



## MEMORANDUM

To: Colorado Department of Transportation (CDOT)  
Division of Transit and Rail & Office of Innovative Mobility

From: Rachel Ackermann, PE - Felsburg Holt & Ullevig  
Cady Dawson, AICP - Felsburg Holt & Ullevig

Date: December 8, 2021

Re: Transit ZEV Roadmap Financial Model Documentation

---

### 1. About the Transit ZEV Roadmap Financial Model

The transit ZEV financial model uses information from the 2018 Colorado Fleet Inventory, available national ZEV model research and existing ZEV procurement and operating experience from Colorado transit agencies. The goal of the financial model is to create a tool to assess the range of ZEV transition scenarios for the 2022-2050 timeframe to answer the following questions:

- What does it take to get to 1,000 ZEVs by 2030?
- What does it take to get to 100 percent ZEVs by 2050?

The Transit ZEV Roadmap financial model evaluates the transition of rubber-tired revenue service transit vehicles in Colorado; the model excludes commuter rail, light rail, and aerial tramway vehicles (i.e., gondola cabins), all of which are existing ZEVs that count towards the goal of a 100 percent transit ZEV fleet by 2050.

The financial model does not include ongoing operating and maintenance costs, nor does it include costs for utility upgrades beyond charger and charger installation due to the high variability of these costs.

All financial model calculations for the Transit ZEV Roadmap were conducted in an Excel Spreadsheet that has been provided to CDOT to serve as an evaluation tool. This memo provides an overview of the data contained in the Financial Modeling Tool and a brief tutorial of how to use the spreadsheet as an evaluation tool.

### 2. Organization of the Financial Modeling Tool

The Financial Modeling Tool is contained in an Excel Workbook that includes several worksheets for inputs and calculations.

Each of the worksheets contained in the Financial Modeling Tool spreadsheet have been color coded as followed:

- The **GREEN** Model tab is home to the inputs and selections. For 90 percent of ZEV fleet evaluations, this is the only tab that will require inputs.
- The **ORANGE** tabs are those with variables and inputs that **can be modified but should be modified with caution.**



# COLORADO

## Department of Transportation

- The **GREY** tabs contain the data, references and calculations for the model outputs. These tabs should NOT be altered without a thorough understanding of the impacts to the calculations.
- The **BLUE** tabs provide automatically generated graphs based on the user inputs and selections on the Model tab.

A brief description of each of the worksheets is provided below.

- The **Fleet Info** tab contains the pertinent vehicle information for the 2018 Colorado Transit Fleet. The columns in **LIGHT BLUE** contain data extracted from COTRAMS and the 2018 National Transit Database (NTD) database and the **GREY** columns contain data, references and calculations for the model outputs.
- The **Model** tab is where the user enters all the desired inputs and selections. This tab and how to use the model, will be discussed in greater detail in **Section 3 - Using the Financial Model Tool**.
- The **Total Fleet** tab provides the financial model calculations for mandatory ZEV replacement for calendar years 2022 to 2030.
- The **Total ZEVS in Fleet** tab includes a graph comparing the forecasted number of ZEVS in the modeled fleet under 2022, 2025, 2027 and 2030 mandatory replacement years against the baseline (replace like with like) scenario.
- The **Number of Non-ZEVs being Replaced** tab includes a graph that shows the number of vehicles that would be due for replacement with a ZEV (by year) modeled under 2022, 2025, 2027 and 2030 mandatory replacement year scenarios.
- The **Replacement Costs** tab shows the projected total vehicle replacement costs for the 2022, 2025, 2027 and 2030 mandatory replacement year scenarios against the baseline (replace like with like) scenario.
- The **Reference** tab includes cost information for national and Colorado transit agency ZEV purchases. The tab includes the assumptions that were used for the financial model outputs presented in the Transit ZEV Roadmap.
- The **Lookup** tab provides the lookup references for the dropdown variable selections on the Model tab. **This data should not be altered without careful consideration**, as it will result in changes to how the model functions as a tool.
- The **Graph Inputs** tab provides the reference data for creating the graphs summarized above. **This data should not be altered without careful consideration**, as it will result in changes to how the model results are graphed on the preset graphs.
- The tabs labeled **1 through 10** provide the calculations for each of the ZEV vehicle replacement types. **This data should not be altered without careful consideration**, as it will result in changes to how the model functions as a tool.



### 3. Using the Financial Model Tool

The **Model** tab is used for evaluating scenarios and extracting information from the Financial Model Tool. This section walks through the model.

The top of the **Model** tab begins with the inputs and assumptions that are used in the financial model calculations and includes a high-level summary of the results.

MODEL ASSUMPTIONS				Fleet: Colorado Transit Fleet							
Vehicle Replacement Schedule: CDOT/FTA MUL											
Revenue Vehicle Type	# of Vehicles in Fleet	ZEV Cost	Non-ZEV Cost	ZEV Replacement Year	Year Parity is Reached	Annual Reduction to Parity	Charger Costs	Charger Unit Cost	Charger Install Cost		
Articulated Bus	124	\$ 1,200,000	\$ 672,000	2027	2029	8.00%	Level 2	\$ 30,000	\$ 20,000		
Standard Bus (35 to 40 ft.)	1044	\$ 950,000	\$ 500,000	2027	2030	8.00%	Level 3	\$ 50,000	\$ 60,000		
Small Bus (less than 35 ft)	198	\$ 580,000	\$ 350,000	2027	2029	8.00%					
Large Cutaway (17 to 30 passengers)	50	\$ 360,000	\$ 200,000	2027	2030	8.00%					Year the Colorado Transit Fleet reaches 1000 ZEVs: 2029
Standard Cutaway (10 to 25 passengers)	779	\$ 170,000	\$ 88,000	2027	2030	8.00%					Year the Colorado Transit Fleet is 100% ZEV: 2038
Passenger Van	250	\$ 100,000	\$ 55,000	2027	2030	8.00%					
Automobile	104	\$ 60,000	\$ 30,000	2027	2031	8.00%					
Minivan	103	\$ 60,000	\$ 33,500	2027	2029	8.00%					Incremental Cost Difference: \$ 234,554,361
Sports Utility Vehicle	4	\$ 60,000	\$ 33,500	2027	2029	8.00%					Cost of First Time Charger Purchases: \$ 228,840,000
Over-the-road Bus/Motorcoach	228	\$ 1,100,000	\$ 630,000	2027	2029	8.00%					Incremental Cost of ZEVs (Less Chargers): \$ 5,714,361

INPUT

Each of the dynamic variables and inputs are discussed in further detail below:

**Vehicle Replacement Schedule:** this input uses a dropdown menu to select the frequency of vehicle replacements.

Vehicle Replacement Schedule: **CDOT/FTA MUL**  
NTD ULB  
CDOT/FTA MUL

- NTD Useful Life Benchmark (ULB): FTA has set a default ULB as the expected service years for which each vehicle class is the average number of years at which a vehicle would reach a 2.5 rating on the FTA Transit Economic Requirements Model (TERM) scale assuming a standard maintenance schedule.
- CDOT Minimum Useful Life (MUL): CDOT defines MUL as the minimum number of years or miles transit vehicles must be in service before they can be retired. This point assumes that most vehicles still have additional years of useful and cost-effective services but that most of the asset's value has been consumed.

**Fleet:** The dropdown menu lets the user select the fleet they wish to evaluate. The first option is the entire Colorado Transit fleet, followed by the different Colorado transit agencies included in the database, in alphabetical order.

Fleet: **Colorado Transit Fleet**  
Colorado Transit Fleet  
Archuleta County  
Baca County Seniors Van  
Bent County  
Berthoud Area Transportation Service (BATS)  
Black Hawk, City of  
Breckenridge, Town of  
Broomfield, City and County of  
Castle Rock Senior Center  
City of Aspen  
City of Colorado Springs  
City of Fort Collins



# COLORADO

## Department of Transportation

- If “Colorado Transit Fleet” is selected, the summary calculations include the year the Colorado Transit Fleet reaches the 1000 ZEV 2030 interim goal and the year the Colorado Transit Fleet reaches the 2050 100 percent ZEV goal:

Year the Colorado Transit Fleet reaches 1000 ZEVs:	2029
Year the Colorado Transit Fleet is 100% ZEV:	2038

- If a specific transit agency is selected, the calculations are the same, less the year that the Colorado Transit Fleet reaches the 1000 ZEV 2030 interim goal, since progress towards this goal that cannot be measured at the individual agency level.

Year the City of Colorado Springs Fleet is 100% ZEV:	2036
------------------------------------------------------	------

green

red

The summary calculations also show the estimated total incremental cost difference of purchasing ZEVs, the corresponding cost of ZEV charging infrastructure and the incremental cost of the ZEVs (less the cost of the chargers):

Incremental Cost Difference:	\$ 14,265,876
Cost of First Time Charger Purchases:	\$ 13,810,000
Incremental Cost of ZEVs (Less Chargers):	\$ 455,876

Assumptions for the Revenue Vehicles by Type: The following assumptions can be set for each class of revenue vehicle type.

Revenue Vehicle Type	# of Vehicles in Fleet	ZEV Cost	Non-ZEV Cost	ZEV Replacement Year	Year Parity is Reached	Annual Reduction to Parity
Articulated Bus	0	\$ 1,200,000	\$ 672,000	2027	2028	10.00%
Standard Bus (35 to 40 ft.)	55	\$ 950,000	\$ 500,000	2027	2029	10.00%
Small Bus (less than 35 ft)	5	\$ 580,000	\$ 350,000	2027	2027	10.00%
Large Cutaway (17 to 30 passengers)	0	\$ 360,000	\$ 200,000	2027	2028	10.00%
Standard Cutaway (10 to 25 passengers)	75	\$ 170,000	\$ 88,000	2027	2029	10.00%
Passenger Van	53	\$ 100,000	\$ 55,000	2027	2028	10.00%
Automobile	12	\$ 60,000	\$ 30,000	2027	2029	10.00%
Minivan	11	\$ 60,000	\$ 33,500	2027	2028	10.00%
Sports Utility Vehicle	2	\$ 60,000	\$ 33,500	2027	2028	10.00%
Over-the-road Bus/Motorcoach	0	\$ 1,100,000	\$ 630,000	2027	2028	10.00%

- ZEV Cost & Non-ZEV Cost:** Each category of vehicle type can accept a cost input for a ZEV and the comparable non-ZEV equivalent.
- ZEV Replacement Year:** The year after which all revenue vehicles of that type are assumed to be replaced with ZEVs
- Annual Reduction to Parity:** This value represents the estimated annual percent decrease in the ZEV purchase cost.



# COLORADO

## Department of Transportation

- **Year Parity is Reached:** This is a calculated value for the year at which the vehicle type is projected to reach purchase cost parity based on the assumption used for the *Annual Reduction to Parity*. Conditional formatting is used to highlight the box in green if the vehicle type purchase price is expected to be at price parity for the selected *ZEV Replacement Year*.
- **ZEV Charger Unit Costs & Installation Costs:** The model also requests inputs for charger unit and installation costs for Level 2 and Level 3 chargers.

Charger Type	Charger Unit Cost	Charger Install Cost
Level 2	\$ 30,000	\$ 20,000
Level 3	\$ 50,000	\$ 60,000

- For the “Colorado Transit Fleet,” these costs are not to include the cost of utility upgrades as historic cost data indicated that these costs vary from agency to agency. However, at the individual agency analysis level, a transit agency could elect to add utility upgrade costs, if available. These costs should be added as a *per charge* cost and should not reflect the total cost of a multi-charger installation project.

### Replacement Ratio

The Transit ZEV Roadmap financial model assumes a 1:1 vehicle replacement. However, throughout the stakeholder engagement process, a number of transit agencies indicated that replacing their existing fleet with ZEVs could require as much as a 2:1 ZEV to Non-ZEV replacement ratio to maintain existing service.

While evaluating a replacement ratio greater than 1:1 is not recommended for the entire Colorado Transit Fleet, the model provides flexibility to effectively model other scenarios using the Financial Model Tool. To do so, it is recommended that the user multiply the desired vehicle type ZEV cost by the desired replacement ratio. This will allow the model to capture the additional vehicle costs associated with the higher replacement ratio, while assuming that these vehicles would share charging infrastructure and that the higher replacement ratio would not artificially track progress towards the 1000 vehicle 2030 interim goal.

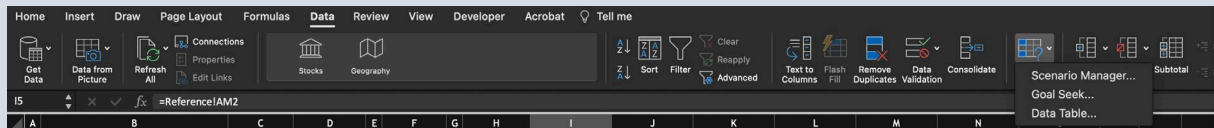


# COLORADO

## Department of Transportation

### Inputting a Year Parity is Reached

The *Year Parity is Reached* is a calculated valuate. However, if the user would like to assume purchase price parity for a specific is reached in a given year, they should go to the Data Tab in Excel, Select “What-if Analyses” and Goal Seek.



This will open a pop-up dialog box, where the user can select the year cell, enter the year parity is reached (e.g., 2027) for the “to value.” The “By Changing Cell:” value should be set to the corresponding cell in the same row for the *Annual Reduction to Parity* column. Click ok and the spreadsheet will automatically calculate the input for the *Annual Reduction to Parity* column.

	H	I	J	K	L	M	N
Fleet:	Colorado Transit Fleet						
ZEV Replacement Year	Year Parity is Reached	Annual Reduction to Parity					
2027	2027	7.85%					
2027	2027	13.97%					
2027	2027	5.46%					
2027	2027	12.43%					
2027	2027	14.23%					
2027	2027	16.25%					
2027	2027	5.26%					
2027	2027	3.19%					
2027	2027	3.19%					
2027	2027	6.40%					

Goal Seek

Set cell: I5

To value: 2027

By changing cell: \$J\$5

Cancel OK

The results of the model are displayed below the inputs. The first set of results provides a summary of the Total Fleet being evaluated for years 2022 through 2050. For each year, the model output indicates the following:

- # of Non-ZEVs being replaced with ZEVs
- Total ZEVs in the Fleet
- % of the total fleet that is ZEV
- Cost of All Vehicle Replacements (ZEV and Non-ZEV)
- Cost of the First Time Charger Purchases
- Incremental Cost Difference

Below the Total Fleet Outputs, model outputs are provided for each individual revenue vehicle type.



# COLORADO

## Department of Transportation

These results are used to generate the corresponding graphs on the **Total ZEVs in Fleet**, **Number of Non-ZEVs being Replaced**, and the **Replacement Costs** tabs. Sample graphs are shown below:

