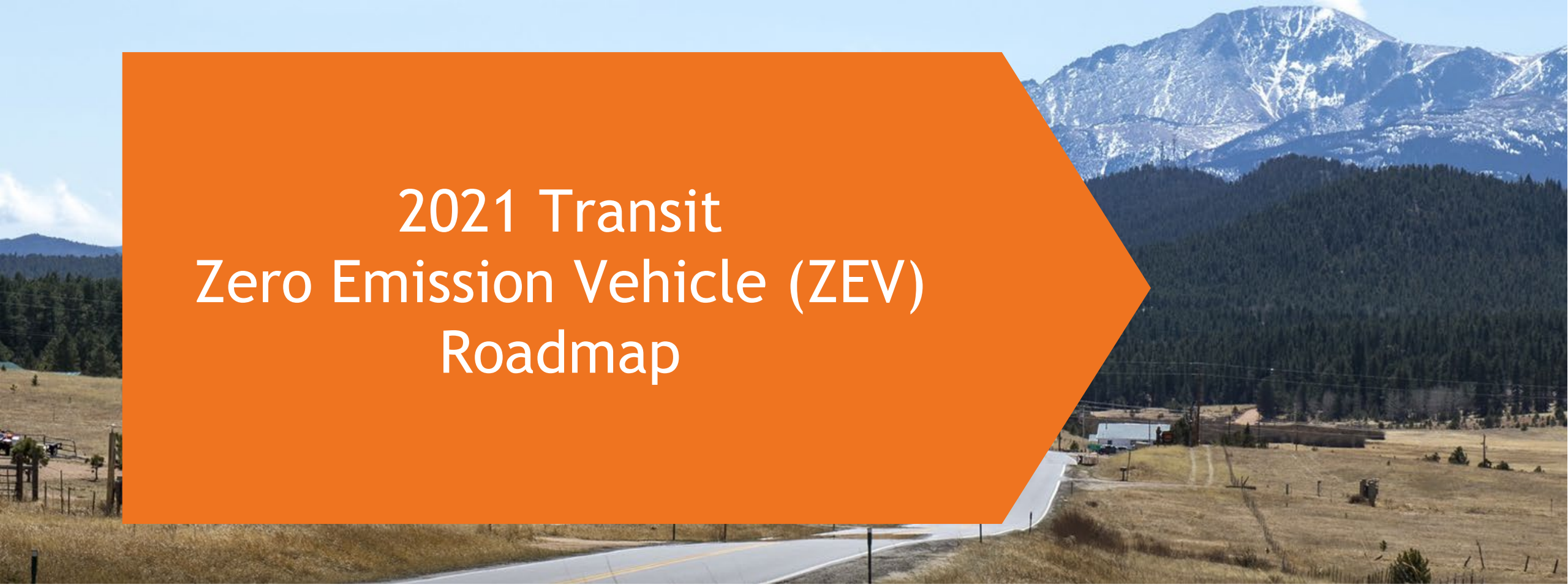


2021 Transit Zero Emission Vehicle (ZEV) Roadmap

COLORADO
Department of Transportation

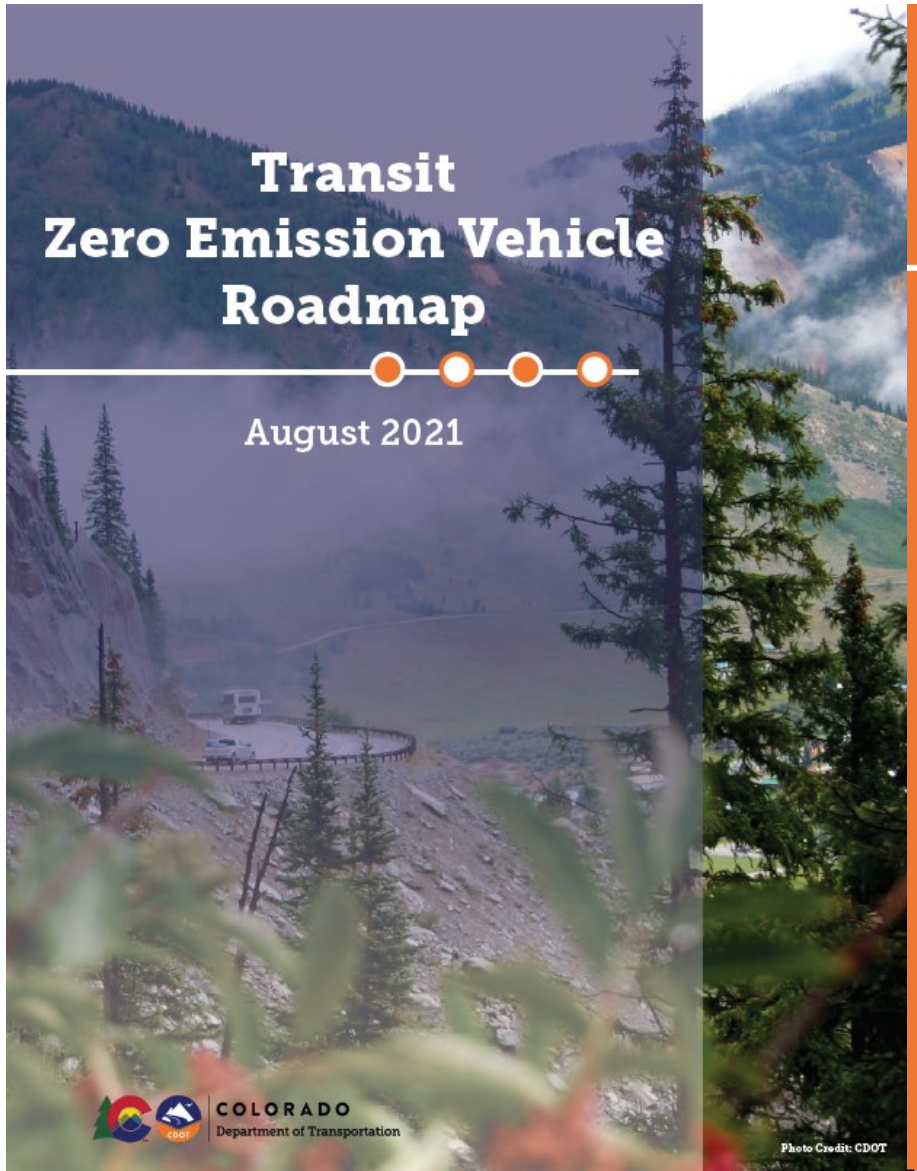
FELSBURG HOLT & ULLEVIG
connecting & enhancing communities

Transit & Rail Advisory Committee
September 10,2021

Transit ZEV Roadmap Project Overview

- Data collection, research, and documentation
- Outreach and engagement
- Develop strategies, policy tools, timelines, and responsibilities
- Craft comprehensive Transit ZEV Roadmap/ Integrate findings from other studies
- Gather stakeholder input on draft plan; address comments and finalize plan

DRAFT ZEV Transit Roadmap



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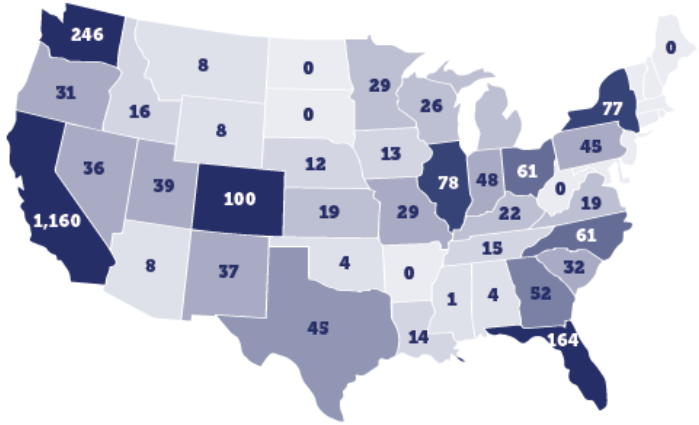
National Transit ZEV Trends

National ZEV Transit Trends

Advancing ZEV transit fleets faces several challenges and barriers to realizing the full financial and environmental benefits of the next generation of transit vehicles. There is increasing national experience transitioning transit fleets to ZEVs, as shown on Figure 1.

Figure 1: 2020 ZEV Transit Buses Deployed, On Order, or Soon to be on Order in the US[1]



Transit agencies must adapt to and embrace new vehicle standards, products and changing mobility needs. In addition to contemplating ZEV fleet adoption, many transit agencies are simultaneously evaluating service and technology changes including integration of mobility-on-demand and mobility-as-a-service options. Remaining on the cutting edge of new transit technology and ZEV planning should be evaluated at the local level with awareness and context of national trends and best practices.

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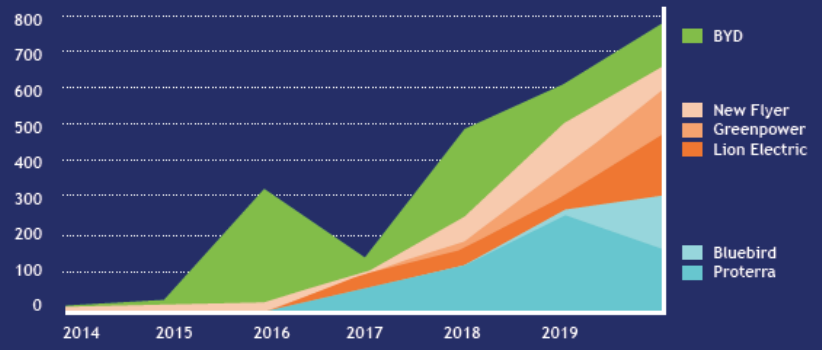
Vehicle Availability

Full sized electric buses have been commercially available and their use has been increasing for over a decade. At the beginning of 2020, approximately 180 transit agencies were operating over 850 electric transit buses throughout the US with an additional 1,000 vehicles on order for delivery by 2022.[2]

Decreasing battery and electricity costs have contributed to the growth of the battery electric ZEV market. Proterra has dominated the American ZEV bus market but faces competition from GreenPower, New Flyer, and BYD. The traditional transit vehicle OEMs - New Flyer, Gillig and Nova Bus - have collaborated with zero-emission powertrain suppliers to develop battery electric models to retain their market share.[2]

Figure 2 provides a summary of zero emission bus sales in North America from manufacturers with at least 10 models. Appendix A provides detailed information about the state of zero emission transit vehicle model availability.

Figure 2. North American Zero Emission Bus Sales (2014-2020)[3]



Manufacturers that initially focused on full-size electric transit buses are pivoting to integrate medium- and small-size cutaway vehicles into their vehicle portfolios to meet the growing demand for vehicle offerings in this market segment. Given the various needs and service delivery models across Colorado, additional ZEV types will support faster adoption of ZEVs as cutaway vehicles make up approximately 25 percent of Colorado's existing transit fleet. ZEV deployment should occur as proven vehicle models are available to meet current and future transit needs. In Colorado, this means vehicles must be able to operate with extended range to serve rural areas and vehicles must be able to operate successfully in areas with cold climates and steep grades.

Page 6

Barriers & Lessons Learned

Barriers to ZEV Fleet Adoption

A comprehensive literature review identified the following barriers to ZEV fleet adoption. These barriers provided context to inform the development of strategies for the Transit ZEV Roadmap for the state, transit agencies and other stakeholders to support a 100 percent transition of Colorado's transit fleet to ZEVs by 2050.

Knowledge Barriers

Lack of understanding of the technical, planning, financial, and governance factors critical to successful ZEV implementation.

- Lack of access to sufficient, reliable, and up-to-date information to conduct a thorough assessment of the feasibility of adopting a ZEV fleet
- Changes to operational characteristics and maintenance requirements of ZEV vehicles, including training for drivers, technicians, and other staff
- Need for new infrastructure planning processes and tools to evaluate the transition to a ZEV fleet
- Need for modified vehicle replacement and procurement processes
- Need for new implementation strategies for maintaining and operating a ZEV fleet
- Design challenges associated with increased space requirements for installing ZEV charging and fueling infrastructure

Technological Barriers

Currently available ZEV transit models cannot meet the range of transit service needs.

- Advancement of battery technologies to improve vehicle range and the ability to operate in environments with varying grades and temperatures
- Required complementary evolution of the electric grid to accommodate charging
- Limited hydrogen fuel availability and affordability - The Colorado Hydrogen Roadmap will be critical to understanding the full impact of this barrier

Financial Barriers

The cost of transit ZEVs is approximately double that of internal combustion engine vehicles, which in combination with the high cost of infrastructure upgrades and the limited experience of transit agencies working with utilities to understand and design electric rates results in significant financial barriers to fleet fleet transition.

- High upfront costs associated with ZEV options relative to traditional transit vehicle options
- Need for more options for financing higher capital costs associated with ZEVs, including mechanisms for accounting for total cost of ownership (TCO) vs. upfront capital costs
- High capital costs associated with required grid infrastructure upgrades and charging equipment
- Lack of familiarity with energy vs. demand charges and impacts on operating costs and/or availability of ZEV charging rates
- The higher purchase prices of ZEVs often forces transit agencies to re-evaluate budgets to decide whether to prioritize capital investment in higher cost vehicles often at the expense of the operating budget.

Institutional Barriers

Transit agency and utility service territories cover diverse and dynamic geographic areas. Colorado utilities and transit agencies have varying levels of experience and inconsistent processes for coordinating across jurisdictional boundaries to meet service planning and transmission distribution planning needs that may lead to regulatory delays.

- Need to address different operating environments (e.g., terrain, weather, population distribution).
- Need for unprecedented coordination between transit agencies and utilities
- Range of experience coordinating across jurisdictional boundaries to meet transit service planning and electrical grid transmission/distribution planning needs
- Need for supporting transit electric infrastructure to be integrated into transmission and distribution system planning
- Need for regulatory agencies to develop processes to expedite infrastructure investments to ensure ZEV goals are attainable

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Fleet Electrification Readiness

Transit agency fleets that have had successful ZEV transitions complete the following actions. Additional information on each fleet electrification readiness action. Appendix A, includes several case studies and lessons learned from ZEV deployment.

Conduct a fleet-wide assessment to develop short- and long-term ZEV transition goals

- Plan for incremental deployment/demonstration projects to verify how well different ZEV options meet the range of fleet needs and to refine ZEV charging and maintenance schedules
- Identify representative routes to model energy and vehicle range requirements
- Evaluate impacts of unique geographic and service characteristics to identify necessary strategies to prevent service quality impacts

Leverage long-term planning goals to maximize use of available funding

- Long-term utility infrastructure sizing (make-ready investments such as upsizing transformer pads or laying additional conduit) strategies add minor additional costs to earlier deployments, but will reduce overall long-term costs

Develop phased plans to upgrade/retrofit maintenance facilities and bus depots

- Assess installation, space and power requirements for short- and long-term fueling infrastructure needs
- Ensure clear communication with new vendors to reduce costs associated with incremental retrofitting
- Evaluate and plan for land purchases to house current and future transit fleets
- Battery Electric Bus - Upgrade/retrofit bus yards to accommodate additional equipment and evaluate potential to use gantries for overhead depot charging or cord management
- Fuel-Cell Electric Vehicle Infrastructure - Evaluate opportunities to retrofit existing fuel storage and CNG fueling stations for compressed hydrogen fuel

Consult early and often with electric utilities to plan for electric infrastructure needs, review rate schedules and collaborate to develop mutually beneficial incentives or pilot programs

- Review reliability reports to understand the frequency and types of outages that have occurred and develop resiliency plans with utilities

Provide proactive training for operations and maintenance staff

- Consult with labor unions to ensure needed accommodations are implemented in deployment plan

Involve diverse stakeholders early in the planning and transition process

- Internal Stakeholders to include: Operations and planning, maintenance and engineering, training, facilities, finance procurement, IT, sustainability manager, contract operators, board or executive leadership, public information officers
- External Stakeholders to include: governmental agencies, electric utilities, labor unions, environmental justice representatives, surrounding communities and other interest groups

Photo Credit: RTD Flickr

Colorado ZEV Environment

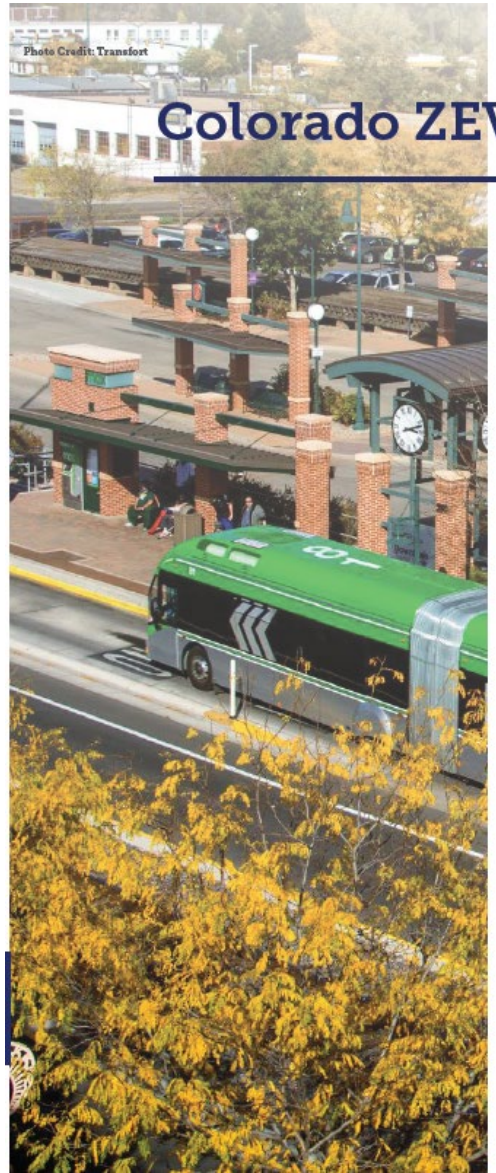
Photo Credit: Transfort

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Colorado ZEV Environment

Current Fleet Snapshot

Colorado is home to a variety of transit options operated by public, private, and non-profit agencies. Transit service across the state includes bus service (local, regional, interregional, intercity), passenger rail service (light rail, commuter rail) and human services transportation.

The current fleet inventory includes open door, general public transit services. This section summarizes the transit agencies and providers included in the Transit ZEV Roadmap. The inventory of the existing general public transit fleet in Colorado was developed referencing the 2045 Statewide Transit Plan (STP), associated rural Regional Transit Plans, federal transit data, and CDOT collected transit fleet information.

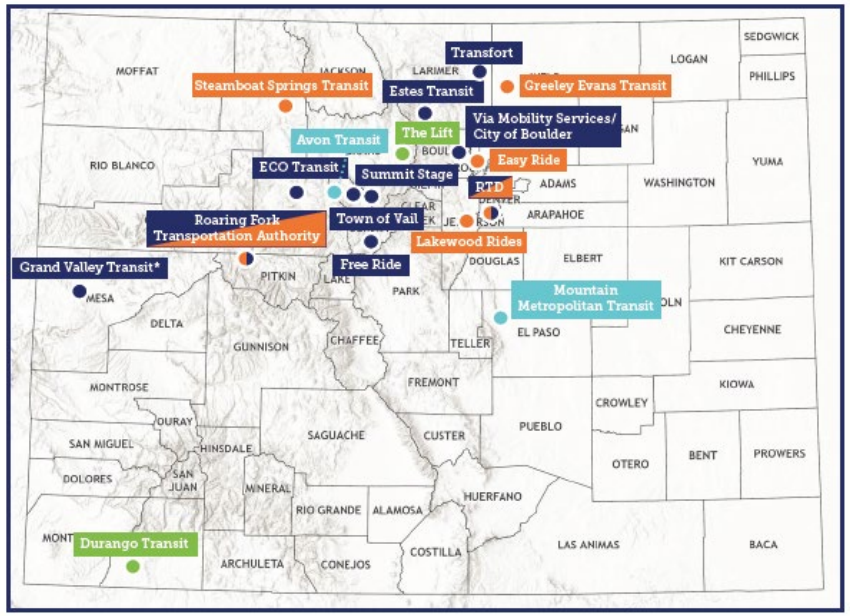
Several databases and resources provide information critical to understanding the current composition of the larger Colorado transit fleet, including:

- Colorado Transit and Rail Awards Management System (COTRAMS) Capital Inventory records
- CDOT's Transit Asset Inventory Master Database
- 2018 Colorado DOT Transit Asset Management Group Plan
- FTA's National Transit Database (NTD) Annual Vehicle Tables

Additional information about the current reporting of transit fleet asset information, including information about which agencies report to each of the above noted databases, is included in Appendix C.

State of Transit ZEVs in Colorado

Ten transit agencies across the State of Colorado have begun operating ZEVs or currently have them on order. Additionally, eight agencies have completed, are in the process, or will be completing a ZEV Transition Plan in the near future.



*Grand Valley Transit uses Renewable Natural Gas (RNG) for 50% of its operations; the remaining 50% uses Xcel Energy natural gas.

- Operating ZEVS
- ZEVs Ordered (not yet in operation)
- Fleet Transition Plan Complete
- Fleet Transition Plan Underway/Imminent

Renewable Natural Gas Defined:

Renewable natural gas (RNG) is natural gas captured from sources such as wastewater treatment plants, landfills, etc. RNG is often considered a carbon-neutral fuel because the carbon it emits via combustion originates from organic sources that absorbed carbon dioxide from the atmosphere during photosynthesis. RNG that is captured from organic waste that would otherwise decay causing methane emissions can be carbon-negative energy sources.

The Role of Utilities

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The Role of Utilities in Transit Fleet Electrification

Colorado is home to 50+ public transportation providers and 50+ electric utilities, highlighting the importance of coordinated planning for BEB deployment. Local electric utilities play an essential role in any successful ZEV planning and implementation process. Utilities have a responsibility to provide customers with reliable electrical service. Proactive coordination between the local utility and transit agency allows both entities to identify fleet electrification needs and constraints early in the process to support ease of implementation.

Utility coordination and collaboration can help reduce the limitations of BEB deployments, including:

- Fleet charging time/scheduling requirements
- Estimating operating costs associated with charging
- High upfront infrastructure capital costs

Electric utilities have the necessary experience to support the expansion of ZEV transit infrastructure at a scale large enough to meaningfully impact the feasibility of transit electrification. Program development and strategic rate design to incentize charging behaviors that benefit customers and society can expand the cost savings and emission reduction potential of transit electrification.

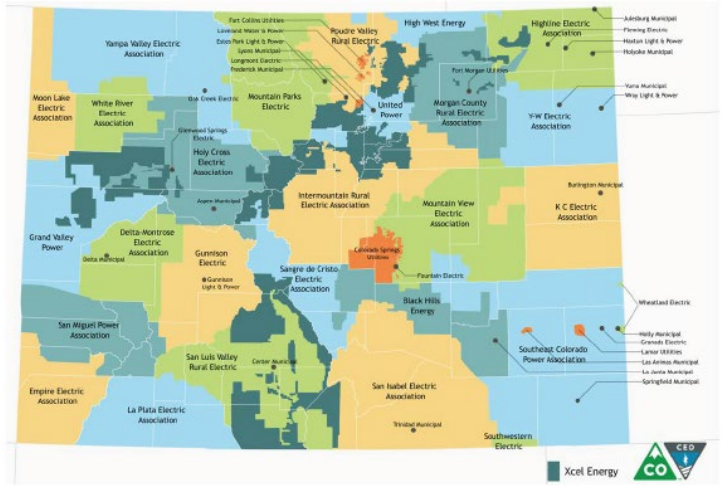
Colorado electricity customers are served by a combination of retail investor-owned utilities, cooperative utilities, and municipal owned utilities. Investor-owned utilities (IOUs) are for-profit monopolies regulated by the Colorado Public Utilities Commission (CPUC).

Figure 5 provides a comparison of electric utility models. Colorado electric utilities' service territories are shown in Figure 6.

Figure 5: Types of Electric Utility Providers in Colorado

	IOU *Investor Owned Utility*	MUNICIPAL UTILITY	CO-OP *Cooperative Utility*
Structure:	Private, for-profit	Public, non-profit	Private, non-profit
Owned by:	Shareholders	Local Government	Member-Owned
Regulated by:	Public Utilities Commission	Elected Officials	Coop Board of Directors
Business Model:	Return on Investment	At-Cost Electricity Rates	At-Cost Electricity Rates

Figure 6: Map of Colorado Utility Service Territories[39]



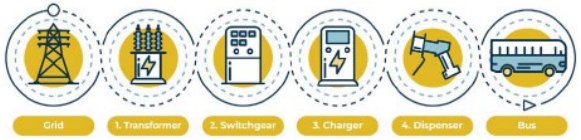
Battery Electric Bus Charging Infrastructure

Electric bus charging infrastructure falls into three categories:

- Plug-in depot charging
- On-route fast charging
- Overhead conductive charging (depot or on-route)

Typical charging configurations require a connection to the electric grid, transformer, switchgear, charger, and plug (dispenser) as shown in Figure 7.

Figure 7: Typical Battery Electric Bus Charging Station Schematic[40]



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Having existing electricity service does not guarantee that a candidate charging location has the necessary site-specific infrastructure to support increased energy demands. The amount and rate at which electricity can be delivered to a customer in real time is a function of the size and type of infrastructure that connects the customer to the electric grid.

Many infrastructure and utility coordination challenges surround how to get the electricity to the vehicles. While conventional fuels such as diesel and gasoline can be stored in large quantities in on-site tanks and pipes, electricity is typically delivered in real time. Accordingly, the energy grid and a customer's on-site connection must be designed to accommodate peak demand rather than just the anticipated average demand.

Accommodating EV transit charging infrastructure requires investment from both the utility and the transit agency. "Make ready" infrastructure refers to the necessary utility investments and electric grid infrastructure additions and upgrades to enable customer side electric vehicle supply equipment (EVSE) installations. The transit agency is responsible for the procurement, installation, and ownership of the EVSE. This model provides the transit agency greater flexibility to choose an EVSE provider and system that best meets their needs.

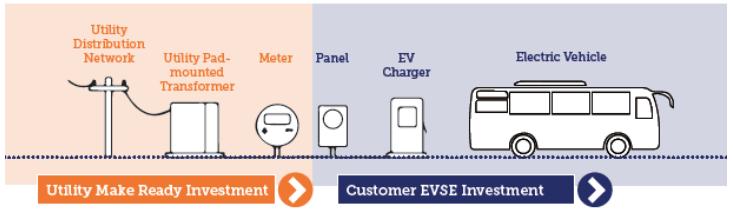
This model allows the utility to leverage its access to capital and low-interest financing to lower the cost of these investments and expedite the rate of expansion of utility infrastructure upgrades.

Customers do not have to come up with the upfront capital for the utility investments to upgrade their electrical service. Rate base cost recovery allows the utility to recover the cost of these investments over the life of the infrastructure through energy and demand rates.

The infrastructure investment component of existing rates and the additional revenue generated from increased electricity sales may account for a portion of these upgrade costs. However, rate increases will likely be needed to finance system-wide infrastructure upgrades.

Transit agencies should factor future rate increases into planning processes. While the "make ready model" eliminates the need for the transit agency to come up with the upfront capital for infrastructure improvements, regulated rate design must ensure equitable allocation of costs to the customers whose usage necessitate infrastructure upgrades - transit agencies will be responsible for bearing the cost of the utility side investments they necessitate.

Figure 8: Utility vs. Transit Investment Responsibility[41]



By working with utilities early in the planning process to integrate electrification plans into the utility's 10-year plan rather than a nearer-term 5-year plan, can significantly reduce the costs of infrastructure investment in substation upgrades, garage refurbishment, additional service lines, etc.[42]

Questions for the Financial Model based on the 2020 EV Plan's identified transit goals:

What does it take to get to 1,000 Vehicles by 2030?

What does it take to get to 100 percent ZEV by 2050?

Is there a reasonable path forward?

Financial Modeling Assumptions

- Updating the 2018 Inventory
- Determining Vehicle Replacement Schedule
- Identifying ZEV Replacement
- Calculating Average Vehicle & Charger Costs

At the start of 2022, the CO transit fleet is 100 ZEVs…puts us at 10 percent of the way to the 2030 goal!

The Thought Exercise…

What will replacing vehicles like-for-like cost?

Do we meet the 2030 goal?	Number of ZEVs in the Fleet in 2030	Do we hit the 2050 goal?	% of Colorado Transit Fleet that is ZEV in 2050	Cost of Vehicle Replacements
✗	100	✗	7%	$1.8-$1.9B

How does this compare to…

Replacing all vehicles with ZEVs starting in 2022?

Replacing all vehicles with ZEVs starting in 2030?

Somewhere in between…2025?

Financial Modeling

Scenario	Do we meet the 2030 goal? (# of ZEVs in 2030 Fleet)	Do we hit the 2050 goal? (% of Fleet that is ZEV in 2050)	Cost of Vehicle Replacements	Incremental Cost
No ZEVs	✗ (100)	✗ (7%)	$1.85B to $1.95B	-
2022	✓ (2,100 to 2,200)	✓ (100%)	$2.05B to $2.15B	$185M to $195M
2025	✓ (1,650 to 1,750)	✓ (100%)	$2.0B to $2.1B	$150M to $160M
2030*	✗ (200 to 300)	✓ (100%)	$1.95B to $2.05B	$145M to $155M

Transitioning the CO fleet to ZEVs is projected $150M to $190M (8-10%) more than maintaining the existing fleet.

Key Takeaways

Transitioning the CO fleet to ZEVs is projected $150M to $190M (8-10%) more than maintaining the existing fleet.

- Cost of EV Chargers are a significant portion of the incremental costs

The near-term push to 1,000 will cost an additional $5-15M to meet the 2030 goal

- Waiting until 2030 delays hitting the 1,000 ZEVs target until 2033-2034

Achieving CO's ZEV Goals

Achieving Colorado's ZEV Transit Goals

Transit ZEV Roadmap Goal: Full transition of Colorado's transit fleet to Zero Emission Vehicles.

The Transit ZEV Roadmap is an outcome of the 2020 Colorado EV Plan and supports the following transit goals:

- Transitioning 1,000 transit vehicles to ZEVs by 2030.
- Operating a 100 percent ZEV transit fleet by 2050.

The 2020 EV Plan includes the following transit specific goals, objectives and actions:

- CEO, CDOT and CDPHE will work with stakeholders to investigate adoption of a Clean Transit Rule that requires a long-term transition to zero emission buses.
- CEO, CDOT, CDPHE and the CEVC will explore equity and rural-focused transit options and provide a recommendation for action in the next iteration of the EV Plan.
- CDOT will develop a state-approved master purchasing contract for zero emission vans, cutaways and large buses to streamline transit agency procurement of EVs.
- CDOT will continue and expand transit electrification planning in order to attain 2020 ZEV Plan Transit Goals.
- CEO will work through CEVC Beneficial Electrification Subgroup on a survey to gather data on utility rates with municipal utilities and rural co-ops to develop new rates that encourage EV charging and adoption by individuals, fleets and transit agencies in spring 2020.
- CDOT's Division of Transit and Rail will continue to utilize remaining VW settlement funds to support the purchase of zero emission transit vehicles.
- CDOT will incorporate EV Plan transit goals into program planning by January 2021.
- CDOT will work to integrate recommendations from CEO's EV Equity Study into its transit electrification grant programs by January 2023.

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The Transit ZEV Roadmap implementation plan has five goal areas:

POLICY
Identify policies to remove/reduce barriers to ZEV transition and implementation.

EDUCATION & TRAINING
Provide training to promote workforce readiness and educational programs for riders and policy/decision-makers.

PLANNING & TECHNICAL SUPPORT
Increase access to technical resources and expertise to support the planning, design, and implementation activities.

INFORMATION SHARING & RESEARCH
Define data collection, research, and analysis methods to facilitate statewide information sharing and support a successful transition to transit ZEVs in Colorado.

FUNDING
Prioritize funding and identify state funding types and methods to effectively support ZEV planning and implementation.

Strategies for each goal area were developed through a collaborative process including CDOT, the Colorado EV Coalition Transit Subgroup, Colorado's transit agencies and other key stakeholders. In support of the development of the Transit ZEV Roadmap and the Implementation Plan, virtual stakeholder interviews were held with transit agencies and an online survey was distributed to all transit agencies to inform the State of the current transit ZEV transition and to understand issues and opportunities and to inform priorities. The transit agency ZEV Transition Survey summary can be found in Appendix I. Stakeholder input, combined with the data, analysis and research informed the implementation plan and priorities to support Colorado's transit agencies in transitioning to ZEV fleets.

Draft Roadmap Stakeholder Input

Draft Roadmap Distribution

TRAC Members	CEVC Transit Subgroup	Transit Agencies	CDOT Staff

14 Agencies Responded, 17 Surveys Completed

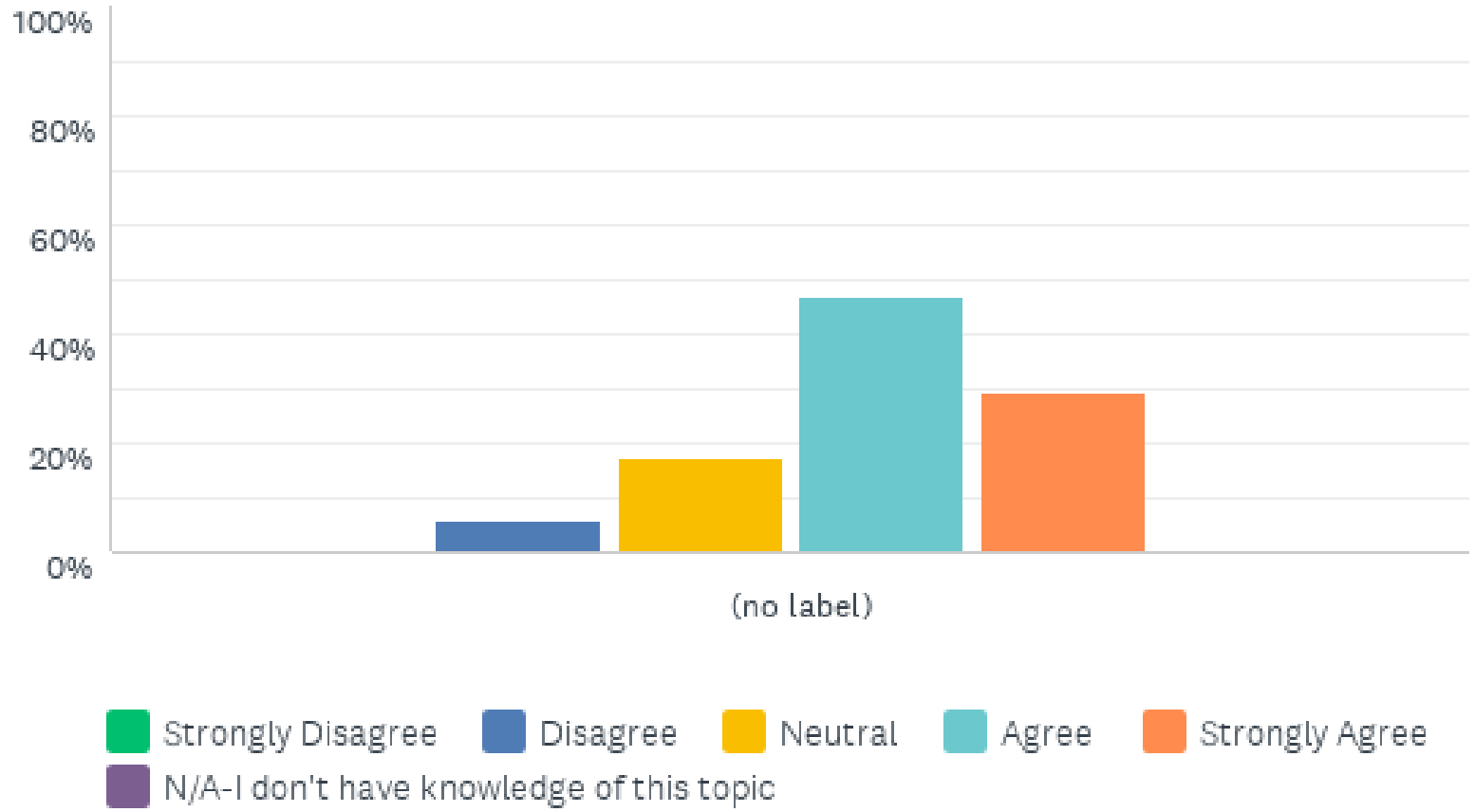
Chaffee Shuttle	RTD	RFTA	Crested Butte	Rocky Mountain Institute	Proterra	University of Colorado Boulder	Weld County	Boulder Valley School District	City of Boulder	Teller Senior Coalition	Town of Snowmass Village	ECO Transit	NECALG

Stakeholder Input Key Themes

Need to consider urban vs. rural needs (e.g., existing/future infrastructure)	Assess charger and vehicle cost assumption	Consider school bus ZEV fleets to meet 2020 EV Plan goals	1:1 vehicle replacement considerations	Battery waste and disposal

Draft Roadmap Stakeholder Input

Overall, the TRANSIT ZEV ROADMAP provides a valuable foundation for guiding the transition of Colorado's transit fleet to ZEVs.



Next Steps

- CASTA Conference Presentations
- Comment Resolution
- Update Roadmap and Finalize Document

Implementation Plan

Goal Areas

Implementation Timeframes		
Near-Term: 2021-2024	Mid-Term: 2025-2028	Long-Term: 2028-2030

Questions?

Colorado Department of Transportation

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