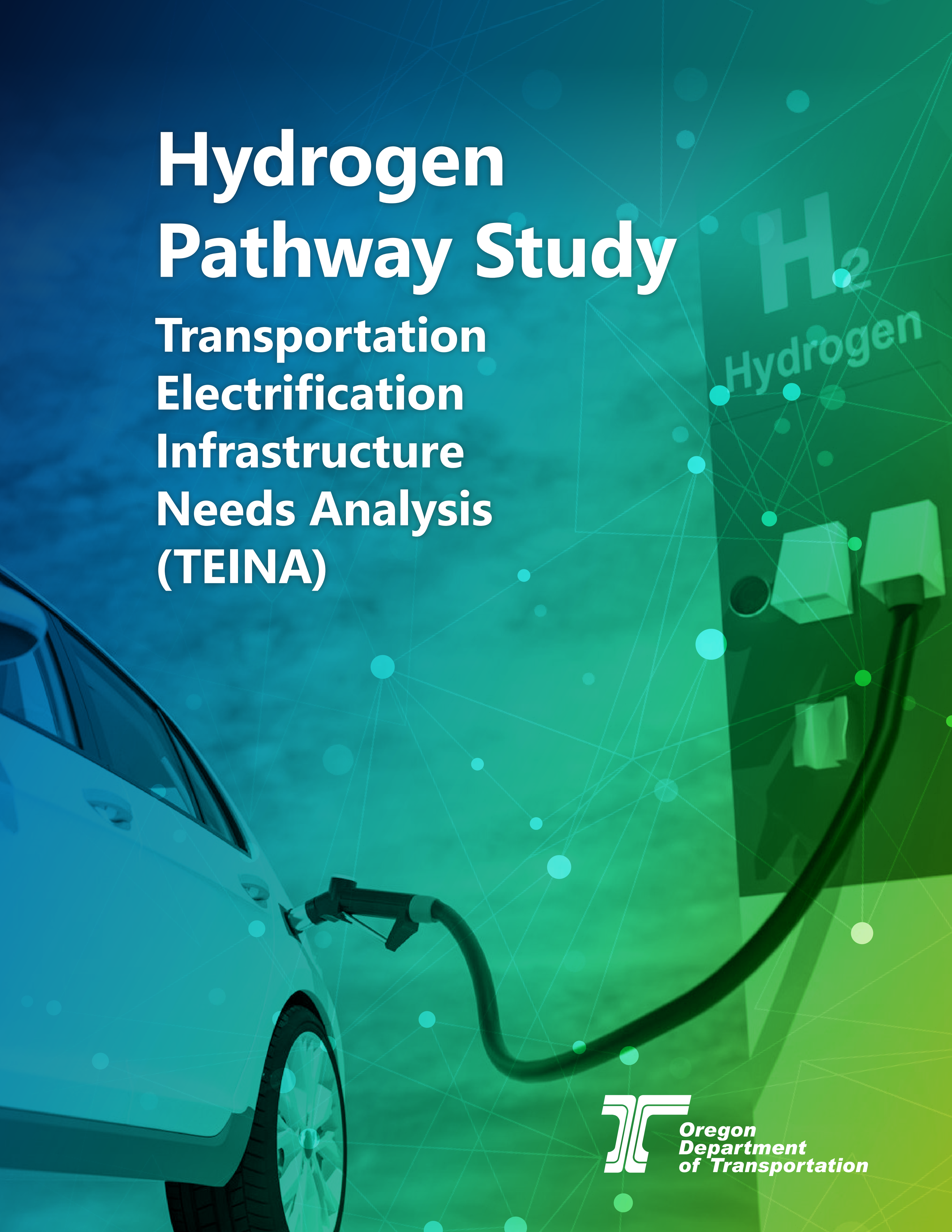
Hydrogen Pathway Study

Transportation Electrification Infrastructure Needs Analysis (TEINA)



Oregon Department of Transportation

Foreword

This report was produced by the Oregon Department of Transportation's Climate Office under the guidance and direction of Mary Brazell (Agency Project Manager), Suzanne Carlson (Climate Office Director), and Jillian DiMedio. The consultant project team that assisted the Climate Office in the production of this report included Wayne Kittelson (project manager) and Susan Mah, Kittelson & Associates (prime contractor); and Britta Gross and Aradhana Gahlaut, RMI. The project received additional feedback and suggestions from an Advisory Group consisting of Greg Alderson, Portland General Electric; Michael Graham, Columbia-Willamette Clean Cities Coalition; Nathan Hill and Diego Quevedo, Daimler Trucks; Whit Jamieson and Rhett Lawrence, Forth; Chris Kroeker, NW Natural; Victoria Paykar, Climate Solutions; Bill Peters, Department of Environmental Quality; Esther Pullido and Kate Hawley, Pacific Power; Evan Ramsey, Bonneville Environmental Foundation; Juan Serpa Munoz, Eugene Water & Electric Board; Jairaj Singh, Unite Oregon; Rebecca Smith, Oregon Department of Energy; and Martina Steinkusz, Renewable Hydrogen Alliance. The Oregon Department of Transportation and the consultant project team acknowledge with sincere appreciation the feedback and suggestions provided by the Advisory Group members while also noting that the members were not asked and have not formally endorsed the content of this Study.

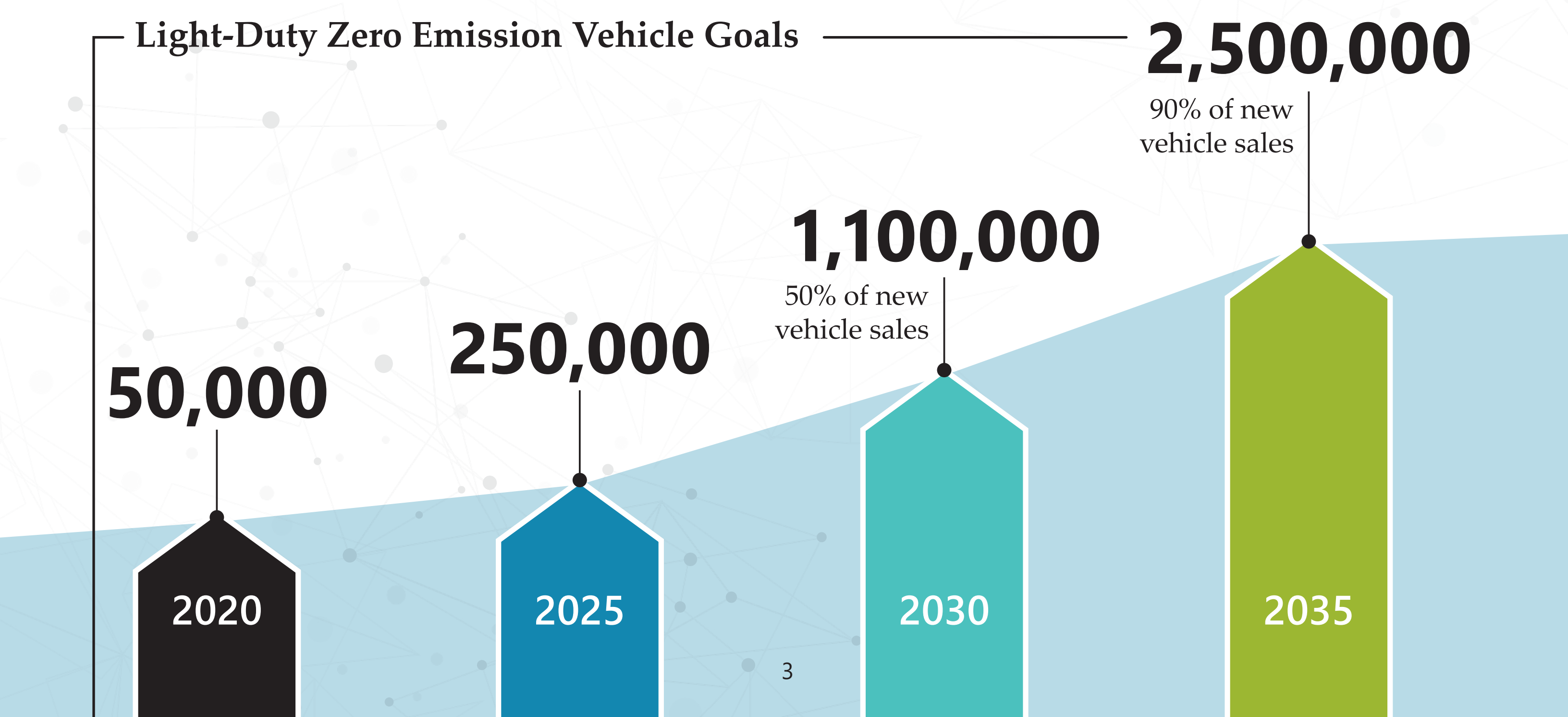
Executive Summary

Transitioning to electrically-powered vehicles can quickly reduce greenhouse gas (GHG) emissions from driving. Vehicles that are powered by electricity are referred to as zero-emission vehicles or ZEVs. ZEVs will play an important role in helping meet the GHG reduction targets in Oregon, where the transportation sector is responsible for nearly 40 percent of the state's GHG emissions.

The electricity used by ZEVs can be stored in batteries or generated in real time through the use of a fuel cell. A fuel cell electric vehicle, or FCEV, is a fully electric vehicle that generates its own electricity by combining oxygen from the air with hydrogen from an onboard storage tank, emitting only water vapor and heat from the vehicle. Both battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs) are viable technologies that have already reached the consumer market. The BEV market is currently much larger and more mature, but the FCEV market is growing and is becoming more cost-competitive as the industry scales. In addition to providing a zero-emission solution, fuel cell vehicle technology offers several key advantages, including longer driving range and quicker fueling times. These are increasingly attractive features when addressing the more challenging on-road mobility use cases such as long-haul trucking.

In support of electrically-powered vehicles and reduced GHG emissions, Oregon established a series of zero-emission vehicle adoption goals in Senate Bill 1044 as shown in **Figure 1**. These goals culminate with 90 percent of light-duty vehicle (LDV) sales within the state being ZEVs by 2035.

Figure 1 . Light-Duty Zero Emission Vehicle goals established in Senate Bill 1044 (Oregon Department of Transportation, 2021)



In July 2021, the Oregon Department of Transportation (ODOT) released the Transportation Electrification Infrastructure Needs Analysis (TEINA), which quantified the charging infrastructure needed to achieve the goals set forth in Senate Bill 1044. The TEINA estimates were based on the assumption that the ZEV targets shown in **Figure 1** would be met entirely by battery electric technology. This Study considers an additional scenario in which a percentage of Oregon's ZEV sales are met by hydrogen fuel cell electric vehicles, and then assesses the fueling infrastructure needs to support this potential fleet of hydrogen cars, trucks and buses.

As in the earlier TEINA study, this focused look at hydrogen fueling needs assumes only a top-down state requirement. It does not reflect a bottom-up fleet needs assessment, nor an estimate of what is possible or likely to happen relative to transitioning to a hydrogen-based on-road mobility system. Thus, the implementation timeline presented in this Study could be quite different from what occurs, including a significant acceleration due to external factors. For example, more concerted hydrogen-related efforts of federal, state, or local governments could accelerate the projected timeline, as could a more rapid development of the zero-emission interests and needs of industry and fleets.

The goal of this Study is to inform future efforts in Oregon by providing an overview of current hydrogen activities in the light-duty, medium-duty, and heavy-duty transportation sectors today; the requirements and estimated capital costs of building out a hydrogen fueling station network to meet state goals; and recommendations that Oregon might consider to support an evolving hydrogen market going forward. As in the earlier TEINA study, upstream hydrogen production and delivery, though a critical consideration in developing an overall hydrogen strategy, is not addressed in this study. The Oregon Department of Energy (ODOE) is currently conducting a parallel study, due to the state legislature by September 2022, of the benefits and barriers to the production and consumption of renewable hydrogen in Oregon.

This Study found a supportive policy landscape in Oregon, where hydrogen and fuel cell vehicles are recognized in state goals, clean vehicle rebates and clean fuels credit programs. There is broad stakeholder interest in locally and renewably produced hydrogen. There is also growing fleet and utility interest in opportunities and potential solutions offered by both hydrogen and fuel cell electric vehicles. Among other activities in Oregon, this Study describes the hydrogen-related efforts of the Portland area transit system (TriMet), Eugene Water & Electric Board (EWEB), and Daimler Trucks North America. Fleet operators seem to be coalescing around a common interest in finding zero-emission solutions to the more challenging on-road mobility use cases, including longer transit bus routes, fleets with continuous 24/7 operations, and long-haul trucking. Where battery technology today can quite easily solve most mobility needs, these challenging scenarios are causing fleets to investigate potential hydrogen fuel cell solutions.

As in the original TEINA study, the targets for light-duty vehicles (LDV) are based on the state's SB 1044 goals - adjusted to assume that FCEVs make up 5% of urban LDV ZEVs in 2035. Since SB 1044 does not, however, provide state targets for transit buses, medium-duty or heavy-duty vehicles, this Study has adopted the same methodology used in the original TEINA study for projecting ZEVs for these additional use cases to ensure a consistent approach. This Study assumes 10% of the ZEV buses in TEINA are fuel cell buses, and it assumes 10% of all medium-duty truck electric vehicle miles traveled (e-VMT) and 25% of all heavy-duty truck e-VMT is met by hydrogen fuel cell electric trucks. The 2035 targets assumed by use case are summarized in **Table 1.**

Table 1 .2035 FCEV Target Assumptions by Use Case

Use Case	Target Assumptions
Light-Duty Vehicles	5% of urban light-duty ZEVs are FCEVs
Transit Buses	10% of TEINA e-buses are FCEVs
Medium-Duty Vehicles	10% of medium-duty TEINA e-VMT are FCEVs
Heavy-Duty Vehicles	25% of heavy-duty TEINA e-VMT are FCEVs

Note: The LDV Highway Corridor use case is a function of the daily traffic of the LDV use case.

This target-driven analysis determined that 47 public hydrogen fueling stations would be required in 2035 to serve hydrogen vehicles in the light-duty vehicle sector. An additional 19 fueling stations would be required to serve medium-duty and heavy-duty vehicles, including both transit buses and the additional demand from Washington and California's Class 8[1] hydrogen trucks that travel across Oregon's highway system. The capital cost of establishing this network is estimated at $232.5 million.

Table 2 .H_2 Fueling Station Infrastructure Costs (Cumulative)

		2025		2030		2035		
Use Case	Assumed Capital Cost/ Station	# Stations	Total Capital Cost	# Stations	Total Capital Cost	# Stations	Total Capital Cost	Assumed Capacity
Light-Duty Vehicles: Urban	$1.9M	0	0	1	$2M	33	$63M	1,500kg
Light-Duty Vehicles: Corridor	$1.9M	6	$11M	7	$13M	14	$27M	1,500kg
Total Light-Duty Vehicles		*6*	*$11M*	*8*	*$15M*	*47*	*$90M*	
Medium-Duty Vehicles	$7.5M	0	0	1	$7.5M	8	$60M	5,000kg
Heavy-Duty Vehicles	$7.5M	0	0	1	$7.5M	6	$45M	5,000kg
Transit Buses	$7.5M	0	0	1	$7.5M	5	$37.5M	5,000kg
Total Medium-and Heavy-Duty Vehicles		*0*	*0*	*3*	*$22.5M*	*19*	*$142.5M*	
Capital Costs Total			**$11M**		**$37.5M**		**$232.5M**	

1 A "Class 8" truck is a Heavy-Duty truck with a Gross Vehicle Weight Rating (GVWR) of 33,001 pounds or more.

The modeling performed for this Study has assumed a relatively slow startup to FCEV deployments in Oregon in the pre-2025 timeframe due to several factors: the lack of current FCEV product availability across sectors; the constrained hydrogen vehicle production capacity of automakers; and the limited geographic areas of FCEV deployment (e.g. automakers are currently focused on California). Beyond 2025, FCEV ramp-up curve an exponential growth curve to meet 2035 targets. Although these targets may appear conservative, the lead time necessary to install five public hydrogen fueling stations by 2025 would require preparatory activities to begin very soon. Furthermore, the availability of hydrogen fueling infrastructure is an important prerequisite to developing the fuel cell vehicle market in the first place. These factors, combined with others discussed in this Study, can significantly influence the pace of FCEV adoption and the broader use of hydrogen across the state and region.

This Study recommends a phased approach to actions that can be taken in the near-term (2022-2023), mid-term (2024-2027), and the longer-term (2028-2035). These actions will establish a collaborative relationship between Oregon's state agencies and other leading public and private stakeholders that is key to understanding the evolving market needs. Given the rapidly growing need to transition to a zero-emission economy, this Study also suggests the leading market indicators to watch for critical signs that the fuel cell vehicle market is evolving sooner or more rapidly than is projected in this analysis. This awareness will allow Oregon to more effectively plan for a future hydrogen fuel cell vehicle market.

Table 3 . Study Recommendations

	Near-term (2022-2023)	**Mid-term** (2024-2027)	**Longer-term** (2028-2035)
KEY ACTIONS	• Assess hydrogen market regularly and coordinate interests • Engage with regional stakeholders • Support industry-led technology demonstrations and pilot projects • Support policies enabling FCEVs and local, low or zero-carbon hydrogen production • Ensure statewide regulations and processes enable FCEVs and hydrogen fueling infrastructure siting	• Establish a statewide hydrogen planning effort • Coordinate fleet interests in hydrogen • Coordinate a regional corridor • Develop and invest in pilot projects • Consider establishing targets • Pursue federal funding opportunities	• Continue to leverage the statewide hydrogen planning effort • Continue to support regional coordination • Transition from pilot projects to scale • Establish a consumer and fleet awareness program

WATCH FOR
(Leading Indicators)

Commercial fleet activity – interest in pilots, FCEV purchase announcements	**OEM activity –** expanding FCEV production and geographical footprint	**California activity –** heavy-duty highway corridor investments encouraging interstate travel	**Fueling provider activity –** station network announcements, investments, fueling/ fleet/OEM partnerships	**H_2 production activity –** utility engagement, ramp-up in local hydrogen production, improving H_2 economics	**Federal policy –** major funding commitments, stricter heavy-duty emission standards

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