y																									
262	262	Frontage Road	N/A	Ferris	N	N/A	N	N	N/A		N	N	0	N	N	N																									
263A	263	TX 561 Loop	N/A	Ferris	N	N/A	N	N	N/A		N	N	0	N	N	Y	N/A	N/A	42031	84062	24%	9961	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	N	N	N	N	N	0
263B	263	Frontage Road	N/A	Ferris	N	N/A	N	N	N/A		N	N	0	N	N	N																									
264	264	Frontage Road	N/A	Ferris	N	N/A	N	N	N/A		N	N	0	N	N	Y																									
265	265	IH 45 Bus	N/A	Ferris	N	N/A	N	N	N/A		N	N	0	N	N	N																									
266	266	FM 660	N/A	Ferris	N	N/A	N	N	N/A		N	N	0	N	N	Y																									
267	267	Frontage Road	N/A	Ferris	N	N/A	N	N	N/A		N	N	0	N	N	Y																									
268	268	IH 45 Bus	N/A	Ferris	N	N/A	N	N	N/A		N	N	0	N	N	N																									
269	269	Mars Road	N/A	Ferris	N	N/A	N	N	N/A		N	N	0	N	N	N																									
270	270	Belt Line Road	NB	Wilmer	N	Y	Y	N	N		N	Y	1	N	N	N	57H83	56008	54152	108304	25%	13376	Belt Line Road	6141	8597	2.3	3434	4808	3.2	Y	N	N	Y	Y	N	N	N	N	N	Y	4
270	270	Belt Line Road	SB	Wilmer	N	Y	Y	N	N		N	Y	1	N	N	N	N/A	N/A	56678	113356	24%	13659	Belt Line Road	3434	4808	3.2	6141	8597	2.3	Y	N	N	Y	Y	N	N	N	N	N	Y	4
271	271	Pleasant Run Road	NB	Wilmer	N	Y	N	Y	N		N	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	0
271	271	Pleasant Run Road	SB	Wilmer	N	Y	N	Y	N		N	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	0
272	272	Fulgrhum	NB	Wilmer	N	Y	N	N	N		N	Y	1	N	N	Y	57H82	60993	56678	113356	24%	13659	Fulgrhum	231	231	3.2	231	231	3.2	Y	N	N	Y	Y	N	N	N	N	N	N	3
272	272	Fulgrhum	SB	Wilmer	N	Y	N	N	N		N	Y	1	N	N	N	57H81	76380	69167	138334	22%	15148	Fulgrhum	231	231	3.2	231	231	3.2	Y	N	N	Y	Y	N	N	N	N	N	N	3
273	273	Wintergreen Road	NB	Hutchins	N	Y	N	Y	N		N	Y	1	N	N	Y	N/A	N/A	69167	138334	22%	15148	Wintergreen Street	9144	12802	3.2	9144	12802	3.2	Y	N	N	Y	Y	N	N	N	N	N	N	3
273	273	Wintergreen Road	SB	Hutchins	N	Y	N	Y	N		N	Y	1	N	N	N	57H81	76380	69167	138334	22%	15148	Wintergreen Street	9144	12802	3.2	9144	12802	3.2	Y	N	N	Y	Y	N	N	N	N	N	N	3

Exit Features												Truck Traffic Data					Statewide Planning Map Data													Amenities At Exit											
																	I-45 Interstate Data						Cross Street Data																		
Exit #	Exit Mile Marker	Exit Name	Direction	City	Part of Existing EV Pending Gap	Cross Street Access-ible both sides	NHS (TxDOT)	HFN (TxDOT)	Direct-Connect Ramps	Distance to Nearest Existing Public Non-Tesla DCFC Station (Miles)	Has an Existing Non-Tesla DCFC Station	Truck Stops (Y/N)	# of Truck Stops at Exit	Funding under AFFP	Funding under VW DCFC	Street-light Exits	Station Flag	AADT 2019	AADT 2020	AADT 2040	24HR % Truck	24HR Truck Count	Name of Cross Street	Cross Street Left AADT 2020	Cross Street Left AADT 2040	Cross Street Left % Truck	Cross Street Right AADT 2020	Cross Street Right AADT 2040	Cross Street Right % Truck	Auto-motive	Bank	Entertain-ment	Food	Fuel	Lodging	Medical	Parks	Pets	Rest Area	Shop-ping	# of Amenity Types
274	274	Dowdy Ferry Road	NB	Hutchins	N	Y	N	N	N		N	**Y**	**1**	N	N	**Y**	57h81	76380	69167	138334	**22%**	**15148**	Dowdy Ferry Road	5025	7035	3.2	4559	6383	15.2	**Y**	N	N	**Y**	**Y**	**Y**	N	N	**Y**	N	N	5
274	274	Dowdy Ferry Road	SB	Hutchins	N	Y	N	N	N		N	**Y**	**1**	N	N	N	57H84	86283	68837	137674	**22%**	**15144**	Dowdy Ferry Road	4559	6383	15.2	5025	7035	3.2	**Y**	N	N	**Y**	**Y**	**Y**	N	N	**Y**	N	N	5
275	275	TX 310 N	**NB**	Hutchins	N	N	N	Y	N		N	N	0	N	N	N	57H84	86283	68837	137674	**22%**	**15144**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	Y	N	N	Y	N	N	N	N	N	N	N	2
276A	276	IH 20 W	**NB**	Hutchins	N	Y	Y	Y	Y	N/A	N	N	0	N	N	**Y**	57H84	86283	68837	137674	**22%**	**15144**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	N	N	N	N	N	N	N	N	N	N	N	0
276A	276	IH 20 W	**SB**	Hutchins	N	Y	Y	Y	Y	25.3	N	N	0	N	N	N																									
276B	276	IH 20E	**NB**	Hutchins	N	Y	Y	Y	Y	N/A	N	N	0	N	N	**Y**	57H84	86283	68837	137674	**22%**	**15144**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	N	N	N	N	N	N	N	N	N	N	N	0
276B	276	IH 20E	**SB**	Hutchins	N	Y	Y	Y	Y	25.6	N	N	0	N	N	N																									
277	277	Simpson Stuart Road	**NB**	Dallas	N	Y	Y	N	N		N	N	0	N	N	N																									
277	277	Simpson Stuart Road	**SB**	Dallas	N	Y	Y	N	N		N	N	0	N	N	N																									
279A	279	TX 12 Loop E	**NB**	Dallas	N	Y	Y	Y	N	N/A	N	N	0	N	N	N	**N/A**	**N/A**	77810	108934	**16%**	**12761**	TX 12 loop	27322	38251	3.6	28052	39273	3.6	**Y**	N	**Y**	N	N	**Y**	N	**Y**	N	N	N	4
279	279	TX 12 Loop E	**SB**	Dallas	N	Y	Y	Y	N	29	N	N	0	N	N	N														N	N	N	N	N	N	N	N	N	N	N	4
279B	279	TX 12 Loop W	**NB**	Dallas	N	Y	Y	Y	Y	N/A	N	N	0	N	N	N	**N/A**	**N/A**	77810	108934	**16%**	**12761**	TX 12 loop	27322	38251	3.6	28052	39273	3.6	**Y**	**Y**	**Y**	**Y**	**Y**	N	N	N	N	N	**Y**	6
279	279	TX 12 Loop W	**SB**	Dallas	N	Y	Y	Y	Y	29	N	N	0	N	N	N																									
280	280	E Illinois Avenue	**NB**	Dallas	N	Y	Y	Y	Y	N/A	N	N	0	N	N	N																									
280	280	E Illinois Avenue	**SB**	Dallas	N	Y	Y	Y	Y	29.5	N	N	0	N	N	N																									
281	281	Overton Road	N/A	Dallas	N	N/A	N	N	N/A		N	N	0	N	N	N																									
283A	283	Lamar Street	N/A	Dallas	N	N/A	N	N	N/A		N	N	0	N	N	N																									
283B	283	S Cesar Chavez Blvd	**NB**	Dallas	N	Y	Y	N	Y		N	N	0	N	N	N																									
283B	283	S Cesar Chavez Blvd	**SB**	Dallas	N	Y	Y	N	Y		N	N	0	N	N	N																									
284A	284	IH 45 N	N/A	Dallas	N	N/A	N	N	N/A		N	N	0	N	N	N	57H204	157261	138390	193746	**13%**	**17299**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	N	N	N	N	N	N	N	N	N	N	N	0
284A	284	IH 30 E/W	**NB**	Dallas	N	Y	Y	Y	Y	N/A	N	N	0	N	N	**Y**	57H204	157261	138390	193746	**13%**	**17299**	IH 30 W	152203	213084	7	154251	308502	9.6	**Y**	N	**Y**	**Y**	**Y**	**Y**	N	**Y**	N	N	**Y**	7
284A	284	IH 30 E/W	**SB**	Dallas	N	Y	Y	Y	Y	34.6	N	N	0	N	N	N																									
284B	284	Main Street W/Elm Street	N/A	Dallas	N	N/A	N	N	N/A		N	N	0	N	**Y**	N																									
284C	284	North Central Expressway	N/A	Dallas	N	N/A	N	N	N/A		N	N	0	N	N	N	57H201	188387	162578	325156	**4%**	**6503**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**Y**	N	**Y**	**Y**	**Y**	**Y**	N	**Y**	**Y**	N	**Y**	8
285	285	Bryan Street E	N/A	Dallas	N	N/A	N	N	N/A		N	N	0	N	N	N																									
286	286	Spur 366	N/A	Dallas	N	N/A	N	N	N/A		N	N	0	N	N	**Y**	57H201	188387	162578	325156	**4%**	**6503**								N	N	N	N	N	N	N	N	N	N	N	0

IH 45 Exit List: Data Dictionary					
Data Column Name	Definition	Data Source	Methodology in Which Data Point Was Used		
			Light-Duty BEV	Heavy-Duty BEV	Heavy-Duty FCEV
Exit Features					
Exit #	A number that is assigned to a interstate exit	Google Maps	Not Filtered	Not Filtered	Not Filtered
Exit Mile Marker	Mile Marker that correlates with exit number	Google Maps	Not Filtered	Not Filtered	Not Filtered
Exit Name	Name of Exit on sign along interstate/cross street name	Google Maps	Not Filtered	Not Filtered	Not Filtered
Direction	Direction correlates to either NB or SB as sides of interstate change depending on direction traveled	Google Maps	Not Filtered	Not Filtered	Not Filtered
City	Name of City associated with exit	Google Maps	Not Filtered	Not Filtered	Not Filtered
Part of Existing EV Pending Gap	Identifies exits located in the segment of IH 45 designated by the FHWA as "Corridor Pending" as detailed in Chapter 3: LD EV Charging Recommendations: Y = yes the exit is a part of the EV Pending Gap/ N = no the exit is not a part of the EV Pending Gap	Alternative Fueling Station Locator	**Y**	Not Filtered	Not Filtered
Cross Street accessible both sides	The through or cross street is both accessible and traversable from both sides of the interstate: Y = the cross street is accessible/ N = the cross street is not accessible	Google Maps	**Y**	**Y**	**Y**
NHS (TxDOT)	A system of highways designated and approved in accordance with the provisions of 23 U.S.C. 103(b): Y = yes the cross street is on the National Highway System/ N = no the cross street is not on the National Highway System	Statewide Planning Map (txdot.gov)	**Y**	Not Filtered	Not Filtered
HFN (TxDOT)	A network of highways identified as the most critical highway portions of Texas freight transportation system determined by measurable and objective data: Y = yes the cross street is on the Highway Freight Network/ N = no the cross street is not on the Highway Freight Network	Statewide Planning Map (txdot.gov)	Not Filtered	**Y**	**Y**
Direct-Connect Ramps	Ramps that lead away from the interstate to another major road network: Y = yes there is a direct connect ramp/N = no there is not a direct connect ramp	Google Maps	**N**	**N**	**N**

IH 45 Exit List: Data Dictionary					
Data Column Name	Definition	Data Source	Methodology in Which Data Point Was Used		
			Light-Duty BEV	Heavy-Duty BEV	Heavy-Duty FCEV
Distance to Nearest Existing Public Non-Tesla DCFC Station (Mile)	Staff used a combination of Google Maps (https://www.google.com/maps) and the AFDC Alternative Fueling Station Locator Public Stations (https://afdc.energy.gov/stations/#/find/nearest) to identify Electric DCFC Chargers that used J1772, CCS, and CHAdeMO connectors. NCTCOG staff then used the addresses of these stations and exits to find the distances to the nearest existing stations. NCTCOG staff chose to leave out Tesla charging stations as they are only proprietary of Tesla brand vehicles.	Alternative Fueling Station Locator: Public Stations	Not Filtered	Not Filtered	Not Filtered
Has an Existing DCFC non-Tesla Station	Refers to if the exit has an existing DCFC non-Tesla Station: Y = there is a DCFC station/N = there is not a DCFC station	Alternative Fueling Station Locator: Public Stations	Not Filtered	Not Filtered	Not Filtered
Truck Traffic Data					
Truck Stops (Y/N)	Whether Exit has an existing truck stop currently there: Y = there is a truck stop/N = there is not a truck stop	TxDOT Truck Parking Study Sites Shape File	Not Filtered	Not Filtered*	Not Filtered*
# of Truck Stops at Exit	NCTCOG staff counted how many truck stops at each exit	TxDOT Truck Parking Study Sites Shape File	Not Filtered	Not Filtered*	Not Filtered*
Funding under AFFP	Whether exit is the location of a project which received funding from the Alternative Fueling Facilities Program: Y = there was funding awarded/N = there was not funding awarded	AFFP Sites	Not Filtered*	Not Filtered*	Not Filtered*
Funding under VW DCFC	Whether exit is the location of a project which received funding from the TCEQ's Texas Volkswagen Environmental Mitigation Program : Y = there was funding awarded/N = there was not funding awarded	Texas Volkswagen Environmental Mitigation Program Funded Sites	Not Filtered	Not Filtered	Not Filtered
Streetlight Exits	Exits that were derived from analysis in the StreetLight software platform that identified key turning points for truck traffic: Y = yes there was a turn off/N = no there was not a turn off	StreetLight Data	Not Filtered	**Y**	**Y**

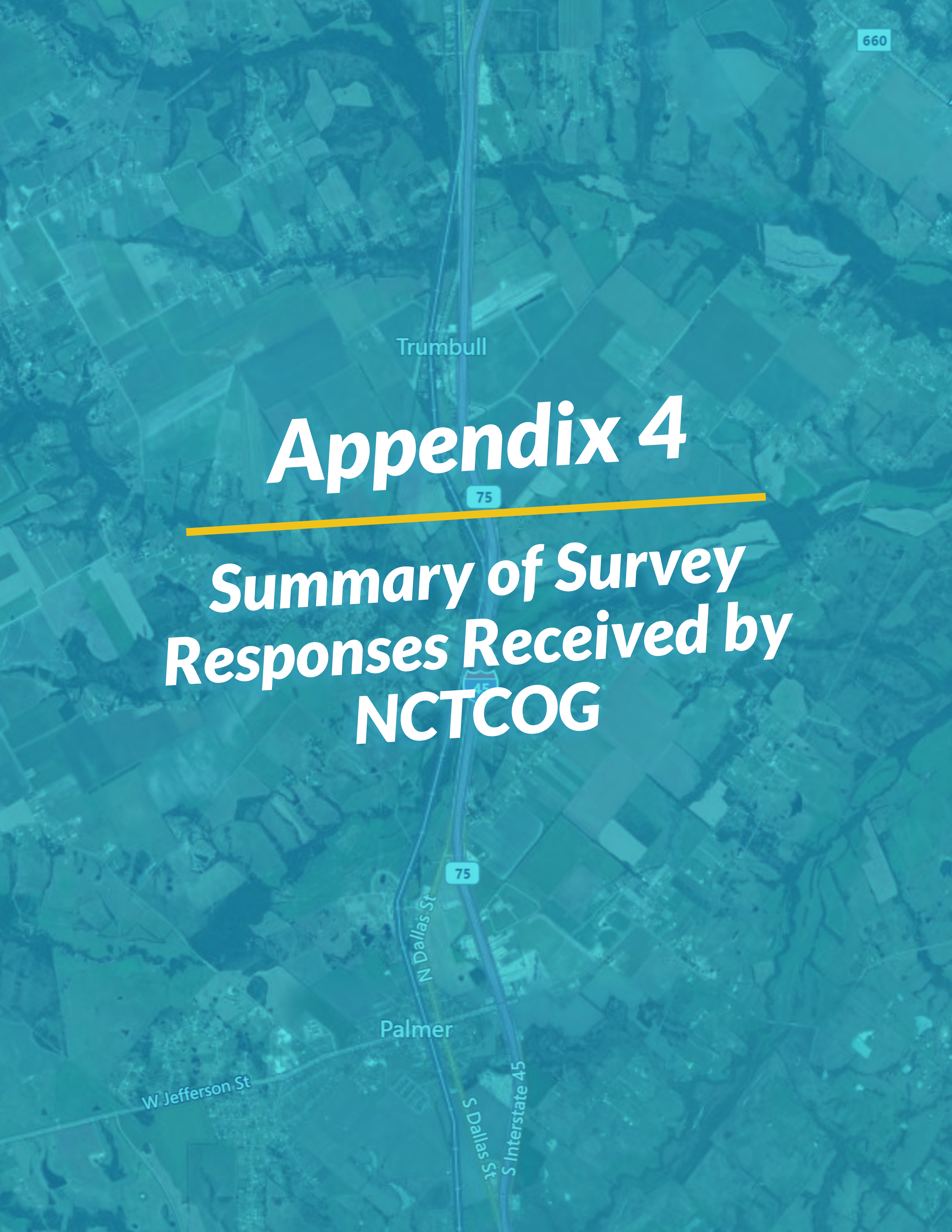
IH 45 Exit List: Data Dictionary					
Data Column Name	Definition	Data Source	Methodology in Which Data Point Was Used		
			Light-Duty BEV	Heavy-Duty BEV	Heavy-Duty FCEV
Statewide Planning Map Data					
Station Flag	Each Individual station was labeled with a specific alphanumeric code that can be searched on the TxDOT Statewide Planning Tool under the AADT layer to find exact points from where they were collected. Staff collected station flags that were right before each exit for both NB/SB.	Statewide Planning Map	Not Filtered	Not Filtered	Not Filtered
AADT 2019	Average Annual Daily Traffic numbers for the year of 2019	Statewide Planning Map	Not Filtered	Not Filtered	Not Filtered
AADT 2020	Average Annual Daily Traffic numbers for the year of 2020	Statewide Planning Map	Not Filtered	Not Filtered	Not Filtered
AADT 2040	An estimated Average Annual Daily Traffic numbers for the year of 2040	Statewide Planning Map	Not Filtered	Not Filtered	Not Filtered
24HR % Truck	A precentage derived from the Average Annual Daily Traffic numbers for the 2020 year	Statewide Planning Map	Not Filtered	Not Filtered*	Not Filtered*
24HR Truck Count	The numerical amount of the percentage of 24HR % Truck calculated by COG staff	Statewide Planning Map	Not Filtered	Not Filtered*	Not Filtered*
Name of Cross Street	Cross Street Name	Statewide Planning Map	Not Filtered	Not Filtered	Not Filtered
Cross Street Left AADT 2020	Average Annual Daily Traffic numbers for the left side of the interstate (directionally indicative) for the 2020 year	Statewide Planning Map	Not Filtered	Not Filtered	Not Filtered
Cross Street Left AADT 2040	Average Annual Daily Traffic numbers for the left side of the interstate (directionally indicative) for the 2040 year	Statewide Planning Map	Not Filtered	Not Filtered	Not Filtered
Cross Street Left % Truck	A percentage of derived from the Average Annual Daily Traffic numbers for Cross Street Left AADT 2020 (directionally indicative)	Statewide Planning Map	Not Filtered	Not Filtered*	Not Filtered*
Cross Street Right AADT 2020	Average Annual Daily Traffic numbers for the right side of the interstate (directionally indicative) for the 2020 year	Statewide Planning Map	Not Filtered	Not Filtered	Not Filtered
Cross Street Right AADT 2040	Average Annual Daily Traffic numbers for the right side of the interstate (directioally indicative) for the 2040 year	Statewide Planning Map	Not Filtered	Not Filtered	Not Filtered

IH 45 Exit List: Data Dictionary					
Data Column Name	Definition	Data Source	Methodology in Which Data Point Was Used		
			Light-Duty BEV	Heavy-Duty BEV	Heavy-Duty FCEV
Cross Street Right % Truck	A percentage of derived from the Average Annual Daily Traffic numbers for Cross Street Right AADT 2020 (directionally indicative)	Statewide Planning Map	Not Filtered	Not Filtered*	Not Filtered*
Amenities					
Automotive	Automotive dealerships, Repair Shops, Auto Part Stores, etc.	IExitApp	Not Filtered	Not Filtered	Not Filtered
Bank	Banks	IExitApp	Not Filtered	Not Filtered	Not Filtered
Entertainment	Tattoo Parlors, Art Studios, Music Halls, etc.	IExitApp	Not Filtered	Not Filtered	Not Filtered
Food	Gas Stations, Restaurants, Fast Food	IExitApp	Not Filtered	Not Filtered	Not Filtered
Fuel	Gas Stations such as Texaco, Valero, and 7-Eleven/ Alt Fuel (where alternative fuel locations are hotels, shopping centers, resturants)	IExitApp	Not Filtered	Not Filtered	Not Filtered
Lodging	Hotels and Motels	IExitApp	Not Filtered	Not Filtered	Not Filtered
Medical	Hospitals, Clinics, and Emergency Rooms	IExitApp	Not Filtered	Not Filtered	Not Filtered
Parks	Dog Parks and Regular City Parks	IExitApp	Not Filtered	Not Filtered	Not Filtered
Pets	Animal Hospitals, Veterniary Offices	IExitApp	Not Filtered	Not Filtered	Not Filtered
Rest Area	Rest Stops and Public Picnic Areas	IExitApp	Not Filtered	Not Filtered	Not Filtered
Shopping	Grocery Stores, Gas Stations, and Shopping Centers	IExitApp	Not Filtered	Not Filtered	Not Filtered
# of Amenity Types	The number of Amenities types was counted by NCTCOG Staff .	IExitApp	**>0**	**>2**	**>2**

*Indicates was seen as higher value, though not requirement for station

Appendix 4

Summary of Survey Responses Received by NCTCOG



Appendix 4

Summary of Survey Responses Received by NCTCOG

Early in the project, NCTCOG issued two surveys – one for fleets and shippers and another for fuel providers – to try to understand plans underway in the industry. These surveys were modeled off of similar surveys completed by other corridor plans in California. Minimal responses were received but are provided below.

IH 45 Fleets and Shippers Survey

Question	Response #1	Response #2
Organization	**Southeastern Freight Lines, Inc.**	**Clear Creek ISD**
Date Completed	**4/1/2021**	**3/11/2022**
Does your organization do its own shipping, or does your organization?	No, we contract it out to an external company	Yes, we do our own shipping
Have you ever considered incorporating contract requirements for shippers to use low-emission fuels that reduce air pollution or make progress toward sustainability goals? (For background or examples of similar initiatives, see SmartWay Shipper Partner Tools and Resources | US EPA)	Yes, we currently have this type of requirement	
If your organization has not yet considered adding these requirements, what would motivate your organization to add them?		
If you chose "Other" please explain.		
Under what sector does your organization's fleet fall under?		
Which of the following categories does your organization's fleet provide services for: (Choose all that apply)	Long-Haul Trucking; Regional Shipping;	School bus
How many vehicles are in your organization's fleet?	3000	474
How many fleet yards/depots does your organization operate?	89	2
What is the average daily distance your organization's fleet travels?	850,000	25
Under what classification does your organization's fleet vehicles fall under? (Check all that apply)	Class 6: 19,501-26,000 lbs (Medium Duty); Class 8: >33,001 lbs (Heavy Duty)	Class 6: 19,501-26,000 lbs (Medium Duty); Class 3: 10,001-14,000 lbs (Medium Duty); Class 2: 6,001-10,000 lbs (Light Duty)
How many vehicles does your organization have that fall under the light-duty category?		100
How many vehicles does your organization have that fall under the medium-duty category?	400	50

Question	Response #1	Response #2
Organization	**Southeastern Freight Lines, Inc.**	**Clear Creek ISD**
How many vehicles does your organization have that fall under the heavy-duty category?	2600	324
When you are considering upgrading your fleet, what are the driving factors of purchasing? (Choose all that apply)	Total Cost of Ownership; Life Cycle of Vehicle; Pre-Determined Fleet Replacement Schedule	Total Cost of Ownership; Up-Front Cost; Fuel Specific Cost; Life Cycle of Vehicle; Pre-Determined Fleet Replacement Schedule
Yearly, how many trips does your organization's fleet take where both the origin and destination is in the Dallas-Fort Worth metroplex or Houston metro area (DFW-Houston pair)?	Don't have an exact number but combined in both markets, over a hundred a day	100% Houston metroplex
What are some major destinations of these trips? (Check all that apply)	North Dallas; East Dallas; West Dallas; South Dallas; Fort Worth; North Houston; East Houston; West Houston; South Houston	South Houston
Yearly, how many trips does your organization's fleet take that travel between the Dallas-Fort Worth metroplex to Houston, but ultimately have another origin or destination?	Again, no exact number but roughly over 75 a day	4
If traveling from Houston to the Fort Worth side of the DFW region, describe the typical route. For example, do trucks travel into Dallas to make stops in Fort Worth, or do they turn off toward Fort Worth south of the DFW urban core? If they turn off, what are the key exits for a Fort Worth area destination?	Not Sure	45
Is your organization currently working on zero-emission vehicle projects for your fleet? (Deployment set to be in 3 years or less)	No	No
What level of funding does your organization need to support these projects?		75%
What would the funding be used for?		Both
What zero emissions vehicles and off-road equipment is your organization interested in adding to its fleets within the next 3 to 5 years?	Not Interested	Had not considered before but we might be interested
If your organization has not yet considered adding these vehicles to its fleets, what would motivate your organization to add them?	Reducing spending on fuel & maintenance	Tax credits available for implementing these
How many battery electric vehicles/off0road equipment does your organization currently operate?		
Does your organization currently operate charging stations? If so, how many?		

Question	Response #1	Response #2
Organization	**Southeastern Freight Lines, Inc.**	**Clear Creek ISD**
For battery electric vehicles, how many miles do you expect your medium/heavy duty battery electric trucks and off-road equipment to travel per year?		
How much are you considering battery electric deployment in Texas if adequate incentives were available?		
If your organization is not interested, can you please explain why not?		
What are your biggest questions or concerns about battery electric vehicles? (Check all that apply)		
If you chose “Other” please explain.		
How would your organization plan to recharge these battery electric vehicles? (Check all that apply)		
What minimum level of funding does your organization need to purchase battery electric vehicles and off-road equipment?		
Will your organization need funding support to purchase and install charging stations for the above-mentioned vehicles?		
How important is it for the funding incentive to pay for both vehicles and infrastructure as a single project, versus incentives for vehicles or infrastructure separately?		
How many trucks would be in your organization’s ideal battery electric pilot project?		
If you chose “Other” please explain.		
How many hydrogen vehicles/off road equipment does your organization currently operate?		
Does your organization currently operate hydrogen fueling stations? If so, how many?		
For hydrogen vehicles, how many miles do you expect your medium/heavy-duty trucks and off-road equipment to travel per year?		
How much are you considering hydrogen deployment in Texas if adequate incentives were available?		
If your organization is not interested, can you please explain why not?		
What are your organization’s biggest questions or concerns about hydrogen vehicles? (Check all that apply)		
If you chose “Other” please explain.4		

Question	Response #1	Response #2
Organization	**Southeastern Freight Lines, Inc.**	**Clear Creek ISD**
How would your organization plan to refuel these hydrogen vehicles? (Check all that apply)		
Prefer to use publicly accessible stations What level of funding does your organization need to purchase hydrogen vehicles and off-road equipment?		
Will your organization need funding support to purchase and install hydrogen refueling infrastructure for the above-mentioned vehicles?		
How important is it for the funding incentive to pay for both vehicles and infrastructure as a single project, versus incentives for vehicles or infrastructure separately?		
How many trucks would be in your organization's ideal hydrogen pilot project?		
If you chose "Other" please explain.		
Where in Texas do you think the best locations would be for charging infrastructure to support medium/heavy duty battery electric trucks? (Please use arrows and rank in order of priority)		
If you chose "Other" please explain.		
Where in Texas do you think the best locations would be for hydrogen fueling infrastructure? (Please use arrows and rank in order of priority)		
If you chose "Other" please explain.		
What project partners does your organization require for each fleet to have in order to install a fueling station? (City, Utilities, Consultants, General Contractor, etc.)		

IH 45 Fuel Provider Zero-Emission Plans Survey:

Question	Response #1	Response #2	Response #3
Organization	**BayoTech**	**Air Products and Chemicals**	**Clear Creek ISD**
Date Completed	**2/22/2021**	**10/22/2021**	**3/11/2022**
Has your organization considered developing or adding BEV/PHEV charging infrastructure to any location in Texas?			
Does your organization plan to develop BEV/PHEV charging infrastructure in Texas within the next three (3) to five (5) years?			
Where in Texas does your organization prioritize BEV/PHEV infrastructure? Dallas-Fort Worth metroplex Houston metro area Austin metro area San Antonio metro area Strategically placed between metros along IH 10 Strategically placed between metros along IH 35 Strategically placed between metros along IH 45 No Option			
Is your organization currently working on any BEV/PHEV charging infrastructure in the State of Texas?			
Where else in the country does your organization plan on developing BEV/PHEV infrastructure?			
How many BEV/PHEV infrastructure sites is your organization planning?			
When does your organization expect the first site to be operational in Texas?			
Will this station be open to the public or will it be private?			
What is the location of this station? (City/County and/or Interchange)			
What kind of charging port(s) will your organization's station have? (Multiple answers accepted)			
Number of charging ports			

Question	Response #1	Response #2	Response #3
Organization	**BayoTech**	**Air Products and Chemicals**	**Clear Creek ISD**
Date Completed	**2/22/2021**	**10/22/2021**	**3/11/2022**
What is the annual charging capacity (kW)?			
What is the minimum megawatt capacity needed for the station?			
Who are the intended users for this facility?			
What is the average estimated capital expense (CAPEX) for this station?			
Do you wish to provide additional details for other stations your organization has planned?			
Will this station be open to the public or will it be private?			
Do any of your organization's projects underway require additional funding?			
How much funding will your organization need? (% of CAPEX)			
What would the funding be used for?			
What is the annual demand for fuel required to justify station development for BEVs?			
What is the projected timeline to develop one fueling station for BEVs?			
What partners are important in infrastructure development? (City, Utilities, Consultants, General Contractor, etc.)			
If funding were available to assist your organization cover the total project cost for developing BEV infrastructure, what is the minimum percentage of total project cost that funding must cover for your organization to consider the development?			
If your organization has not yet considered developing this type of infrastructure for BEV/PHEVs, what would motivate your organization to add these services to the existing sites? (Please use arrows and rank in order of priority)			

Question	Response #1	Response #2	Response #3
Organization	**BayoTech**	**Air Products and Chemicals**	**Clear Creek ISD**
Date Completed	**2/22/2021**	**10/22/2021**	**3/11/2022**
Has your organization ever considered developing or adding hydrogen fueling infrastructure to any location in Texas?	Yes	Yes	No
Does your organization plan to develop hydrogen fueling infrastructure in Texas within the next three (3) to five (5) years?	Yes	Yes	
What would motivate your organization to add hydrogen fueling services to your existing sites? (Please use arrows and rank in order of priority)	Funding support to add this fuel; Identifying minimum number of 'anchor' customers/getting requests for this fuel from key customers; Seeing success at other facilities that add this fueling first; Seeing market penetration of these technologies on the road in a broad sense (not specific to key customers); Policies/incentives that encourage development;	Funding support to add this fuel; Policies/incentives that encourage development; Identifying minimum number of 'anchor' customers/getting requests for this fuel from key customers; Seeing market penetration of these technologies on the road in a broad sense (not specific to key customers); Seeing success at other facilities that add this fueling first;	Funding support to add this fuel; Policies/incentives that encourage development; Seeing success at other facilities that add this fueling first; Identifying minimum number of 'anchor' customers/getting requests for this fuel from key customers; Seeing market penetration of these technologies on the road in a broad sense (not specific to key customers);
Where in Texas does your organization prioritize hydrogen fueling infrastructure?			
Has your organization commissioned any Hydrogen Refueling Stations in the State of Texas?			
Where has your organization commissioned these stations?			
Is your organization currently working on any hydrogen infrastructure in the state of Texas?			
How many hydrogen sites is your organization planning?			
Where else in the country does your organization plan on developing hydrogen infrastructure?			

Question	Response #1	Response #2	Response #3
Organization	**BayoTech**	**Air Products and Chemicals**	**Clear Creek ISD**
Date Completed	**2/22/2021**	**10/22/2021**	**3/11/2022**
Approximately what year does your organization expect the first site to be operational in Texas?			
Will this station be open to the public or will it be private?			
What is the location of this station? (City/County and/or Interchange)			
What is the annual fueling capacity?			
What is the minimum megawatt capacity needed for the station?			
Number of dispensers:			
Who are the intended users for this facility?			
What is the average estimated CAPEX for this station?			
Do you wish to provide additional details for other stations your organization has planned?			
Will this station be open to the public or will it be private?			
Do any of your organization's projects underway require additional funding?			
How much funding will your organization need? (% of CAPEX)			
What would the funding be used for?			
What is the annual demand for fuel required to justify station development for hydrogen?			
What is the projected timeline to develop one fueling station for hydrogen?			
What partners are important in infrastructure development? (City, Utilities, Consultants, General Contractor, etc.)			

Question	Response #1	Response #2	Response #3
Organization	**BayoTech**	**Air Products and Chemicals**	**Clear Creek ISD**
Date Completed	**2/22/2021**	**10/22/2021**	**3/11/2022**
If funding were available to assist your organization cover the total project cost for developing hydrogen infrastructure, what is the minimum percentage of total project cost that funding must cover for your organization to consider the development?			

Appendix 5

Visualizations from StreetLight Top Routes Analyses Conducted for IH 45 Corridor Plan

Appendix 5

Visualizations from StreetLight Top Routes Analyses Conducted for IH 45 Corridor Plan

As further detailed in Chapter 4, StreetLight offers transportation analytics based on location-based data from applications on smartphones and in-vehicle navigation devices. The software platform, StreetLight InSight® is web-accessible, and enables the user to analyze and visualize travel patterns. A feature within StreetLight enables the user to analyze travel for commercial trucks, which are tagged as medium-duty trucks (defined as 14,000 to 26,000 pounds gross vehicle weight rating or heavy-duty trucks (defined as anything over 26,000 pounds). For the purposes of this project, both medium-duty and heavy-duty trucks were included in the analysis. Notably, the source data points, or 'pings,' are linked together into anonymous truck 'trips,' and a truck trip ends when the individual truck is stationary for five or more minutes.

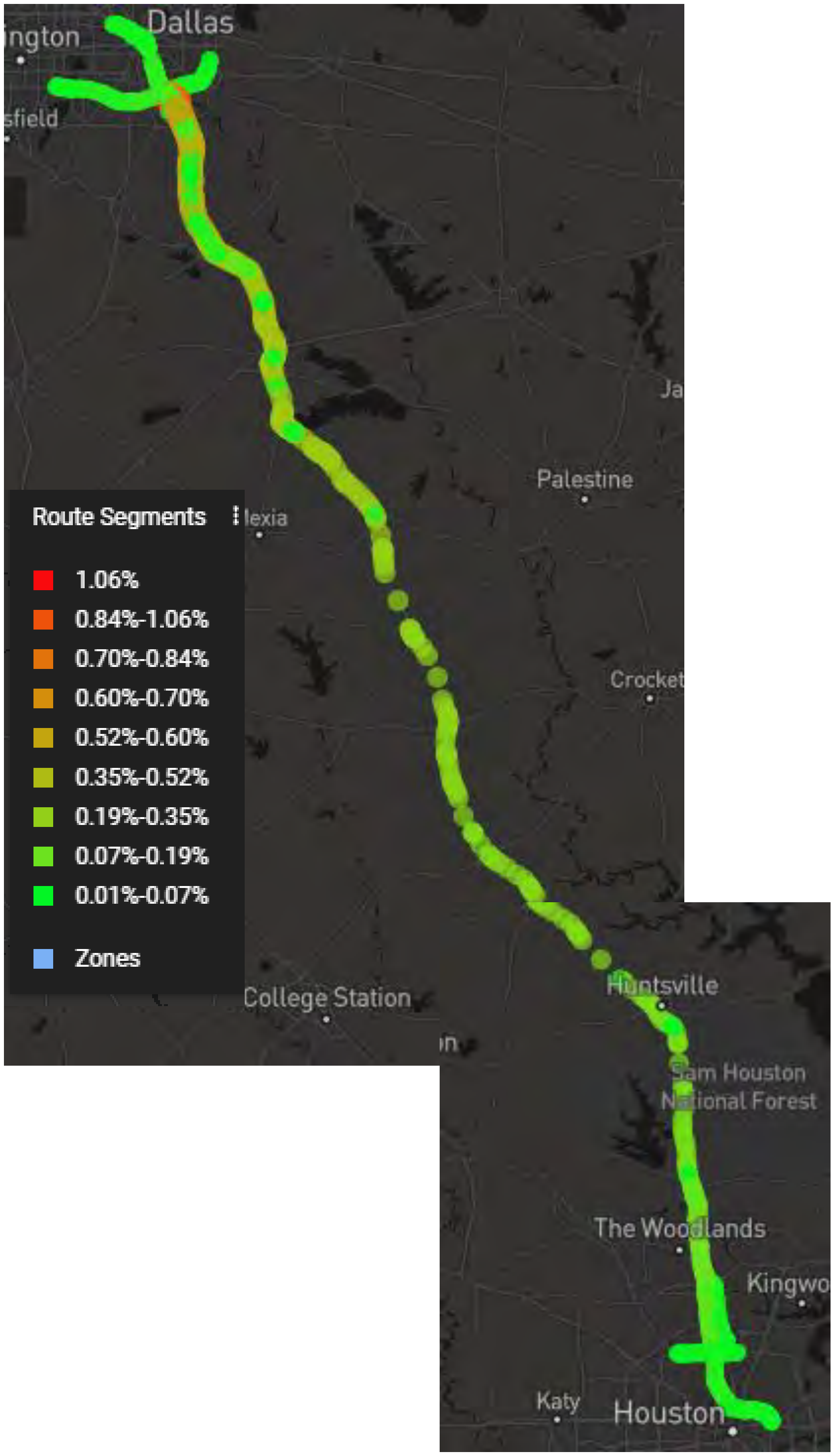
The Texas Department of Transportation (TxDOT) had a contract to access StreetLight Data's InSight® platform during the drafting of this plan. As Metropolitan Planning Organizations, the North Central Texas Council of Governments (NCTCOG) and the Houston-Galveston Area Council (H-GAC) were able to access the platform through the TxDOT contract. In collaboration with NCTCOG, Mr. Larry Meyer of H-GAC completed analysis in the platform to support development of this plan and provided the visualizations provided in this appendix. H-GAC predominantly used the "top routes" analysis method to evaluate the origins or destinations of trucks coming through defined zones along or across IH 45. This analysis was used to identify major routes taken by trucks traveling the corridor.

Analysis reflected data gathered from January 1, 2019 through December 31, 2019 to capture pre-pandemic traffic behavior. The color gradient is indicative of a magnitude of truck trips along that roadway segment, with red indicating the highest magnitude. Data was gathered for both northbound and southbound trips to understand the flow of traffic between the two regions, as well as the pattern of traffic that travels off the corridor.

Top Routes Originating from Pass-Through Zones Placed Along the IH 45 Corridor

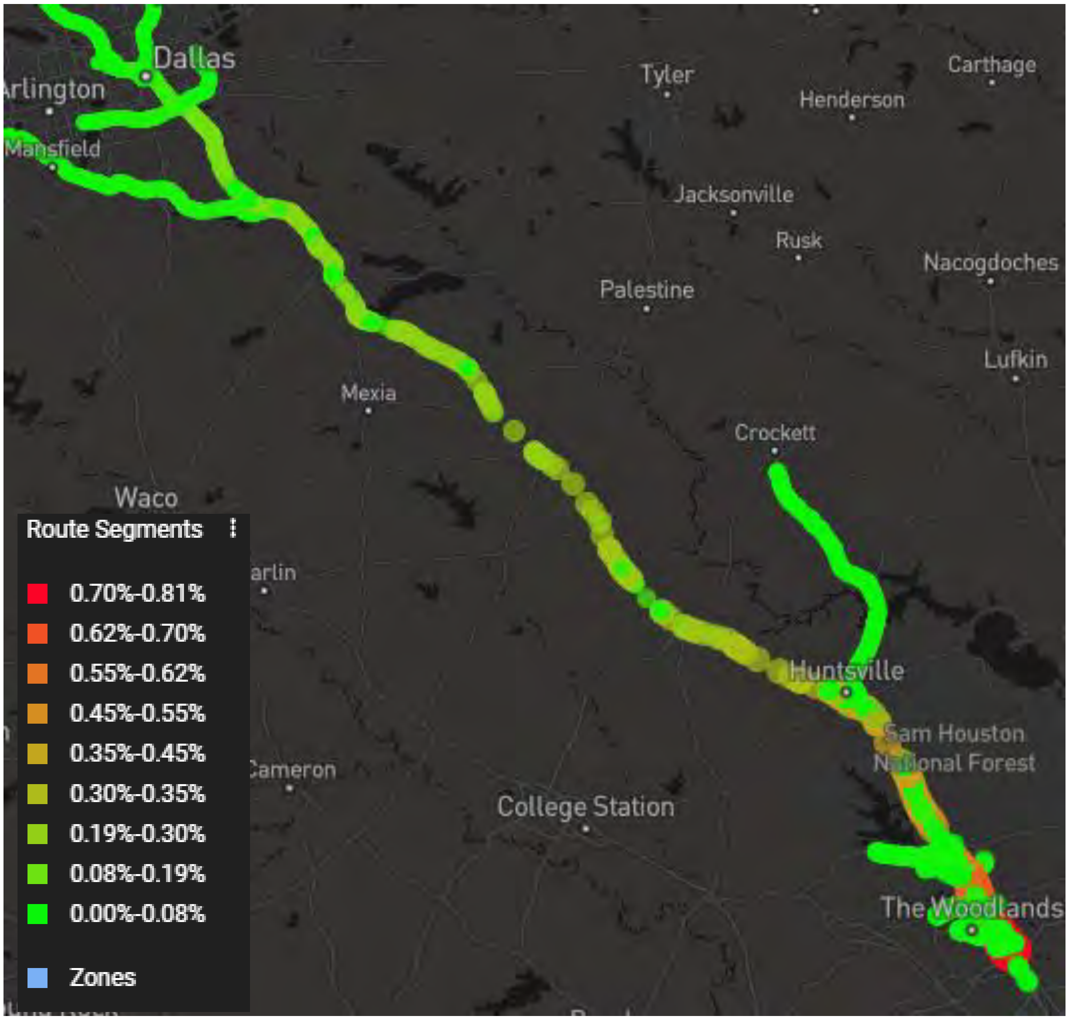
Pass-through zones, also referred to as gates, were placed on IH 45 far enough outside of the downtown areas of Dallas and Houston to isolate traffic that is leaving the urban core to travel the corridor, versus trucks that are staying within each metropolitan area. Gates were set on IH 45 south of the IH 20 interchange in Dallas, and on IH 45 just north of the interchange with SH 99/Grand Parkway. This placement captured the entirety of the corridor without crossing into the urban core. Further justification for selection of these site as corridor "endpoints" is presented in Chapter 4. Notable points at which routes turned off the corridor using this analysis were marked in the IH 45 Exit List as "Y" to indicate that trucks were using these exits.

Exhibit 1: Top Routes Analysis: Southbound Travel, Gate Placed on IH 45 Just South of IH 20
(Note: the image below includes two separate screen shots of the visualization.
Due to the proportions of the corridor, a single screen shot was not able to capture all detail.)



Key Takeaways: Most traffic stays on IH 45 southbound to Houston, with some turns occurring at the exits to the Hardy Toll Road (Exit 72/72B), Beltway 8 (Exit 60B), and IH 610 (Exit 51). The few trucks turning north on IH 45 are statistically insignificant.

Exhibit 2: Top Routes Analysis: Northbound Travel, Gate Placed on IH 45 Just North of SH 99/Grand Parkway

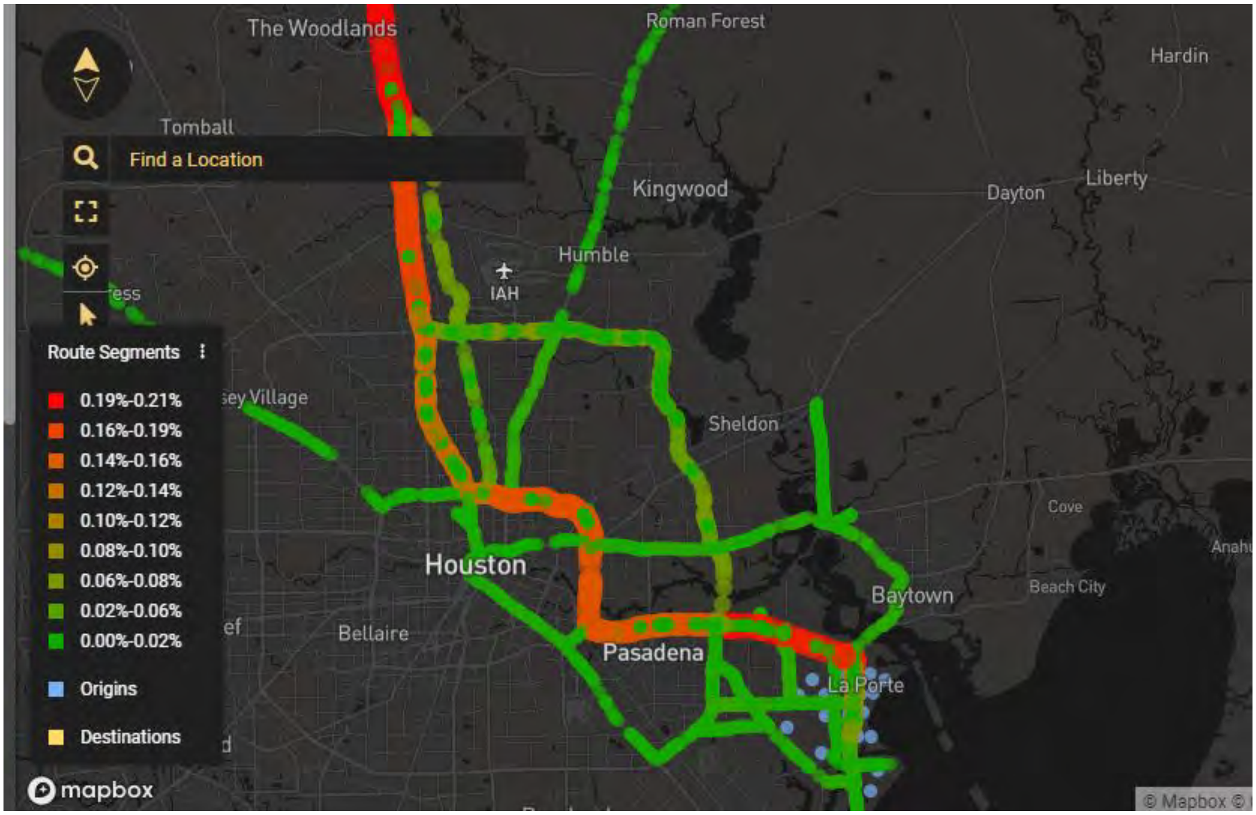


Key Takeaways: Most traffic stays northbound on IH 45, with some turns occurring at TX 19 (Exit 113/112) in Huntsville, US 287 N (Exit 247) in Ennis, and IH 20 (Exit 276A/B) in Dallas.

Top Routes Originating from Freight-Oriented Developments

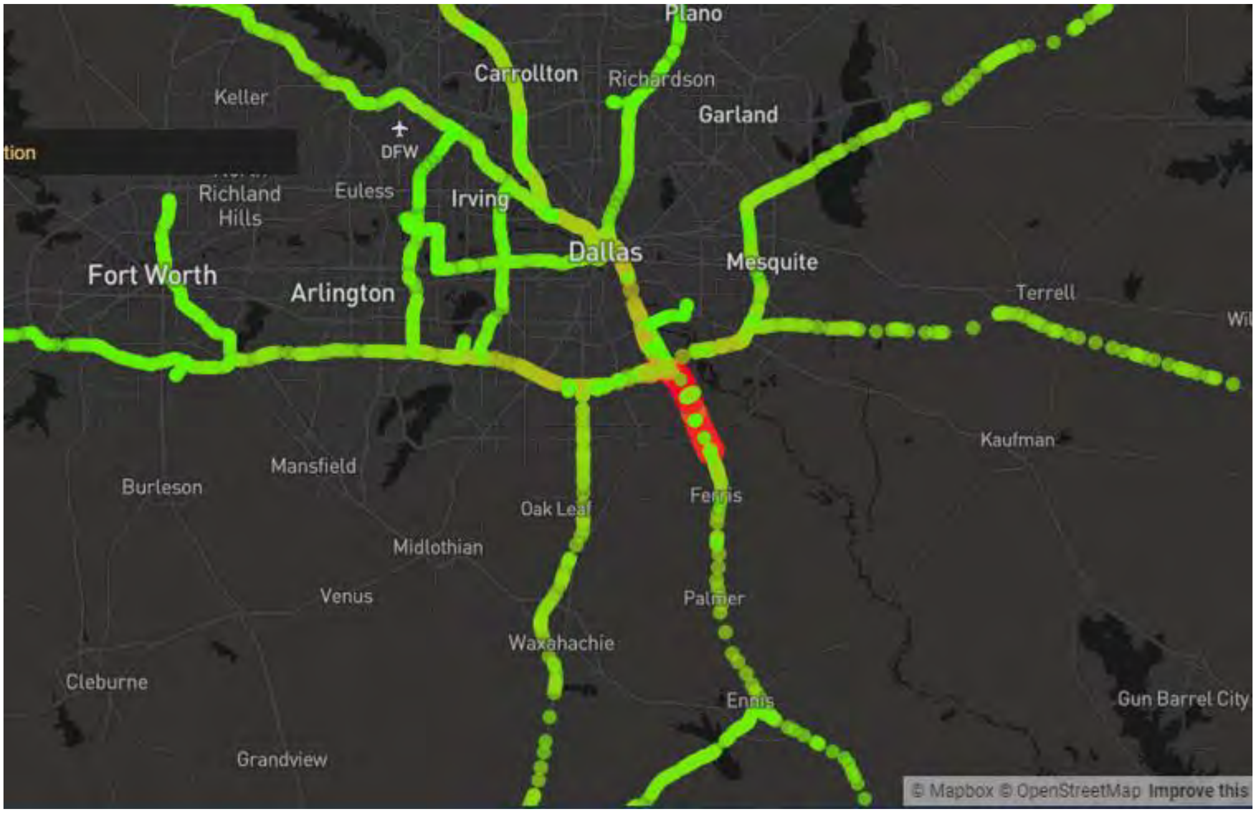
Second, Top Routes analysis originating at a zone placed at freight-oriented developments was conducted for large freight-oriented developments near the corridor in both Houston and Dallas. This was done to determine if large freight centers resulted in a substantial amount of truck traffic that followed different routes.

Exhibit 3: Top Routes Analysis: Non-Pass-Through Zones at the La Porte Freight-Oriented Development



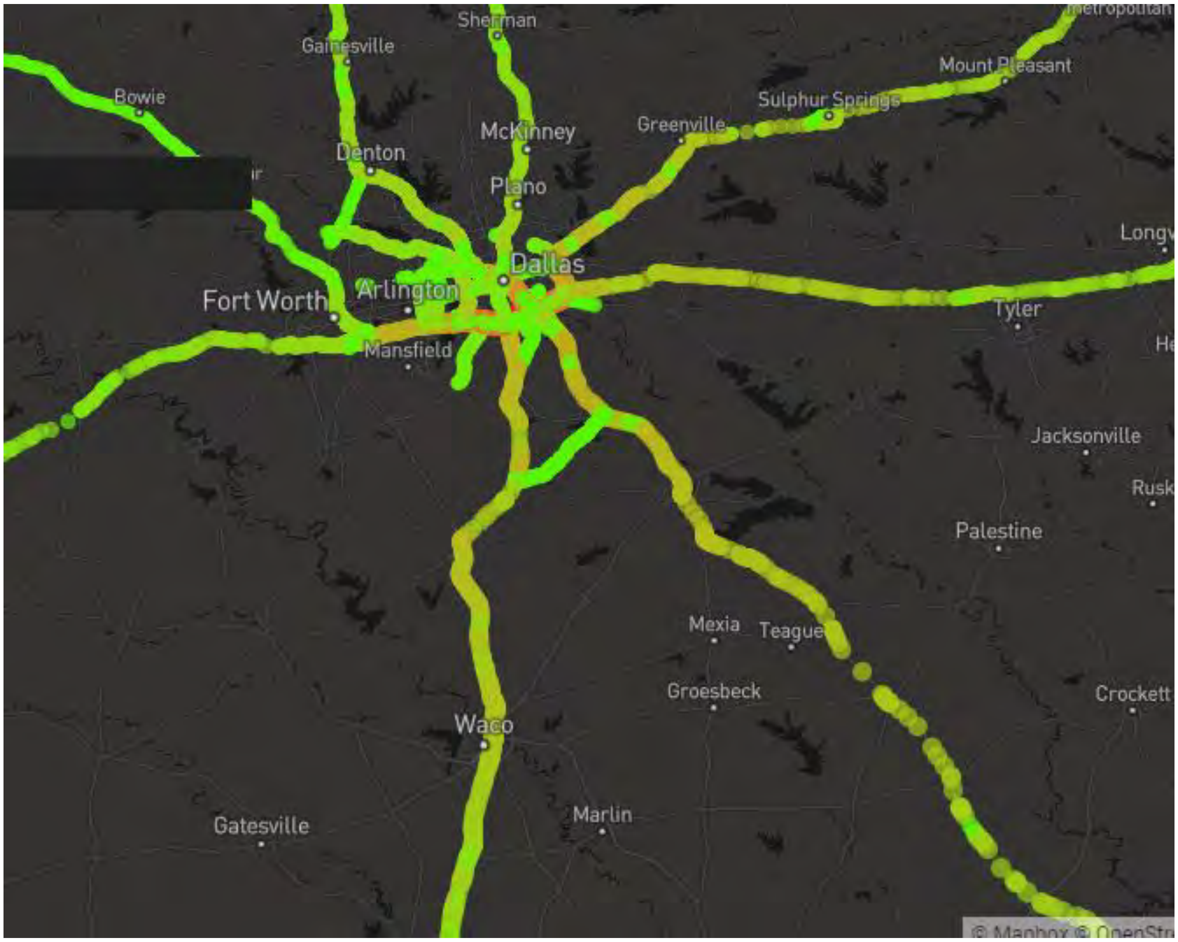
Key Takeaways: Truck traffic that leaves the freight-oriented development largely follows the IH 610 Loop around Houston, then continues to IH 45 traveling northbound, entering the Interstate near Exit 51.

Exhibit 4: Top Routes Analysis: Non-Pass-Through Zones at Freight-Oriented Developments in Ennis, TX



Key Takeaways: Traffic mostly travels north on IH 45 towards Dallas, then disperses throughout the region using main arterial Interstates and highways such as IH 20 (Exit 276A/B).

Exhibit 5: Top Routes Analysis: Non-Pass-Through Zones at the South Dallas Inland Port Freight-Oriented Development



Key Takeaways: Traffic appears to be widely dispersed. The traffic that did travel southbound towards Houston stayed on IH 45 and did not turn off until TX 99 (Exit 71A) and IH 610 (Exit 51), following previously observed routes.

North Central Texas Council of Governments

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