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# TRANSIT TOOL USER GUIDE

Presented by:  
*the ODOT Public Transportation Division*

With support from:  
*Oregon Department of Energy (ODOE), Department of Environmental Quality (DEQ)  
and Zero Emission Vehicle Interagency Working Group (ZEVIWG)*

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## User Guide: Electric and Alternative Fuel Transit Bus Lifecycle Cost Analysis Tool

The Electric and Alternative Fuel Transit Bus Lifecycle Cost Analysis Tool is a product of the Oregon Department of Transportation in collaboration with the Oregon Department of Energy and support from the Oregon Department of Environmental Quality. The development of the tool was directed by Governor Kate Brown in Executive Order 17-21 *Accelerating Zero Emission Vehicle Adoption to Reduce Greenhouse Gas Emissions and Address Climate Change*. The purpose of this tool is to provide the user with a first-pass assessment of the lifecycle costs of new 35- to 40-foot standard, electric, and alternative fuel buses. The tool also provides information on the carbon footprint of different transit bus options.

The tool provides default values for all required inputs once the user selects a specific bus and fuel type. However, the tool allows for and can be improved by providing your fleet's specific data in place of these default values. Please note that there is one field that cannot be modified – Bus Useful Lifetime, which is set at 12 years.

Fleet operational costs are highly specific to routes, usage, and even driver habits, and some of the start-up and operating costs included in the tool may vary between transit agencies. For this reason, this tool is intended to be used as a first pass analysis of alternative fuel vehicles. The tool should not be used to make final procurement or business decisions. Calculations in the tool can be modified to highly refine the outputs for a specific user. Please contact the [Oregon Department of Energy](#) for technical assistance if you wish to add modifications beyond the inputs available in the tool interface.

The following is a step-by-step walkthrough of the different inputs for the tool ([click here for a printable version of these instructions](#)). Each input correlates to a specific spreadsheet row on the Inputs tab of the tool.

### Bus and Fuel Type

#### Line 4 (Required Input)

This line is the primary toggle for alternative buses and fuels in the tool. The user can select from bus types, including diesel, diesel hybrids, compressed natural gas (CNG), renewable natural gas (RNG), and electric formats. Diesel and diesel hybrids are further split out by diesel and renewable diesel fuel types (B5, B20, R20, R99). Note: the baseline format of a bus is a 2019 or newer model year diesel bus using B5 diesel fuel.

### Bus, Service, Driver, and Environment Section

Please note that default values are provided in the yellow boxes to the right of the green and red input fields. These cells have been locked to avoid accidental changes to the default calculations. The green input fields will automatically populate with the default values but can be changed to a specific value by the user. When the default value and input value are different these cells will turn to gold to flag for the



user that the amounts differ. Red fields are pulldown menus, which require the user to make a selection. Where the user has fleet-specific values, they can enter these instead of the default value. More specific data inputs will yield a more refined output.

The tool will compare costs and emissions for the different platforms of buses and fuel types. This can be seen on the “Financial Cost Comparison,” “Lifecycle Cost Comparison,” and “Fleet Carbon Footprint” tabs. However, it is recommended that if the user is interested in more accurately comparing two or more bus platforms that they complete a separate analysis for each bus type. Further, to avoid inadvertent cell changes, it is highly recommended that users start with a fresh spreadsheet template for each analysis.

#### **Line 8 – Bus Price (Highly Recommended Input)**

A default price for each bus type will populate in this cell. The default prices listed were developed by averaging costs for the different platforms of transit buses. Where available, Oregon-specific pricing was used; however, for platforms not currently utilized, or have limited usage in Oregon, national price averages were used. Pricing on buses is highly dependent on contract terms as well as additional features, so it is highly recommended that the user add their own bus costs to this input if known.

#### **Line 9 – Bus Expected Useful Life**

This is a default of 12 years and cannot be adjusted by the user assuming a newly purchase vehicle. 12 years is the standard federal useful life for this vehicle classification and thus used by most agencies use for cost assessments, however buses often remain in service past their 12 year useful life.

#### **Line 10 – Full Burden Labor Costs Per Hour (Highly Recommended Input)**

This is inclusive of the transit agency’s overall labor costs for the bus drivers. The default value is \$30.00, which includes salary and benefits. This value can be adjusted to also include other operations costs determined on a per-hour basis. Alternatively operating costs can be input using a per-mile rate under Line 24 below for “Other Per Mile Operating Costs”

#### **Line 11 – Asphalt Conditions (Highly Recommended Input)**

Select the asphalt condition for the route the bus or buses will be traveling. Fuel usage and maintenance costs greatly increase as asphalt conditions deteriorate. This is a qualitative assessment for the user and should be assessed based on the asphalt conditions present during the majority of the route. Options include: Very Good, Good, Fair, Poor. For more information on road conditions see the ODOT Pavement Condition Standards at <https://www.oregon.gov/odot/Construction/Pages/Pavement-Condition.aspx>

#### **Line 12 – Inflation Rate**

This establishes the rate at which fuel and maintenance costs are expected to rise over the lifetime of the vehicle. The inflation rate was derived from the U.S. Congressional Budget Office’s Consumer Price Index for transportation.



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### Basic Schedule Section

#### **Line 16** – Annual Vehicle Miles Traveled Per Bus (Highly Recommended Input)

Total number of miles the bus is anticipated to drive on an annual basis. Note that increased mileage will have associated increases in fuel and maintenance costs. A default value of 30,000 miles per year is entered into the spreadsheet. This is not a calculated default value but can be used in an initial pass if VMT is unknown. If you are using the tool to assess costs for multiple buses that have varying routes lengths it is recommended you conduct separate analyses for each route.

#### **Line 17** – Annual Vehicle Hours Traveled Per Bus (Highly Recommended Input)

Total number of hours the bus is anticipated to be operating on an annual basis. Note that increases in hours will have associated increases in driver costs. A default value of 2,080 hours per year is entered into the spreadsheet, which is equivalent to a driver operating a bus 40 hours per week over the course of the year. This is not a calculated default value but can be used in an initial pass if annual hours are unknown.

#### **Line 18** – Number of Buses

Enter the number of buses you anticipate procuring.

### Operations and Maintenance Section

#### **Line 22** – Maintenance Costs Per Mile

Add all maintenance costs for each bus (cleaning, oil changes, tires, emission filter regeneration, etc.) then divide by the number of miles driven as entered into Line 16. The default value shown is based on Argonne National Laboratory information for the specific type of bus and the 12-year expected useful life (line 9). Maintenance costs should be determined on an annual basis for the vehicle and then divided by the annual VMT used in line 16.

#### **Line 23** – Fuel Economy (mpg or equivalent)

A default value is calculated for each vehicle and fuel type. B5, B20, R20 and R99 units are in miles per gallon, CNG and RNG units are in diesel gallon equivalent (dge), and electric is in kilowatt hours/mile (kWh per mile). Note that CNG and RNG are generally purchased in therms; however, for ease of use with this tool CNG and RNG are reported in dge/mile. You can calculate dge from therms/mile by multiplying the therms/mile by a conversion factor 1.27. Fuel economies vary, even for the same bus. If your buses have different fuel economies (for example, due to different routes) it is recommended that you conduct separate analyses for each bus.



#### **Line 24 – Other Per Mile Operating Costs**

This enables the user to add in other operational costs on a per mile basis. Examples of other costs not accounted for elsewhere are diesel exhaust fluid or battery leasing costs. Any additional costs should be determined on an annual basis for the vehicle and then divided by the annual VMT used in line 16. Operating Overhead and indirect expenses could also be accounted for in this section. Recommended default is \$0 unless specific costs are known.

#### **Line 25 – Engine Overhaul Costs**

Most combustion engines will need to be overhauled at least once in the lifetime of the vehicle. This model uses 250,000 miles as the trigger point for a diesel engine overhaul (see cell B28). Overhaul needs will vary based on vehicle usage.

#### **Line 26 – Transmission Overhaul Costs**

Most bus transmissions will need to be overhauled at least once in the lifetime of the vehicle. This model uses 250,000 miles as the trigger point for a diesel engine overhaul (see cell B28). Overhaul needs will vary based on vehicle usage.

#### **Line 27 – Mileage Point for Conventional Overhaul**

This will change the mileage point that triggers a diesel bus engine and transmission overhaul. The tool does not enable you to have different trigger points for the engine overhaul separate from the transmission overhaul trigger point. The default is set at 250,000 miles.

#### **Line 28 – Mileage Point for Battery Overhaul**

Because electric and hybrid electric buses are relatively new to transit authorities, data and information on the need and timing for battery replacements is limited. Many electric bus manufacturers offer 12-year lifetime battery warranties or leasing options for the batteries themselves (see line 24). If the user knows the mileage point for the warranty on a battery, they should enter that mileage here. If unknown, ODOE recommends not including a mileage point for battery replacement.

#### **Line 29 – Battery Replacement Cost**

Because electric and hybrid electric buses are relatively new to transit authorities, data and information on the need and timing for battery replacements is limited. Early research indicates batteries are lasting longer than anticipated and improving rapidly. The user should be aware that the cost for a transit electric bus battery would be significant, but there is no data on average cost for such a replacement. However, if the user has a cost of a replacement battery from the vehicle manufacturer, they can enter it here.



### **Line 30 – Fuel Cost**

The tool will provide default costs for all fuels, which includes modeled projections on fuel cost changes over the lifetime of the vehicle. You may enter your actual fuel costs instead; however, the tool will project cost increases using only the inflation rate entered in cell B12. Diesel and hybrid diesel fuel is included as cost per gallon, electric as cost per kWh, CNG/RNG are included as cost per dge (see line 23 for conversion from therms to dge).

### **Line 31 – Select Electricity Provider (Input Required)**

Click on cell B35 and use the pulldown menu to select your specific electric utility. This information is used to calculate the Carbon Intensity of the electricity and is directly related to the amount of Clean Fuels Program Credits an EV charger can receive. See below for more information on the CFP.

### **Line 32 – Do you want to include potential Clean Fuels Program credit revenues in the analysis?**

Click on cell B32 and select yes or no. Please note that participation in the CFP is not required. The owner of the charging infrastructure can generate these credits and monetize them. The funds received from this monetization can be used to offset the costs for adding or upgrading the equipment needed for electric or CNG/RNG buses. Credit values in the tool are based on 2019 CFP credit data and are not a forecast; actual revenue from the sale of credits will vary. Note that some alternative fuels (B20, R20, R99) are also eligible to generate credits in the CFP but those typically go to the importers of those fuels and not the end users of the fuel; but you might be able to get a lower price because of the credits. Note that in some scenarios, fuel costs can appear as a negative value due to CFP program credits generated.

## **Infrastructure and Miscellaneous Section**

### **Line 36 – Fueling Infrastructure Cost Per Bus**

If additional fueling infrastructure is needed (e.g., chargers for electric buses, leasing CNG/RNG fueling infrastructure) you can include the costs of that infrastructure here. Please note that if you are considering multiple buses you will need to divide the total cost of the needed infrastructure by the total number of buses you entered in cell B18. Note that the cost of some infrastructure may be high for one bus but would be spread out over multiple buses if more are procured. . For example, the charging infrastructure for one electric bus will create a much higher cost per that bus than the infrastructure cost across multiple buses. For diesel fuel, the assumption is that the infrastructure already exists and therefore the cost is \$0.



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### Line 38 – Fueling Infrastructure Annual Maintenance Cost

Anticipated annual costs to maintain the fueling infrastructure for the bus could include pump maintenance, filter replacement, and parts replacements.

### Analyzing the Results

After the user completes the Inputs tab (using default data or their own fleet-specific data) the remaining tabs provide an assessment of operational and maintenance costs, lifecycle costs, greenhouse gas emissions, and other air pollutant emissions. These are available across the different tabs:

- Summary Tab (costs and emissions)
- Financial Cost Comparison Tab (provides lifecycle cumulative costs across all bus and fuel types)
- Lifecycle Cost Comparison Tab (adds social cost of carbon to the lifecycle cumulative costs across all bus and fuel types)
- Fleet Carbon Footprint (compares greenhouse gas emissions across all bus and fuel types versus a diesel baseline)
- Assumptions (provides a breakdown of assumptions that were made to create the tool)

It is recommended that the user should use the comparative charts in the above tabs of the tool only when using the default values in the Inputs tab. If the user wishes to make more specific fleet comparisons it is recommended that they complete a different analysis for each bus and/or fuel type. Please note, when the user alters the information in the inputs column B to no longer reflect the default value, then changing the bus and fuel type on the toggle button at the top of the page will no longer populate the inputs column with the default data. Therefore, to conduct separate analyses the user should either start with a fresh, unused tool, or the user can type the default values from column C into the inputs in column B. The cells in column B will be gold when the value in that cell does **not** match the default amount in the cell in column C.