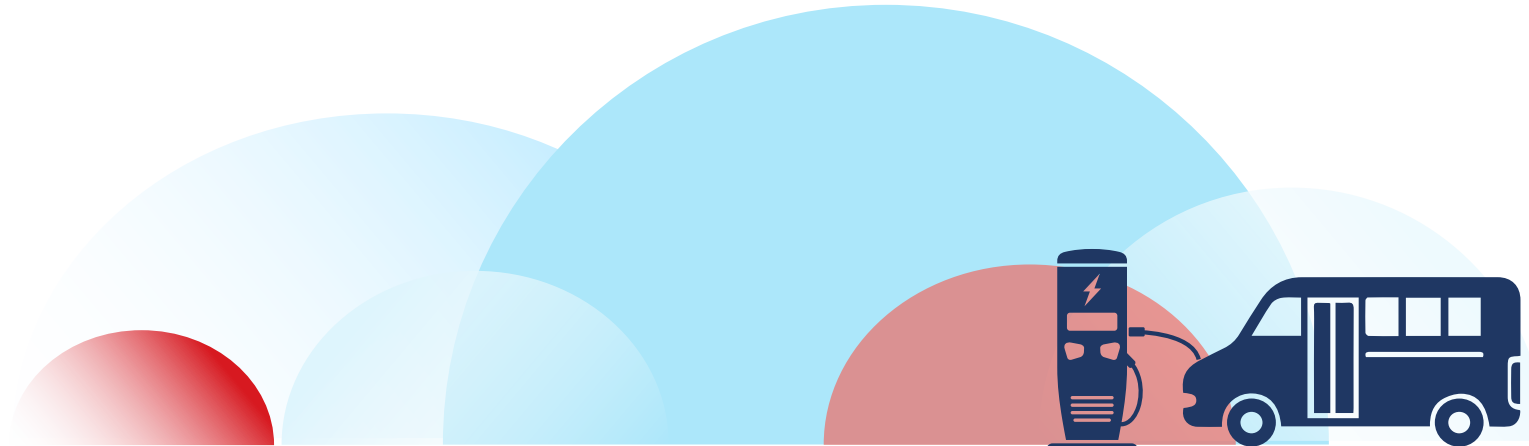
CENTRAL TRANSIT

2023 ZERO EMISSION TRANSITION PLAN

5/30/2023



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AGENCY OVERVIEW

Central Transit is a rural public transit system serving a population of 19,530 residents within a total area of 7.65 square miles. Located just east of the Cascade Range at the junction of Interstate 90 and 82, Ellensburg is known as the most centrally located city in the state of Washington. Central Transit serves the public throughout the city limits of Ellensburg. Central Transit is a safe reliable fare free Ellensburg Public Transit System which operates 7 days a week (except certain holidays). All buses are ADA accessible and are equipped with bicycle racks.

ORGANIZATION AND OPERATIONS

The Ellensburg City Council is responsible for Central Transit's operations. The Public Transit Advisory Committee (PTAC) provides oversight of the transit system and reports to the City Council on those, and other elements as directed. The City Manager and Public Works and Utilities Director also report to the City Council on Transit activities, policies, and finances. The Transit Manager oversees and manages the operational activities of the Transit System.

To advance Central Transit's environmental goals and meet state requirements Central Transit evaluated the feasibility of alternative fuel vehicles and developed a zero emission transition plan to convert the bus fleet to zero emissions. This study includes route modeling and simulations, lifecycle cost analysis, infrastructure and facility need, utility coordination, and a phased fleet transition strategy. This plan also meets the federal requirements to apply for FTA funding.

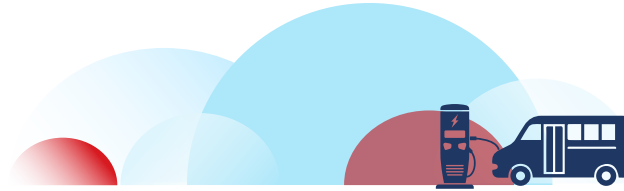
Central Transit provides accessible fixed route and complimentary ADA paratransit services. Central Transit operates 5 fixed routes daily from 7:00 AM to 8:00 PM. Central Transit's system maps show the locations of each route, the direction of bus movement, scheduled bus stops, on demand bus stops, bus shelters and transfer service points.

Transfer locations allow connections to other ground transportation which include the Kittitas County Connector, Greyhound, Flixbus, the Yakima-Ellensburg Commuter, the Travel Washington Apple Line, and the Bellair Airporter Shuttle which connects with SeaTac International Airport and Amtrak. Central Transit also connects passengers with many shared-use biking and walking trails including the Palouse to Cascades State Park Trail.

ADA Paratransit services are available within ¾ miles of the fixed route service during the same time as the Central Transit fixed route services. Central Transit's Cabulance service operates independently 24-7 to provide accessible non-emergency medical transportation for individuals within the City limits of Ellensburg to and from specific medical facilities as initiated by Kittitas Valley Fire and Rescue and other contracted facilities.

HOPESOURCE

The City of Ellensburg contracts all transportation operations to HopeSource, a local private nonprofit organization. All operational equipment is owned and maintained by HopeSource located



at 606 West 3rd Avenue, Ellensburg, Washington 98926. HopeSource contracts out maintenance to garages to perform work on transit buses used by Central Transit.

HopeSource is a private, non-profit organization that has provided a wide range of human services in Kittitas County since 1966. The service area stretches from the east side of Snoqualmie Pass to the Columbia River. HopeSource was created through the Economic Opportunity Act of 1964 to address the needs of low-wealth households and has provided emergency and sustained support to thousands of families in the Upper and Lower Kittitas County since that time. There is a Community Action Agency in every county in Washington State and in most counties nationwide.

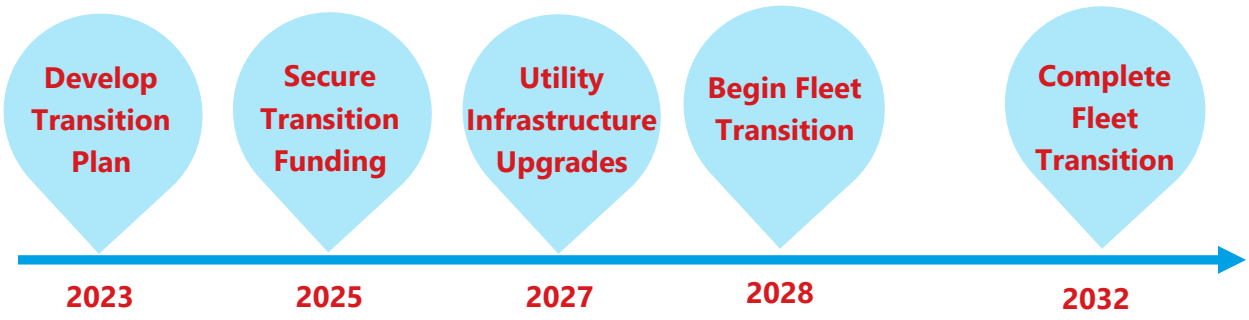
ZERO EMISSION TRANSITION PLAN

The Federal Transit Administration (FTA) requires a Zero Emission Transition Plan from each transit agency that applies to the FTA Low or No Emission Grant Program and the FTA Bus and Bus Facilities Grant Program for zero emission projects. The Zero Emission Transition Plan must include the following six elements:

1. **Policy & Legislative Impacts**: Consideration of policy and legislation impacting relevant technologies
2. **Fleet Transition Plan**: Demonstration of a long-term fleet management plan with a strategy for how the applicant intends to use the current request for resources and future acquisitions
3. **Facility & Infrastructure Plan**: Evaluation of existing and future facilities and their relationship to the technology transition
4. **Utility & Fuel Partnerships**: Description of the partnership of the applicant with the utility or alternative fuel provider
5. **Funding Plan**: Address the availability of current and future resources to meet costs for the transition and implementation
6. **Workforce Transition Plan**: Examination of the impact of the transition on the applicant's current workforce by identifying skill gaps, training needs, and retraining needs of the existing workers. This focuses on supporting the applicant's short-term and long-term needs to operate and maintain zero emission vehicles while avoiding displacement of the existing workforce.

FLEET TRANSITION OVERVIEW

Central Transit will continue to replace the fleet with gasoline vehicles between 2023 and 2027, with a transition to zero emission beginning in 2028 with the purchase of three battery electric busses (BEBs). The fleet will be 100 percent battery electric in 2032, assuming necessary funding is secured in each biennium. Charging infrastructure will be installed at the HopeSource facility and on-route at a common layover point downtown at the intersection of East 4th Avenue and North Ruby Street in Ellensburg, Washington. The following graphic shows key milestones in the transition.



The additional power demand associated with charging Central Transit's vehicles will require coordination with the utility, City of Ellensburg Electrical Power Department, to plan for utility infrastructure upgrades. Utility infrastructure upgrades must be complete prior to delivery and installation of BEBs and chargers in 2028; due to anticipated lead times, utility infrastructure upgrades should begin in 2027, one year prior to delivery of vehicles. The transition will begin with the purchase of three BEBs, all on-route chargers, and depot chargers would be installed in 2028; not all chargers would be utilized at first, but there would be no construction rework required to install the remaining chargers with later bus procurements.

Table 1. Transition Timeline Strategic Actions

Year	Category	Strategic Action
2023	Planning	• Complete Zero Emission Transition Plan • Incorporate ZE Plan into City of Ellensburg Sustainability Plan
2024	Funding	• Apply for infrastructure funding and identify local match as required • Update service provider contract terms for ZE plan elements • Coordinate with the selected vendor for vehicle procurement(s) • Develop vehicle and charging specifications
2025	Planning and Funding	• Secure funding for infrastructure and vehicles • Clarify roles between City and vendor(s) for chargers and infrastructure • Consider phasing if partial funding is secured to match funding award(s)
2026	Infrastructure and Permitting	• Plan and coordinate infrastructure upgrades and grid connections • Gain approvals for infrastructure upgrades at bus depot and on-route
2027	Infrastructure	• Substantially complete infrastructure upgrades and utility coordination
2028	Implement Transition	• Begin transition to zero emission buses and infrastructure • Consider phasing of implementation as necessary

EQUITY & DIVERSITY

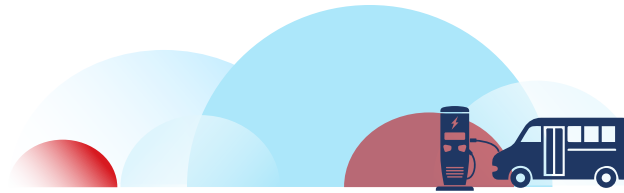
Ensuring equitable outcomes through sustainable practices is reflective of Central Transit's core values as Ellensburg's primary public transportation provider. Environmental justice and equity factors relating to income, race and ethnicity, health and level of environmental burden were analyzed during the route analysis process and documented to meet Central Transit's commitment to following equity and environmental justice best practices. The following section works to describe Central Transit's position on equity initiatives, highlighting federal policy as well as action taken at the local level.

Environmental justice can be defined as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and polices. Developed by the U.S. Environmental Protection Agency (EPA), this definition works to highlight best practices to be followed when aiming to ensure individuals experience the same degree of protections from environmental hazards, conditions leading to adverse health impacts, and equal access to the decision-making processes which promote healthy environments that benefit everyone. A critical component of achieving environmental justice in communities requires identifying areas where individuals may be disproportionately vulnerable to adverse environmental impacts, such as contaminated air pollutants, with the goal of mitigating potential environmental hazard.

Threats to healthy air quality levels greatly impacts quality of life, compromising the health and well-being of individuals. One of the leading threats to air quality is the air pollutants emitted from vehicular traffic, including particulate matter, nitrogen oxides, carbon monoxide, and ozone. These are some of the pollutants released from emissions that are known to be linked to respiratory and cardiovascular health concerns in individuals. In addition, research has demonstrated that traffic noise can also lead to stress and sleep disturbances, both of which can lead to a higher risk for type 2 diabetes. Low-income households and minority populations are more likely to live near busy roadways and highways and therefore these communities are often disproportionately impacted by these negative outcomes than their non-Hispanic white counterparts.

JUSTICE40

Accounting for the agency's zero-emission bus transition, Central Transit aims to uphold the mission of Executive Order (EO) 14008, Tackling the Climate Crisis at Home and Abroad, which emphasizes the need for agencies to prioritize environmental justice in their program development, policy making, and activities impacting communities. A range of action items, policies and programs came from EO 14008's inception, including the Justice40 initiative. The Justice40 Initiative aims to direct Federal investments in a way that allows at least 40 percent of the overall benefits of such investments to flow to disadvantaged communities. The U.S. Department of Transportation (USDOT) developed a definition for disadvantaged communities, to be utilized in connection with certain federal grant programs. Informed by an internal and external collaborative research process, this definition comprises data for 22 indicators collected at the U.S. census tract level, which are then grouped into the following six categories of transportation disadvantage:



- **Transportation Access**: This disadvantage identifies communities and places that spend more, and longer, to get where they need to go. (CDC Social Vulnerability Index, Census America Community Survey, EPA Smart Location Map, HUD Location Affordability Index)
- **Health**: This disadvantage identifies communities based on variables associated with adverse health outcomes, disability, as well as environmental exposures. (CDC Social Vulnerability Index)
- **Environmental**: This disadvantage identifies communities with disproportionate pollution burden and inferior environmental quality. (EPA EJ Screen)
- **Economic**: This disadvantage identifies areas and populations with high poverty, low wealth, lack of local jobs, low homeownership, low educational attainment, and high inequality. (CDC Social Vulnerability Index, Census America Community Survey, FEMA Resilience Analysis & Planning Tool)
- **Resilience**: This disadvantage identifies communities vulnerable to hazards caused by climate change. (FEMA National Risk Index)
- **Equity**: This disadvantage identifies communities with a high percentile of persons (age 5+) who speak English "less than well." (CDC Social Vulnerability Index)

In accordance with USDOT's Office of Management and Budget (OMB), USDOT identifies highly disadvantaged communities as exceeding the 50th percentile (75th for resilience) across four or more of the six Transportation Disadvantaged indicators listed above. Census tracts with four or more Transportation Disadvantaged indicators are considered highly disadvantaged.

The map in Figure 1 highlights Transportation Disadvantaged communities as well as communities that will benefit from the Justice40 initiative by census tract. For communities identified based on Transportation Disadvantage, census tract level data was collected using publicly available datasets consistent with OMB's Interim Guidance, developed by USDOT. The Justice40 layer displayed on the map reflects Justice40 factors based on datasets that identify indicators of burdens. The data is accessible through the Council on Environmental Quality's (CEQ) Climate and Economic Justice Screening Tool. Due to the interlining of bus routes, benefits will be seen across multiple communities with the initial deployments of zero-emission buses.

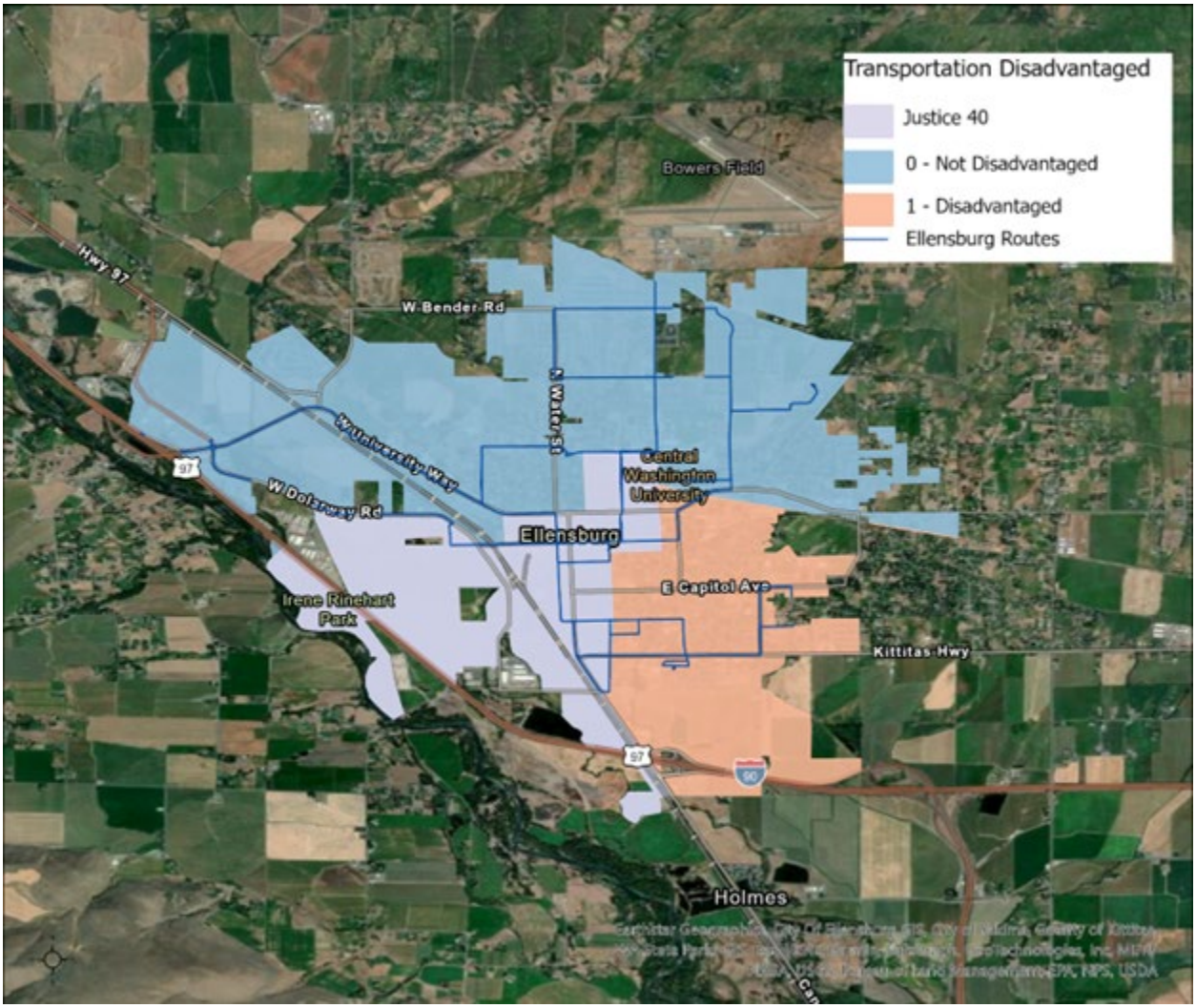


Figure 1. Justice40 Transportation Disadvantaged Communities in Ellensburg (USDOT 2022, CEQ 2022)

MINORITY POPULATION

Minority populations were identified using The American Community Survey (ACS) 2016–2020 5-year estimates. The block group is the smallest geographic unit for which the U.S. Census Bureau tabulates 100 percent data. The reference population, Ellensburg, has a population of around 17,800. Within this population, the percentage of people who identify as non-White or of Hispanic/Latino origin is 27 percent, according to the Decennial Census in 2020. The location of these block groups is shown in Figure 2, breaking down per square mile the people who are non-White or of Hispanic/Latino origin, by census block.

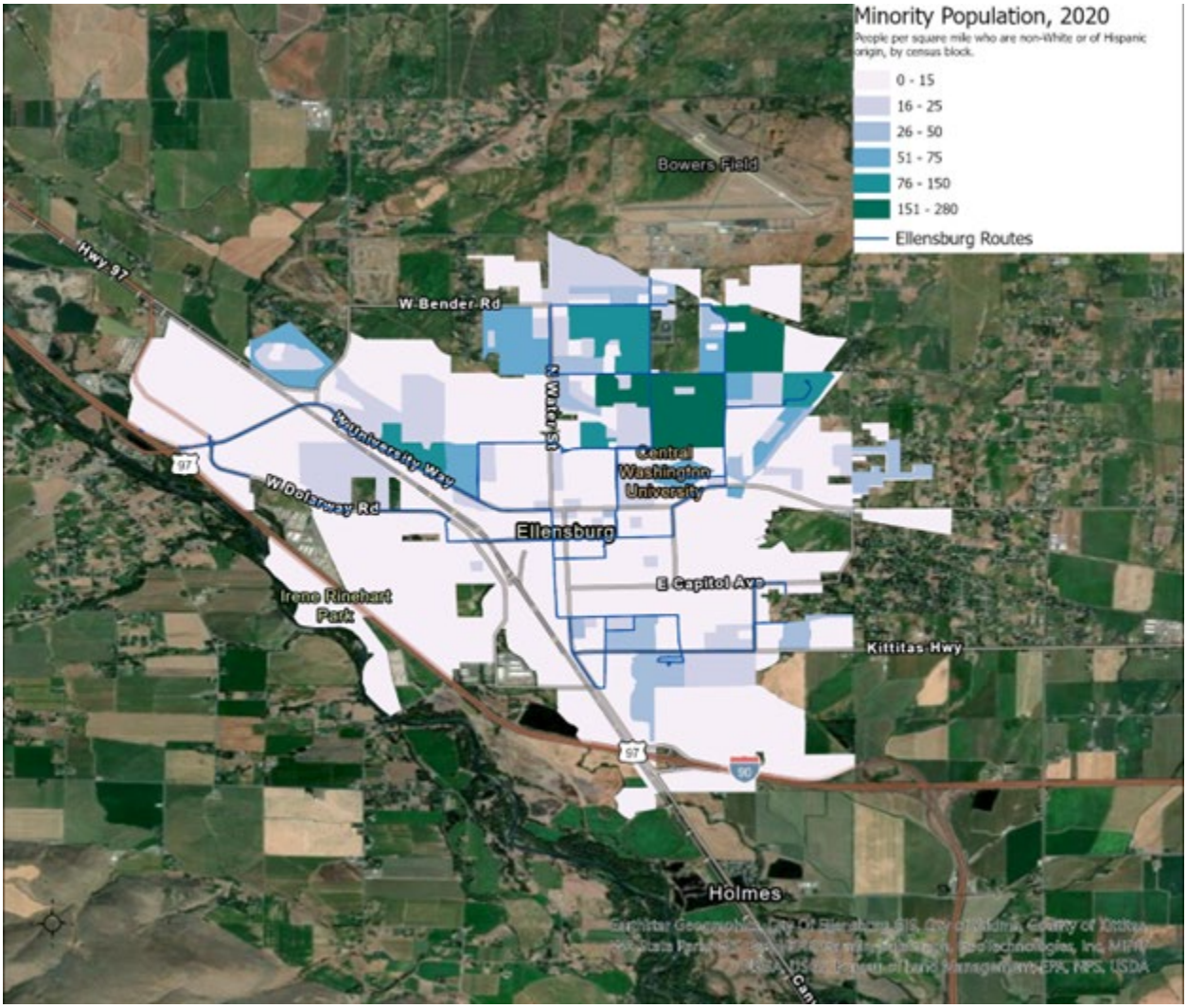


Figure 2. Minority Population by Block Group in Ellensburg, 2020 (ACS, 2016-2020)

LOW-INCOME POPULATION

To determine how much of the population is living below the poverty threshold, the ratio of income to poverty level in the past 12 months were identified using the ACS 2016–2020 5-year estimates at the census block group level. The block group is the smallest geographic unit for which the U.S. Census Bureau tabulates 100 percent data. The reference population, the city of Ellensburg, has a low-income population of 29 percent, qualifying the census block groups within the city boundary as environmental justice communities. The location of these block groups is shown in Figure 3.

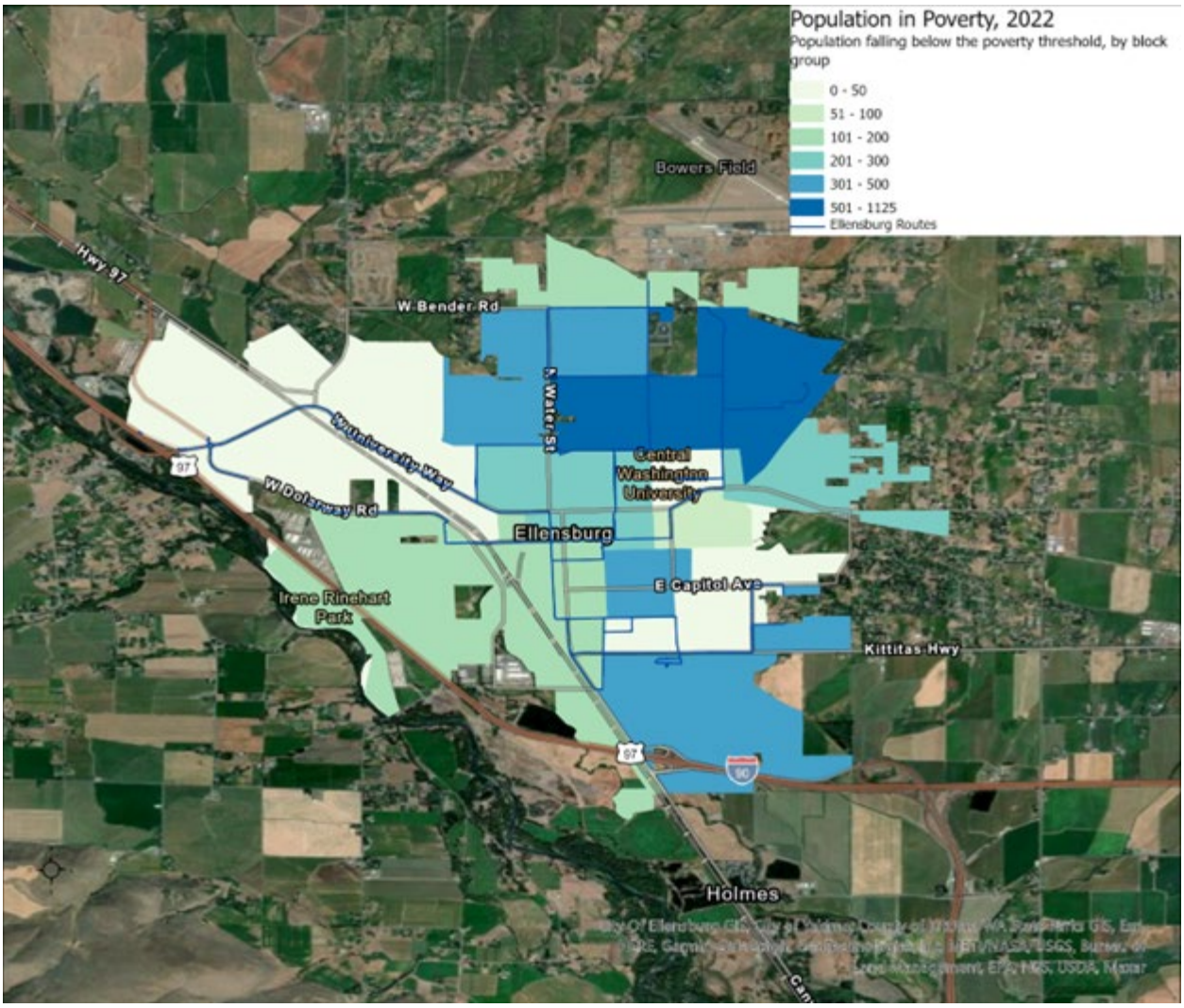


Figure 3. Income Projection by Block Group in Ellensburg, 2022 (ACS, 2016-2020)

POLICY & LEGISLATION IMPACTS

Central Transit is anticipating future changes to policy, legislation, and the development of supportive technologies locally in addition to the plans already put in place that will impact this plan. In addition to FTA's direction, Central Transit has identified specific supportive policies at the local, state, and federal level that will help ensure the success of the full fleet's transition.

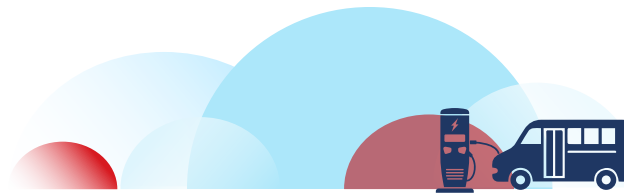
CITY OF ELLENSBURG AND CENTRAL TRANSIT

From 2022 through 2027, Central Transit will focus on several key priorities that convey how Central Transit's local priorities align with state goals established in the Washington State Transportation Plan. Central Transit strives to provide safe, reliable transportation services connecting passengers to employment, essential services, education, and many other services, which increases the quality of life in the community. To that end, Central Transit's proposed project and action strategies align its goals with regional and state public transportation objectives. The State's six policy goals are:

1. **Economic Vitality:** To promote and develop transportation systems that stimulate, support, and enhance the movement of people and goods to ensure a prosperous economy.
2. **Preservation:** To maintain, preserve, and extend the life and utility of prior investments in transportation systems and services.
3. **Safety:** To provide for and improve the safety and security of all passengers and the transportation system.
4. **Mobility:** To improve the predictable movement of goods and people throughout Washington State.
5. **Environment:** To enhance Washington's quality of life through transportation investments that promote energy conservation, enhance healthy communities, and protect the environment.
6. **Stewardship:** To continuously improve the quality, effectiveness, and efficiency of the transportation system.

Central Transit also includes the following specific goal, objective, and three strategies in their 2022-2027 Transit Development Plan to meet these needs reflected above across the state policy goal areas of Economic Vitality, Environment, and Stewardship.

- **Goal 3:** Enhance the integration of transit services to support the economy and preserve the environment.
- **Objective 3.1**: Reduce fossil fuel consumption through the consideration of alternative fuel vehicle technology.
  - **Strategy 3.1.1:** Acquire a zero-emissions transition plan.
  - **Strategy 3.1.2**: Support the procurement of alternative fuel transit vehicles.
  - **Strategy 3.1.3**: Support the development of a zero-emissions infrastructure.



Central Transit's transition to ZEBs will support the City, County, and State goals outlined here and below.

KITTITAS COUNTY

Kittitas County lies east of the Cascade Mountain range, with a total area of 2,333 square miles. The geography of the county results in long periods of high pressure and air inversions during the winter months where any pollution released into the air stays in the lower atmosphere until changing weather conditions stir air out of the valley. Air quality data indicate Ellensburg has one of the highest levels of PM2.5 in Washington State during the winter home-heating season. Ellensburg has been identified as a vulnerable community for PM2.5. In recent years, fine particle air pollution in Ellensburg has reached unhealthy levels several times, which is a concern not only for health reasons, but also because higher levels of fine particles could cause the Ellensburg area to violate the federal health-based National Ambient Air Quality Standards (NAAQS).

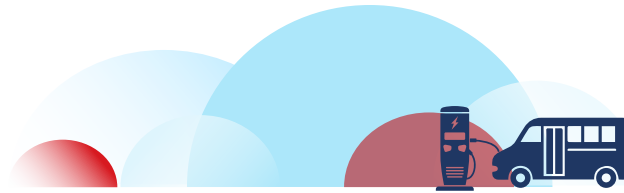
Kittitas County Public Health Department (KCPHD) has evaluated air monitoring data from the Washington State Department of Ecology's real time air monitoring station in Ellensburg, Washington, since 1999 as an environmental health indicator. In the 2012 Kittitas County Community Health Assessment, poor air quality was identified as an area of concern by a group of key community partners. In this assessment, it was also noted that Kittitas County has a significantly higher mortality rate for influenza and pneumonia compared to Washington State as a whole. This may be one of many factors related to poor air quality.

Kittitas County Public Health partnered with the EPA and joined the PM Advance program in August of 2016. The PM Advance program encourages communities to take proactive steps to improve air quality and avoid violation of federal health-based standards. As part of this program, the Kittitas County Air Quality Advisory Committee and KCPHD are creating a sustainable 5-year Strategic Plan which includes voluntary efforts to limit harmful emissions.

Efforts to reduce PM2.5 county-wide will benefit all the communities of Kittitas County. The aims of Central Transit's zero emission transition plan align with the objectives of KCPHD's 5-year Strategic Plan, particularly in the prioritization and utilization of resources to provide cleaner air for all people in the county and surrounding areas. With an emphasis on increased opportunities to collectively address population health issues in Kittitas County, Central Transit's ZEBs will work to support the County's goals by incorporating sustainability principles and efficiency into its operational standards.

QUAD COUNTY REGIONAL TRANSPORTATION PLANNING ORGANIZATION

Quad County Regional Transportation Planning Organization (QUADCO RTPO) is a four-county region made up of the counties, cities, and towns within Adams, Grant, Kittitas, and Lincoln Counties. Geographically, it covers an area of 9,214 square miles of central and eastern Washington. The primary purpose of QUADCO RTPO is to provide a forum for continuing, cooperative, and



comprehensive transportation planning and decision-making among the member agencies in the region.

QUADCO RTPO is currently updating its Regional Transportation Plan (RTP). This plan was first adopted in 1994 and has been updated regularly since. An important element of QUADCO RTPO's RTP is a description of transportation improvements needed to sustain QUADCO's economic vitality. Other important elements will include accessibility, mobility, safety, and preservation. These elements will show what transportation improvements should be considered, where there are challenges and opportunities, and what future trends and growth patterns will impact the transportation system. QUADCO RTPO's RTP plays an important role in achieving consistency between state, county, city, and town plans and policies. QUADCO RTPO is a supportive partner agency in reducing emissions in the transportation sector.

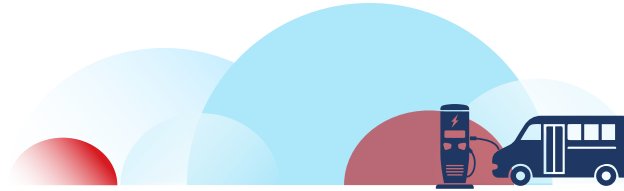
WASHINGTON STATE

In Washington, the transportation sector is the largest source of greenhouse gas (GHG) emissions and a major contributor to other types of air pollution. Under a 2020 law, Washington is required to reduce its overall GHG emissions 45 percent by 2030, 70 percent by 2040, and 95 percent by 2050. Since almost 45 percent of Washington's annual GHG emissions come from transportation, cleaner cars and trucks are essential to meeting these limits. Increasing the number of zero emission vehicles on our roads will reduce total GHG emissions by the equivalent of 1 million metric tons of carbon dioxide a year by 2030.

To support the environmental performance of state government operations, several EOs have been signed in recent years explicitly addressing transportation measures that will be taken in Washington. In 2014, Governor Inslee signed EO 14-04, titled "Washington Carbon Reduction and Clean Energy Action." This order superseded two orders by Washington's previous governor (EO 07-02 and EO 09-05) to serve as the framework for Governor Inslee's actions on climate change. From this framework, ten measures were produced to address the issues raised by research into climate change, including a Clean Transportation measure. Several goals were set for the Washington State Department of Transportation (WSDOT), including the development of an action plan to advance electric vehicle use, programs related to transportation efficiency (covering a comprehensive plan to maximize transportation efficiency update); and identifying increased investment opportunities in multimodal transportation. In January 2018, EO 14-04 was superseded by EO 18-01, taking measures further by requiring the agencies with the largest share of statewide GHG emissions to significantly cut their emission usage from operations.

MOTOR VEHICLE EMISSION STANDARDS — ZERO EMISSION VEHICLES BILL

Governor Jay Inslee signed the Motor Vehicle Emission Standards – Zero Emission Vehicles bill (RCW 70A.30.010) on March 25, 2020. The result of this bill will be the adoption of California vehicle



emission standards, including new requirements to increase the number of zero emission vehicles sold in Washington.

CLIMATE COMMITMENT ACT

The Climate Commitment Act (CCA) (SB 5126), signed by Gov. Jay Inslee on May 17, 2021, reduces GHG emissions from Washington's largest emitting sources and industries, allowing businesses to find the most efficient path to lower carbon emissions. The CCA establishes a "cap and invest" program that sets a limit on the amount of GHGs that can be emitted in Washington (the cap) and then auctions off allowances for companies and facilities that emit GHGs until that cap is reached. Over time the cap will be reduced, allowing total emissions to fall to match the GHG emission limits set in state law. Auctioning allowances will raise money that will raise funds for investing in climate resiliency, reducing pollution in disproportionately affected communities, and expanding clean transportation.

CLEAN FUEL STANDARD

On May 17, 2021, Governor Jay Inslee signed the Clean Fuel Standard (HB 1091). The standard will cut statewide GHG emissions by 4.3 million metric tons a year by 2038 and will stimulate economic development in low carbon fuel production. The Clean Fuel Standard will work beside the Climate Commitment Act to target the largest source of emissions in Washington. The Clean Fuel Standard law requires fuel suppliers to gradually reduce the carbon intensity of transportation fuels to 20 percent below 2017 levels by 2038. There are several ways for fuel suppliers to achieve these reductions, including:

- Improving the efficiency of their fuel production processes
- Producing and/or blending low-carbon biofuels into the fuel they sell
- Purchasing credits generated by low-carbon fuel providers, including electric vehicle charging providers

WSTA Clean Fuel Standard Credit Generation Program

The Clean Fuel Standard (CFS) creates the possibility of credit generation opportunities for public transit operators in Washington State, specifically those operating using alternative fuels, renewable fuels, electrification, and hydrogen. As a result of this legislation, the Washington State Transit Association (WSTA) is seeking consultant support in aggregating and marketing CFS credits on behalf of its membership. WSTA is seeking to act as an agent to aggregate the needs of its members under a single contract that would serve to assist members in education and generation of CFS credits and realizing the credits.

ZERO EMISSION VEHICLE INFRASTRUCTURE PARTNERSHIP PROGRAM

The Washington State Alternative Fuel Vehicle Charging and Refueling Infrastructure Program (RCW 47.04.350) directs WSDOT's Innovative Partnerships Office to develop and maintain a program to support the deployment of clean alternative fuel vehicle charging and refueling infrastructure supported by private financing. WSDOT refers to the program as the Zero Emission Vehicle Infrastructure Partnership (ZEVIP) program. ZEVIP consists solely of projects that provide a benefit to the public through development, demonstration, deployment, maintenance, and operation of clean energy technologies that save energy and reduce energy costs, reduce harmful air emissions, or otherwise increase energy independence for the state. Program funds are invested in the deployment of electric vehicle charging and hydrogen fueling stations at key intervals along state and federal highway corridors to support interurban, interstate, and interregional travel for clean alternative fuel vehicles.

GREEN TRANSPORTATION GRANT PROGRAM

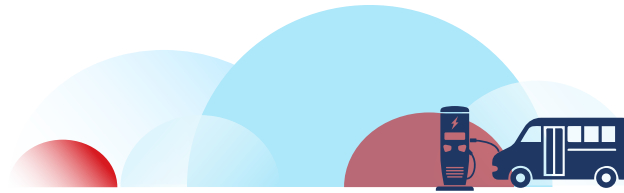
The WSDOT Green Transportation Capital grant program provides funding to transit agencies for capital projects that reduce the carbon intensity of the Washington transportation system. This grant is supported by state funding through RCW 47.66.120. Project types include fleet electrification, including battery and fuel cell electric vehicles, modification, or replacement of capital facilities to facilitate fleet electrification and/or hydrogen refueling, necessary upgrades to electrical transmission and distribution systems, and construction of charging and fueling stations. It is anticipated that there will be a minimum of $12 million and up to $50 million in state funding for Green Transportation Capital Grants in the 2023–2025 biennium. The Legislature will determine the funding level in the 2022–2023 legislative session.

OTHER RELATED STATE POLICIES

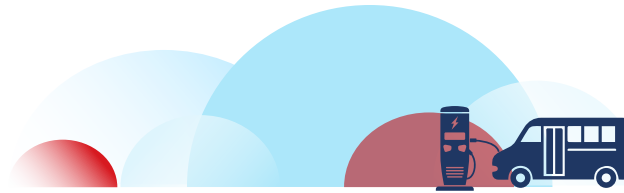
EO 21-04: Governor Jay Inslee affirmed urgent commitments to addressing the climate crisis by signing a range of emission reductions in November 2021. This EO fully commits to electrify Washington State's public fleets and transition to a 100 percent zero-emission light-duty fleet by 2035, as well as 100 percent zero-emission medium- and heavy-duty state fleets by 2040.

SB 5910: This legislation advances Washington's first statewide strategy to pursue a renewable hydrogen economy by authorizing financial support from the State for a public-private partnership, in efforts to apply for the Bipartisan Infrastructure Law's clean hydrogen hub funding. Existing renewable energy resources in the Pacific Northwest make Washington an ideal location for a hydrogen hub that is supported by both public and private partnerships.

HB 1988: This act establishes a retail sale and use tax deferral program for certain investment projects in clean technology manufacturing, clean alternative fuels production, and renewable energy storage. Permitted investments include renewable hydrogen production and zero emission vehicle



refueling infrastructure. Investments in these areas will work to expand accessibility to clean hydrogen resources, while encouraging more robust deployment and use.



FLEET TRANSITION PLAN

Transitioning to a zero-emission fleet goes beyond purchasing vehicles and a fueling system. It involves integrating new technology and processes into daily operations. Effective fleet transition plans adopt a comprehensive approach that considers operational needs, market conditions, available power, infrastructure demands, and costs. The analysis summarized below offers Central Transit data to guide decisions around capital programs and operations necessary to support transition actions and phases.

ZERO EMISSION VEHICLES & FUELING OPTIONS

As transit agencies look for zero emission technology to replace gasoline vehicles, there are two primary options: BEBs and hydrogen fuel cell electric buses (FCEBs). Currently, BEBs are the leading replacement choice because they are readily available on the market today and use the electric grid as their fuel source, which is universally available and relatively "easy" to connect to and draw the required power. Based on today's technology, BEBs limited range compared to gasoline vehicles can mean that not all gasoline vehicles can be replaced 1-to-1 with a BEB. In some cases, additional vehicles or mid-day recharging would be necessary to maintain the same level of service.

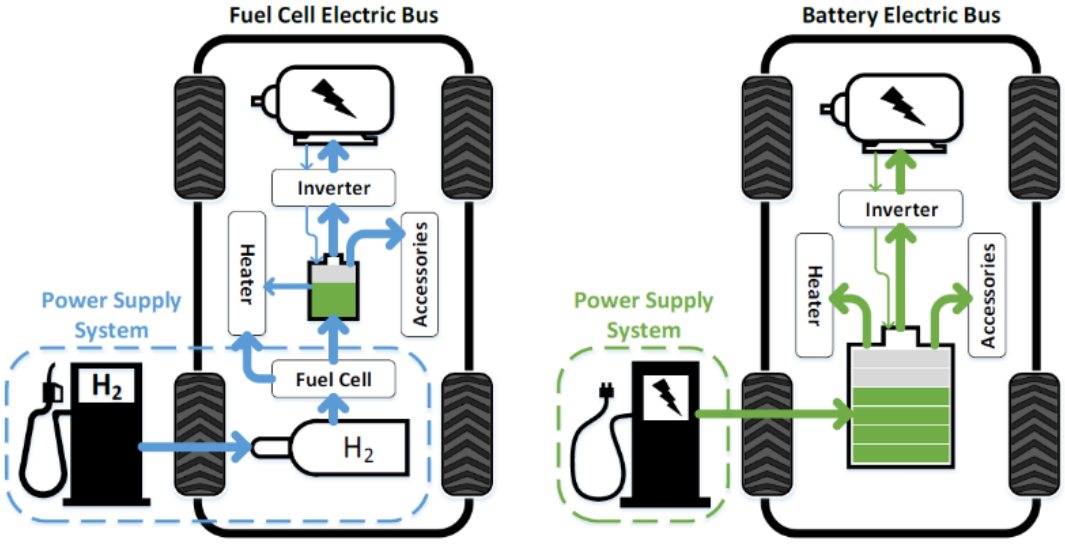


Figure 4. BEV and FCEV Vehicle Technology Comparison

Hydrogen FCEBs are the other primary option as a propulsion type for a zero-emission transition. FCEBs utilize a similar drivetrain to BEBs but have a smaller battery that is recharged by an on-board fuel cell that generates electricity from hydrogen as the vehicle travels. The energy density of hydrogen is much greater than a battery, which allows for the range of these vehicles to match a conventional gasoline vehicle more closely. Therefore, the greatest benefit of FCEBs is that their range is comparable to gasoline vehicles. However, the challenge with deploying FCEBs is the lack of a current market for cutaway vehicles, locating a source of hydrogen, which is not as readily available as electricity, and the cost of hydrogen.

ENERGY MODELING & ANALYSIS

Understanding energy consumption is a key component of fleet transition planning, as it informs the choice of vehicle technology, infrastructure requirements, finances, and fleet replacement strategies. The energy consumption model, Zero+, provides a comprehensive understanding of the potential impacts ZEB technology may have on Central Transit's existing service.

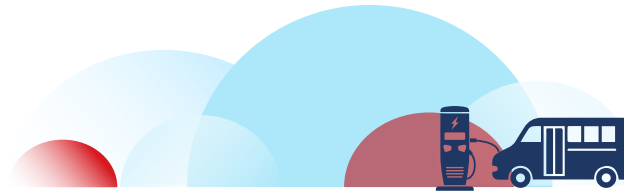
The Zero+ model also analyzes variables known to impact lifetime vehicle performance, like energy density; battery degradation; operating environment; heating, air conditioning, and auxiliary power loads; and the lifecycle of bus batteries and hydrogen fuel cells. The model is fed by General Transit Feed Specification (GTFS) data, geographic information system (GIS) data, and vehicle profile assumptions to create an accurate energy consumption profile unique to Central Transit's existing service. In sum, Zero+ results include many data variables, yielding the most accurate results possible to influence strong, effective decision making.

The Zero+ model results, combined with discussions with agency staff, provide the basis upon which the preferred refueling strategy will be determined. This modeling effort included a review of available hydrogen FCEBs, but it was found that no comparable vehicles exist for the Central Transit fleet so FCEBs were not simulated. For a BEB scenario, this modeling evaluated whether the optimal charging strategy is depot charging only, a mix of depot and on-route charging, or on-route charging only, and identifies potential strategies that best complement Central Transit's service and fleet plans. Simulations were performed at the granular level, so that the strategy can inform individual vehicles, routes, and blocks as well as the full Central Transit fleet. Examining each vehicle individually drives decisions for the right technology at the system, depot, route, and block levels. This analysis balances impacts to operations, overall fleet size, and infrastructure requirements and ultimately provides Central Transit with the information to make a data-driven determination of the preferred BEB transitional technologies and deployment pace. Details of the energy modeling and analysis for all scenarios can be found in the accompanying Appendix.

ZERO EMISSION TRANSITION STRATEGY

Central Transit's current service profile and existing fleet was modeled to determine the feasibility of a transition to zero emission vehicles using currently available vehicle and charging technology. The modeling analysis revealed that either the current fleet size would need to double, or on-route chargers would need to be introduced in addition to overnight charging at the HopeSource Facility to maintain the same level of service.

Doubling the fleet size is not a viable option, so the focus turned to on-route charging as a possible solution. The following strategy outlines the infrastructure requirements necessary to allow Central Transit to transition to a zero-emission fleet with a 1-to-1 vehicle replacement ratio and maintain the same level of service. The transition would begin in 2028 with the purchase of the first three BEBs, utilizing on-route charging with depot assisted charging, and all future vehicle replacements will be electric. The agency currently replaces vehicles in line with the biennium vehicles that have already been planned show the actual replacement year, while vehicles that do not currently have



replacements planned assume the next replacement is the end of the biennium. Vehicles rebuilt in 2023 will be replaced with BEBs in 2028.

Table 2. Existing Fleet Replacement Schedule

Vehicle	Model Year	Make/Model	UFL Description	Next Replacement
CT-6	2017	Ford E-450	REBUILD – 2023	2028
CT-7	2017	Ford E-450	REBUILD – 2023	2028
CT-8	2019	Ford E-450	REPLACE 2023-2025	2023
CT-9	2018	Ford E-350	REPLACE 2023-2025	2025
CT-10	2021	Diamond VIP2200	REPLACE 2025-2027	2027
CT-11	2021	Diamond VIP2200	REPLACE 2025-2027	2027
CT-12	2021	Ford E-450	REPLACE 2025-2027	2027

The replacement schedule shown in Figure 5 shows gasoline replacements are purchased between 2023 and 2027 with electric replacements beginning in 2028, but gasoline vehicles are replaced with BEBs at a 1-to-1 ratio. With the inclusion of on-route charging, there is no need for an increased fleet size, so procurement quantities in each year mirror the existing replacement schedule through 2032. Replacements beyond 2032 will be subsequent replacements of BEBs, which have an assumed 8-year useful life instead of the current 5-year useful life of gasoline vehicles. This figure shows vehicle purchases that get the fleet to 100 percent zero emissions, but does not include any future, incumbent replacements of electric vehicles.

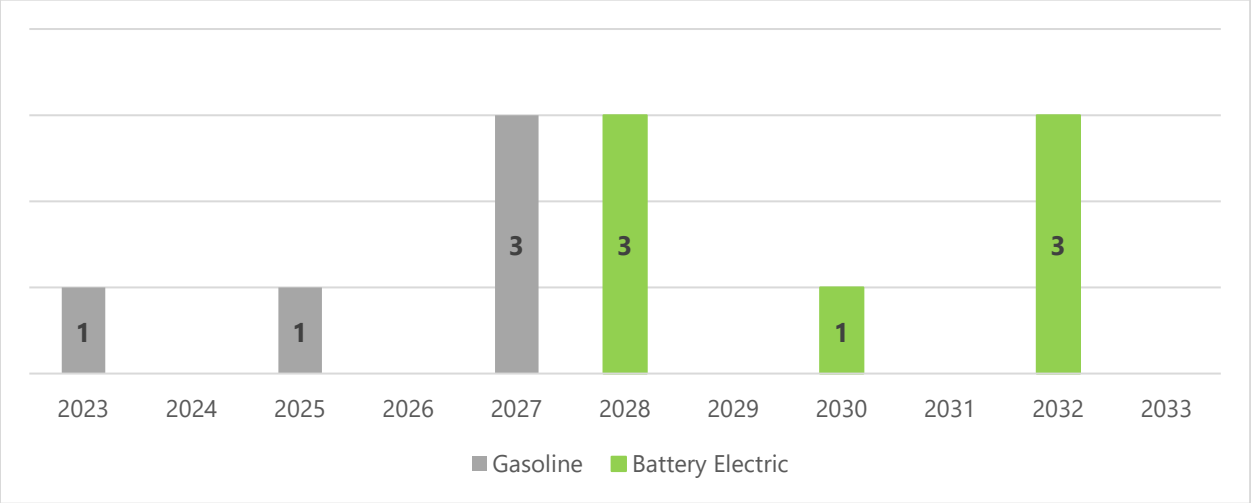


Figure 5. Vehicle Transition Schedule

The transition would begin with all four on-route chargers being installed in 2028 with the first three BEBs; not all chargers would be utilized at first, but there would be no construction rework required to install the remaining two chargers with later bus procurements. At the HopeSource Facility there will be a total of five Level 2 chargers; three of these chargers will be installed in 2028 with future installations in 2030 and 2032. The charger installation schedule is shown below in Figure 6.

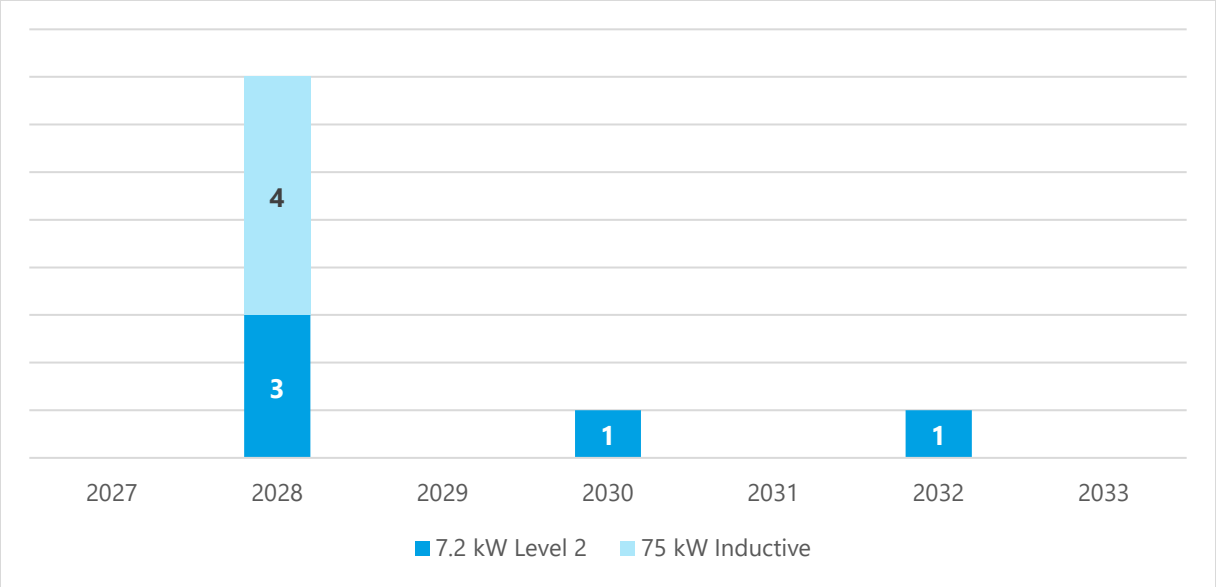


Figure 6. Charger Installation Schedule

FACILITY & INFRASTRUCTURE PLAN

The following section identifies Central Transit's current service profile, operations, and maintenance facilities. These elements were captured to develop the Zero Emission Transition Strategy that best suits the agency based on discussions following the energy modeling and analysis effort, as well as how the proposed strategy will impact existing service and facilities. In coordination with the City of Ellensburg's Electrical Power Department, the availability and accessibility of power, utility rate structures, and potential incentives or rebate programs for electrification were assessed. A summary of estimated up-front capital costs for the purchase and installation of charging and supporting utility infrastructure is also provided, including a detailed financial analysis for Central Transit's reference.

EXISTING CONDITIONS

Central Transit does not own their own facility, so all vehicles are stored overnight at the HopeSource Facility located at 606 West 3rd Avenue in Ellensburg. The existing fleet is currently fueled by the drivers at Midstate Coop Fuel Station adjacent to the HopeSource Facility. Most driver shift reliefs take place at the HopeSource Facility, but some routes have on-street shift reliefs in addition to vehicles periodically being swapped at shift change for maintenance and upkeep.

HopeSource leases its facility space in a historical building, so coordination and approvals will be required with both the building owner and historical review within Ellensburg. Additional time may be needed to secure approvals for charger installations. HopeSource is also developing plans for transitioning to zero emissions, so additional coordination will be needed to ensure plans align between Central Transit and HopeSource.

DEPOT CHARGING INFRASTRUCTURE

To support the BEBs within the Central Transit fleet, five 7.2 kW Level 2 plug-in chargers are needed at the HopeSource BEB storage location. For the layout shown in Figure 7, all chargers would be located behind the gate on the northwestern corner of the property. In coordination with the HopeSource team, this location was identified as the current parking space for the transit fleet and has available space for the required infrastructure footprint. The point of interconnect (POI) with the utility is located adjacent to the park, south of the parking area. The utility has confirmed that the existing overhead utility line provides feed to an existing transformer on the west side of the park through an electrical manhole. This existing feed would be the POI for a new 50 kVA transformer to support the charging equipment at the HopeSource facility.

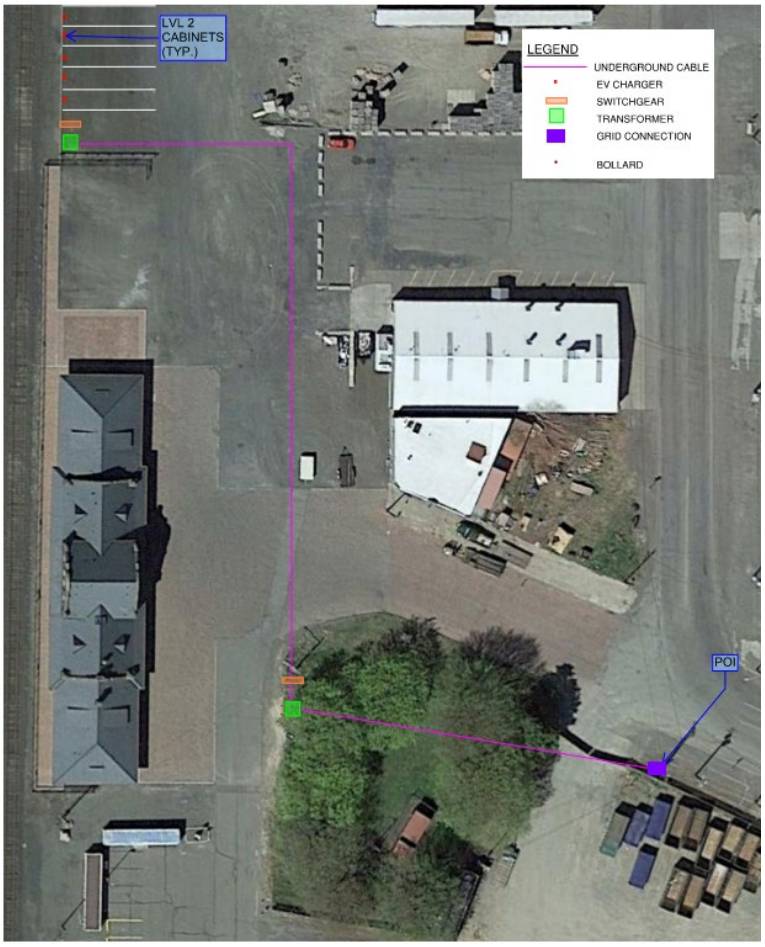


Figure 7: HopeSource Facility Proposed Charging Layout

ON-ROUTE CHARGING INFRASTRUCTURE

All Central Transit routes share a common layover point downtown at the intersection of East 4th Avenue and North Ruby Street in Ellensburg, Washington. Based upon current vehicle battery technology, four wireless inductive direct current fast chargers (DCFCs) would be required at this location: three chargers on the northbound side of the street and one charger on the southbound side of the street as shown in Figure 8. The green space located between the northbound bus stop bench and Safeway parking lot is owned by the City of Ellensburg and would house the required infrastructure for the on-route charging. The POI from the utility for the infrastructure is provided by the overhead line located one block west of the charging location. The utility confirmed there is a pole available, Figure 9, to tap off the overhead line and trench to the new 500 kVA transformer.

Figure 8: On-Route Proposed Charging Layout

Figure 9: On-Route Charging Location Overhead Utility POI

UTILITY & FUEL PARTNERSHIPS

Coordination with local utility providers is a critical element to a successful transition to zero emissions. Discussions with the City of Ellensburg Electrical Power Department provided valuable insight on what infrastructure exists and what the current grid capacity is at both the HopeSource Facility and the on-route charging location near Safeway. In addition to current and future availability of and need for supporting infrastructure, discussion also included currently available utility rate structures and potential rebates, incentive programs, and the possibility of utility rate structures unique to electric vehicle charging.

COORDINATION WITH ELECTRIC UTILITY

UTILITY POWER SUPPLY

For each of the final site layouts reviewed, initial design considerations were discussed to ensure ease of implementation of the infrastructure. Through this process, the utility also confirmed the availability of required POIs for each location and indicated that any equipment over 400 Amps, which is common for DCFC infrastructure, is considered owned by and the sole responsibility of the customer.

Industry-wide supply chain shortages have increased procurement lead times for electrical equipment which has led to large delays in project completion; backlogged inventory of transformers for standard ratings is a concern. The lead times for switchgears and electrical panels are also impacted by supply chain shortages and inventory backlogs which may further impact the project timeline.

UTILITY RATE CONSIDERATIONS

Many utilities are incentivizing BEB adoption by introducing utility rate structures unique to BEB charging that are often less expensive than general residential and commercial rate structures. At this time, there is not an available BEB rate structure available for Central Transit, but discussion with the utility included potential rates that can further reduce costs such as the demand charge in the future.

Standard Rate Structures

The existing rate structures are E500 (Municipal) and E201 (General Service Three Phase Demand) were identified as the potential rates that may be associated with the BEB charging. While a formal application for each rate would be required, the E500 rate was suggested as the more suitable rate structure for Central Transit's operational profile.

E500 (Municipal) Rate

The E500 rate structure only includes a flat-rate daily customer charge and charges for energy consumption on a per kWh basis. It does not include a per kW demand charge, making this rate structure more appealing when compared to the E201 rate structure.

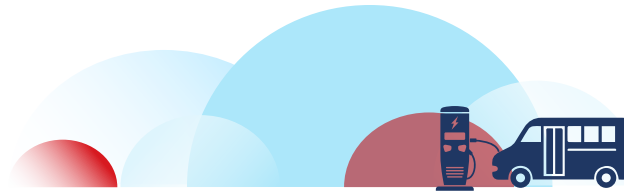


Table 3: E500 (Municipal) Rate Structure

Effective Date	1/1/2022	1/1/2023	1/1/2024	1/1/2025
Unit	All usage (per kWh)			
Consumption Charge	$ 0.0696	$ 0.0696	$ 0.0724	$ 0.0724
Unit	Three Phase (per day)			
Customer Charge	$ 2.4658	$ 2.4658	$ 2.5644	$ 2.5644

E201 (General Service Three Phase Demand) Rate

While the per kWh energy consumption charge is slightly lower than the E500 value, the E201 rate structure includes a demand charge in addition to energy consumption and customer charges. For the anticipated load profile of charging the BEBs, the E201 rate is forecasted to be a higher monthly cost than the E500 rate and is reviewed further in the Task 4 Technical Memorandum.

Table 4: E201 (General Service Three Phase Demand) Rate Structure

Effective Date	1/1/2022	1/1/2023	1/1/2024	1/1/2025
Unit	All usage (per kWh)			
Consumption Charge	$ 0.0524	$ 0.0524	$ 0.0534	$ 0.0534
Unit	All demand (per kW)			
Demand Charge	$ 6.30	$ 6.30	$ 6.43	$ 6.43
Unit	Three Phase (per day)			
Customer Charge	$ 3.7808	$ 3.7808	$ 3.8564	$ 3.8564

Electric Vehicle Charging and Special Consideration Rates

Separate metering is required when recording the electrical associated directly with BEB charging. While there are currently no incentives or special rate structures provided for BEB charging, the utility recommended applying for the E700 (Nonprofit Agency Serving the Disadvantaged) rate structure. This rate structure provides an additional 50 percent reduction in any demand and customer charges associated with the primary rate structure.

FINANCIAL ANALYSIS & FUNDING PLAN

The following section evaluates the lifecycle costs associated with the zero-emission fleet transition scenario currently being considered by Central Transit for its public transit bus fleet. The costs evaluated include capital, maintenance, and fuel/electricity over a 20-year period, from 2023 through 2042. The transition includes the replacement of all gasoline buses with BEBs. This BEB fleet is compared to a baseline scenario in which Central Transit continues to utilize the existing gasoline fleet and does not transition to BEBs. A lifecycle cost analysis is used to inform a decision between acquiring one of two assets, determining each asset's benefits, and create an informal budget. In this case, the analysis will show how the cost schedule of continuing with a gasoline fleet compares to transitioning to electric buses. The analysis will not consider any external benefits, such as noise reduction or harmful GHG emissions reductions, realized by the transition, which may play a large part in policy choices; these external benefits are not monetized but should be considered in final decisions.

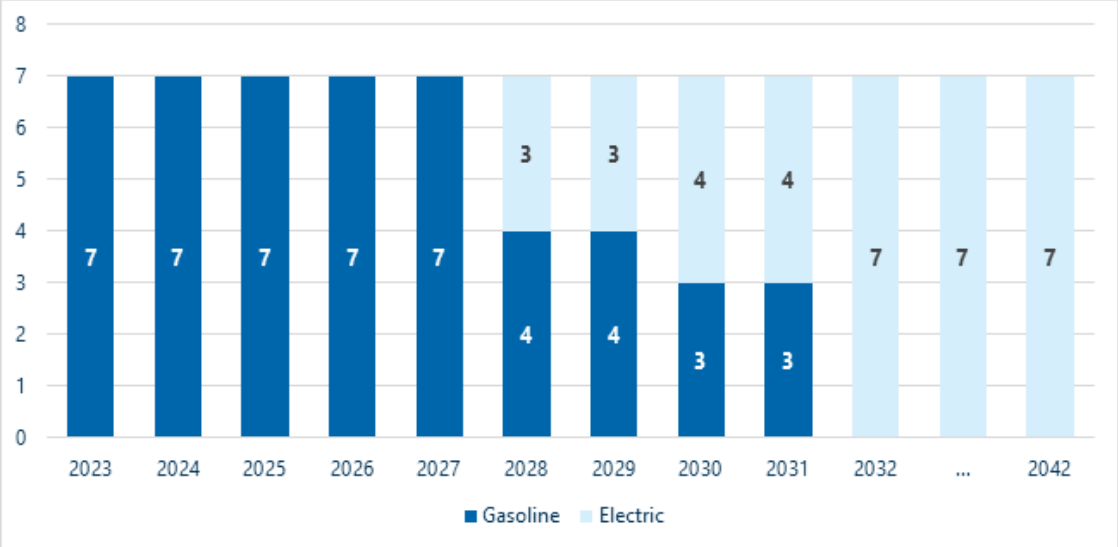
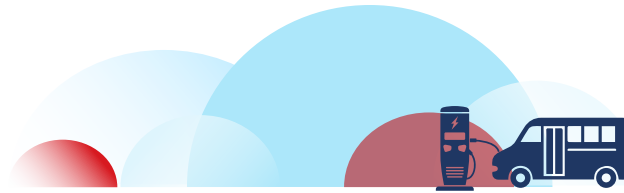


Figure 10: Annual Fleet Composition by Fuel Type

Figure 10 depicts the fleet composition by fuel type in each year as the fleet transitions from gasoline to electric. Because vehicles would be replaced at a 1-to-1 ratio, vehicle operating hours and miles remain the same regardless of fuel type. Associated costs can generally be separated into three categories: capital costs, operating and maintenance (O&M) costs, and fueling costs. While some operating statistics, like revenue hours and miles, may remain consistent across fuel types, there are differences in the cost of vehicles, the cost to maintain and fuel vehicles, and the added cost of charging infrastructure. These costs are compared in Table 4, which clearly indicates that transitioning to zero emissions will cost more than continuing with a gasoline fleet. There is a realized savings on fueling costs by transitioning to zero emissions, but these savings are far outweighed by the additional capital and O&M costs.

Table 5: Lifecycle Cost Breakdown, FY 2023 to FY 2042 (2023 $)

Capital Costs	Baseline	EV Transition
Vehicle Purchases	**$1,976,000**	**$3,716,000**
Gasoline Vehicle Purchases	$1,976,000	$356,000
EV Purchases	-	$3,360,000
Infrastructure Purchases	**N/A**	**$1,535,563**
Chargers	-	$312,500
Utility Infrastructure	-	$1,223,063
Total	**$1,976,000**	**$5,251,563**
O&M Costs	**Baseline**	**EV Transition**
Vehicle Maintenance	**$719,499**	**$441,774**
Gasoline Vehicles	$719,499	$159,318
Electric Vehicles	-	$282,457
Infrastructure O&M	**N/A**	**$154,500**
EV Chargers	-	$154,500
Total	**$719,499**	**$596,274**
Fueling Costs	**Baseline**	**EV Transition**
Gasoline	$3,097,610	$1,148,585
Electricity	-	$372,534
Total	**$3,097,610**	**$1,521,119**



WORKFORCE TRANSITION PLAN

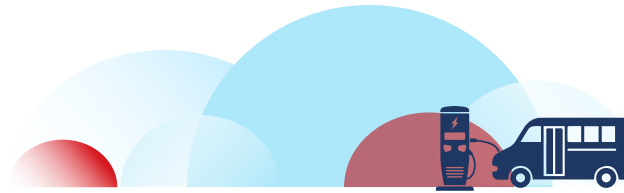
Alongside the introduction of zero emission technology to the Central Transit bus fleet, proper training on bus systems and subcomponents unique to ZEBs is critical to ensure safe, efficient operation and maintenance of the transitioned fleet. Central Transit will ensure the selected contractor works with internal training departments and in close coordination with original equipment manufacturers (OEMs) to acclimate the existing workforce to the new technology, avoiding displacement of the existing workforce. This section addresses the necessary steps that will need to be taken by contractors to evaluate the skills of the existing workforce, identify skill gaps on an individual basis, and develop a plan to build and implement an effective training program for both bus operators and bus maintenance personnel. In addition to the development of the existing workforce, this section also conveys a workforce growth strategy for attracting new employees, retaining new and current employees, and funding opportunities to sponsor growth. Central Transit should consider building the following information into the next contracting period to ensure that workforce planning is included in partnership with the selected contractor.

TRAINING PROGRAM DEVELOPMENT

Central Transit intends to deploy a fleet of BEBs operated by contractors. Central Transit will review the training program provided by the selected contractor, making sure the appropriate technologies are included into a comprehensive curriculum. The development of a high-quality training program will entail coordination with internal and external resources. The following potential resources may assist Central Transit's selected contractor with program development:

- Vehicle and charger OEM training curriculum purchased as part of new rolling stock procurements
- Vehicle subsystem/subcomponent OEM training curriculum
- Partnership with local first responding agencies
- Collaboration with transit agencies with operational zero emission fleets and in-house training programs
- Washington State Transit Insurance Pool
- GEM (Grounds, Equipment, and Maintenance), a Pacific Northwest Interagency Cooperative for all public agencies to the mutual benefit of all constituents
- Membership through training consortiums like National Transit Institute
- Participation in transit associations like Washington State Transit Association, American Public Transportation Association, Center for Transportation and the Environment, and Zero Emissions Bus Resource Alliance

Central Transit is committed to working closely with the contractor to develop a comprehensive training program that integrates a BEB curriculum with any existing internal training programs, including bus maintenance technical training and behind-the-wheel training. Technical training includes shop and system safety, system familiarization and operations, troubleshooting and



diagnostics, rebuild, and preventative maintenance. All BEB curriculums will be developed and reviewed by Central Transit, the contractor, and any labor unions.

TRAINING CURRICULUM

BEBs contain high voltage batteries, requiring all maintenance technicians to be certified to work on high voltage systems. Central Transit will work closely with the selected contractor to ensure the existing Electronic and Electrical Safety Program with guidance from the National Fire Protection Agency (NFPA 70E), Occupational Safety and Health Administration, OEMs, and industry best practices are supplemented appropriately. These programs can be reviewed and utilized by the contractor as a foundation to establish and maintain electrically safe work conditions for bus maintenance personnel servicing Central Transit's fleet of BEBs. The selected contractor should consider including the following programs in their curriculum:

- Proper use and inspection of personal protective equipment
- CPR and first aid training
- High voltage onboard systems familiarization and identification
- Lock-Out-Tag-Out training and compliance

SKILLS ASSESSMENT, CATEGORIZATION, AND GAP IDENTIFICATION

This section outlines workplace hierarchical structure and authorized responsibilities of individuals based on qualifications; skill level requirements for work needing to be performed; and initial, refresher, and proficiency guidelines and requirements for training and associated qualifications that may be implemented by the contractor. Operational staff can be grouped into four main categories:

- Operations Support: Staff includes those who are critical to bus operations but do not directly interact with the buses.
- Bus Operations Staff: Includes operational staff who directly interact with the buses but do not perform any vehicle maintenance.
- Bus Maintenance Support: Staff includes operational staff who directly interact with the buses and are responsible for the assignment and oversight of maintenance functions.
- Bus Maintenance: Staff includes operational staff who directly interact with the buses and perform routine and unplanned maintenance functions.

For Operations Support, contractor-developed training requires a high-level overview of the technology and its capabilities. For example, it is important for dispatchers and schedulers to understand the operational range of the vehicles to avoid assigning vehicles to unsuitable routes.

Those categorized under Bus Operations will undergo extensive training developed by the contractor compared to Operations Support staff, given their direct interaction with the vehicles. For example, bus operators must be familiar with all dash indicator lights, operation of doors and wheelchair access, and safety procedures.

Bus Maintenance Support staff include key personnel responsible for the assignment and oversight of maintenance work, both preventative and unplanned, and are responsible for troubleshooting and dispatching for vehicle road calls. Staff in this category will receive the same contractor-developed training as bus maintenance personnel because their roles include making "game time" decisions that require full familiarity with all vehicle systems and mechanical components.

Bus Maintenance personnel will require the most training by the contractor because they have the most frequent and in-depth interaction with the vehicles. It is strongly encouraged that the contractor individually assesses each Bus Maintenance personnel on current skills and assign to training modules as necessary, ensuring that all Bus Maintenance personnel receive all training required without duplicating efforts. For example, Bus Maintenance personnel who can demonstrate proficient multiplexing skills will not be assigned to multiplexing courses.

TRAINING PROGRAM IMPLEMENTATION

Central Transit will work closely with the contractor to ensure current technical training programs are up to date, moving forward from older systems and making sure newer systems are adequately integrated into program. The selected contractor is expected to provide a training program that includes a comprehensive curriculum on all vehicle systems and subsystems. Through the selected contractor's program, Central Transit will review all Maintenance Department training, to make sure employees are provided with specialized training that encompasses current information about new and existing equipment, including modern electronic and mechanical bus systems, OEM changes that impact maintenance practices, and refresher training if necessary.

Central Transit encourages the selected contractor to identify maintenance management and front-line supervisors for Safety Orientation Training and Maintenance Department training sessions. Additional programs and supplemental professional development events supported by the contractor, including Federal Emergency Management Agency (FEMA) National Incident Response Training, Maintenance Program and Process Benchmarking, and National Transit Institute's Transit Trainers Workshops, have been identified as useful for training purposes.

Initially, the selected contractor should identify and develop a core group of subject matter experts to serve as BEB fleet specialists to be reviewed by Central Transit. This approach will proactively develop qualified fleet specialists through hands-on experience and learning.

Central Transit will work with the contractor to develop an appropriate timeline for training. The training effort is envisioned to be phased; as the zero-emission fleet grows, more mechanics will complete zero-emission maintenance training under the contractor. For example, if Central Transit is expecting delivery of 10 BEBs, transition training for five mechanics to become BEB-certified fleet specialists will begin 1 month prior to delivery.

WORKFORCE RIGHT-SIZING

As Central Transit transitions to a zero emissions fleet, the agency will work closely with the selected contractor to evaluate staffing needs on a rolling basis, based on overall fleet growth, and approve additional apprentice mechanic, mechanic, and lead mechanic positions as determined by the contractor's maintenance staffing personnel.

Central Transit and its selected contractor should continue to develop more creative recruitment strategies to combat the nationwide shortage of mechanics and bus operators. Properly marketing the Central Transit Zero Emission Fleet Transition, including the opportunity for a cutting-edge technical career, is critical to the attraction, development, and retention of the largely contracted workforce.

FUNDING OPPORTUNITIES

The anticipated cost of workforce training will likely fluctuate in response to the adoption of ZEBs. Suggested contractor funding is anticipated to come from several sources, including procurement, existing funding sources used for training, and federal and local funding shares.

While the cost of the training is one item to consider, the labor cost to train bus maintenance personnel is anticipated to be high. As highlighted by the International Transportation Learning Center, the following costs should be considered when budgeting for workforce training:

- Classroom training hours
- Instructor hours (instruction and preparation)
- Instructor hourly wages and benefits
- Instructor costs per class
- Instructor cost per trainee
- On the job training hours
- Mentor hours
- Mentor hourly cost
- Mentor cost per trainee
- Facilities cost
- Training materials, mock-ups, software, and simulation cost

Central Transit will work closely with the contractor to identify funding sources for worker training and retraining and utilize the training funding offered through federal grants to support the agency's zero-emission workforce training costs. Ellensburg will work to secure funding for zero emissions vehicle maintenance and operation training on behalf of the contractor.

ENERGY MODELING APPENDIX

Understanding energy consumption is a key component of fleet transition planning, as it informs the choice of vehicle technology, infrastructure requirements, finances, and fleet replacement strategies. The energy consumption model, Zero+, provides a comprehensive understanding of the potential impacts ZEB technology may have on Central Transit's existing service. Figure 11 shows the Zero+ Model inputs, outputs, and process. Energy consumption is impacted by several factors, including slope and grade of the bus routes, number of vehicle stops, anticipated roadway traffic, and ambient temperature. The Zero+ model also analyzes variables known to impact lifetime vehicle performance such as energy density; battery degradation; operating environment; heating, air conditioning, and auxiliary power loads; and the lifecycle of bus batteries and hydrogen fuel cells. The model is fed by GTFS data, GIS data, and vehicle profile assumptions to create an accurate energy consumption profile unique to Central Transit's existing service. In sum, Zero+ results include many data variables, yielding the most accurate results possible to influence strong, effective decision making.

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By using this data and applying existing Central Transit service information, the Zero+ tool produced a heat map showing the vehicle state of charge (SOC) throughout the day on any given route block. This report details which blocks and routes could perform within currently available BEB vehicle range capabilities, as well as forecasts of at what point in each route BEB range is exceeded. This insight provides clear data for planning operational adjustments and fleet demands to maintain service levels and maximize BEB utilization while also highlighting changes that may affect riders and recommending tactics to avoid or mitigate these impacts.

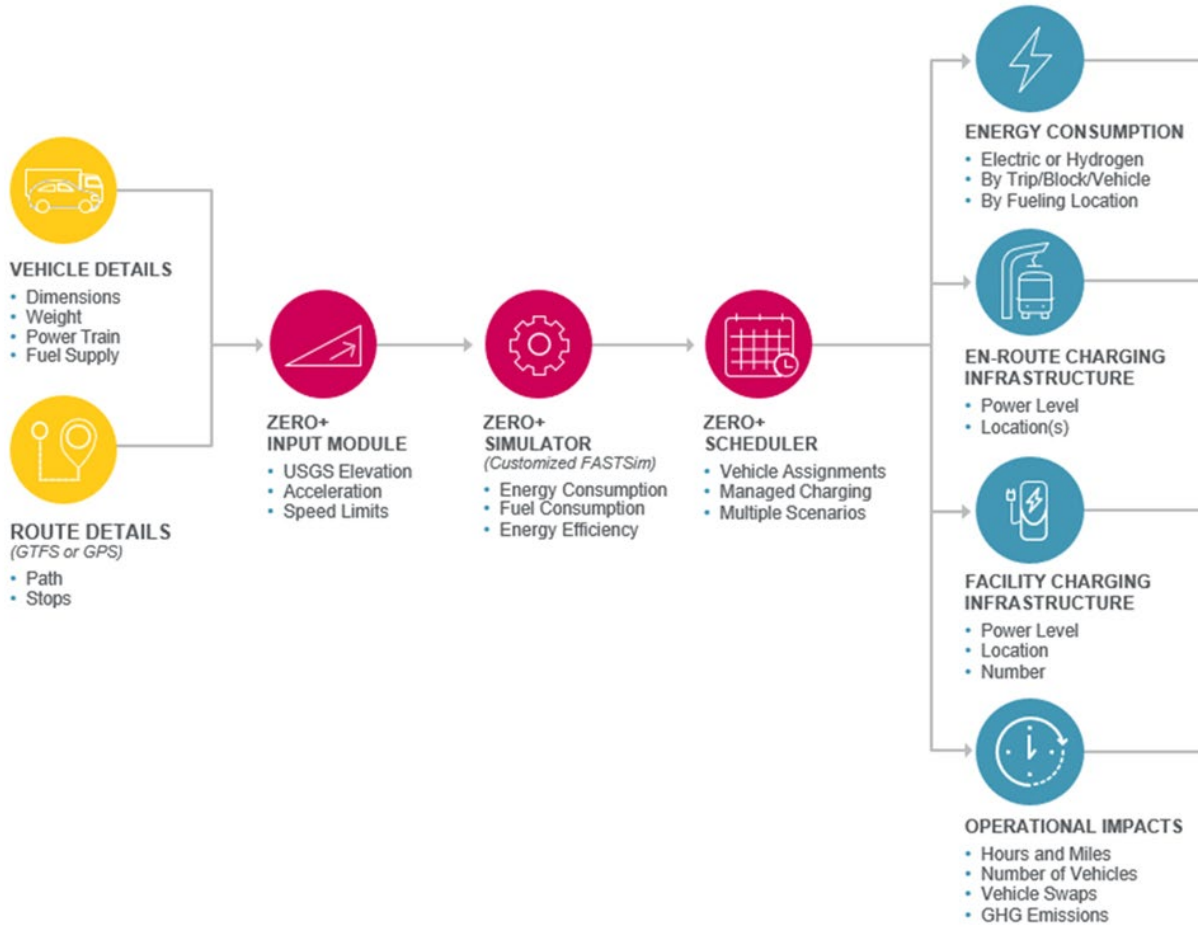

Figure 11. Zero+ Model Inputs, Outputs, and Process

ENERGY MODELING & ANALYSIS

Based on the evaluation and collection of data described above, a baseline gasoline scenario is simulated of current Central Transit service. This validates both the data provided and the functionality of the model by comparing simulation results to observed Central Transit existing gasoline operations. This validation provides confidence that the simulations of BEB scenarios are not missing critical data points that influence the transition. BEB scenarios simulated include two alternatives: BEBs with depot charging only, and BEBs with both depot and on-route charging.

BEB DEPOT CHARGING SIMULATION

Depot charging only was modeled first to establish a baseline feasibility. This scenario allows the Zero+ Model to identify which existing service blocks can be electrified without an increase in peak vehicle requirements, the need for on-route charging, or the need for schedule modifications to achieve the same level of service. By electing a depot-only charging profile, the model calculates what staff, vehicle, and service modifications would be needed to maintain the current level of service.

SIMULATION ASSUMPTIONS

To develop a model relevant for Central Transit's fleet and operations, a set of assumptions and variables were identified (Table 5). This simulation modeled service with a GreenPower EV Star, but not all vehicle OEMs will meet the same specification. When Central Transit procures vehicles for this transition, it is crucial to ensure that vehicle procurements meet or exceed this minimum specification to deploy BEBs that can match the operations simulated in this profile.

Table 6: Assumptions and Variables for Modeling Central Transit Operations

Variable	Input
Battery Capacity GreenPower EV Star	118 kWh
End-of-Life Battery Health	80% (Maximum Battery Degradation)
Energy Reserve	20% SOC
Heating	Electric Heater
Ambient Temperature	20ºF (Coldest Day, 10th Percentile)
Passenger Capacity	20
Maximum Charging Power	61 kW

SIMULATION RESULTS

Key Takeaways:

- Revenue hours and miles remain the same
- Non-revenue hours: **216% increase**
- Non-revenue miles: **209% increase**
- Peak vehicle requirement: **100% increase**
- Increase fleet from 5 to 10 buses
- 5 more vehicles required
- At least two depot chargers will be required

Figure 12 shows the vehicle battery SOC plot for each block. Each block is represented by a line on the chart with the color of the line corresponding to the SOC of the vehicle. The color changes from green to yellow to red as the SOC drops from 100 to 0 percent. Bus swaps (shown in blue) are introduced only between trips to minimize service impacts.

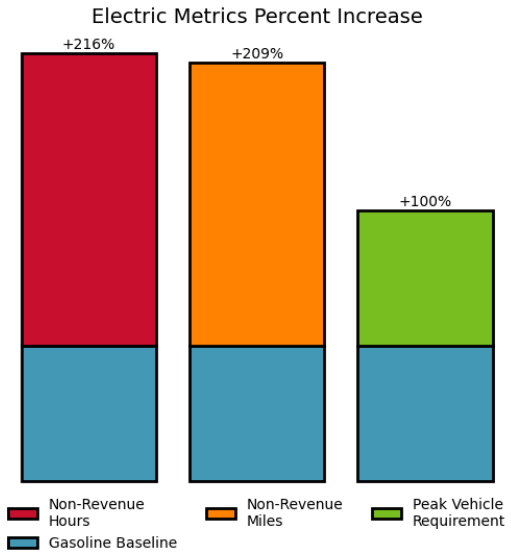

Figure 12. BEB Depot-Only Charging Model Outputs

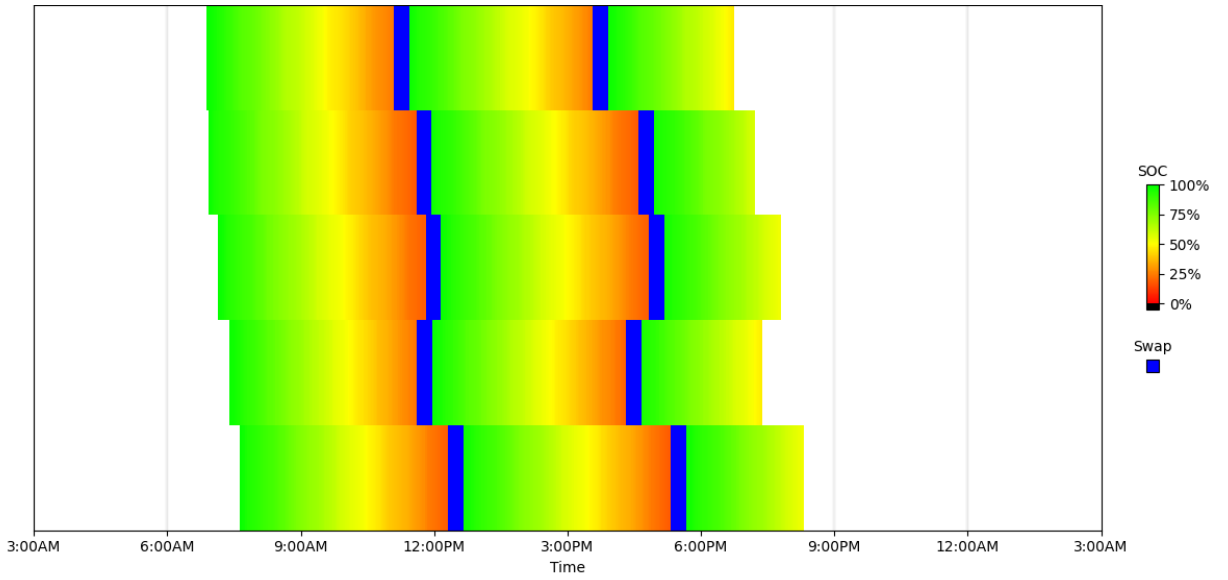

Figure 13. BEB Depot-Only Charging Block State of Charge

Bus swaps are also inserted in locations to guarantee the minimum SOC does not dip below the required 20 percent reserve capacity, including the energy needed to return the vehicle to the depot when a swap is needed. Whenever a vehicle is swapped out, it is replaced with a BEB that has a fully charged battery. Swapping buses is only helpful when the bus either stays near the depot all day or returns within a close distance to the depot at multiple points throughout the day. If a block is scheduled to travel a long distance one way away from the depot, then there is no opportunity for a swap. All Central Transit's service (five blocks) can only be operated with two swaps.

BEB DEPOT & ON-ROUTE CHARGING SIMULATION

On-route charging is an enhancement that can greatly improve the feasibility of BEBs in many situations. This is particularly helpful with circulatory routes where the same on-route charger can be used by a vehicle multiple times throughout the day. The on-route charging infrastructure is ideally located at places such as transit centers where buses operating on multiple routes all have scheduled layover time. On-route charging is capable of greatly extending the range of a BEB and facilitating 1-to-1 replacement of gasoline vehicles when the routes are conducive to this charging strategy.

SIMULATION ASSUMPTIONS

The simulation assumptions for the BEB Depot & On-Route Charging Scenario are identical to the assumptions for the BEB Depot Charging Scenario (Table 5). Although there are on-route chargers on the market that offer more power than the assumed 61 kW, there are currently no vehicles of the size used by Central Transit on the market that can accept a higher level of power. When Central Transit procures vehicles for this transition, it is crucial to ensure that vehicle procurements meet or exceed this minimum specification to deploy BEBs that can match the operations simulated in this profile.

ON-ROUTE CHARGER LOCATION

Layover times in the existing schedule were used to identify potential locations for on-route chargers. All Central Transit routes share a common layover point downtown at the intersection of East 4th Avenue and North Ruby Street in Ellensburg. The GreenPower EV Star modeled in this simulation has a wireless inductive charging option available that provides 61 kW of power, the same power level supported for depot charging.

At this location, three on-route chargers would be installed in the northbound lane, one on-route charger would be installed in the southbound lane, and all four chargers would be operated on a first-come, first-served basis. With minor changes to Central Transit's operating schedule, this on-route charger quantity could likely be reduced to a total of three between both the northbound and southbound lane. To maintain operations with only three on-route chargers, layover times would need to be slightly extended at the on-route chargers and instead of first come, first served, vehicles that run a larger deficit over the day would be given preference for charging.

SIMULATION RESULTS

The plot shown in Figure 14 illustrates the SOC for each block during service when including on-route charging in the simulation. With on-route charging, no bus swaps would be required and there is no change to non-revenue operations or fleet size. At least one depot charger would still be required for overnight vehicle charging; additional chargers may be desired depending on overnight staffing to facilitate swapping buses and build in resiliency. With more than one charger at the depot facility buses would not necessarily need to be shuffled around overnight and vehicles could still be charged if one charger is out of operation.

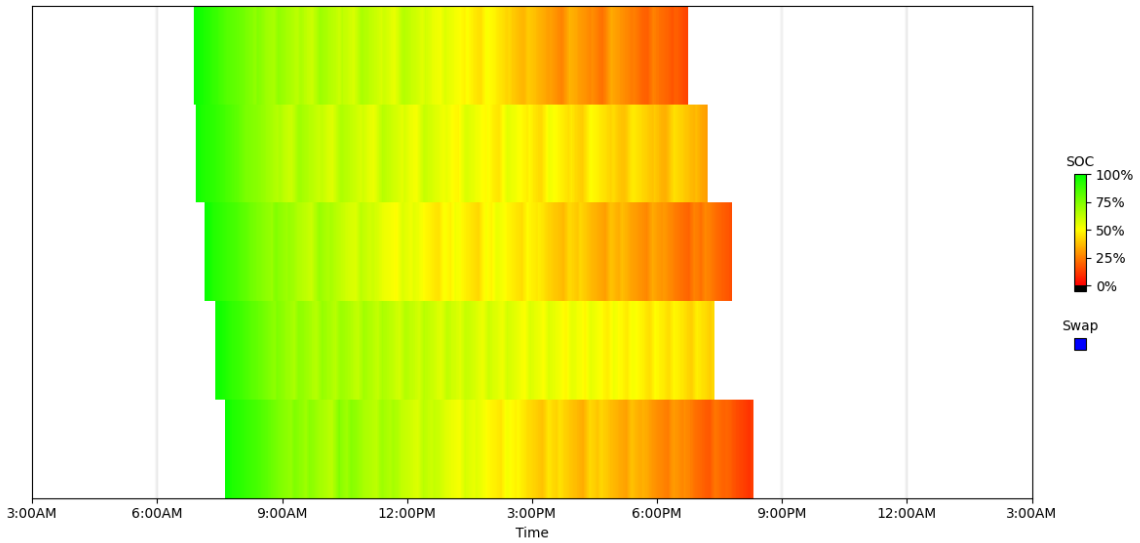

Figure 14. Depot and On-Route Charging Block State of Charge

ON-ROUTE CHARGER UTILIZATION

The charging infrastructure that achieves the greatest number of feasible blocks for conversion to BEB includes both depot and on-route chargers. The usefulness of an additional charger is dependent on how layover times overlap between vehicles. The use of chargers at this location and the energy they would provide is shown in Figure 15, based on their utilization of a 24-hour day. The addition of on-route chargers also reduces the power requirements at the depot facility. The second on-route charger northbound and the third on-route charger southbound both have very low utilization, but they provide energy that is necessary based on the current schedule. Minor schedule adjustments could likely eliminate the need for these two chargers and shift that energy to one of the other chargers.

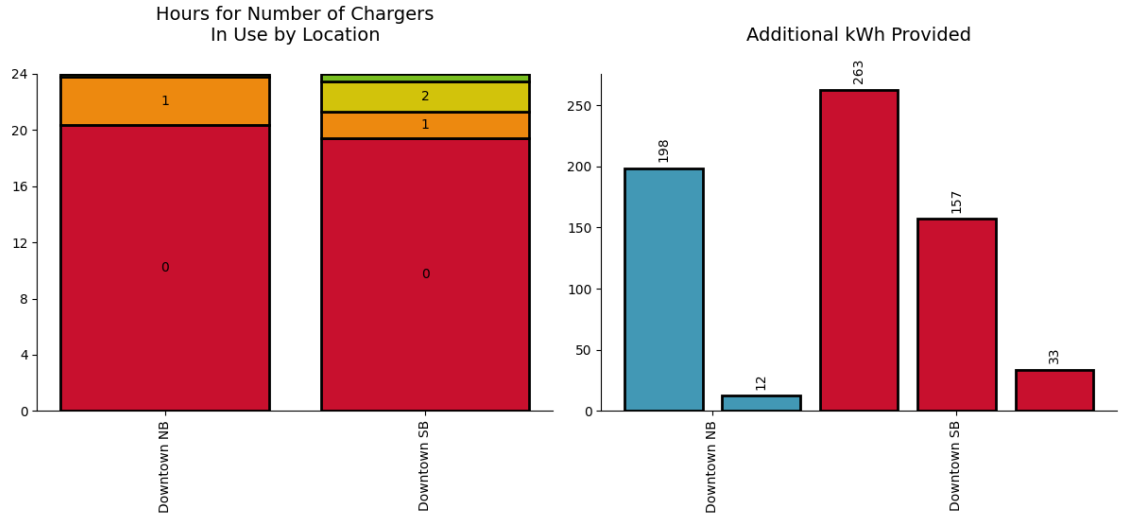

Figure 15. On-Route Charger Utilization by Location

ZEB TRANSITION SCENARIOS

Following the analysis above, two transition scenarios were developed based on Central Transit's fleet replacement schedules and block feasibility. This section shows how many vehicles should be purchased in each year and identifies the infrastructure required to accommodate the new vehicles and when that infrastructure would be needed.

The two scenarios have the same replacement schedule through 2027 but diverge in 2028 with the introduction of BEBs to the fleet. In both scenarios vehicles will be purchased in the same years, but in the depot-charging-only scenario, two BEBs will be purchased for each gasoline vehicle replacement due to range limitations. For subsequent replacements of BEBs, an 8-year useful life is assumed because that is the standard factory battery warranty offered on BEBs.

PROCUREMENT SCHEDULE

Central Transit currently operates five vehicles plus two available spares, all of which are gasoline cutaways with the existing fleet replacement schedule shown in Table 6. The vehicle procurement

schedule in Figure 16 shows all vehicle procurements between 2023 and 2036, where both the initial replacement of the vehicles is shown as well as the second replacement 5 years after the first replacement shown in Table 6. A 5-year useful life was assumed for gasoline replacements as well as for the rebuilt vehicles (CT-6 and CT-7).

Table 7: Ellensburg Central Transit Existing Fleet Roster

Vehicle	Model Year	Make/Model	UFL Description	Next Replacement
CT-6	2017	Ford E-450	REBUILD – 2023	2028
CT-7	2017	Ford E-450	REBUILD – 2023	2028
CT-8	2019	Ford E-450	REPLACE 2023-2025	2023
CT-9	2018	Ford E-350	REPLACE 2023-2025	2025
CT-10	2021	Diamond VIP2200	REPLACE 2025-2027	2027
CT-11	2021	Diamond VIP2200	REPLACE 2025-2027	2027
CT-12	2021	Ford E-450	REPLACE 2025-2027	2027

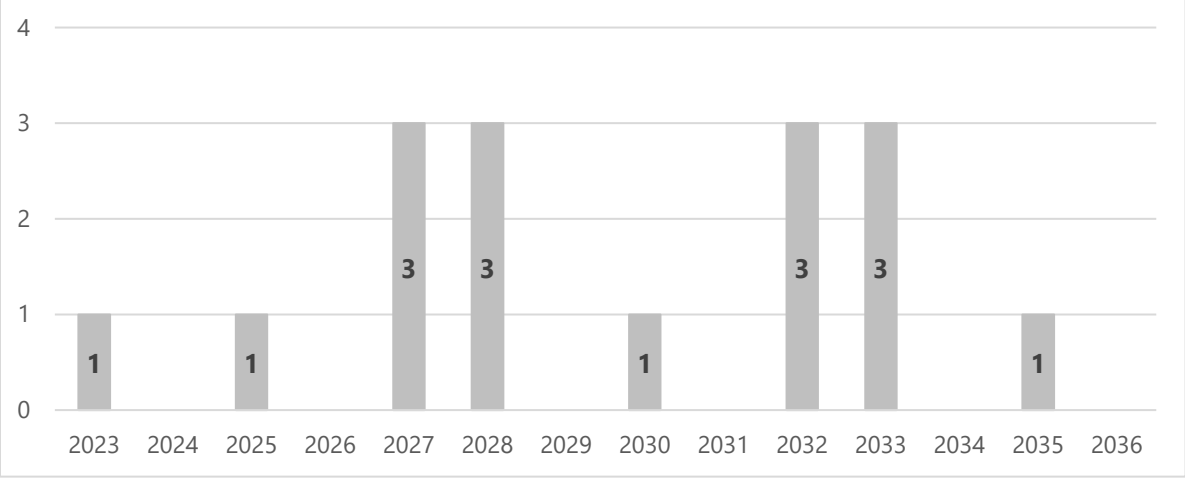

Figure 16: Ellensburg Central Transit Existing Vehicle Procurement Schedule

BEB WITH DEPOT CHARGING ONLY

This scenario shows gasoline vehicles are purchased between 2023 and 2027, with BEB purchases beginning in 2028. When modeling the existing fleet with depot charging only, it was determined that vehicles must be replaced at a 2-to-1 ratio to maintain the same level of service. The vehicle procurement schedule assumes the first battery electric purchases take place in 2028 with six BEBs to replace CT-6, CT-7, and CT-8. If only depot charging were to be utilized, chargers would be purchased and installed in the same year as the first BEB replacement of each vehicle.

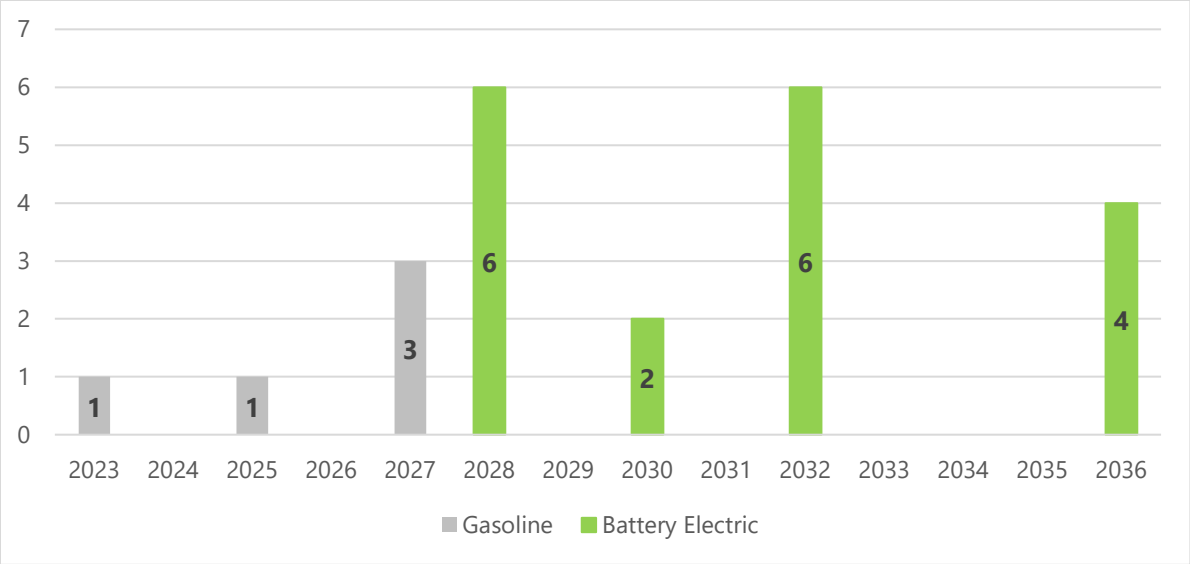

Figure 17. Ellensburg Central Transit Vehicle Procurement Schedule (Depot Charging Only)

BEB WITH DEPOT & ON-ROUTE CHARGING

This scenario also shows gasoline replacements are purchased between 2023 and 2027 with electric replacements beginning in 2028, but gasoline vehicles are replaced with BEBs at a 1-to-1 ratio. With the inclusion of on-route charging, there is no need for an increased fleet size, so procurement quantities in each year mirror the existing replacement schedule through 2032. Replacements beyond 2032 will be subsequent replacements of BEBs, which have an assumed 8-year useful life instead of the current 5-year useful life of gasoline vehicles. Under this scenario, all on-route chargers would be installed in 2028 with the first three BEBs; not all chargers would be utilized at first, but there would be no construction rework required to install the remaining two chargers with later bus procurements. Any depot chargers purchased would also be installed with the delivery of the first three BEBs in 2028.

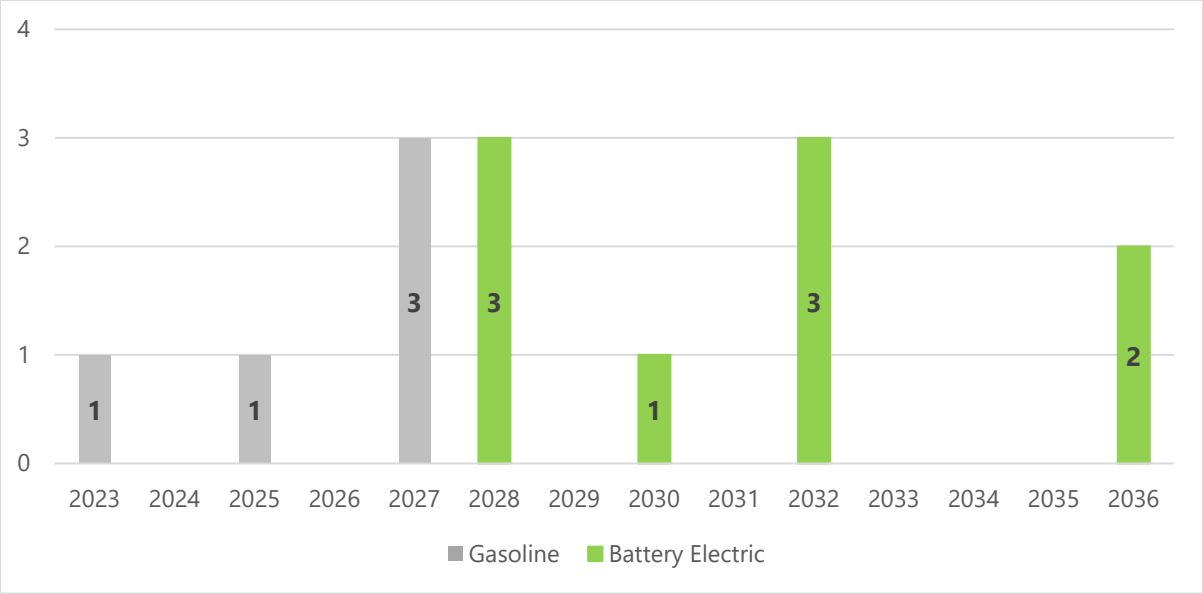

Figure 18. Ellensburg Central Transit Vehicle Procurement Schedule (Depot and On-Route Charging)