April 2024

Community Transit Zero-Emission Bus Transition Plan

Final Draft

Prepared by:

Community Transit
Center for Transportation and the Environment

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Executive Summary

Community Transit (CT) is a special-purpose, municipal corporation providing public transportation services in Snohomish County, WA. As part of CT's commitment to equity, efficiency, and the environment, CT partnered with the Center for Transportation and the Environment (CTE) to perform a zero-emission bus (ZEB) transition study to create a plan for a fully zero-emission fixed-route transit bus fleet by 2044.

Recognizing the pivotal role of public transit in reducing greenhouse gas emissions, CT is undertaking an ambitious journey to expand transit service along high-demand corridors. With its planned service increases, CT is anticipating increased ridership and focusing on providing more frequent and equitable transit service throughout Snohomish County. As service expands, the expected benefits of transforming the agency's transit bus fleet include reducing traffic noise, reducing GHG emissions, and improving air quality.

The agency's existing fixed-route transit bus fleet, as of 2023, consists of 13 30' low-floor buses; 69 40' low-floor buses; 128 60' articulated buses, including 54 devoted to CT's Swift bus rapid transit (BRT) routes and 74 devoted to other routes; and 47 double-decker buses. The fleet operates out of two facilities in Everett: the recently renamed Hardeson Campus (formerly Merrill Creek Operating Base (MCOB)) at 7000 Hardeson Rd, and the Kasch Park Operating Base (KPOB) at 2300 Kasch Park Rd. Hardeson Campus currently operates a fuel bay that includes two service lanes, with a total of five (5) aboveground fuel tanks, to serve buses and non-revenue vehicles. KPOB similarly operates a fuel bay with eight (8) underground tanks to serve buses, non-revenue vehicles, and vanpool operations. To support a future ZEB fleet, CT will require significant investments in battery-electric bus (BEB) charging and hydrogen fueling infrastructure at its depots, as well as inductive charging infrastructure at its transit centers and other feasible layover locations.

In 2024, CT is prioritizing the adoption of innovative clean technologies and will be the first agency operating a hydrogen fuel powered bus in the Puget Sound region. The agency will undergo testing of battery-electric bus (BEB) and hydrogen fuel cell-electric bus (FCEB) as modeling has demonstrated a mixed fleet is the optimal solution for its diverse topography and routes. Through this locally funded pilot deployment, service and financial modeling results will be assessed and compared with real-world data to validate and improve the transition strategy outlined in this plan.

In response to the Community Transit Board of Directors' direction, the agency is committed to a sustainable environmental, financial, and operational future. As the fleet transition strategy develops, three key guiding principles serve as the foundation - Community Transit is: (1) focused on a green wells-to-wheels solution; (2) striving for 1:1 vehicle replacement; and (3) striving to not unduly compromise service growth to achieve the fleet transition. The agency must maintain service delivery commitments throughout the transition period.

To achieve its 2024 target for full zero-emission fleet conversion, CT plans to replace its existing revenue fleet with zero-emission buses (ZEB) through 100% ZEB procurements starting immediately in FY2024, with 2027 as the initial year of significant ZEB fleet deployment. For long-range planning purposes, CT intends to replace Swift BRT transit buses with FCEBs and deploy BEBs on non-BRT lines of service. For fleet modeling, a 40' BEB configuration was used to best identify segments where BEBs will provide the required duty cycle; however, 30' or double-decker BEBs may be deployed in areas that prove difficult to deliver service with 40' vehicles due to physical space constraints. Community Transit's rollout plan achieves a zero-emission transit bus fleet by 2038, in line with the agency's 2044 target. By 2038, 191 of the agency's buses are expected to be BEBs and 90 will be FCEBs. By 2050, CT will expand its transit bus fleet to 300, of which 210 will be BEBs, and 90 will be FCEBs.

The transition to ZEB technologies represents paradigm shifts in workforce planning, bus procurement, fueling operations, and infrastructure, which have been reasonably quantified in the ZEB assessments of this Transition Plan. The agency has estimated total projected costs (not inclusive of construction) of **$158M in vehicle and supporting infrastructure** capital costs to support a 30% fleet conversion by 2029, comprised of 50 BEBs and 25 FCEBs. Full conversion of the fleet is projected by 2038, although the plan for an expanded fleet of 300 buses will be met in 2050. To achieve these goals and move toward a successful deployment of zero-emission buses, CT's projects will require approximately **$1.4B** in funding to cover the procurement of vehicles and infrastructure through **2050**. This cost estimate includes the necessary costs for the transition, as determined via the cost analyses completed for the Fleet and Facilities Assessments.

Transitioning CT staff to operate and maintain a ZEB fleet will require iterations and adaptations of its training plan over time. CT will build on an existing training structure for bus maintenance and operators to provide the necessary BEB- and FCEB-specific training required for the agency to own and operate these technologies. CT anticipates significant training requirements for the following: propulsion systems, electronic controls boards, wheel and braking mock-ups, diagnostic systems, telematics components, and potentially others. During the transition CT will also need to continue training for supporting its diesel buses and hybrid-electric buses. Use of effective training aids within maintenance programs will continue to provide great benefit to CT's workforce.

CT is proud to be an early adopter of clean transit technologies, and recognizes that federal, state, regional, and local partnerships are key to bridging the funding gap and ensuring the plan's success. The agency will actively pursue grant opportunities at all levels throughout the transition period. CT presents the analysis in this study to the Federal Transit Administration (FTA) with steadfast commitments to close collaboration and to equity, efficiency, and environmental sustainability.

This Zero-Emission Fleet Transition Plan will guide all of CT's future vehicle and infrastructure deployments. The plan meets the requirements of 49 U.S.C. 5339(c)(3)(D) for applicants to the FY2024 Low or No Emission Grant Program (Low-No) and/or the Grants for Buses and Bus Facilities Competitive Program (BBF) and includes reference to the project(s) requesting FY2024 funding. Additional grants to be pursued include an implementation grant from the USEPA Climate Pollution Reduction Grant program, and multiple state and regional grant opportunities.

Transit Agency Information

Community Transit Service Area and Bus Operations

Community Transit (CT) provides public transit services for the community in and around Snohomish County, Washington. CT operates more than 257 buses on 35 routes, across 19 cities and two counties. CT provides fixed-route bus service, vanpool programs, dial-a-ride paratransit transportation, and other innovative services with local communities and jurisdictions to test new transportation solutions.

Service Area Demographics

Demographic Profile

CT is a special-purpose, municipal corporation providing public transportation services. In 1976, Snohomish County voters created CT with an approved sales tax to support a public transportation benefit area (PTBA). The PTBA is the area that CT serves. Today, the PTBA encompasses most of urbanized Snohomish County, excluding the City of Everett. CT's service area includes lands of the federally recognized Tulalip Tribes. As of 2022, Community Transit's PTBA service area had an estimated population of 621,930 residents, representing approximately 73% of Snohomish County's population. Snohomish County is the third most populous county in the state, with a population of 850,881 in 2022.[3]

Snohomish County is home to over 23,000 businesses, ranging from small family farms to the world's largest advanced manufacturing facility producing state-of-the-art aerospace equipment. The county boasts a labor force of about 303,000 workers, and the median household income is $100,615. The county is the manufacturing center of Washington State, with about 25% of the county's workforce engaged in manufacturing jobs. Snohomish

County also has the state's second highest concentration of tech-based jobs. Employment rates are in line with pre-pandemic levels and trending up.[1]

Snohomish county contains large, well-known employers including Boeing and Philips. In neighboring counties, headquarters for other global employers such as Microsoft, Amazon, T-Mobile, and Starbucks strengthen the need for regional transit connections to support commuters. The county has about 410,000 commuters aged 16 and over, including out-of-county residents. The average commute time within Snohomish County is 33 minutes, with about 16% of commuters carpooling or taking public transit. In addition, Snohomish County Airport-Paine Field (PAE) is in Community Transit's service area. Paine Field supports an estimated 46,000 jobs and an economic output of about $60 billion annually.[2] Paine Field began offering scheduled commercial service to destinations around the country in 2019. Community Transit's Swift Green Line serves Paine Field. **Table 1** identifies Snohomish County and PTBA populations from 2018 through 2022.

Table 1 Snohomish County Population and Demographic 2018 – 2022[3]

Year	County Population	PTBA Population	Age Distribution for Snohomish County 0-19	20-64	65+
2018	805,120	587,366	24.8%	61.5%	13.7%
2019	822,083	598,002	25.0%	61.6%	13.4%
2020	831,107	607,522	Not available (due to COVID19 pandemic)		
2021	840,131	613,289	24.4%	60.5%	15.1%
2022	850,881	621,930	24.4%	60.4%	15.2%

Snohomish County is growing. The region has a variety of diverse communities, many of which are highlighted in CT's Destination Guides. Snohomish County has a diversity index score of 63.5, meaning that in a random sample of any two people in the county, there is a 63.5% chance that the individuals would identify with different racial or ethnic backgrounds. About 67% of residents over the age of 25 have completed some form of higher education.[4]

[1] Employment rates per www.economicforecaster.com, September 2023.
[2] Paine Field data comes from the Paine Field website: https://www.painefield.com/27/About-Our-Airport
[3] Data Sources: U.S. Census Bureau; County population by age and gender: https://www.economicalliancesc.org/
[4] Data retrieved September 2023 from https://www.economicalliancesc.org/

Equity and Justice 40 Communities

CT is dedicated to providing equitable and sustainable transportation to Snohomish County. To further evaluate disadvantaged census tracts, CT used the Climate and Economic Justice Screening Tool (CEJST). Based on the CEJST, CT identified fourteen disadvantaged tracts across its service area[5]. Two tracts including lands of the Tulalip Tribe are classified as partially disadvantaged. Overall, the disadvantaged tracts represent roughly 87,541 residents or 14% of CT's service area population. The partially disadvantaged tracts are comprised of 9,846 individuals or an additional 1.6% of the service area population.

Based on the CEJST burden criteria, the top burden categories in Community Transit's service area are identified as Workforce Development (10 tracts), Climate Change (9), Water and Wastewater (9), Housing (5), Transportation (4), Health Burdens (4), and Legacy Pollution (2).

Transforming the bus fleet to zero-emissions will contribute to uplifting disadvantaged communities by creating opportunities for work, reducing climate warming emissions, improving air quality and associated health outcomes, and reducing the volume of traffic noise. Further, the intersecting routes in disadvantaged communities help increase transportation equity. **Figure 1** demonstrates the CEJST Justice 40 disadvantaged tracts within CT's service area and **Appendix B** further discusses the methodology that CT utilized.

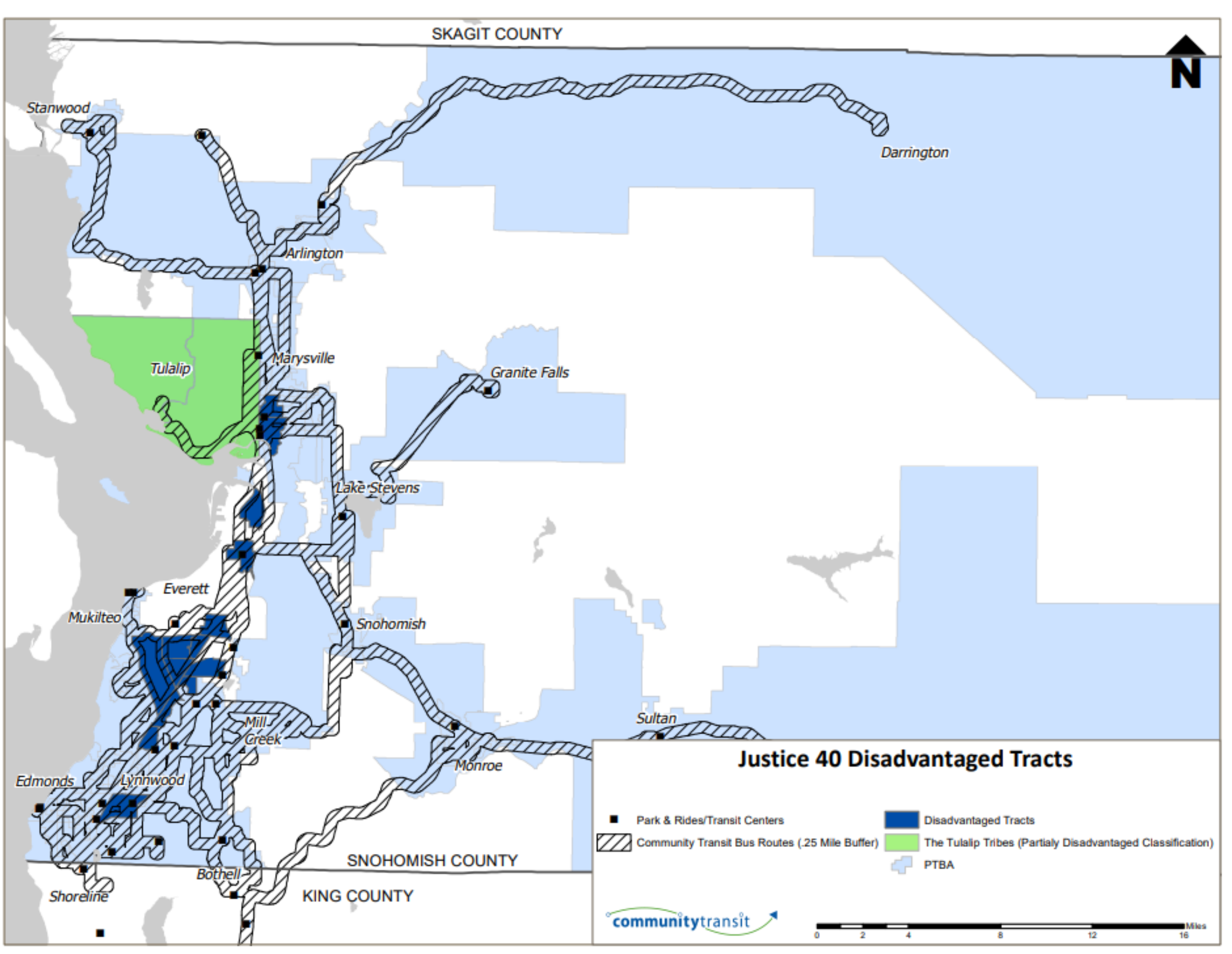

Figure 1 Map of CEJST Justice40 Disadvantaged Tracts in CT's Public Transportation Benefit Area (PTBA) and Route Buffers to Demonstrate the Benefits of the Zero-Emission Transition

[5] https://screeningtool.geoplatform.gov/en/#8.66/48.0228/-122.2809

Zero-Emission Technology Adoption

Community Transit has undertaken a series of logically sequenced initiatives to develop its Zero-Emission Fleet Program, beginning with a Feasibility Study in 2021. The study informed the Board of Directors' recommendations for the fleet replacement plan and the program was officially created in 2022 as commitment to transition the fleet. In 2022, the agency bridged the gap between feasibility study and active initiatives, with the deployment of a leased 60' BYD BEB, serving as a training, knowledge validation, and culture change pilot program. Additionally, the agency purchased one (1) GILLIG battery-electric and one (1) New Flyer FCEB, for a side-by-side pilot deployment. 2024 marks the first year of ZEB revenue service, with the BEB and FCEB entering service, side-by-side, towards the end of the year.

Appendix E contains more details about specific accomplishments and notable activities within the Zero-Emission Program. The agency is committed to a complete fleet transition, and continues to perform market analysis, due diligence, and practical application of technologies to ensure the core strategy is valid based on the best point-in-time data available.

Service Assessment

The project team first applied the methodology to conduct a Service Assessment on Community Transit's routes and blocks to assess efficiency, energy consumption, and range, as detailed in **Appendix A.**

The results of the assessment were used to determine if/when a full transition to BEBs for the 40-ft. fleet, or a full transition to FCEBs for the 60-ft. fleet may be feasible within the identified transition period. **Figure 2** indicates the yearly BEB and FCEB block achievability throughout the transition period.

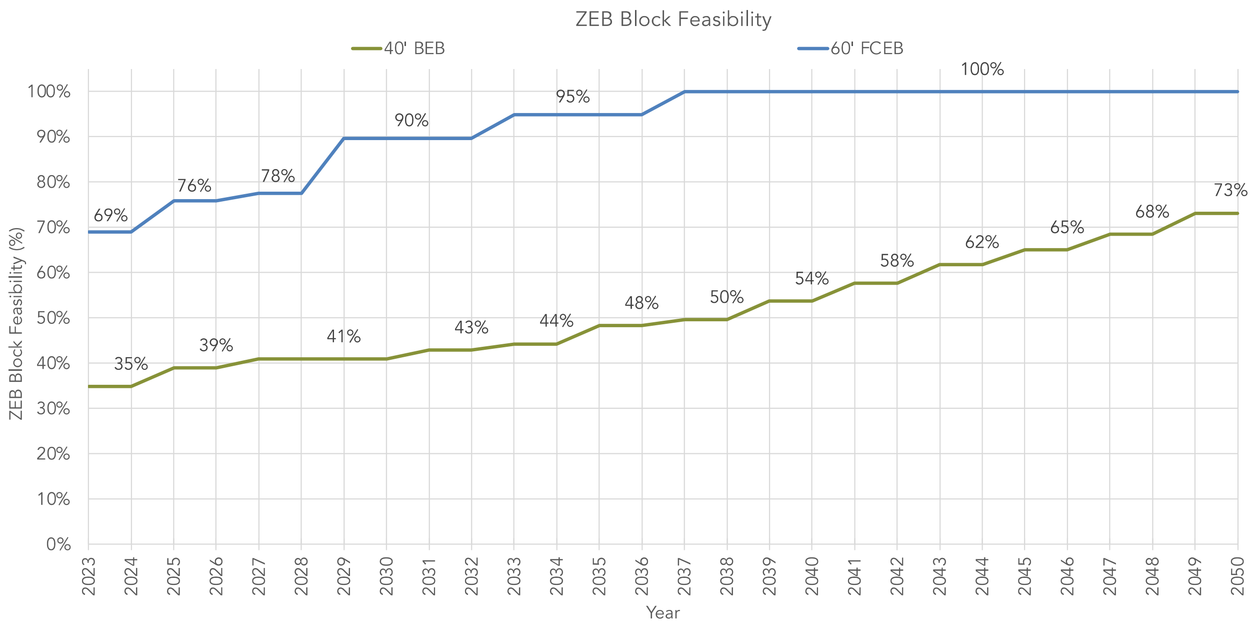

Figure 2 Community Transit's ZEB Block Feasibility, 2023 – 2050

At the end of the ZEB transition period in 2050, only 73% of CT's 149, 40-ft. blocks are feasible with BEBs. Thus, a transition to zero-emissions sooner than 2050 would require on-route charging, midday charging at the depot, or assigning two BEBs to infeasible blocks (without expanding overall fleet size), each of which imply changes to present-day service and operations. By 2037, 100% of CT's 58, 60-ft. blocks are feasible with FCEBs.

Fleet Assessment

Once the service assessment for the ZEB transition was completed, the agency's fleet replacement schedule was used to project bus replacement timelines for the existing fleet, as well as the subsequent replacements of ZEBs at the end of their service lives.

Appendix A details the fleet assessment methodology, as well as the cost assumptions. **Figure 3** depicts the annual fleet composition through the transition period. The fluctuating annual fleet sizes identify years when, (1) new ZEB purchases are planned but there are no retirements of existing vehicles from the fleet, or (2) vehicles are added to expand the fleet, as captured in CT's fleet plan. As identified by the legend, CT's existing fleet of 30', 40', and double-decker diesel transit buses may be replaced by a combination of 30', 35', or 40' BEBs in the future.

Based on the existing procurement schedule, CT will begin to operate a 100% zero-emission fleet by 2038, although the overall goal for an expanded fleet of 300 buses will be met in 2050. Although CT will operate one 40' BEB and 40' FCEB in 2024 as part of the agency's ZEB pilot testing program, these vehicles are not included in the overall ZEB transition plan.

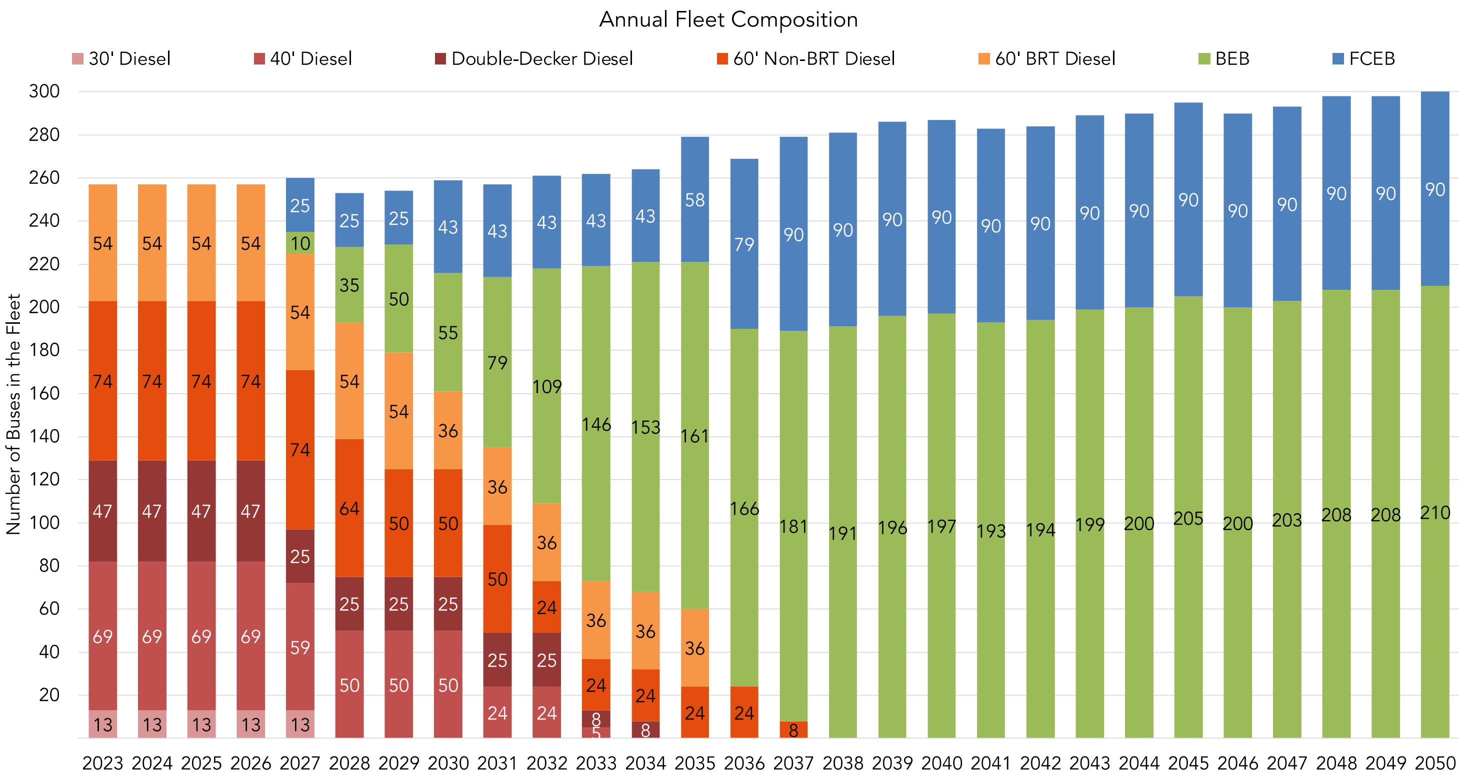

Figure 3 Annual Fleet Composition, 2023 – 2050

Figure 4 below provides the number of each vehicle type that will be purchased each year through 2050 with the existing fleet replacement strategy. The procurement costs outlined annually include costs to replace and retire existing ZEBs as defined by Community Transit's replacement cycle for its transit buses. The overall costs to transition CT's existing fleet to 100% ZEB by **2038** is approximately **$560M**, although the overall goal for an expanded fleet of 300 buses will only be met in 2050. Annual costs are incurred in the year the ZEB is delivered and enters transit service. Orders and funding allocation shall occur at least one year prior.

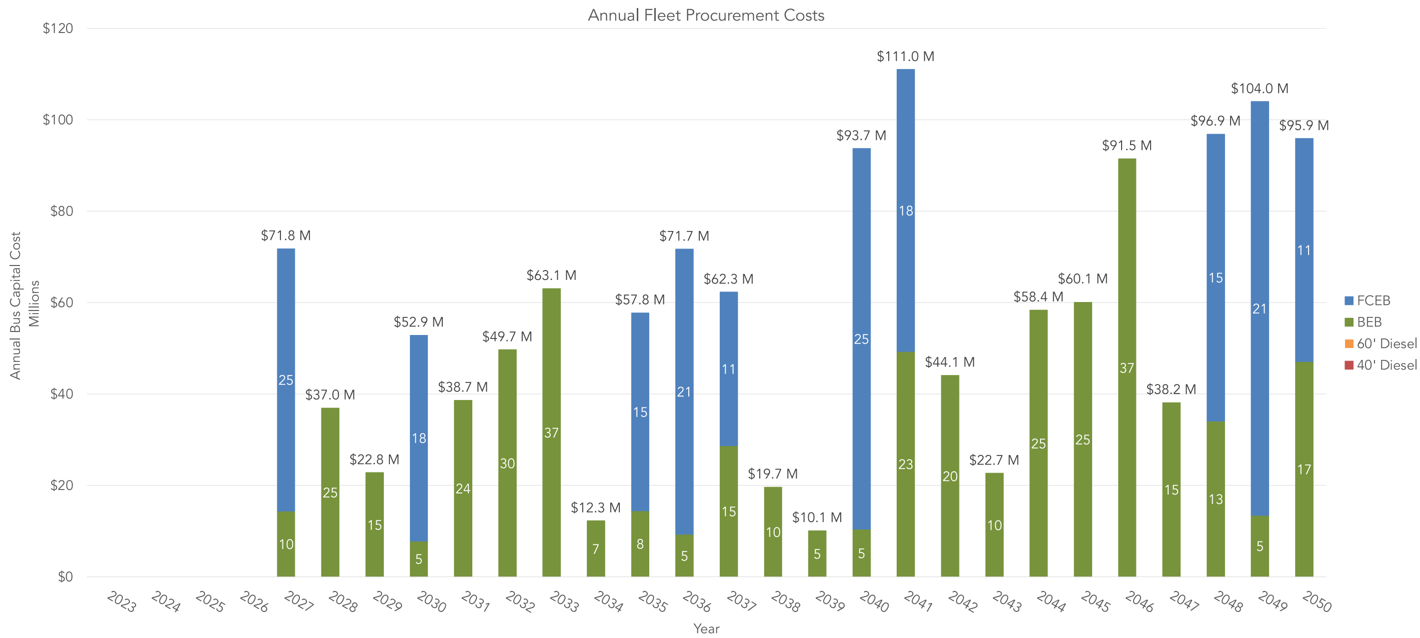

Figure 4 Annual Fleet Procurement Costs, 2023 – 2050

Fuel Assessment

The project team conducted a Fuel Assessment to determine the projected annual cost of fuel during the transition period by fuel type (i.e., diesel, electricity, or hydrogen), as detailed in **Appendix C**. The results of the assessment were used to determine phases of fuel consumption, during the transition to a full fleet of BEBs and FCEBs. **Figure 5** indicates the annual fuel consumption estimates for the BEB and FCEB fleet from 2023 through 2050 in diesel gallon equivalents (DGE). The fluctuating annual fuel consumption estimates identify years when, (1) new ZEB purchases are planned but there are no retirements of existing vehicles from the fleet, or (2) vehicles are added to expand the fleet, as captured in CT's fleet plan.

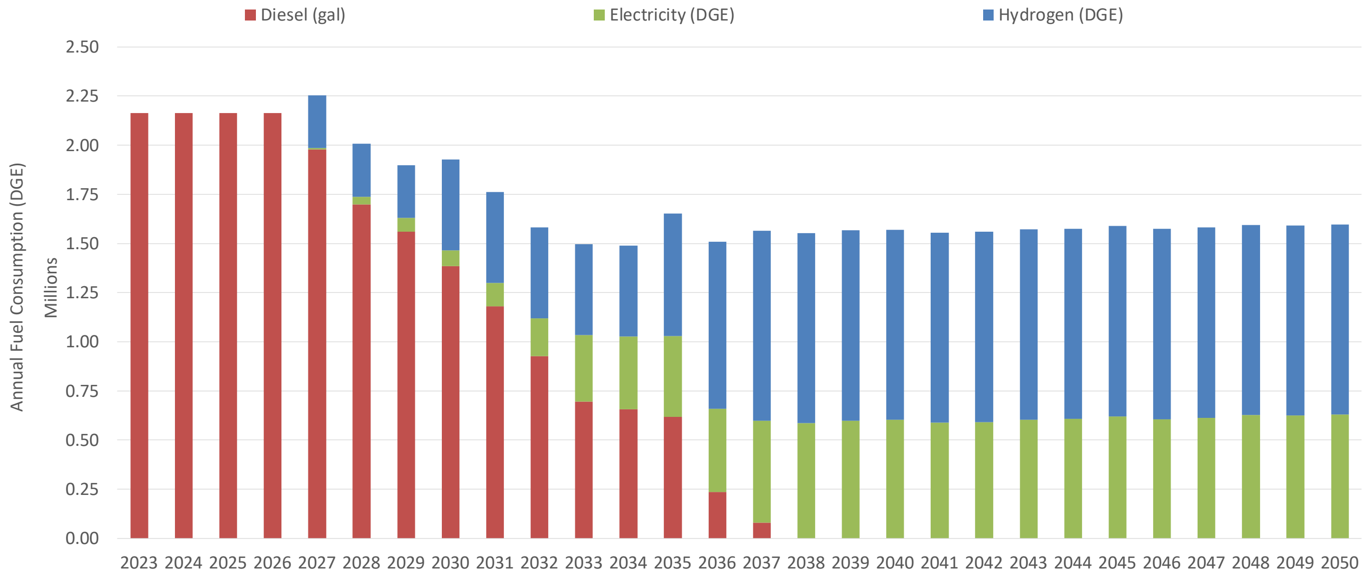

Figure 5 Annual Fuel Consumption, 2023 – 2050

Understanding CT's fuel consumption allows for the identification of distinct phases of facilities projects that can be planned for within the ZEB transition period. **Figure 6** below provides the annual fuel costs for each vehicle type that will be purchased each year through 2050, with the existing fleet replacement strategy. The average cost per mile estimate through the ZEB transition period is **$1.28/mile**.

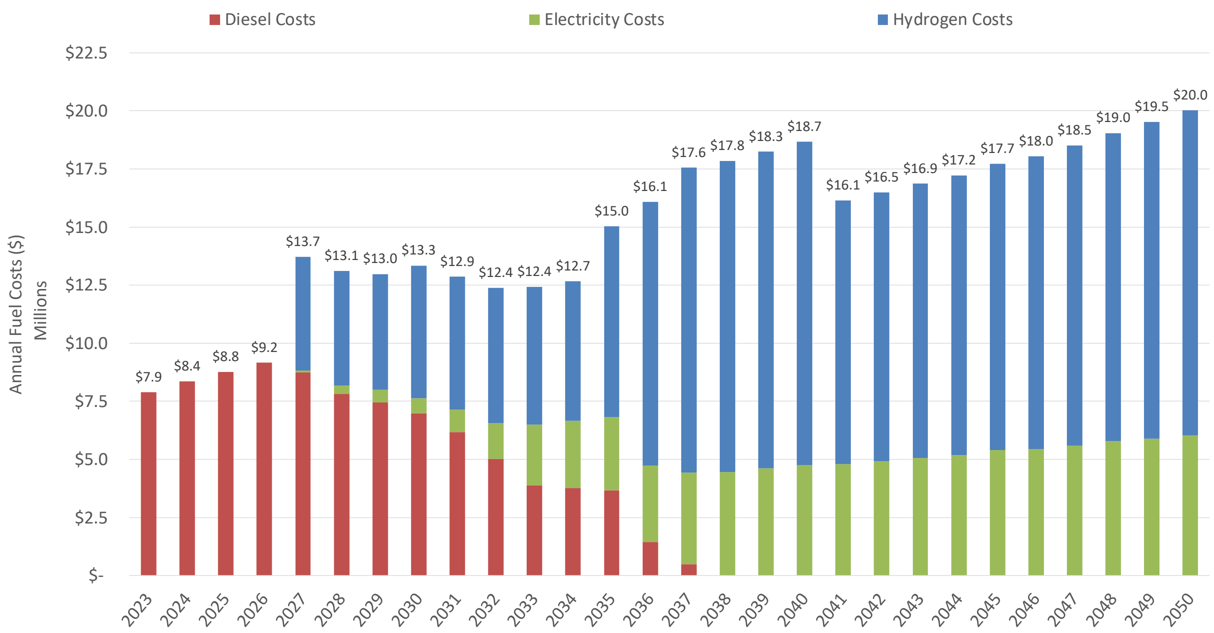

Figure 6 Annual Fuel Costs, 2023 – 2050

Facilities Assessment

Once bus and fueling requirements are understood for the ZEB transition, the requirements for supporting infrastructure are determined, which includes the charging equipment for BEBs and hydrogen fueling equipment for FCEBs. The Facilities Assessment determines the scale of charging and hydrogen infrastructure necessary to meet the demands of the projected fleet prepared in the Fleet and Fuel Assessments. The Facilities Assessment includes estimates for the costs of the associated infrastructure.

The following section introduces the timeline and cost estimates for the infrastructure associated with Community Transit's transition to a mixed fleet of BEBs and FCEBs.

Community Transit's Current Facilities

CT's transit bus fleet operates out of the Hardeson Campus at 7000 Hardeson Rd, and the KPOB at 2300 Kasch Park Rd. The Hardeson Campus currently operates a fuel bay that operates two service lanes, with a total of five (5) aboveground fuel tanks, to serve buses and non-revenue vehicles. The KPOB similarly operates a fuel bay with eight (8) underground tanks to serve buses, non-revenue vehicles, and vanpool operations. CT has indicated that major ZEB depot fueling infrastructure projects will occur at KPOB.

Battery Electric Bus Facilities Assumptions Overview

Scaling a BEB deployment requires substantial infrastructure upgrades and a significantly different approach to charging compared to smaller deployments. With initial deployments, charging requirements are met relatively easily with a limited number of plug-in pedestal chargers and minimal infrastructure investment. Full fleet deployments of BEBs, however, require installation of a significant number of charging stations and improvements to existing electrical infrastructure. These improvements may include upgrades to switchgear or service connections. Planning and design work, including development of detailed electrical and construction drawings required for permitting, is also necessary once specific charging equipment has been selected.

To determine the installation timeline and costs for charging equipment, this assessment breaks the infrastructure scope of work into three key project types: planning, power upgrades, and charging equipment (charger and dispensers) installation. CT's BEB charging infrastructure installations were further split into three (3) major depot projects: to meet the infrastructure needs of an initial fleet size, a second infrastructure project to support expansion of the fleet up to 150 BEBs, and a final infrastructure project to meet the needs of the projected final fleet mix in accordance with the 2023 Transit Development Plan (TDP). Estimated unit costs associated with each project type are included in **Table 2. This is not inclusive of construction and contingency. Extended costs are outlined in Figure 7.**

Table 2 Battery Electric Bus Infrastructure Project Cost Assumptions

Project	Estimated Components	Cost Estimates in 2023 $
Infrastructure Planning	**Infrastructure Design and Planning**	$200,000
5 MW Depot Power Upgrade Projects	**Design, Construction, & Equipment**	$250,000
1MW On-Route Charging Power Upgrade Projects	**Design, Construction, & Equipment**	$125,000
150kW Depot Charging Equipment Installation Projects	**Charging Equipment & Installation**	$190,600
300kW On-Route Charging Equipment Installation Projects	**Charging Equipment & Installation**	$331,700
WSDOT Cost Construction Index	**Average annual cost increase**	3.08%

Key assumptions applied in the agency's Facilities Assessment are as follows:

1. One (1) plug-in dispenser per BEB;
2. Two (2) BEBs per 150 kW plug-in charger;

3. Four (4) BEBs per 300 kW inductive charger per hour assuming 15 minutes alignment and charging sessions; and
4. Incremental power requirements are met over time. Power upgrades are consolidated to occur in selected years, in accordance with the required demand based upon fleet size and service consumption

The location and timing of on-route charger procurements was driven by the feasibility and vehicle procurement timelines identified through the service and fleet assessments outlined in **Appendix A**. The project team identified all potential layover locations where on-route chargers could feasibly be installed. Then, BEB blocks that required on-route charging were matched to these layover locations, to more accurately predict the number of on-route charging installations required. A full list of potential on-route charger locations can be found in **Table 3.**

Table 3 On-Route Charger Locations

On-Route Charger Location	No. of Charger Installations	Max No. of BEB Blocks Served
Ash Way P&R	1	4
Edmonds Station	2	8
Everett Station	2	5
Lake Stevens P&R	2	6
Lynnwood Transit Center	3	12
Mountlake Terrace TC	1	4
Seaway TC	1	4
Snohomish P&R	1	3
Smokey Point TC	1	2
137th St SE & Puget Park Dr	2	7
Total	16	55

Hydrogen Fueling Facilities Assumptions Overview

Deploying FCEBs requires infrastructure to store hydrogen and dispense the fuel to buses. One of the many benefits of hydrogen fuel is the scalability of the fueling infrastructure as fleet size increases. Maintenance facilities must also meet the required safety regulations for working with hydrogen, including gas and fire detection, alarm systems, and upgrades to ventilation, heating, and electric systems. The configuration and scale of hydrogen fueling infrastructure is dependent on several factors such as size of the bus fleet, operating logistics, location, space availability, and available funding. Other variables that will impact the design of a hydrogen fueling station include access to gaseous and liquid hydrogen supplies in the region; availability of power, gas, and water utilities; local permitting and environmental compliance requirements; and the environmental conditions or need to remediate existing contamination at a particular site. CT is committed to using “green” hydrogen in the future but acknowledges that early adoption of FCEBs may require compromise on this strategy. The agency will endeavor to use the least carbon-intensive fueling for FCEBs as producers enter the market. **Table 4** highlights unit cost estimates for hydrogen fueling infrastructure and facility improvements to support fuel cell electric buses. Construction and contingency costs are not included. Extended costs are summarized in Figure 7

Table 4. Hydrogen Fueling Infrastructure Cost Assumptions

Infrastructure Element	Cost Estimates in 2023 $
Infrastructure Design and Planning	$200,000
Permanent Liquid Hydrogen Fueling Station	$10M
Permanent Liquid Hydrogen Fueling Station Infrastructure Upgrades	$5.2M
Maintenance Bay Upgrades with Gas Detection	$200,000
WSDOT Cost Construction Index	3.1%

Key assumptions applied in the agency's Facilities Assessment are as follows:

1. Design & engineering costs are incurred once for each depot where refueling infrastructure is installed;
2. Hydrogen refueling station builds for an initial fleet size of up to 50 FCEBs include a storage tank with a capacity of 15,000 to 25,000 gallons, vaporizers, fueling pumps, and two dispensers, configured to fuel simultaneously; and
3. Additional capacity upgrades for an increased fleet size of up to 100 FCEBs include, but are not limited to, upgrades to onsite liquid hydrogen storage, additional components to increase hydrogen fill speeds, additional dispensers, etc.
4. CT will upgrade four (4) maintenance bays at the KPOB, to meet the required safety regulations for working with hydrogen, with hydrogen gas detection equipment, and other ancillary equipment.

Mixed Fleet Infrastructure Costs Summary

To account for inflation, the project team applied WSDOT's construction cost inflation index across annual BEB and FCEB infrastructure cost estimates. **Figure 7** summarizes all costs for BEB charging and FCEB hydrogen refueling infrastructure costs by year at the depot, as well BEB charging infrastructure at on-route charging locations, as Community Transit transitions to a mixed fleet of ZEBs. The estimated total infrastructure costs through 2050 are approximately **$54.4M**. This total cost includes infrastructure planning projects, power upgrade projects, maintenance bay upgrades, depot charger and dispenser installations, on-route charger installations, and hydrogen refueling infrastructure projects.

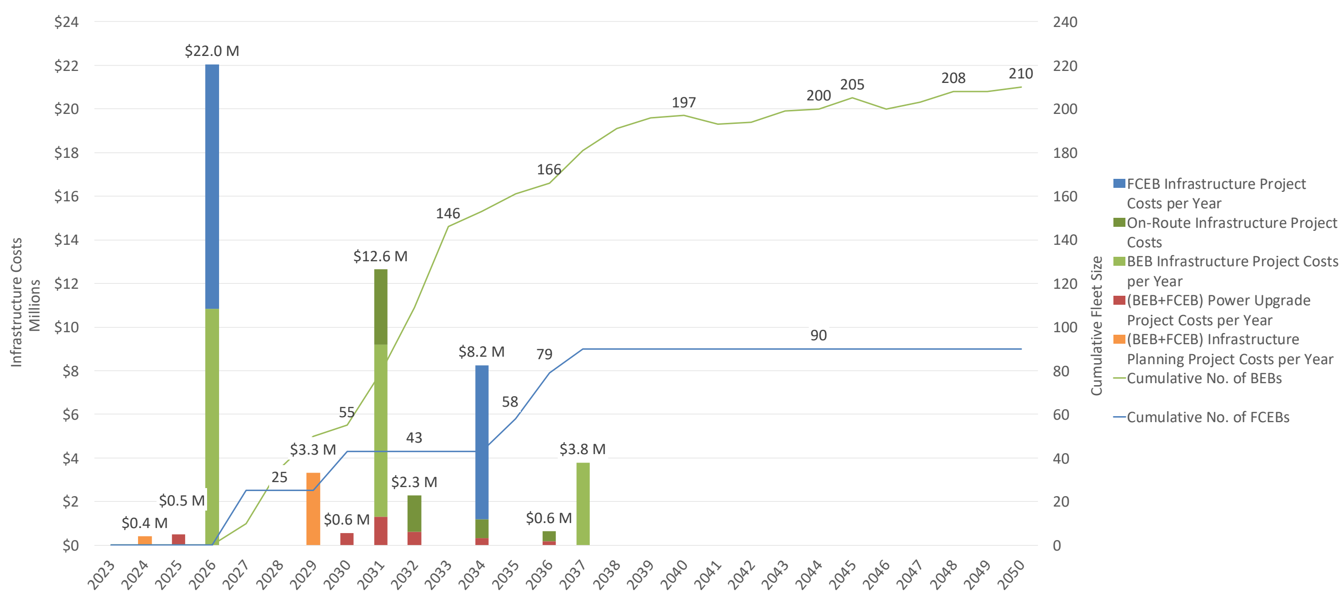

Figure 7 - Cumulative Infrastructure Costs – BEB Charging and Hydrogen Fueling Infrastructure

Funding Needs Assessment

Funding Assessment Overview

Community Transit allocates funds based on an established procurement timeline determined by the useful life of its buses. Transitioning to a zero-emission bus fleet increases overall fleet costs because of the incremental cost of zero-emission buses, the installation of new infrastructure, and required modifications to maintenance facilities. Additionally, the necessary infrastructure to support these zero-emission buses adds to the financial burden of transitioning to a zero-emission fleet.

For the purposes of the Zero-Emission Fleet Transition Plan, vehicle costs and infrastructure costs are assessed individually in the Fleet and Facilities Assessments. The results of the cost assessments are compiled here as total costs and then compared to Community Transit's budget to better understand funding gaps and needs.

Community Transit Funding Needs

Over the course of the transition period, Community Transit plans to transition to a fleet of 210 BEBs, and 90 FCEBs, for a 100% ZEB mix of transit buses. The agency has projected costs of **$158M in vehicle capital and infrastructure costs to support a 30% fleet conversion by 2029, comprised of 50 BEBs and 25 FCEBs**. Conversion of the fleet to 100% zero-emissions is projected by 2038, although the overall goal for an expanded fleet of 300 ZEBs will be met in 2050. To achieve these goals and move towards a successful deployment of ZEBs, Community Transit's projects will require **$1.4B** in funding to cover the procurement of vehicles and infrastructure during the entire ZEB transition period through **2050**. This cost estimate includes the necessary costs for the transition, as determined via the cost analyses completed for the Fleet and Facilities Assessments.

Available Funding Resources & Resulting Funding Shortfalls

Based on the funding needs identified above and an assessment of Community Transit's current projections, Community Transit must identify resources that can cover this funding gap. Traditional formula funding will provide support for the transition to a zero-emission fleet (e.g., using formula funds to cover the base price of a ZEB and applying for Low-No funds for the incremental cost difference), but it is likely Community Transit will require additional funding to offset the higher costs associated with zero-emission technology. Community Transit is prepared to pursue funding opportunities at the federal, state, and local level, as necessary and as available.

Federal Funding sources Community Transit is considering include:

Table 5 Federal Funding Sources

Opportunity	Eligibility Requirements	Funding Amounts	Application Timeline	Application Considerations/Priorities
Discretionary Programs				
Federal Transit Administration's Low or No Emission Vehicle Program 5339(c)	The purpose of the program is to provide funding for the purchase or lease of zero-emission and low-emission transit buses as well as acquisition, construction, and leasing of required supporting facilities.	$1,125 M (FY24) $1,127 M (FY25) $1,128 M (FY26)	FTA is required to issue the NOFO within 30 days of the funding obligation for a full fiscal year.	• Replacing buses that have met useful life • Gives consideration to applications proposing to use funding only for the incremental cost of the new technology • Availability of other funds (e.g., 5307/5311)

Opportunity	Eligibility Requirements	Funding Amounts	Application Timeline	Application Considerations/Priorities
	Low-No applicants are able to name partners in their applications. Eligible applicants include designated recipients, States, local governmental authorities, and Indian Tribes. Except for projects proposed by Indian Tribes, proposals for funding projects in rural (non-urbanized) areas must be submitted as part of a consolidated State proposal.		For the last three FYs, the NOFO release has occurred in Q1	to cover base cost of bus • Documented availability of cost share
Federal Transit Administration's Buses and Bus Facilities 5339(b)	The purpose of the program is to assist in the financing of buses and bus facilities capital projects, including replacing, rehabilitating, purchasing or leasing buses or related equipment, and rehabilitating, purchasing, constructing or leasing bus-related facilities. Applicants must demonstrate how the project will address an unmet need for capital investment in bus vehicles and/or supporting facilities. Designated recipients that allocate funds to fixed route bus operators, states, or local governmental authorities that operate fixed route bus service, and Indian tribes are eligible recipients.	$394 M (FY24) $402 M (FY25) $412 M (FY26)	Since FY22, FTA has released a joint NOFO for the Buses and Bus Facilities competitive program and the Low-No program	• New under BIL, applicants submitting the same application to the Low-No program may also name partners in their Buses and Bus Facilities application.
US Department of Transportation Rebuilding American	The purpose of the program is providing funding to complete critical freight and passenger	$1.5 B (FY24)	2024 NOFO released 11/30/23; applications due 2/28/24	• Minimum RAISE capital grant awards in FY23 for urban areas is $5M, no minimum for planning grants

Opportunity	Eligibility Requirements	Funding Amounts	Application Timeline	Application Considerations/Priorities
Infrastructure with Sustainability and Equity (RAISE)	transportation infrastructure. The program supports communities implementing projects with significant local or regional impact. The predecessor programs to RAISE are BUILD and previously TIGER. Eligible applicants are States and the District of Columbia; any territory or possession of the United States; a unit of local government; a public agency or publicly chartered authority established by one or more States; a special purpose district or public authority with a transportation function, including a port authority; a Federally recognized Indian Tribe or a consortium of such Indian Tribes; a transit agency; and a multi-State or multijurisdictional group of entities that are separately eligible.			• Awards are for large-scale projects, but are beginning to see some awards supporting ZEBs/ZEB activity, but generally in the context of a larger project • ZEB-related awards in FY23: ○ Leveraging Infrastructure for Transportation, Western Reserve Transit Authority ○ OKC MOVES Facilities Implementation ○ Potomac Highlands H2 Fuel Initiative • ZEB-related awards in FY22: ○ Zero-Emission Bus Operations, Maintenance, and Administration Facility – Capital (Yuba-Sutter Transit Authority CA) ○ Wood River Valley Mobility Corridor - Capital (ID DOT) ○ Bi-State Sustainable Reinvestment Corridor -Planning (Mid-America Regional Council)
FHWA Charging and Fueling Infrastructure Grants	This FHWA Grant Program has 2 sub-programs, the Community Grant Program and the Corridor Grant Program. Community Grant infrastructure must be "located on any public road or in other publicly accessible locations, such as parking facilities at public buildings, public schools, and public parks, or in publicly accessible parking	$500 M (FY24) $600M (FY25) $700M (FY26)	FY22/23 awards were announced 1/11/24	• This program is expected to reduce greenhouse gas emissions and to expand or fill gaps in access to charging or alternative fueling infrastructure. • Community Grants range in amount from $500,000-$15 million • Corridor Grants have a minimum amount of $1 million with no maximum award amount

Opportunity	Eligibility Requirements	Funding Amounts	Application Timeline	Application Considerations/Priorities

	facilities owned or managed by a private entity." Corridor Grant infrastructure must be "located along a designated AFC; EV charging within 1 mile and other alternative fuels within 5 miles of the AFC."
	
	Eligible infrastructure includes electric vehicle charging infrastructure, hydrogen fueling infrastructure, propane fueling infrastructure, or natural gas fueling infrastructure
	
	Eligible Applicants (for both programs) include states or political subdivisions thereof, metropolitan planning organizations, local governments, or **public authorities with a transportation function.**
				• 80% federal share, 20% cost share from awardee
				• ZEB-related awards in FY22/23:
				  ○ VVTA
				  ○ City of Mount Vernon (WA) – transit component

Discretionary Programs – Potentially of Interest				
FHWA Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT)	The purpose of the program is to help make surface transportation more resilient to natural hazards. Eligible activities fall under four categories: 1) Planning; 2) Resilience Improvement; 3) Community Resilience and Evacuation Routes; and 4) At-Risk Coastal Infrastructure.	\$848 M (FY22/23) \$300 M (FY24) \$300 M (FY25) \$300 M (FY26)	FY22/23 applications due 8/18/23; award announcement pending	• This is a new program under BIL; the FY22/23 NOFO is the first solicitation for the program
FTA Metropolitan, Statewide & Non-Metropolitan Planning	The purpose of the program is to support planning programs that provide funding and set procedural requirements for multimodal transportation planning in metropolitan areas and states that result	\$193 M (FY24) \$197 M (FY25) \$202 M (FY26)		• Eligible recipients are states and Metropolitan Planning Organizations (MPOs)

Opportunity	Eligibility Requirements	Funding Amounts	Application Timeline	Application Considerations/Priorities
	in long-range plans and short-range programs of transportation investment priorities. The planning programs are jointly administered by FTA and FHWA.			
FTA Capital Investment Grants Program –Small Starts	Design and construction of corridor-based bus rapid transit projects operating in mixed traffic that represent a substantial investment in the corridor and emulate the features of rail.	Authorized up to $4.6 billion per year, subject to Congressional appropriations (includes New Starts, Small Starts, and Core Capacity)		• Eligible recipients are State and local government agencies, including transit agencies. • Total project cost is less than $400 million and total Small Starts funding sought is less than $150 million • New fixed guideway systems (light rail, commuter rail, etc.) • Extension to existing system • Fixed guideway BRT system • Corridor-based BRT system
Formula Programs				
CMAQ	The Congestion Mitigation and Air Quality Improvement (CMAQ) Program provides funds to States for transportation projects designed to reduce traffic congestion and improve air quality, particularly in areas of the country that do not attain national air quality standards.	Annual apportionment		• CMAQ funds support state- and locally selected transportation projects that reduce mobile source emissions in both current and former areas designated by the U.S. Environmental Protection Agency (EPA) to be in nonattainment or maintenance of the national ambient air quality standards for ozone, carbon monoxide, and/or particulate matter.
II Urbanized Area Formula Grants	The Urbanized Area Formula Funding program makes federal resources available to urbanized areas and governors for transit capital and operating assistance in urbanized areas and	$6,633 M (FY24) $6,770 M (FY25) $6,943 M (FY26)		• Funding is made available to designated recipients that must be public bodies with the legal authority to receive and dispense federal funds.

Opportunity	Eligibility Requirements	Funding Amounts	Application Timeline	Application Considerations/Priorities
	for transportation-related planning.			
State of Good Repair	The formula component of the State of Good Repair Grants Program (49 U.S.C. 5337) provides capital assistance for maintenance, replacement, and rehabilitation projects of high-intensity fixed guideway and motorbus systems to help transit agencies maintain assets in a state of good repair in urbanized areas.	Annual apportionment		• Funding for urbanized areas with a population of 200,000 or more is made available to designated recipients that are public bodies with the legal authority to receive and dispense federal funds. Funding for urbanized areas with a population of between 50,000 and 199,999 is made available to a State's or territory's governor or governor's designee.
State Programs				
Move Ahead Washington	New state transportation funding package that provides $3 billion for public transportation over the next 16 years.	• Green Transportation Capital grants provide funding to transit agencies for cost-effective capital projects that reduce the carbon intensity of the Washington transportation system. • State Buses and Bus Facilities grants provide funding to transit agencies for the replacement, expansion, rehabilitation, and purchase of transit rolling stock; construction, modification, or rehabilitation		• WSDOT received 17 applications, representing 13 transit agencies across the state, during the 2023-2025 application cycle; awarded 11 projects. • WSDOT awarded 6 new State Buses and Bus Facilities projects funded for $38 million and awarded for the 2023-2025 biennium.

Opportunity	Eligibility Requirements	Funding Amounts	Application Timeline	Application Considerations/Priorities
		of transit facilities; and funding to adapt to technological change or innovation through the retrofitting of transit rolling stock and facilities.		
Other Programs				
Surface Transportation Block Grant Program	The Surface Transportation Block Grant program (STBG) provides flexible funding that may be used by States and localities for projects to preserve and improve the conditions and performance on any Federal-aid highway, bridge and tunnel projects on any public road, pedestrian and bicycle infrastructure, and transit capital projects, including intercity bus terminals.			
EPA Climate Pollution Reduction Grants	The Climate Pollution Reduction Grants (CPRG) program provides $5 billion in grants to states, local governments, tribes, and territories to develop and implement ambitious plans for reducing greenhouse gas emissions and other harmful air pollution.	EPA has announced two competitions for CPRG implementation grants – a general competition for applications from states, municipalities, tribes, tribal consortia, and territories, and a competition only for tribes, tribal consortia, and territories. These competitions are open to entities that received planning grants to develop Priority Climate Action Plans (PCAPs) as well as entities that did not directly receive a planning grant that are applying for funds to implement measures included in an applicable PCAP. Eligible applicants may only apply for funding to implement measures contained in an applicable PCAP. Applications are due April 1, 2024.		

Reserves and Budgets Set Aside for Zero Emissions Program Costs

During the development of the annual budgets for fiscal years 2022 to 2024, Community Transit set aside local funding in reserve with the intention to support the development and implementation of the Zero Emissions Program. In pandemic era times, service and ridership declined in accordance with new travel patterns. During this period, Community Transit was able to set aside operating margin to address future agency needs such as a sustainable fleet. The agency plans its fleet replacements thirty years in advance and has been formulating a plan to address future infrastructure costs related to green technologies.

Table 6 Community Transit Budgets and Reserves

Purpose	Source	Fund	Description	Amount
Zero Emissions Vehicle Reserve	Local Funds	Facilities and Technology Fund	Reserve	$91,879,000
Zero Emissions Project Contingency	Local Funds	Facilities and Technology Fund	2024 Budget	$25,800,000
ZE Buses/ Infrastructure – 40' and 60' Coaches	Local and Federal Grant Funds	Federal Grant Fund	2024 Budget	$20,000,000 (est. grant) $45,598,000 (local)
Zero Emissions Fleet Pilot Project	Local Funds	Facilities and Technology Fund	2024 Budget	$2,300,000
2024 ZE Program Development	Local Funds	Facilities and Technology Fund	2024 Budget	$1,000,000
ZE Utility Infrastructure	Local Funds	Facilities and Technology Fund	2024 Budget	$700,000
FMP 7/8 – ZE Improvements to Operating Bases	Local Funds	Facilities and Technology Fund	2024 Budget	$1,300,000
Reserve for Service Quality, Innovation & Sustainability*	Local Funds	Facilities and Technology Fund	2024 Budget	$85,000,000
**Not specifically reserved for Zero Emissions Technology, but this was intended for use toward projects or programs that could include Zero Emissions technology costs; hence the designation for service quality, innovation and sustainability.*				

Policy Assessment

Policies and regulations supporting the transition to zero-emission vehicles are proliferating as the efforts to decarbonize the transportation sector expand. Community Transit is monitoring the implementation of relevant policies and legislation. While relevant funding programs are considered in the Funding Needs Assessment above, policies and regulations that direct aspects of zero-emission transit deployments beyond funding are considered in this section. Community Transit will thoroughly assess all relevant policies and legislation throughout the fleet transition.

Alignment with Federal Priorities and Policies

With the passage of the *Bipartisan Infrastructure Law* and issuance of *Executive Order 14008: Tackling the Climate Crisis at Home and Abroad*, the federal government has set a renewed focus on zero-emission transit. Community Transit's goal to deploy 300 zero-emission buses for fixed-route service supports the federal administration priorities of renewing transit systems, reducing greenhouse gas emissions from public transportation, equity, creation of good paying jobs, and connecting communities.

A key element of the agency's fleet conversion strategy is the deployment of FCEBs on Swift routes, connecting Federal investment in Link Light Rail and the recently announced PNW Hydrogen Hub. The agency is leading the way in the Puget Sound region and will be one of the first transit operators to have FCEBs on the road.

Washington State Policies & Goals

The Washington State Department of Transportation (WSDOT) submitted a plan for the National Electric Vehicle Infrastructure (NEVI) Formula Program to the Joint Office of Energy and Transportation in July 2022. Washington's portion of the formula funding is $71M over five years, and although this funding is specifically to improve public electric vehicle charging infrastructure for light-duty vehicles, it demonstrates the state's commitment to accelerate the adoption of zero-emission technologies and reduce greenhouse gas emissions.

Washington's Climate Commitment Act (CCA) (E2SSB 5126), signed into law on May 17, 2021, caps and reduces greenhouse gas (GHG) emissions from Washington's largest emitting sources and industries, allowing businesses to find the most efficient path to lower carbon emissions. This powerful program works alongside other critical climate policies to help Washington achieve its commitment to reducing GHG emissions by 95% by 2050. The Move Ahead Washington grant program, supported by state funding from the CCA, will provide $3 billion for public transportation over the next 16 years. For the 2023-25 biennium, the Legislature appropriated $406 million under the Climate Transit Programs Account.

The state's Clean Fuels Standard (HB 1091), also adopted in 2021, works beside the Climate Commitment Act to target the largest source of emissions in Washington. The law requires fuel suppliers to gradually reduce the carbon intensity of transportation fuels to 20% below 2017 levels by 2034. By requiring fuel suppliers to reduce the carbon intensity of transportation fuels, the Clean Fuel Standard will cut statewide greenhouse gas emissions by 4.3 million metric tons a year by 2038 and will stimulate economic development in low carbon fuel production.

On May 7, 2019, Governor Jay Inslee signed into law the Clean Energy Transformation Act (CETA) (SB 5116, 2019), which commits Washington to an electricity supply free of greenhouse gas emissions by 2045. Clean electricity will allow Washington's transit agencies to power their vehicles with carbon-free resources, such as wind and solar.

WSDOT submitted the Washington State Transportation Carbon Reduction Strategy to the Federal Highway Administration (FHWA), to receive federal Carbon Reduction Program funds, furthering the state's commitment to reduce the carbon intensity of transportation emissions by electrifying vehicles and switching to low-carbon fuels.

Partnership Assessment

Battery Electric Bus Partnership

Establishing and maintaining a partnership with the local electric utility is critical to successfully deploying zero-emission vehicles and maintaining operations. With the addition of battery electric buses to a fleet, a transit agency may likely become a utility's largest customer with added implications for grid-side infrastructure and agency operational costs. Early coordination and discussions can avoid costly delays and misaligned operational strategies while also revealing opportunities for lower operational costs and smart investments. Fortunately, electric utilities are beginning to develop electric vehicle rates and streamlined processes for charging infrastructure interconnections that can support successful zero-emission fleet deployments.

The collaboration with the Snohomish County Public Utility District (SnoPUD) is a significant step towards achieving Community Transit's goal of deploying a green fleet. Notably, the PUD's energy portfolio is 97% carbon free by MWh[6]. SnoPUD[7]. The reliable access to clean and renewable energy resources uniquely positions Community Transit to move towards a more sustainable, lower carbon future.

To further the agency's goals of decarbonizing the fleet, Community Transit and the PUD have engaged early and often to assess and evaluate the impacts of adding load capacity to support charging and clean fueling infrastructure. In June 2023, SnoPUD completed a System Impact Study for the Kasch Park Operating Base (KPOB) and the Hardeson Campus. The additional load capacities were evaluated in two phases based on CT's procurement schedule. Phase 1 of the project assesses adding 8 MW at KPOB and 4 MW at Hardeson Campus to accommodate planned deployments through 2029. The second phase evaluated the requirements for the full zero-emission fleet conversion at both operating bases, and an option for on-site electrolysis for produced hydrogen, should the agency choose to pursue this path. Additional site improvements in Phase 2 include adding 8 MW of capacity at KPOB and 4 MW at Hardeson Campus, for a total of 16 MW and 8 MW, respectively.

The active collaboration and trusted partnership with SnoPUD will contribute to the successful deployment of Community Transit's zero-emissions fleet while maintaining service lines. Community Transit is committed to making significant investment in electrical infrastructure to support the growing electricity demand as CT scales a mixed fleet of hydrogen fuel cell and battery electric buses. Transitioning to cleaner transit technologies not only benefits the community of Snohomish County but supports the shared commitment of investing in carbon-free technologies.

In the initial phases, the electricity rates will be based on SnoPUD Rate Schedule 20 – General Service, Medium Load. Specifically, Schedule 20 is assigned to PUD customers that have Billing Demand of 100 kW at least once or those that have energy usage of "at least 30,000 kWh per month[8]". As of November 1, 2023, the energy charge for the first 30,000 kWh is $0.0900 for Schedule 20 users and demand charges are $6.76 per kW over 100 kW. As CT scales its fleet, the per kWh energy cost will decrease due to more preferential rates with the PUD. When CT reaches a minimum of 5 MW demand, Schedule 36 will be used, which has demand charges of "$4.92 per kW of monthly billing demand" and energy charges of $0.0595 per kWh.

Snohomish Public Utility District offers a New Load Policy, which reimburses qualified costs back to the customer over a 10-year period. A significant portion of the utility work to be completed in support of the zero-emission fleet transition is eligible for this reimbursement, mitigating a significant portion of the total cost of bringing the requisite power to both Merrill Creek and Kasch Park facilities.

Community Transit is aware that taking advantage of these benefits and ensuring a successful battery electric bus deployment requires close, ongoing coordination with SnoPUD. Community Transit's discussion of short- and long-term fleet goals with Snohomish Public Utilities Department (SnoPUD) ensures that SnoPUD can properly plan grid-side electrical infrastructure upgrades and that Community Transit can adequately upgrade behind-the-meter equipment to support battery electric buses. Once the infrastructure upgrade needs are established, Community Transit will incorporate the design and construction timelines into the overall Transition Plan timeline.

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6 https://www.snopud.com/wp-content/uploads/2021/12/Final_2021_IRP.pdf
7 https://www.snopud.com/community-environment/clean-energy/carbon-emissions-data/
8 https://www.snopud.com/wp-content/uploads/2023/03/electricrates.pdf

Community Transit recognizes SnoPUD as a critical partner in electrification and will continue to partner with SnoPUD after the planning stages, so that charge management strategies and fleet expansion efforts can be coordinated effectively.

Fuel Cell Electric Bus Partnership

Establishing and maintaining a partnership with the alternative fuel provider is critical to successfully deploying zero-emission vehicles and maintaining operations. Hydrogen fueling requires a plan for infrastructure installation, delivery, storage, dispensing, and upgrades to maintenance facilities. While fueling operations for hydrogen may require less operational changes than electric bus charging, understanding the local hydrogen supply market can be its own challenge. To overcome this challenge, a competitive bid process for a design/build project is a reasonable approach to determine the appropriately sized station and to select the most appropriate fueling technology at the best price. Transit agencies are purchasing a complete system requiring careful integration of multiple components managed by a programmable logic controller. The supplier of that system is in the best position to design the system. The hydrogen for transportation supply market is growing but regional differences exist that can dictate what hydrogen fueling operations may look like.

The Pacific Northwest Hydrogen Association (PNWH2) is a multi-state nonprofit coalition of public and private partners planning to create a hydrogen network in the Pacific Northwest, called the PNWH2 Hub, to develop and bring to market clean hydrogen power solutions that can help us meet the nation's clean energy goals. The agency plans to engage with this group to establish a market demand for consumption of hydrogen and create appeal for potential producers to create more local sources of fuel, mitigating costs and environmental impacts related to delivery.

The growth in hydrogen demand is bringing more competition to the marketplace for both infrastructure and fuel supply. A larger pool of competitive vendors for hydrogen infrastructure will work towards driving fuel costs down and achieving price parity with conventional fuels. The Pacific Northwest's abundant low-carbon power and environmentally focused state policies, combined with strong community benefit programs and federal incentives, will enable the Pacific Northwest Hydrogen Association's (PNWH2) efforts to establish of a network of production, storage, and distribution systems in the region. Over the course of its ZEB transition, the success of the PNWH2 Hub may increase CT's access to low-carbon and low-cost hydrogen fuel in Washington state.

A strong partnership with a fuel supplier can support the decision-making process that an agency must undertake to develop a robust fueling operation. Once established, maintaining this partnership will facilitate a dependable fuel supply and the ability to scale supply needs with fleet size.

Community Transit is actively investigating multiple pathways to confidently resolve the supply issues as outlined above:

1. Small-Scale Hydrogen Production RFI to support 5-10 FCEBs.
2. Facility Design Study (10% design) highlighting needs for liquid fueling, as well as 1,000kg/day production capability.
3. Discussions with local partner agencies and private entities regarding hydrogen fuel demand targets over near-term, intermediate-term, and long-term horizons.
4. Discussions with county, state, and national representation from the Regional Clean Hydrogen Hubs Program and the Office of Clean Energy Demonstrations (OCED).
5. Contract with Linde to supply a mobile refueling unit and supporting tank trailers to fuel the agency's New Flyer FCEB during the pilot phase.

Workforce Analysis

Community Transit, located in Everett, WA, operates a fleet of 257 buses, that will eventually evolve into a 300-bus fleet, comprised of 210 40' BEBs, and 90 60' FCEBs. CT is currently operating ZEBs through its beta and side-by-side pilots in 2023 and 2024, as part of its efforts to grow its ZEB fleet. CT's near-term procurement plans will introduce 25 FCEBs and 10 BEBs to its fleet by 2027, eventually growing to 25 FCEBs and 50 BEBs by 2029.

To support ZEB operations at this scale, CT has conducted some initial assessments as identified in **Appendix D**, to ensure the current and future workforce is prepared to manage its long-term vision of a full fleet of more than 300 future ZEBs. This Workforce Development Plan focuses on ZEB operations and maintenance. In alignment with FTA's requirements under the Workforce Development for the 2024 Low-No program, CT will build a ZEB workforce program in consultation with labor representatives and will continue to build on the current apprenticeship program that has been in place for over 25 years that includes active participation by represented employees during the selection and progress monitoring process for apprentices.

Workforce Analysis Overview

Developing and training the workforce required to operate and maintain zero-emission buses requires significant investment and planning. CT is experienced in recruiting, hiring, training, and integrating new staff to ensure that employees are qualified to provide quality services to riders. The level of training that CT staff engage in, upon hiring, is dependent upon their level of experience at that time. CT recognizes that a trained ZEB workforce is not readily available, and the transit industry must address the shortage of technicians and mechanics together.

The labor contract for CT maintenance staff ends in 2024; the necessary workforce development for CT's transition to zero-emission will be subject to those negotiations. For the near future, CT will focus on further development of staff on hybrid electric vehicles and developing a Transition Plan for ZEB knowledge, skills, and abilities (KSAs). Labor representatives are active, important members of CT's apprenticeship program, including invaluable selection and mentorship roles, new journey mechanics are trained by represented instructional staff and provided on-the-job training (OJT) by CT's represented journey mechanics. As CT continues the journey from hybrid electric buses to full fleet of ZEBs, training and maintenance staff will continue to play a key role in the transition. CT is a participant of the Women in Trades advocacy group, and are working without Local Tulalip Tribe, that draws first people from across the United States to their pre-apprentice building trades program, to evaluate a partnership for roles in the transit industry.

CT plans to develop and maintain a qualified ZEB staff by hiring qualified new staff and retraining existing staff who have previously worked with internal combustion engine (ICE) systems. Meaningful investment is required to upskill maintenance staff and bus operators that were originally trained in diesel vehicle maintenance and fossil fuel fueling infrastructure. Transitioning to zero-emission vehicles is a paradigm shift for all aspects of transit operations including but not limited to scheduling, maintenance, and yard operations. CT's workforce development activities will address the identified skills and tools needed for each relevant team.

Completed Trainings

CT operated a BYD battery electric bus for most of 2023 and learned a great deal in regard to gaps in staff training, which is being incorporated into current training programs.

CT has participated in APTA's system safety program plan (retitled multiple times) since inception. All of CT's maintenance employees must complete certifications on Safety Critical Components. CT will continue to expand this program as it learns and develop new certifications. In order for maintenance instructors to develop these certification programs, CT will provide opportunities for their skill development through job shadowing at other transit agencies, learning opportunities with various vendors, and contacts with subject matter experts (SMEs) in the field of ZEBs, to develop their understanding of the technologies.

The following OEM/vendor SOPs have already been made available, and are in-use by CT operations and maintenance staff:

- 2011 New Flyer 40' service manual
- BAE HDS System Manual

- 2009 New Flyer 60' service manual
- Allison Electric Drive Ep40/50 system manual

CT's current diesel and diesel hybrid bus training offers the foundation by including the following courses. Those in *italics* are included in CT's System Safety Critical Component Training and Certification Program. By increasing the certification/qualification of increasing numbers of maintenance staff, CT is able to build the foundation for the transitioning to ZEBs.

- *Electrical/Multiplex system*
- *Hybrid Safety/LOTO/ARC Flash safety*
- *Air Systems/Brakes/Interlock*
- *Entrance & Exit doors*
- *Steering and suspension*
- *Wheelchair Ramp system*

The above-listed training programs provide a foundation to build from, and there are additional courses and significant changes to current courses for ZEB training. The in *italics* courses below will require new curriculum, either in total or part, and all of the related training aids will require replacement.

- *Electrical/Multiplex System(s)*
- *Energy Storage System and Battery Management(s)*
- *Propulsion System(s) Familiarization & Troubleshooting*
- *On/Off Board Charging System(s) Equipment*
- *HVAC System(s)*
- *Brake and Air System(s)*
- *Steering, Suspension and Axle System(s)*
- Wheelchair Ramp System
- *Entrance & Exit Doors*
- *ZE Propulsion System(s) Overhaul*

The agency has two metrics for success related to the workforce development and ZEB; its strategic Priorities "Strengthen Employee Experience" and "Prioritize Sustainability" have metrics throughout various departments and divisions. These metrics will shift as CT's ZEB program matures. CT's commitment to ZEB and growth of its employees is clearly identified as these are 2 of just 3 Strategic Priorities.

CT maintains qualification/certification information on all employees to provide a solid understanding of how many are able to complete work on which they are qualified. CT leads use this information to assign work to employees.

Identified Training Needs

Community Transit has operated hybrid buses since 2009; CT has not fully-qualified the entire maintenance team. The first step is to provide this training to CT's entire journey mechanics team. CT will continue to expand the development and application of skills on hybrid vehicles for maintenance staff. CT will also look to expand troubleshooting capabilities, as the specific knowledge needed for troubleshooting diesel & hybrid diesel, and BEBs & FCEBs are different.

In addition, CT will begin working with bus operators to develop driving skills that extend the battery charge as those skills also save fuel and can be improved now. CT are evaluating the need for a different level of technician for BEB charging systems, while CT will begin the development of new skills related to BEB charging and FCEB fueling for the Facilities Maintenance Team, as CT receives the two-pilot demonstration ZEBs in 2024 noted earlier in this document.

CT will continue to roll out certifications on hybrid vehicles to build additional skills in preparation for additional ZEB. As the ZEB training materials are developed, CT will roll out training to employees in consideration of the work hours necessary to maintain the fleet as it grows.

Several training needs have been identified by CT staff in order to support their transition to a 100% ZEB fleet. CT is committed to ensuring new training and technologies do not displace current workers and has placed a priority on training existing staff as well as developing an apprenticeship program. The identified training needs are anticipated to evolve as CT's fleet expands. As such, the following training plans are intended to provide a framework.

1. **Apprenticeship Program:** CT currently has a State Certified Apprentice Program. CT will continue to add to the program including ZEB as CT has for the 25 years the program has existed. CT has also begun determining best methods for assisting secondary education partners in developing ZEB education programs shifting away from heavy-duty diesel programs that support Washington State's move to ZEVs.
2. **Train-the-Trainer Approach:** Many procurement contracts include train-the-trainer courses through which small numbers of agency staff are trained, integrate the materials into CT's Bus System Safety Certification Program and subsequently train and certify agency colleagues. This method provides a cost-efficient opportunity to minimize the need for external training while maintaining institutional knowledge and providing widespread agency training on new equipment and technologies. CT currently relies on OEM training but has a desire to use a train-the-trainer program to maintain knowledge expertise in-house. Third party resources will continue to be used as needed.
3. **Vendor/OEM training from New Flyer, GILLIG:** CT plans to take advantage of trainings from the ZEB manufacturers and infrastructure suppliers, including maintenance and operations training, maintenance, and safety, first responder training, and other trainings that may be offered by the providers. OEM trainings provide critical information on operations and maintenance aspects specific to the equipment model procured. CT training staff will work closely with the OEMs providing vehicles to ensure all mechanics, service employees, and bus operators complete necessary training prior to deploying ZEB technology. CT staff will also be able to bring up any issues or questions they may have about their training with their trainers. Additionally, trainers will observe work activities periodically to determine if any staff would benefit from further training.

The following tools/training aids have been identified as top needs to bring in-house, as more of the maintenance and management falls to internal staff with an expanded ZEB fleet.

1. Electronic control board(s): New Flyer ZEB and GILLIG ZEB
2. Air conditioning training units (if substantively different from current)
3. High-Voltage (HV) training system (may need multiple, as facilities maintenance staff will also need training)
4. Regenerative braking system mock-up
5. Air system(s) supply

CT currently has training aids for both GILLIG and New Flyer diesel buses with Cummins engines, and CT are in the process of procuring one High-Voltage training system. As CT adds to the ZEB fleet and vehicles move out of warranty, CT will need to add these training mock-ups. These will add both significant costs and create additional space pressures.

1. **Retraining/Refresher Training Courses:** CT has begun certifying additional maintenance staff on existing Hybrid Buses; this will increase staff with base knowledge of high voltage systems. CT also recognizes the need to develop better troubleshooting skills as the technology on buses changes, technicians have less collective experience to rely on. CT will be developing training programs for Bus Operators to build better driving habits that will maximize energy efficiency and create habits that return energy via vehicle regenerative systems.
2. **ZEB Training from Other Transit Agencies:** There is the potential for several programs that are yet to be fully realized but may provide opportunities in the future. These ZEB early adopters are creating learning centers for other agencies embarking on their ZEB transition journeys. One such agency is SunLine Transit Agency, which provides service to the Coachella Valley and hosts the West Coast Center of Excellence in Zero Emission Technology (CoEZET). The Center of Excellence supports transit agency adoption, zero-emission commercialization, and investment in workforce training. Similarly, AC Transit plans to offer training courses covering hybrid and zero-emission technologies through their ZEB University program. Community Transit plans to take advantage of these training courses offered by experienced agencies and has already met with AC Transit to discuss the agency's programs. The Puget

Sound Regional Council which provides oversees economic growth and transportation coordination in the region has expressed early interest in combing regional resources to create programs at the State level to assist Transit agencies to solve the current employee shortage as well as advance program offerings for potential transit employees to learn ZEB skills through High School and College level programs.

3. **Local Partnerships and Collaborations:** CT's current focus is to work with the regional STEM Program, workforce development and Puget Sound Regional Council (they pull together economic and transportation efforts across the Puget Sound Region) to coordinate efforts in creating high school and college interest in ZEBs and build programs to replace current heavy-duty diesel programs. In addition, CT is working with local workforce development partners to help fill the current short fall of journey level mechanics.
4. **Professional Associations:** CT is active within APTA's Zero Emission Fleet Committee, which includes stakeholders involved in planning, operating, and maintaining ZEBs. CT is also a member of the Zero Emission Bus Resource Alliance (ZEBRA), an organization that allows transit agencies to share lessons from their experience with zero-emission buses. As part of CT's workforce development strategy, development, and training for all levels of the team, including the executives, managers, and technical staff that represent the agency, is of critical importance to better understand ZEBs and make informed performance, maintenance, operating, and purchasing decisions related to zero-emission vehicles and infrastructure.

Resources and Strategies to Meet Identified Needs

In order to incorporate the above training needs, Community Transit envisions using following resources and strategies. To achieve these goals and ensure a successful deployment of zero-emission buses, Community Transit will require **$1.1—1.9M** in funding to cover the workforce development initiatives identified. FY2024 Low-No funding will ensure the workforce development plan can be implemented in parallel with deployment of vehicles and infrastructure.

Table 7 Training Strategy Budgets

Training Resource/Strategy	FY2024 Low-No Budget
Bus OEM Operator, Maintenance, First Responder Training Curriculum Development, Deployment, and Program Staffing for 3 Years (Initial Deployments)	$750,000 - $1,000,000
Training Aids, Simulators, Components, Equipment	$350,000 - $850,000
Professional Associations	Excluded

Workforce Development Timeline

As of February 2024, CT has begun training additional staff in hybrid vehicles to broaden their skills on cleaner technologies. The goal is to transition staff as the vehicles are delivered and transitioned out of warranty. CT will also need to compare the ZEB vehicles' performance as it relates to service needs, and to avoid training and certifying more staff than are needed to maintain the vehicles. CT's primary focus is on eliminating the knowledge, skills, and abilities gap for the existing workforce, while also beginning to develop career pipelines through local and regional partnership with workforce development entities and secondary education establishments.

CT will provide vehicle OEM/vendor training to additional mechanics, maintenance instructors, vehicle service workers, and vehicle service attendants, when the first two pilot ZEBs arrive in early 2024. CT looks to provide this training to maintenance instructors as well.

Once the maintenance instructors have received training from vehicle OEMs/vendors, they will be sent to various other transit agencies to learn about their training and certification programs, in the April – December 2024 time period.

From 2025 through 2028, CT will develop its own training and certification program. This task is dependent upon where the ZEB industry is situated as it relates to transitioning to 100% zero-emission. To accomplish this task, CT will need to expand its training staff, as well as their abilities. Transitioning the various roles on the maintenance team will require a dedicated, full-time ZEB training staff in the employee development division. These roles include Journey Mechanics, Apprentices, Vehicle Service Workers and Vehicle Service Attendants. Beyond vehicle maintenance staff, the agency will also need to develop similar programs supporting body shop and facilities maintenance groups.

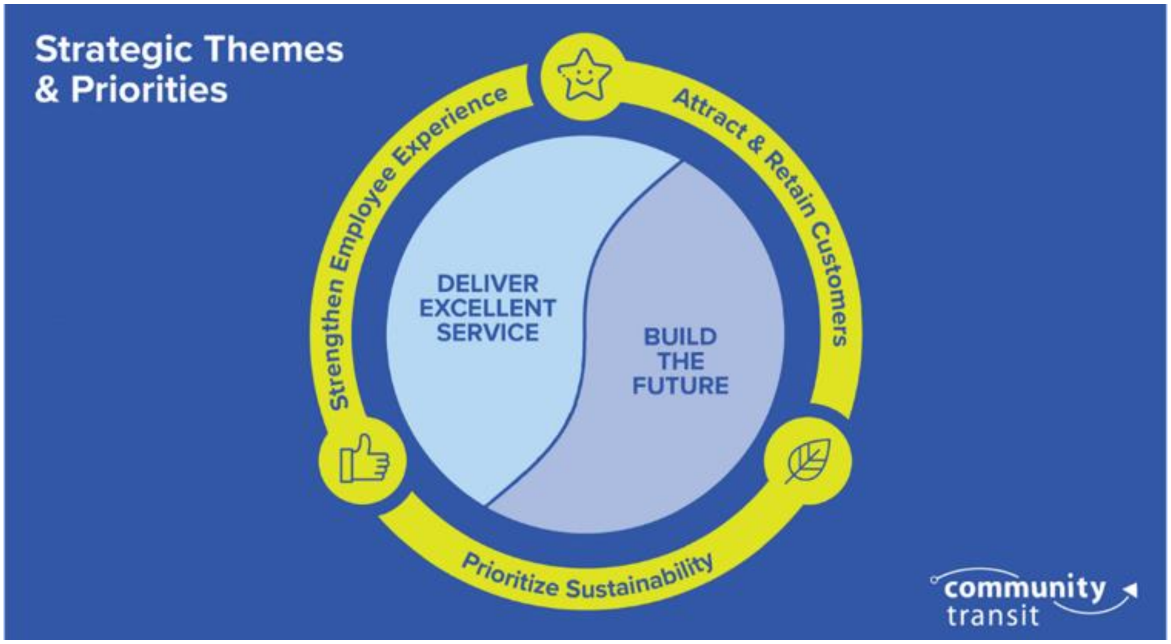
The training approach will require evolving adapting training plans to enhance materials in response to as technology and knowledge changes over time. CT will evaluate the best practices and recommendations from the initial workforce development assessments identified in **Appendix D**, before solidifying future plans, with the intention to transition existing employees to work on ZEBs as soon as possible. CT will need additional maintenance staff in large numbers by 2038, as the first ZEBs move out of their warranty period, and the ZEBs exceed 50% of the entire fleet.

Workforce development is an ongoing process that must continue, as fleets scale up and deploy additional ZEBs to ensure that the workforce scales efficiently and cost-effectively, CT will employ training strategies that support additional ZEB deployments in the future. CT anticipates that it will evolve to support the workforce and training needs going forward.

CT continues to have a strong commitment to employees and the implementation to ZEBs. The current efforts include building interest at the primary and secondary-grade levels in STEM, specifically transit and ZEB technologies, environmental impacts of ZEB technologies, and the potential for careers in the field. CT is dedicated to assisting regional higher education programs to transition away from diesel programs and towards ZEBs at technical colleges, and in encouraging regional 4-year institutions to recognize the importance of ZEB technologies to contribute to creating stable, well-paying jobs in the public transportation sector, while improving the environment.

CT believes that ZEBs are an opportunity to partner with local Tulalip Tribes, STEM programs, and workforce development programs to advance careers for the BIPOC population. The transit industry has traditionally provided stable, well-paid career opportunities. By partnering with community members, CT not only provides opportunities for the BIPOC population in the region, but also supports the reduction of carbon emissions in those neighborhoods most impacted.

These goals are in alignment with the Agency’s Strategic Themes and Priorities.



Appendix A

Topography and Climate

Community Transit operates services in and around Everett, WA, which was used as a reference point for climatic and topographical conditions affecting ZEB operating performance.

The geographical coordinates of Everett, WA, are 47.87818 deg latitude, -122.29397 deg longitude, and the city sits at an average elevation of 226 feet above sea level[9]. CT operates service across relatively hilly terrain, indicating steeper grades and longer elevation routes resulting in significantly more energy consumption, thereby defining strenuous energy requirements for ZEB technologies.

Everett, Washington, enjoys a mild climate with temperatures rarely dipping below freezing or exceeding 90°F. Average lows in winter months reach near 35°F and the city can experience light snowfall, while the summer months bring highs around 75°F with plenty of sunshine. Rainfall is abundant, particularly during the winter months, recording an average of 36.05 inches of rain annually, and the region also experiences some windy days that often come with the Pacific Northwest storms that roll in off the coast[10].

These operational conditions affect the HVAC loads onboard ZEBs, particularly below 50°F, which in turn have seasonal impacts on energy requirements. Energy requirements are also affected by precipitation and turbulent driving conditions, as regenerative braking is deactivated under slippery road conditions; the abundance of rain during winter implies significant impact on the regenerative braking functionality of the vehicles.

Service Assessment

40-ft. BEB Service Assessment Methodology

BEB operating efficiencies and range are primarily driven by vehicle specifications; however, it can be impacted by a number of variables including the route profile (i.e., distance, dwell time, acceleration, sustained top speed over distance, average speed, traffic conditions, etc.), topography (i.e., grades), climate (i.e., temperature), driver behavior, and operational conditions such as passenger loads and auxiliary loads. As such, BEB vehicle performance and range can vary dramatically from one agency to another. Therefore, it is critical to determine efficiency and range estimates that are based on accurate representation of the operating conditions associated with CT's service to complete the assessment. This prevents an operator from assigning vehicles to a route or service day that requires a heavier duty cycle than the vehicle is capable of performing.

CT's existing fleet of 30', 40', and double-decker diesel transit buses may be replaced by a combination of 30', 35', or 40' BEBs in the future. However, for an understanding of the worst-case service energy requirements for future BEB replacements, the project team utilized a model of a 40-ft. BEB using *Autonomie*, a powertrain simulation software program developed by Argonne National Labs for the heavy-duty trucking and automotive industry. This model was then simulated on CT's Swift Green route, and corresponding BEB energy efficiencies, energy consumption, and range projections were developed. Elevation and speed data from the remaining routes, as well as the specifications for a generic 40' BEB was used to simulate operation on each of the 149 40-ft. BEB service blocks. Blocks are defined as a group of trips assigned for one bus, and block assignments are derived from peak pull-out, which in this case is weekday service. Blocking and annual mileage for service are not expected to change.

The project team utilized **screening-level analyses** to determine energy consumption values, which were paired with a library of varied performance data from multiple agencies, topographies, energy demands, and other operating conditions to create a customized and realistic service scenario representative of anticipated conditions for Community Transit. The 40-ft. BEB model was run with varying loads to represent "nominal" and "strenuous" loading conditions. **Nominal loading conditions** assume average passenger loads and moderate temperature

[9] *https://en-us.topographic-map.com/map-563q/Everett/*
[10] *https://www.usclimatedata.com/climate/everett/washington/united-states/uswa0647*

over the course of the day, which places marginal demands on the motor and heating, ventilation, and air conditioning (HVAC) system. **Strenuous loading conditions** assume high or maximum passenger loading and either very low or very high temperature (based on agency's latitude) that requires near maximum output of the HVAC system. To determine block feasibility for the 40-ft. BEB service, strenuous operating conditions were utilized for each of CT's 149 40-ft. service blocks. **Table 8** outlines the nominal and strenuous efficiencies for each of CT's 40-ft. BEB routes.

Table 8 40-ft. BEB Route Efficiencies

Route ID	Vehicle Group	Route Length (mi)	Topography (Gradient %)	Average Speed (mph)	Nominal Efficiency (kWh/mi)	Strenuous Efficiency (kWh/mi)
101	40'	21.25	2.51%	16.80	2.44	3.65
102	40'	11.35	3.97%	14.10	2.49	3.66
103	40'	33.15	2.70%	19.31	2.45	3.39
105	40'	19.20	3.48%	15.67	2.49	3.66
106	40'	29.96	2.81%	21.71	2.50	3.40
109	40'	39.89	3.36%	16.93	2.49	3.66
111	40'	7.03	2.98%	16.59	2.49	3.66
112	40'	16.52	2.31%	12.92	2.44	3.65
114	40'	11.77	2.79%	17.98	2.49	3.66
117	40'	21.81	3.03%	16.91	2.49	3.66
119	40'	22.28	4.49%	14.02	2.49	3.66
120	40'	21.27	3.73%	14.50	2.49	3.66
121	40'	19.71	3.40%	15.37	2.49	3.66
130	40'	21.02	3.29%	15.80	2.49	3.66
132	40'	38.60	1.86%	19.73	2.45	3.39
166	40'	34.73	1.84%	21.07	2.45	3.39
201	40'	54.03	2.41%	22.23	2.45	3.39
202	40'	56.21	1.79%	17.75	2.44	3.65
209	40'	32.37	2.47%	19.11	2.45	3.39
220	40'	13.65	2.73%	20.17	2.50	3.40
222	40'	22.39	1.62%	34.84	2.45	3.39
223	40'	25.29	2.13%	24.27	2.45	3.39
230	40'	70.91	2.37%	27.31	2.45	3.39
240	40'	38.21	2.28%	25.72	2.45	3.39
270	40'	47.36	2.56%	22.43	2.45	3.39
271	40'	64.67	2.60%	18.47	2.45	3.39
280	40'	41.10	3.57%	14.40	2.49	3.66
901	40'	25.35	1.72%	28.58	2.45	3.39
902	40'	22.00	1.66%	32.59	2.45	3.39
903	40'	38.68	1.72%	30.00	2.45	3.39
904	40'	40.43	2.47%	24.84	2.45	3.39
905	40'	80.67	2.89%	14.95	2.49	3.66
906	40'	18.00	3.05%	17.37	2.49	3.66
907	40'	53.48	3.48%	17.62	2.49	3.66
908	40'	66.31	2.81%	23.24	2.50	3.40
909	40'	11.30	2.79%	18.37	2.49	3.66

Once the strenuous energy demand for each of the 40-ft. BEB blocks was determined, it was compared to the usable capacity of a market-representative 40-ft. BEB, with a **nameplate capacity of 515 kWh**, to determine whether that service day would be feasible or infeasible with a single, overnight depot-charge. Since this analysis does not assume a specific vehicle manufacturer, there are currently vehicles with larger nameplate capacities available. The project team also assumed the **available service energy** onboard the generic 40-ft. BEB is **90%** of the battery's nameplate capacity. The project team conducted the service assessment for a BEB at half its service life, or at **90% state-of-health (SOH)**. At the time of the development of this report, there are multiple BEB manufacturers that are moving towards allowing a larger percentage of the battery (greater than 90%) to be available for use; however, the overall **81% usable battery capacity** represents a conservative assumption of available battery capacity at the mid-life of a vehicle. Block feasibility is expected to decrease over the life of a BEB, based on degradation in energy storage capacity, at which time battery pack replacements would be necessary. The project team did not model end-of-life service feasibility, since it is assumed that CT will invest in midlife battery replacements, maintaining service feasibility modeled on the 90% SOH.

Research suggests that the **energy storage density** for batteries in electric vehicles has improved by an average of **5%** each year[11]. For the purposes of this study, considering the extended period of a complete fleet transition (e.g., through 2050, with 2044 being the 100% zero-emission goal for CT), the project team assumed 5% improvement every two years. As such, these projections should be considered conservative for the purposes of planning. If the trend continues, it is expected that buses may continue to improve their ability to carry more energy without a weight penalty or reduction in passenger capacity. Vehicle OEMs are currently developing energy systems with higher storage capacity and energy density. Over time, BEBs are expected to approach the capability to replace all of an agency's fossil-fuel buses one-for-one.

60-ft. FCEB Service Assessment Methodology

FCEB operating efficiencies and range are primarily driven by vehicle specifications and are not impacted by as many variables as their battery-electric counterparts. 60-ft. FCEB deployments are relatively limited, and data collected under real-world conditions are scant. In addition, there is only one 60-ft. equivalent FCEB currently available for commercial purchase with federal funds, the New Flyer XHE60. The latest generation of the XHE60's technical specifications were compared to the modelled efficiency of an XHE60 for a transit agency operating under similar weather conditions to Community Transit in Everett, WA[12]. The project team developed a correlation between vehicle range and operating temperatures, based on seasonal fluctuations in weather conditions. CT's strenuous conditions were set by warmer temperatures, resulting in reduced range expectations It was identified that the strenuous conditions for CT's service is under warmer temperatures, when the range expectation of the 60-ft. FCEB reduces to **275 mi** for a full-tank of **56 kg** of onboard hydrogen storage. Under nominal conditions, the range expectation for the vehicle could improve to **285 mi** for a full tank of fuel. The corresponding nominal and strenuous efficiencies per route were determined. **Table 9** 60-ft. FCEB Route Efficiencies outlines these results for CT's 60-ft routes.

Table 9 60-ft. FCEB Route Efficiencies

Route ID	Vehicle Group	Route Length (mi)	Topography (Gradient %)	Average Speed (mph)	Nominal Efficiency (mi/kg)	Strenuous Efficiency (mi/kg)
701	60'	33.52	2.26%	19.42	5.09	4.91
703	60'	22.90	3.12%	20.39	5.09	4.91
704	60'	28.47	2.63%	29.11	5.09	4.91
702	60'	32.70	3.48%	14.53	5.09	4.91

For FCEBs, improvements to a combination of lightweight materials, tank capacity, storage technology, fuel cell efficiency, battery energy density, and traction motor efficiency improvements are expected to occur over the course of the transition period. When comparing the latest 60-ft. FCEB model's projected performance to the Altoona test results for its previous iteration, an improvement in range expectations was identified[13]. Based on this observation, the project team assumed a **5% improvement in range** for FCEBs, every two (2) years. A majority of this increase in range over time will be through FCEB vehicle architecture improvements that incorporate

[11] *https://arpa-e.energy.gov/technologies/publications/long-range-low-cost-electric-vehicles-enabled-robust-energy-storage*
[12] *https://www.newflyer.com/site-content/uploads/2023/08/Xcelsior-CHARGE-FC.pdf*
[13] *https://www.altoonabustest.psu.edu/bus-details.aspx?BN=1615*

additional onboard storage tanks. It is expected that these improvements in vehicle technology will continue until FCEBs hit range parity with existing diesel and CNG buses, and only likely to occur during the early years of ZEB transition, as the market evolves out of nascency.

Similar to battery-electric technologies, FCEBs are expected to be capable of replacing all conventional buses one-for-one, although at a much more accelerated pace.

ZEB Service Assessment Results

The results from the block analysis were used to determine if/when a full transition to BEBs for the 40-ft. fleet, or a full transition to FCEBs for the 60-ft. fleet may be feasible. **Figure 8** indicates the yearly BEB and FCEB block achievability throughout the transition period.

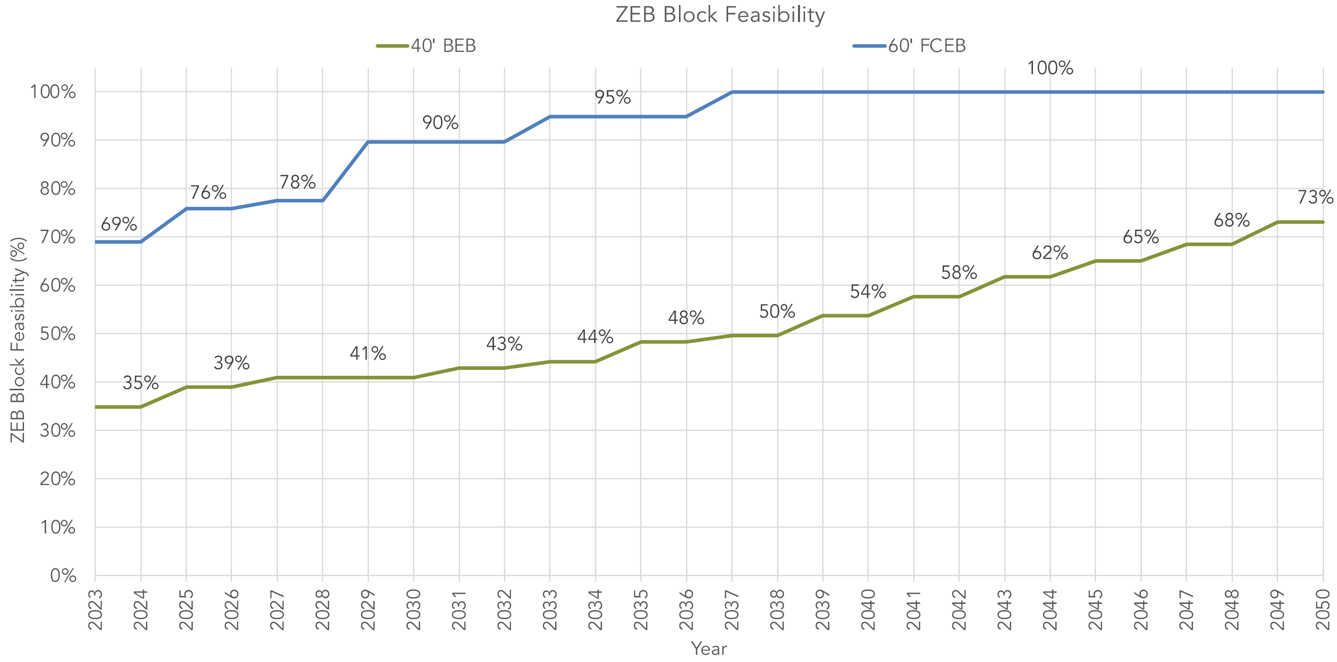


Figure 8 Community Transit's ZEB Block Feasibility, 2023 – 2050

At the end of the ZEB transition period in 2050, only 73% of CT's 149, 40-ft. blocks are feasible with BEBs. By 2037, 100% of CT's 58, 60-ft. blocks are feasible with FCEBs.

Fleet Assessment

The goal of the Fleet Assessment is to determine the type and quantity of ZEBs, as well as the schedule and cost to transition the fleet to zero-emission. Results from the Service Assessment are typically integrated with the transit agency's current fleet replacement plan. For Community Transit's fleet assessment, the project team utilized the agency's fleet purchase schedule to project bus replacement timelines for the existing fleet, as well as the subsequent replacements of ZEBs at the end of their service lives.

The fleet procurements also incorporate known expansion plans to increase the fleet size to 300 buses through the end of the transition. CT's plans include standardization of the existing fleet to 40' BEBs and 60' FCEBs during the ZEB transition. Accordingly, a 1:1 replacement strategy was utilized to replace existing double-deckers, 30', and 40' conventional buses with 40' BEBs, and 60' BRT buses with 60' FCEBs. The assessment also accounted for CT's plans not to replace existing conventional vehicles with newer ICEs, implying that all future fleet procurements starting in 2027 would be ZEBs.

Despite recent increases in energy storage, BEBs are still subject to range limitations and typically cannot be placed into service on all of CT's bus blocks on a 1:1 replacement basis for diesel without planning for on-route charging; modifying block distances and durations; or multiple BEBs to accommodate a single conventional vehicle's current levels of service. As discussed in the Service Assessment section, BEBs can currently be operated on approximately 35% of CT's blocks today, improving to approximately 73% by the end of the transition period. The project team therefore assumes that every 40' BEB procured during the transition period will be equipped with on-route charging equipment onboard the vehicle to meet the requirements of service through their entire service lives.

Cost Assumptions

CT's existing fleet of 30', 40', and double-decker diesel transit buses may be replaced by a combination of 30', 35', or 40' BEBs in the future. For the purpose of arriving at a higher-end cost estimate for the battery-electric fleet, it was assumed that all future BEB procurements are 40' BEBs. The project team developed cost assumptions for this analysis for 40' BEB and 60' FCEB lengths. The project team produced the annual procurement scenario for 2023 through 2050 and annual capital costs for buses.

Key assumptions for the bus cost estimates are as follows:

1. Base prices for all ZEB and non-ZEB purchases are based off the April 2023 updates to the WA state contract pricing.
2. An inflation rate of 3% was applied to estimate bus prices in 2024, and 2.9% was applied for 2025 through 2050, year over year.
3. The costs for inductive charging equipment onboard the 40' BEBs were based off a $90,000 price quote provided to CT.
4. Configurable options costs are priced at a flat rate dependent on CT's standard options pricing of $120,000 per bus.

Conventional wisdom dictates that the costs of BEBs will decrease over time due to higher production volumes and competition from new vendors entering the market. While initially this was true, costs appear to have stabilized and begun to increase again in recent years. However, it should also be noted that OEMs have added more battery storage over the same time period. FCEB prices are expected to decrease over time as vehicle orders increase (e.g., California transit agencies have committed to purchasing over 1,300 FCEBs by 2035); however, the project team does not currently have an adequate basis to reduce the costs over time for the purchase of FCEBs.

Table 10 provides cost estimates for new vehicle purchases used in the analysis.

Table 10 Cost Estimates Utilized in Fleet Assessment

Vehicle Type	40'	60'
BEB	$ 1,280,100	-
FCEB	-	$ 2,048,200

ZEB Fleet Transition Schedule and Composition

Based on Community Transit's replacement schedule and planned procurements, a transition to a 100% zero-emission fleet was developed. **Figure 9** depicts the annual fleet composition through the transition period. The fluctuating annual fleet sizes identify years when, (1) new ZEB purchases are planned but there are no retirements of existing vehicles from the fleet, or (2) vehicles are added to expand the fleet, as captured in CT's fleet plan. As identified by the legend, CT's existing fleet of 30', 40', and double-decker diesel transit buses may be replaced by a combination of 30', 35', or 40' BEBs in the future. Based on the existing procurement schedule, CT will begin to operate a 100% zero-emission fleet by 2038, although the overall goal for an expanded fleet of 300 buses will be met in 2050. Although CT will operate one 40' BEB and 40' FCEB in 2024, as part of the agency's ZEB pilot testing program, the project team did not include these vehicles in the overall ZEB transition plan.

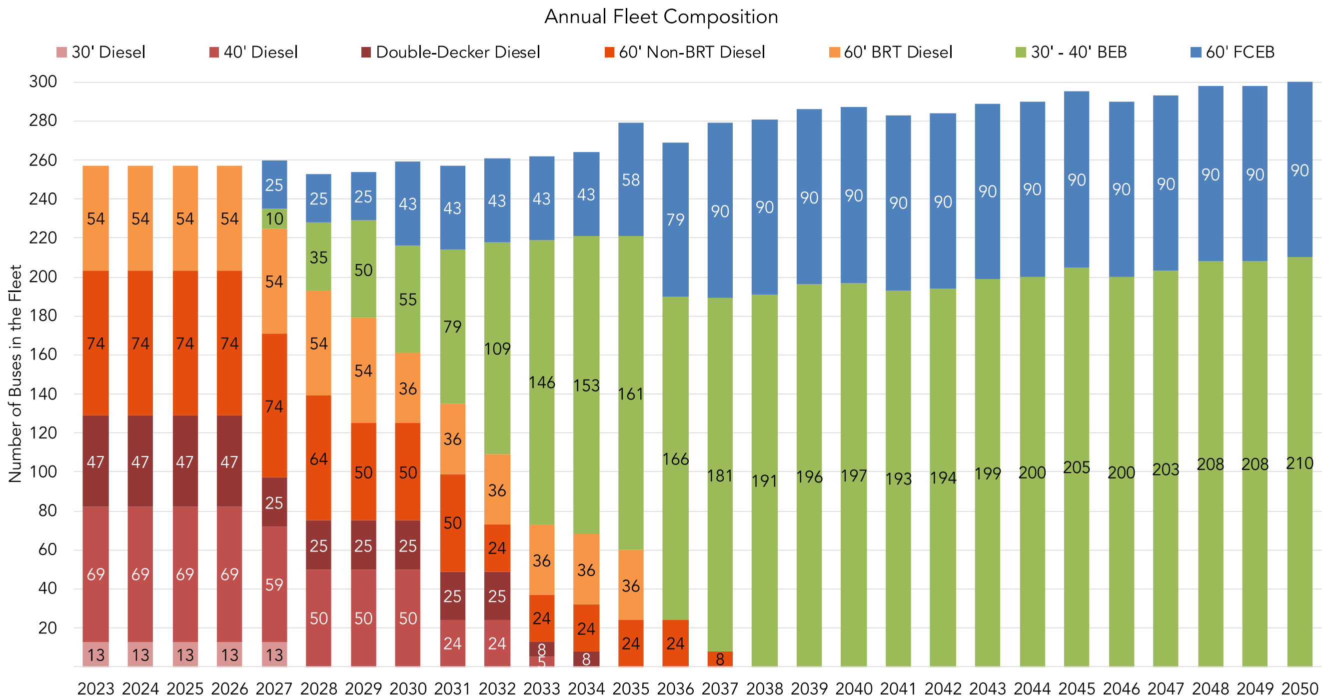


Figure 9 Annual Fleet Composition, 2023 – 2050

Figure 10 below provides the number of each vehicle type that will be purchased each year through 2050 with the existing fleet replacement strategy and the total cost of procurements. As identified in the legend, CT's battery-electric fleet procurement costs are based on 40' BEB pricing. The procurement costs outlined annually include costs to replace and retire existing ZEBs on Community Transit's replacement cycle for transit buses. The overall costs to transition CT's existing fleet to 100% ZEB by 2038 is approximately **$1.4B**. Annual costs are incurred in the year the ZEB is delivered and enters transit service. Orders and funding allocation shall occur at least one year prior.

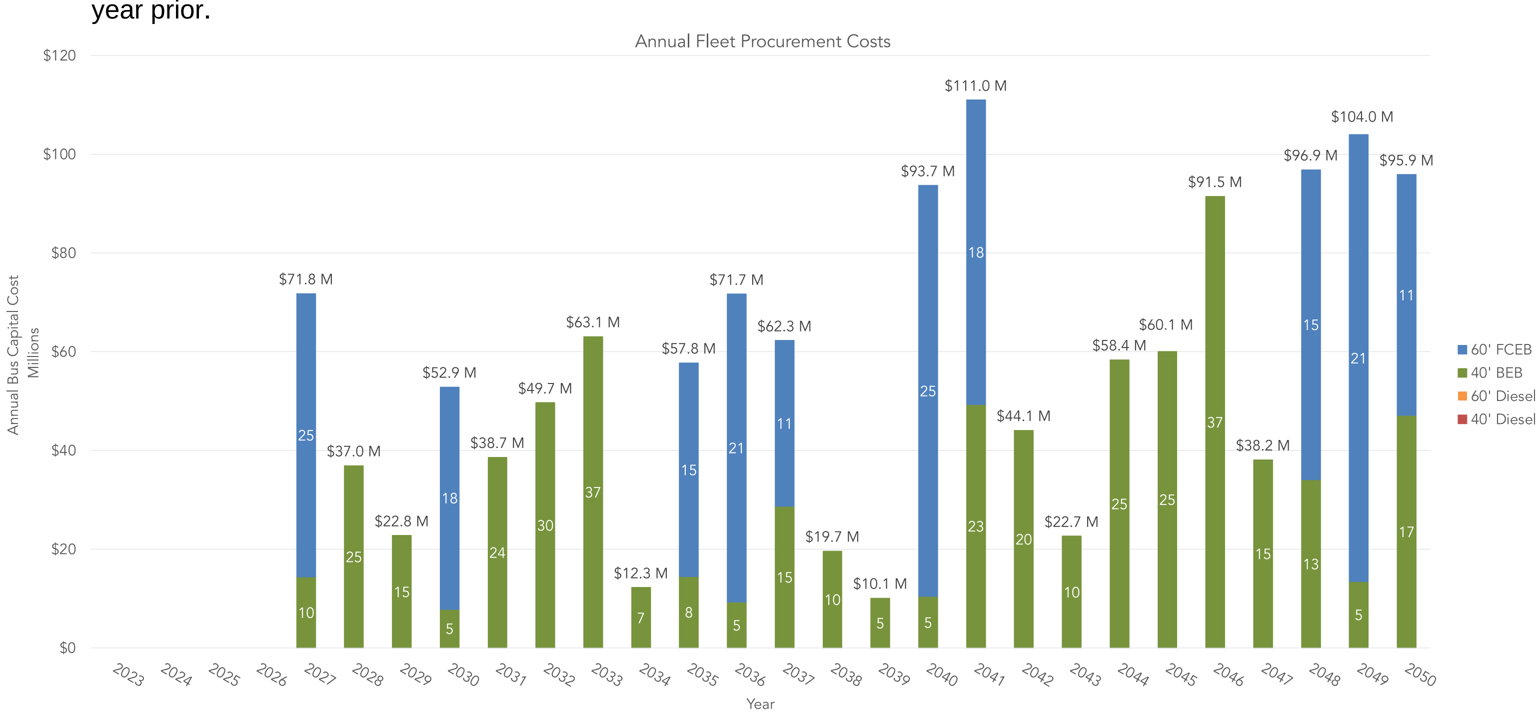


Figure 10 Annual Fleet Procurement Costs, 2023 – 2050

Appendix B

Supplemental Demographic & Equity Information

CEJST Methodology

Following is the methodology for assignment of CEJST Justice40 tracts and a summary of the top categories in Community Transit's service area. To meet the burden category requirements, the tract must meet or exceed the thresholds for the burdens as identified below and meet socioeconomic burden criteria[14]. Further, a tract may be classified as DAC if it is "completely surrounded by disadvantaged communities and is at or above the 50% percentile for low income is also considered disadvantaged"[15].

DAC Category	Quantity of Tracts	CEJST & Justice40 Burden Criteria
Workforce Development	*10*	*"ARE at or above the 90th percentile for linguistic isolation OR low median income OR poverty OR unemployment AND more than 10% of people ages 25 years or older whose high school education is less than a high school diploma"*
Climate Change	*9*	*"ARE at or above the 90th percentile for expected agriculture loss rate OR expected building loss rate OR expected population loss rate OR projected flood risk OR projected wildfire risk AND are at or above the 65th percentile for low income"*
Water and Wastewater	*9*	*"ARE at or above the 90th percentile for underground storage tanks and releases or wastewater discharge AND are at or above the 65th percentile for low income"*
Housing	*5*	*"Experienced historic underinvestment OR are at or above the 90th percentile for housing cost OR lack of green space OR lack of indoor plumbing OR lead paint AND are at or above the 65th percentile for low income"*
Transportation	*4*	*"ARE at or above the 90th percentile for diesel particulate matter exposure OR transportation barriers OR traffic proximity and volume AND are at or above the 65th percentile for low income"*
Health Burdens	*4*	*"ARE at or above the 90th percentile for asthma OR diabetes OR heart disease OR low life expectancy AND are at or above the 65th percentile for low income"*
Legacy Pollution	*2*	*"Have at least one abandoned mine land OR Formerly Used Defense Sites OR are at or above the 90th percentile for proximity to hazardous waste facilities OR proximity to Superfund sites (National Priorities List (NPL)) OR proximity to Risk Management Plan (RMP) facilities* *AND are at or above the 65th percentile for low income"*

[14] https://screeningtool.geoplatform.gov/en/methodology
https://screeningtool.geoplatform.gov/en/methodology

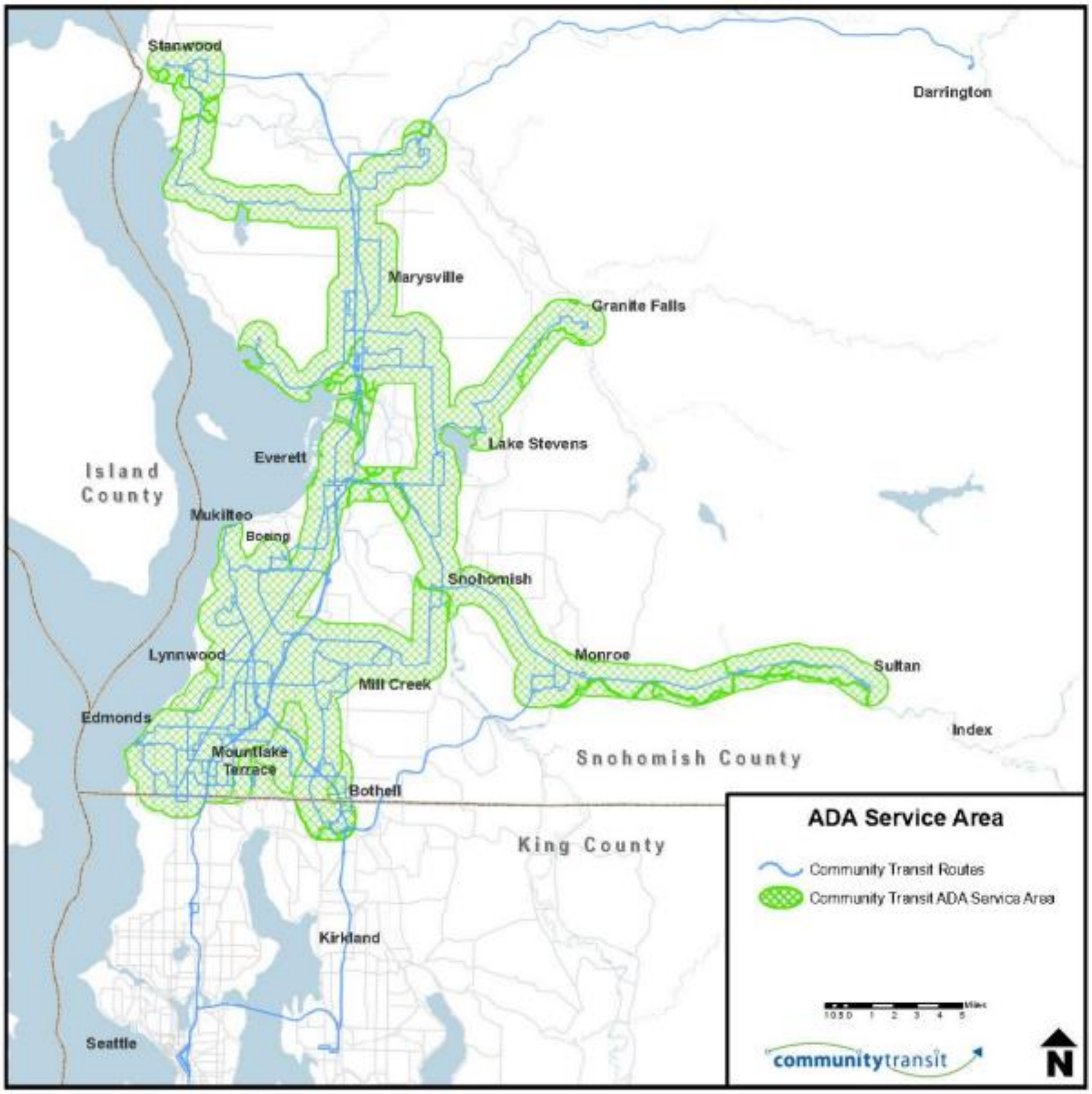
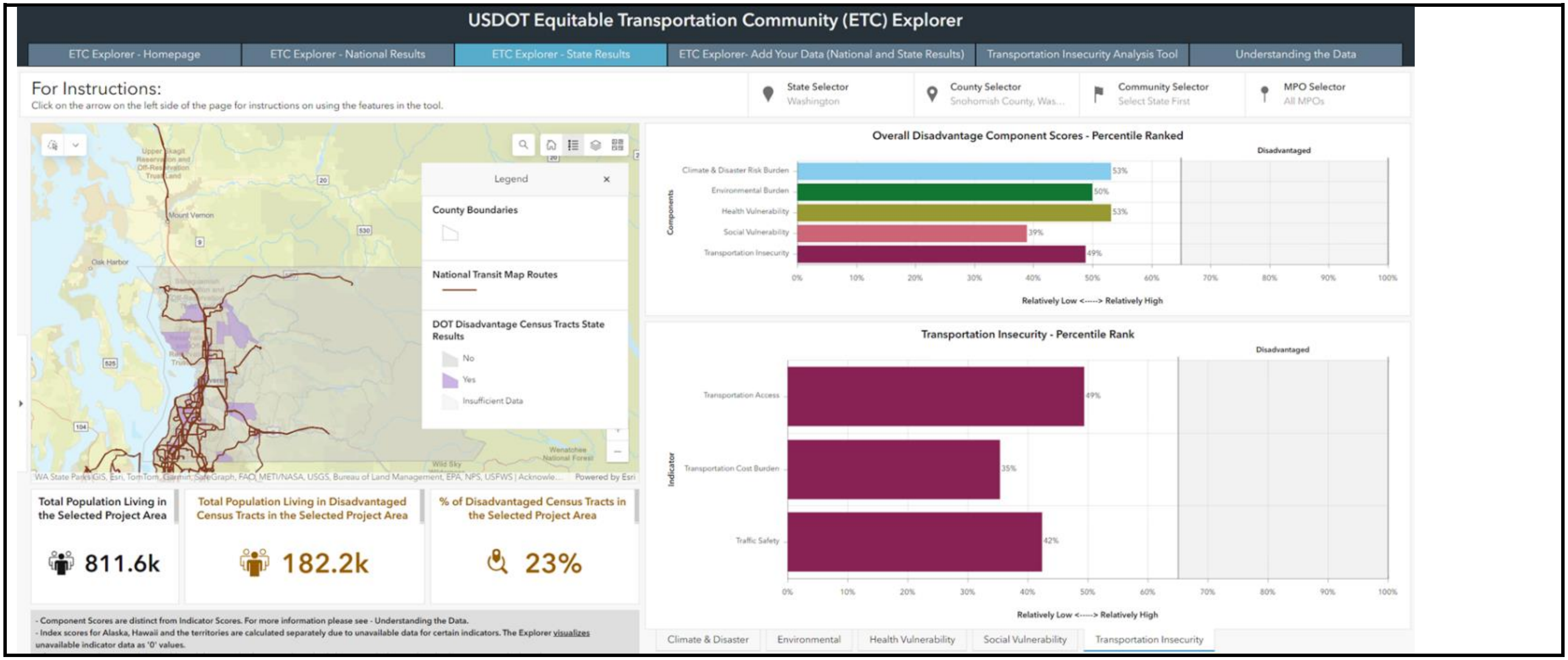


Figure 11 Community Transit ADA Service Area

USDOT Equitable Transportation Community (ETC) Explorer Analysis

To complement the CEJST analysis, CT gathered equity data for Snohomish County utilizing the USDOT's Equitable Transportation Community (ETC) web application. The ETC utilizes 2020 Census Tracts and data that demonstrates the burden and underinvestment that communities are experiencing[16]. The following are results of the burden criteria, including Climate & Disaster, Environmental, Health Vulnerability, Social Vulnerability, and Transportation Insecurity.



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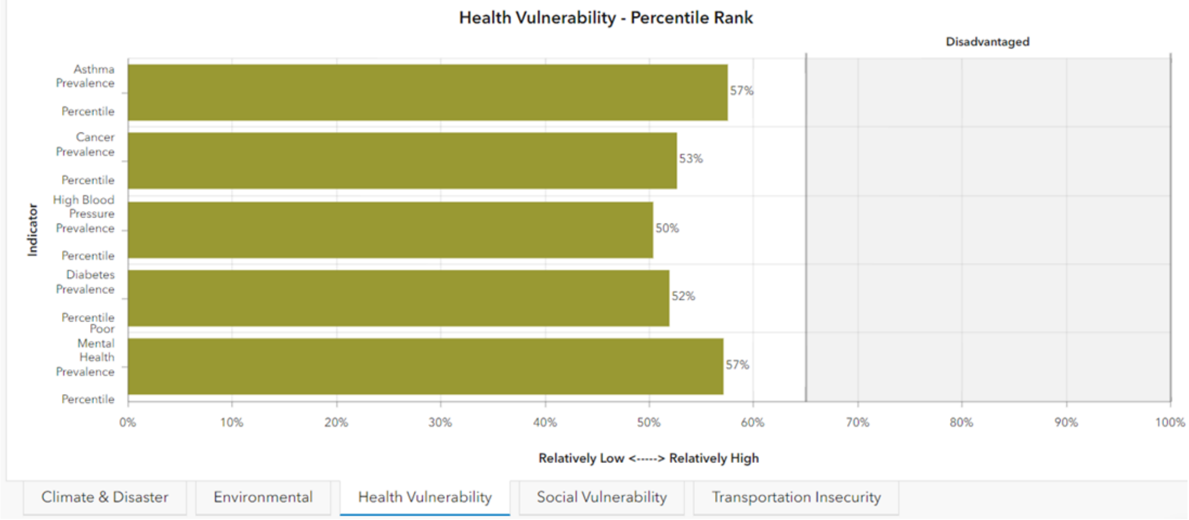
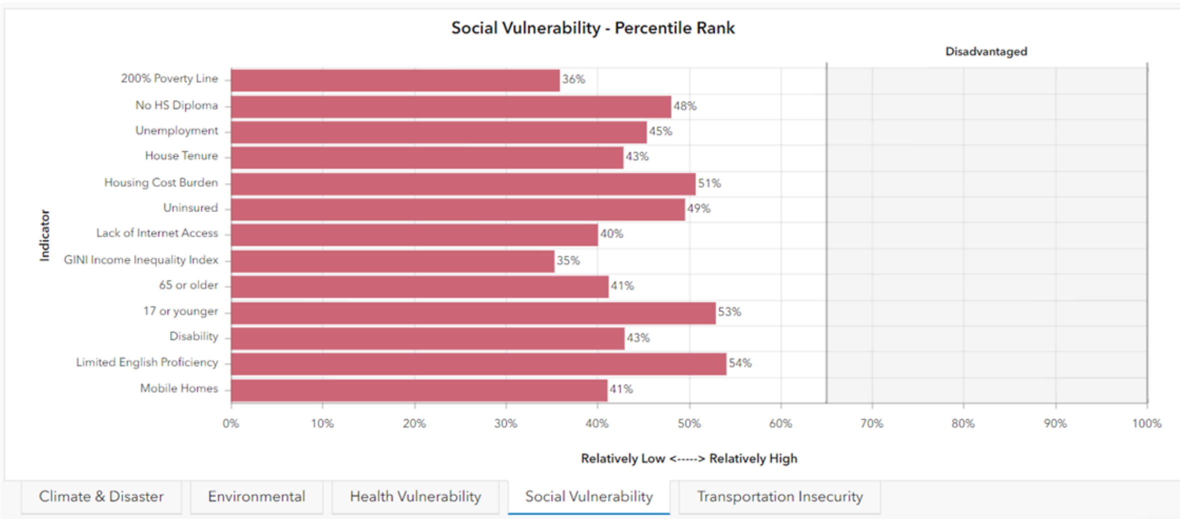
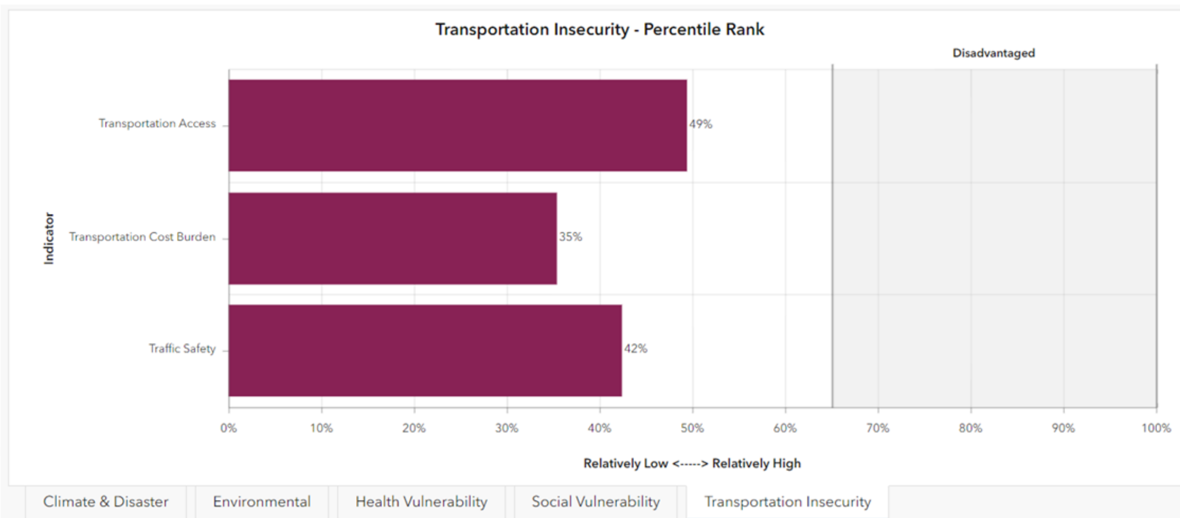
16 https://experience.arcgis.com/experience/0920984aa80a4362b8778d779b090723/page/Homepage/


State Selector
Washington
County Selector
Snohomish County, Was...
Community Selector
Select State First
MPO Selector
All MPOs
Overall Disadvantage Component Scores - Percentile Ranked
Disadvantaged
Components
Climate & Disaster Risk Burden 53%
Environmental Burden 50%
Health Vulnerability 53%
Social Vulnerability 39%
Transportation Insecurity 49%
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Relatively Low <-----> Relatively High
Climate & Disaster Risk Burden - Percentile Rank
Disadvantaged
Indicator
Anticipated Changes in Extreme Weather 51%
Annualized Disaster Losses 55%
Impervious Surfaces (from Land Cover) 54%
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Relatively Low <-----> Relatively High
Climate & Disaster
Environmental
Health Vulnerability
Social Vulnerability
Transportation Insecurity
Environmental Burden - Percentile Rank
Disadvantaged
Indicator
Ozone Level 31%
PM 2.5 Level 65%
Diesel PM Level 57%
Air Toxics Cancer Risk 63%
Hazardous Sites Proximity 52%
Toxic Release Sites Proximity 45%
Risk Mgmt Sites Proximity 20%
Coal Mine Proximity 0%
Lead Mine Proximity 0%
Pre-1980s Housing 37%
High-Volume Road Proximity 49%
Railway Proximity 31%
Airport Proximity 51%
Port Proximity 9%
Impaired Surface Water 60%
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Relatively Low <-----> Relatively High
Climate & Disaster
Environmental
Health Vulnerability
Social Vulnerability
Transportation Insecurity


Health Vulnerability - Percentile Rank
Disadvantaged
Asthma Prevalence Percentile
Cancer Prevalence Percentile
High Blood Pressure Prevalence Percentile
Diabetes Prevalence Percentile
Poor Mental Health Prevalence Percentile
Indicator
57%
53%
50%
52%
57%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Relatively Low <-----> Relatively High
Climate & Disaster
Environmental
Health Vulnerability
Social Vulnerability
Transportation Insecurity


Social Vulnerability - Percentile Rank
Disadvantaged
200% Poverty Line
No HS Diploma
Unemployment
House Tenure
Housing Cost Burden
Uninsured
Lack of Internet Access
GINI Income Inequality Index
65 or older
17 or younger
Disability
Limited English Proficiency
Mobile Homes
Indicator
36%
48%
45%
43%
51%
49%
40%
35%
41%
53%
43%
54%
41%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Relatively Low <-----> Relatively High
Climate & Disaster
Environmental
Health Vulnerability
Social Vulnerability
Transportation Insecurity


Transportation Insecurity - Percentile Rank
Disadvantaged
Transportation Access
Transportation Cost Burden
Traffic Safety
Indicator
49%
35%
42%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Relatively Low <-----> Relatively High
Climate & Disaster
Environmental
Health Vulnerability
Social Vulnerability
Transportation Insecurity

Appendix C

Fuel Assessment

The project team conducted a fuel assessment to determine the projected annual cost of fuel during the transition period by fuel type (i.e., diesel, electricity, or hydrogen).

The terms “fuel” and “energy” are used interchangeably in this analysis, as ZEB technologies do not always require traditional liquid fuel. For clarity, in the case of BEBs, “fuel” is electricity, and costs include energy, demand, and other utility charges. The primary source of energy for a BEB comes from the local electrical grid. Utility companies typically charge separate rates for total electrical energy used and the maximum electrical demand on a monthly basis. As more buses and chargers are added to a system, both the energy used and the demand increase. Rates may also vary throughout the year and throughout the day (also called time-of-use rates); this makes costs highly variable. Costs not only depend on seasonal differences like temperature or local school schedules, but also the time of day that buses are charged.

FCEBs are more similar to diesel vehicles, as they are fueled by gaseous or liquid hydrogen fuel. In addition to the cost of the fuel itself, however, there are additional operational costs associated with the hydrogen fueling station that must be considered. Operations and maintenance costs to maintain fueling infrastructure are built into the Fuel Assessment.

Fleet Composition and Block Feasibility

Based on the service and fleet assessments conducted by the project team, **Figure 12** indicates the BEB block feasibility improvements over time, and the ratio of the 40’ fleet that is transitioned to battery-electric based on the procurement schedule. It was identified that the 40’ BEB block feasibility begins lagging the ratio of the 40’ fleet that is transitioned to zero-emission starting in 2030. This implies that Community Transit will either be required to modify current operations, or invest in additional on-route charging infrastructure, to maintain 2023 levels of service.

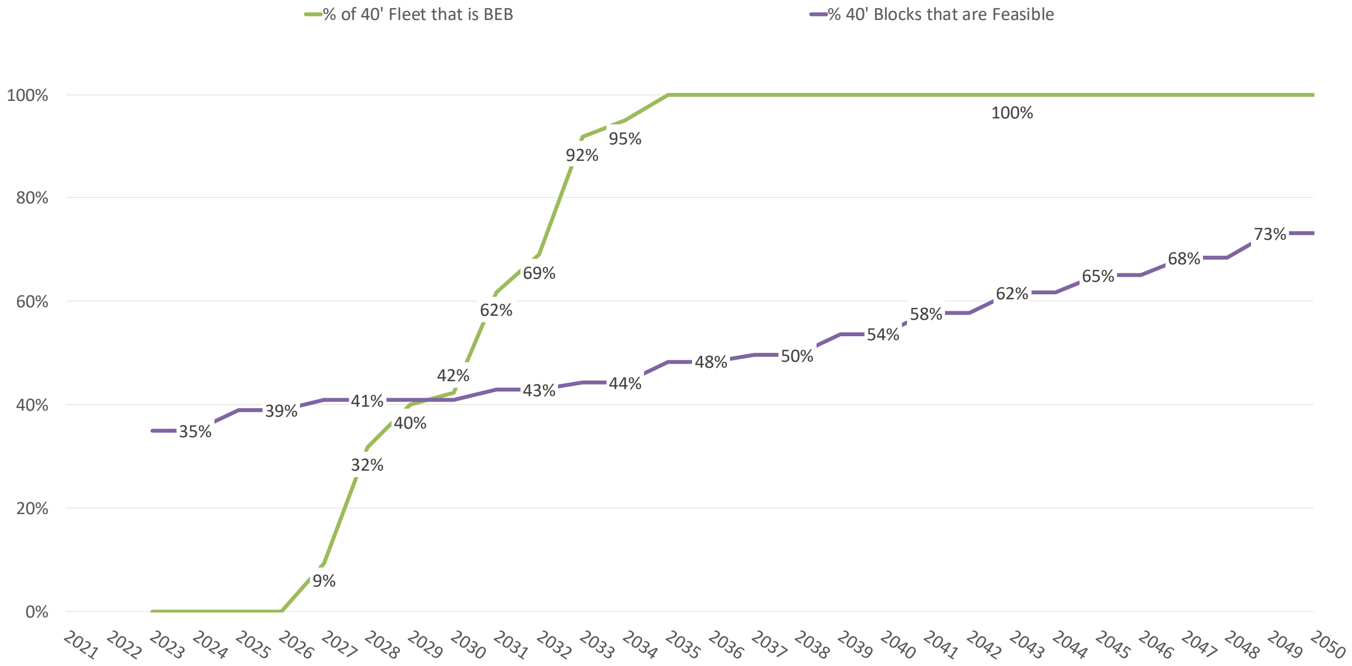


Figure 12 40' BEB Fleet Composition vs. Block Feasibility

Since the 40’ fleet size is larger than the total number of daily bus blocks performed, the project team identified that starting in 2030, Community Transit will meet current levels of service with a combination of doubling-up BEBs, as well as utilizing on-route charging infrastructure to perform the longer infeasible blocks. This approach to ZEB deployments minimizes the number of on-route chargers to be procured and implemented, and maximizes the number of BEB service miles, while maintaining a 10% spare ratio of vehicles in the fleet. **Figure 13** below illustrates a potential deployment strategy for 40’ BEBs across 149 40’ daily service blocks, based on the block feasibility improvements and procurement cycles through the ZEB transition period. Although CT will operate one 40’ BEB and 40’ FCEB in 2024, as part of the agency’s ZEB pilot testing program, the project team did not include these vehicles in the ZEB transition plan service assessment.

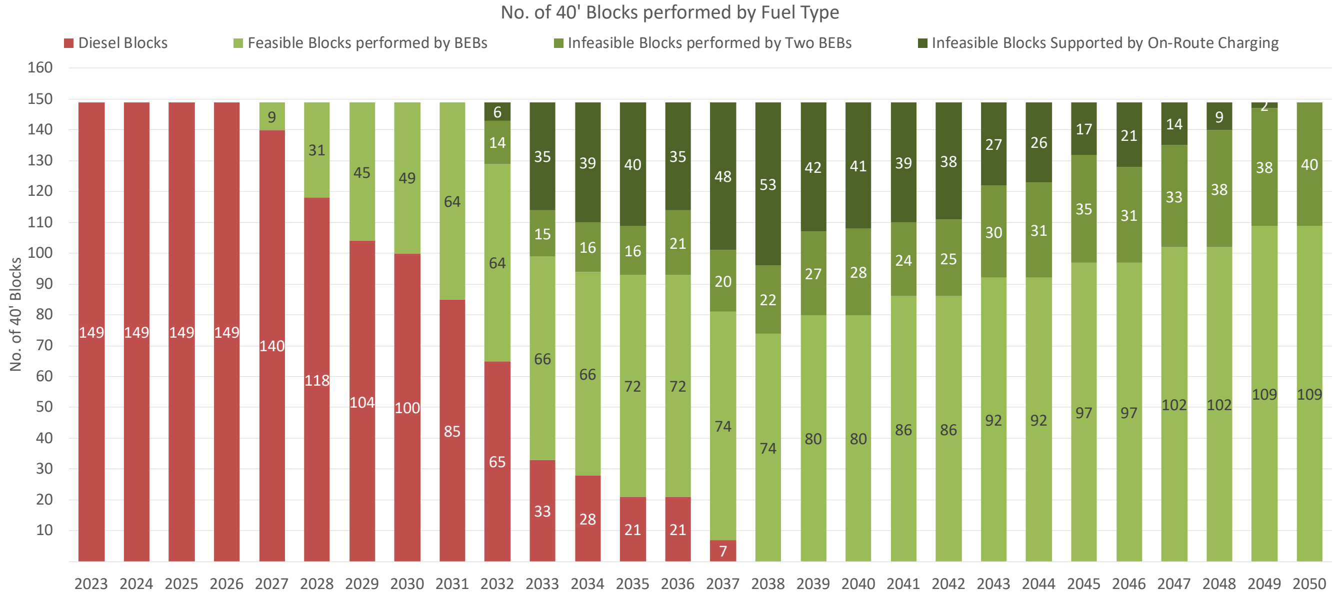


Figure 13 40' Bus Blocks as Performed by Fuel Type

Accordingly, the BEB electricity costs will be impacted by depot charging the fleet of BEBs performing feasible service, infeasible blocks performed by two BEBs, and infeasible blocks supported by opportunity-charging. As the block feasibility lags the ratio of the 40’ fleet that is transitioned to zero-emission starting in 2030, the ZEB facilities assessments will similarly be driven by the need for adequate on-route charging infrastructure to sustain current levels of service.

Fuel Consumption Assumptions

For the purpose of this fuel assessment, annual mileage estimates per vehicle by fleet and fuel type are constant throughout the transition period. For CT’s existing fleet of diesel buses, annual fuel consumption estimates are based on 2022 recorded service data. For future ZEB procurements, annual BEB fuel consumption estimates are calculated from the daily average service mileages and nominal fuel efficiencies for 40’ routes, and annual FCEB fuel consumption estimates are calculated from daily average service mileages and nominal fuel efficiencies for 60’ routes. **Table 11** provides the annual mileage, annual fuel consumption, and fuel efficiency assumptions for each fleet by fuel type.

Table 11 Annual Mileage, Fuel Consumption, and Fuel Efficiency Estimates

Fleet Type	Fuel Type	Est. Annual Mileage (mi)	Est. Annual Fuel Consumption	Est. Fuel Efficiency
Double-Decker	Diesel	23,500	4,900 gal	4.80 mpg
30’	Diesel	54,300	8,700 gal	6.28 mpg
40’	Diesel	43,300	7,900 gal	5.54 mpg
	BEB	45,000	111,000 kWh	2.47 kWh/mi
60’	Diesel	42,000	9,800 gal	4.28 mpg
	FCEB	60,800	12,000 kg	5.09 mi/kg

To understand the energy consumption requirements for the battery-electric fleet as BEB block feasibility improves, and additional BEBs are procured over the ZEB transition period, the project team analyzed the strenuous block energy requirements for CT’s 149 BEB blocks. The project team ranked each of the blocks based on their energy requirements. In each year of the transition, blocks with feasible energy requirements were considered depot-charged BEBs, blocks with infeasible energy requirements were divided into blocks completed by two depot-charged BEBs, and blocks completed with on-route charging.

Table 12 summarizes the total BEB energy requirements, and the percentage of BEB block energy charged at the depot vs. charged on-route.

Table 12 BEB Block Energy Requirements Met by Depot Charging vs. On-Route Charging

Year	Annual BEB Energy Requirements (kWh)	Depot-Charging Requirements	On-Route Charging Requirements
2023	-	0%	0%
2024	-	0%	0%
2025	-	0%	0%
2026	-	0%	0%
2027	-	1%	0%
2028	295,000	8%	0%
2029	1,517,300	13%	0%
2030	2,566,200	15%	0%
2031	2,987,600	22%	0%
2032	4,414,600	35%	0%
2033	7,115,800	59%	3%
2034	12,569,900	62%	4%
2035	13,753,700	69%	5%
2036	15,278,500	69%	5%
2037	15,694,800	81%	9%
2038	19,213,400	87%	13%
2039	21,684,800	89%	11%
2040	22,180,500	89%	11%
2041	22,293,700	90%	10%
2042	21,777,300	90%	10%
2043	21,889,900	92%	8%
2044	22,375,400	93%	7%
2045	22,484,500	95%	5%
2046	22,962,700	94%	6%
2047	22,422,300	96%	4%
2048	22,696,100	97%	3%
2049	23,216,800	99%	1%
2050	23,119,100	100%	0%

In the year 2038, 13% of CT's energy requirements will come from on-route charging. By 2050, with improvements in battery technology, none of CT's blocks will require on-route charging and may be supported by one or two depot-charged BEBs.

Table 13 summarizes the battery-electric charging infrastructure assumptions that affect the energy consumption and power demand requirements for the BEB fleet at the depot and on-route charging locations.

Table 13 BEB Charging Infrastructure Assumptions

Charger Type	Charger Type	Power Rating (kW)	Charger Efficiency	BEBs per Charger
Depot Charger	Plug-In	150	90%	2
On-Route Charger	Inductive	300	80%	4

Fuel Cost Assumptions

CT's 2023 diesel fuel costs per gallon were considered to estimate annual fuel costs through the ZEB transition period. Annual BEB fuel costs were estimated based on SnoPUD's Schedule 20 for Medium Load General Service.[17] It is likely that CT's electricity costs will migrate to a different, lower-cost rate schedule with increased charging demands and energy consumption. Electricity rates may also be influenced by future utility schedules and pilot programs as developed specifically for commercial EV charging requirements.

The project team conducted market research in January 2024, to develop present-day and future hydrogen cost per kilogram estimates for the fuel in the state of Washington. Given the uncertainties around ongoing green hydrogen production project timelines in the Pacific Northwest (PNW) region, the ability for CT to leverage production tax credits for subsidized fuel costs, and the effects of increased economies of scale on fuel delivery costs, hydrogen fuel pricing to the end-user is expected to fluctuate significantly throughout the ZEB transition period. The primary drivers of these high fuel costs are the high electricity costs incurred by electrolytic production of hydrogen in the region. If utilities develop incentivized rate schedules for hydrogen producers in the PNW, these high fuel costs may be reduced.

Accordingly, the project team identified four major phases of hydrogen fuel pricing in the PNW region:

1. Currently, there are no reliable sources of hydrogen fuel accessible to CT within the state, and prices for gaseous hydrogen deliveries to support the agency's deployment of a single pilot FCEB are steep. Therefore, between 2024 and 2026, CT will be subject to a premium on **out-of-state, gaseous hydrogen delivery pricing, at low-consumption volumes**.
2. As CT procures its first fleet of 25 60' FCEBs in 2027, it is anticipated that the agency will consume approximately 900 kg of hydrogen a day. At this stage, CT will still incur **out-of-state, liquid hydrogen delivery costs, at high-consumption volumes**, as in-state production projects come online.
3. CT will see an increased number of hydrogen fuel deliveries per week to support its fleet of 43 60' FCEBs in 2030. With significant activity surrounding the PNW hub, and hydrogen production projects in the PNW region that are expected to come online in the late-2028, early-2029 timeframe, CT may incur **in-state, liquid hydrogen delivery pricing, at high consumption volumes** from 2030 – 2040.
4. Lastly, from 2041 through 2050, with hydrogen producers in the region identifying significant off-takers for the fuel, and as the hydrogen market matures and fuel is commoditized, CT may realize **in-state, liquid hydrogen delivery costs, with economies of scale**.

Table 14 summarizes the cost breakdowns per unit of fuel taken into consideration for the ZEB transition period.

Table 14 Estimated Fuel Cost per Unit of Fuel

Fuel	Costs and Fees[18]	Fuel Units and Metrics
Diesel	$3.65	Per gal
Electricity	$0.09	First 30,000 kWh
	$0.07	Over 30,000 kWh (Jul – Mar)
	$0.05	Over 30,000 kWh (Apr – Jun)
	$6.76	Per kW (over 100 kW)
	$1.35	Per Day
Hydrogen, 2024-2026 (Out-of-State Gaseous Delivery, Low Consumption)	$20 – $30	Per kg

[17] https://www.snopud.com/wp-content/uploads/2023/03/electricrates.pdf
[18] Hydrogen delivery costs are not included in the cost per kilogram estimates.

Fuel	Costs and Fees[18]	Fuel Units and Metrics
Hydrogen, 2027-2029 (Out-of-State Liquid Delivery, High Consumption)	$16	Per kg
Hydrogen, 2030-2040 (In-State Production Liquid Delivery, High Consumption)	$10	Per kg
Hydrogen, 2041-2050 (In-State Production Liquid Delivery, Economies of Scale)	$8	Per kg

The project team applied the EIA's forecast for average annual fuel prices to estimate future transportation costs for diesel and electricity through 2050. Since hydrogen is not yet a commoditized fuel, the project team utilized the EIA's projection for compressed natural gas (CNG), to forecast hydrogen fuel pricing through 2050.[19] The team then adjusted the estimated fuel costs for inflation by applying a standard annual inflation rate of 1.03%, based on the 20-year historical CPI.[20] **Table 15** summarizes the combined EIA and CPI inflationary rates utilized to forecast fuel costs through the ZEB transition period.

Table 15 Inflation Estimates for Transportation Fuel 2023 - 2050

Year	Diesel	Electricity	Hydrogen
2023	100%	100%	100%
2024	106%	101%	99%
2025	111%	104%	100%
2026	116%	107%	101%
2027	121%	110%	102%
2028	126%	113%	103%
2029	131%	116%	104%
2030	138%	119%	111%
2031	143%	122%	112%
2032	149%	125%	114%
2033	153%	129%	115%
2034	158%	133%	117%
2035	163%	136%	119%
2036	167%	139%	120%
2037	173%	142%	122%
2038	179%	145%	125%
2039	183%	148%	127%
2040	191%	151%	129%
2041	197%	154%	132%
2042	203%	157%	135%
2043	210%	160%	137%
2044	216%	163%	140%

[19] https://www.eia.gov/outlooks/aeo/data/browser/#/?id=3-AEO2023&region=1-0&cases=ref2023&start=2023&end=2050&f=A&linechart=~~~~~ref2023-d020623a.30-3-AEO2023.1-0~~ref2023-d020623a.32-3-AEO2023.1-0~ref2023-d020623a.33-3-AEO2023.1-0&map=ref2023-d020623a.3-3-AEO2023.1-0&ctype=linechart&sourcekey=0
[20] https://fred.stlouisfed.org/series/CPIAUCSL

Year	Diesel	Electricity	Hydrogen
2045	221%	166%	143%
2046	230%	170%	147%
2047	236%	173%	150%
2048	242%	177%	154%
2049	250%	180%	158%
2050	256%	184%	163%

Annual Fuel Consumption and Costs

Figure 14 shows the annual fuel consumption estimates in DGE for CT's fleet, if CT replaces existing double-deckers, 30', and 40' diesel buses with 40' BEBs, and existing 60' non-BRT and Swift diesel buses with 60' FCEBs. The fluctuating annual fuel consumptions estimates identify years when, (1) new ZEB purchases are planned but there are no retirements of existing vehicles from the fleet, or (2) vehicles are added to expand the fleet, as captured in CT's fleet plan. Although CT will operate one 40' BEB and 40' FCEB in 2024, as part of the agency's ZEB pilot testing program, the project team did not include these vehicles as part of the ZEB fuel assessments.

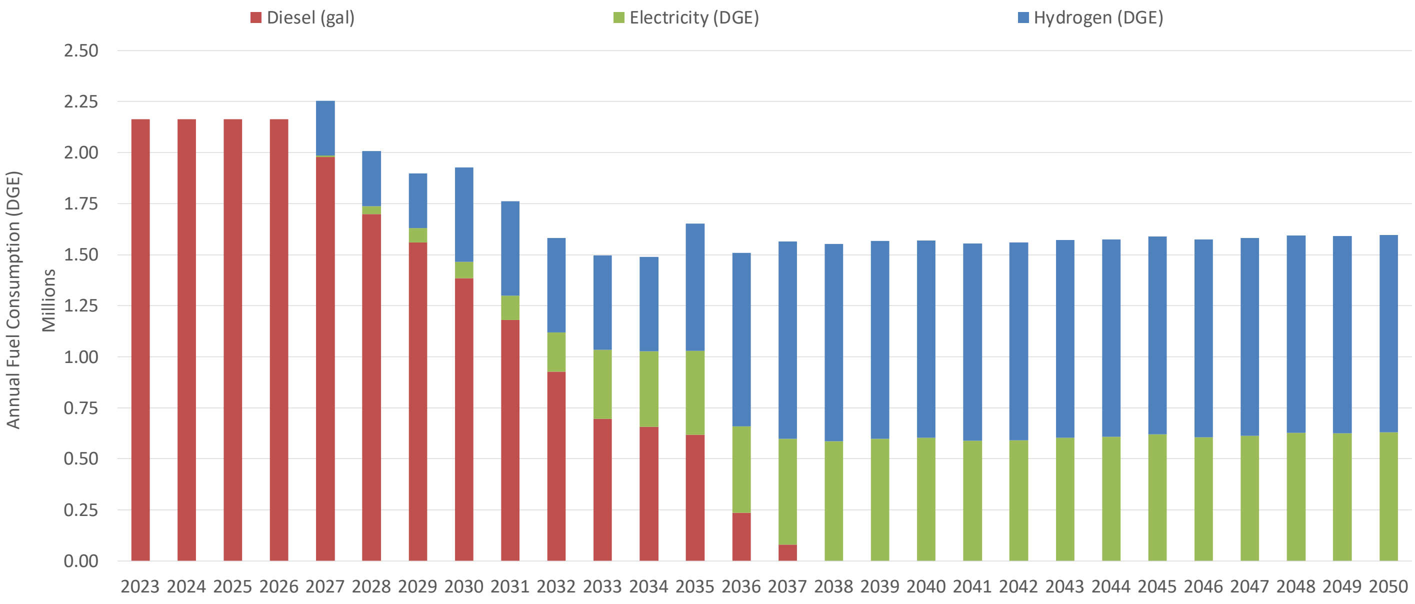


Figure 14 Annual Fuel Consumption (DGE)

Figure 15 details the annual fuel costs for CT's fleet during the ZEB transition period. As shown, the total expenditures to CT during this timeframe amounts to approximately **$420.8M**, and the average cost per mile estimate through the transition period is **$1.28/mile**.

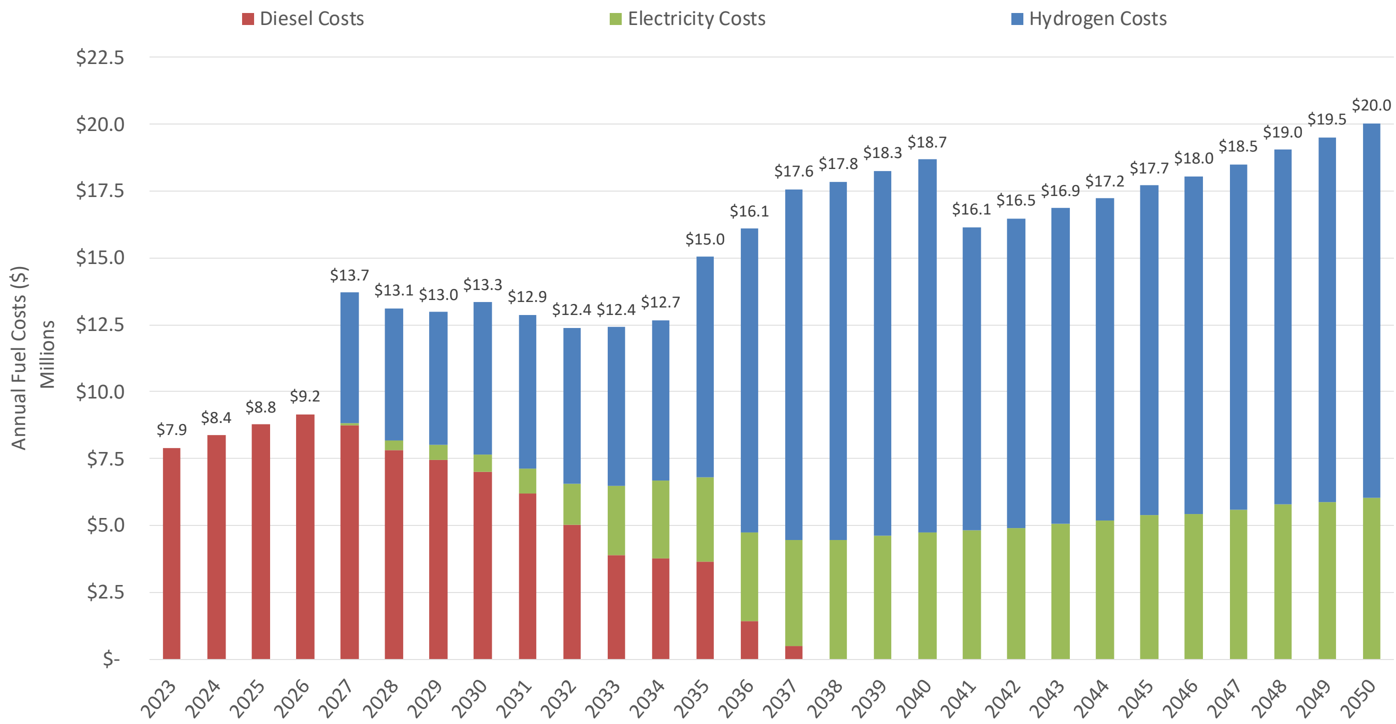


Figure 15 Annual Fuel Costs

Appendix D

Workforce Development Assessment

The primary objective of this assessment is to offer an overview of the impact that the transition to a zero-emission fleet will have on CT's workforce. This assessment also aims to identify potential challenges and opportunities resulting from the transition to ZEBs, enabling CT to proactively address workforce-related considerations, optimize training efforts, and ensure a smooth transition to zero-emission operations.

The project team has identified a series of four distinct phases between the beginning of a ZEB transition and the completed transition where specific training processes are necessary to instill confidence with the new technology. For each department, the expectation is that the staff will develop introductory skills during the planning phases, then build on those skills through phases two and three. By phase four, ZEBs will have become a normalized part of CT's operations, and all staff should have developed the skills appropriate for their job requirements. The phases and training required are outlined in **Figure 16.**

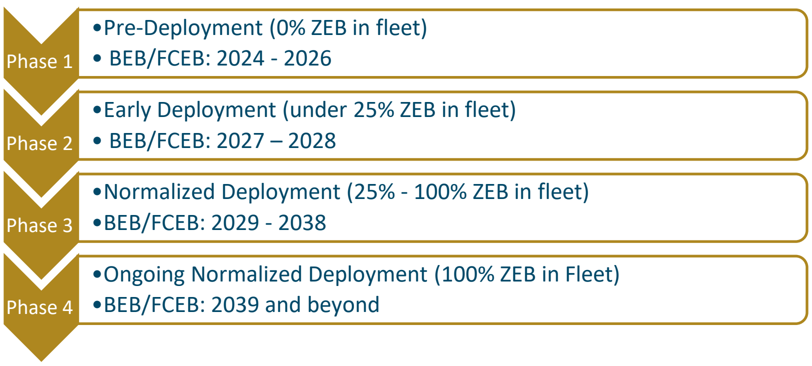


Figure 16 Overview of Workforce Development Training Phases

To better identify the needs of the existing workforce, CT will be undertaking a Concept of Operations study beginning in 2024 to review people, process, and technology supporting the transition by identifying the desired future state, reviewing the existing conditions, and identifying the gaps between the two. This effort will produce recommendations to mitigate identified gaps and create a plan to inform training curricula and supporting technology tools to bridge the gap.

Operations Department

Existing Conditions

The transit operator team at Community Transit is comprised of 400 total drivers. The allocation of routes and buses is determined through a seniority-based bidding system, allowing drivers to select bus and route based on their seniority. CT operators are trained through a combination of self-directed learning, instructor-led training, both on the bus and in the classroom, and a mentorship program. CT has a subgroup of drivers, known as STAR operators, who can be trained quickly for special projects or public-facing activities. Some of the STAR operators have been trained on BEB operations as part CT's beta pilot project.

Skill Gap Assessment

Employees at Community Transit will need to understand all the new procedures and protocols unique to ZEBs, to be able to operate their fleet most-effectively. This could include docking a BEB at a charger, fueling an FCEB and any OEM-specific pre and post charging/fueling inspection procedures. Vehicle operators will also need to have a heightened understanding of the OEM's high voltage exposure warning emergency response procedure and should complete Level 1 High-Voltage (HV) Awareness Training.

Operators must also be familiar with monitoring the remaining operating time of the BEB (State of Charge) and understanding the technological limitations of FCEBs. Finally, regenerative braking will significantly change how it feels to drive a ZEB. The more the operator relies on regenerative braking, the more efficiently the bus will use its onboard energy.

Best Practices

One of the most important Phase 1 best practices is to engage in planning study concerning ZEB technology and relay ZEB education and planning outcomes to senior leadership. Another critical component to training is education. Community Transit can begin integrating ZEB education during quarterly group safety meetings before the first bus arrives onsite. CT could also consider sending a few interested drivers to tour facilities and speak to drivers of nearby fleet operators.

Phase two is defined by buses arriving onsite and implementing a ZEB training regimen with support from the OEM. CT can conduct classroom and field training with the OEM once the first bus arrives on-site. Because a large portion of CT's routes are not feasible for BEBs in the beginning of the transition, CT will need to create a tracking system to ensure that ZEBs are deployed on feasible routes and only trained operators are driving them.

Phases three and four are where ZEB operations should become relatively routine. At this point all of CT's blocks will be feasible through a combination of vehicle swapping and on-route charging, however, the scheduling these routes may present challenges.

Building, Utility, and Fleet Services: Garage Mechanics

Existing Conditions

The maintenance team at Community Transit consists of 68 Journey Mechanics. CT's mechanics are qualified to work on all diesel buses, and a subset have received specialized training to work on buses with hybrid powertrains. CT's mechanics are trained using a combination of train-the trainer, classroom, and on-the-job training. Mechanics are sent to local technical colleges and OEM training courses when they are available.

Skill Gap Assessment

There are a few main changes that will arise from CT's ZEB adoption:

- Buses will contain HV components
- UCSC will need to procure new tools and equipment
- HV tasks will require two (2) fully trained employees
- Maintenance staff will no longer able to service a bus in its entirety
- The nature of maintenance work will change as ZEBs require not only more computer skills for diagnostic troubleshooting, but also electrician skills for electrically driven components, rather than mechanical skills typically required for traditional internal combustion engine (ICE) bus maintenance

All maintenance staff will need to have at least HV awareness training and understand how to safely disable HV systems to work on the low-voltage (LV) systems on a ZEB. HV training has two levels: the first level focuses on high voltage awareness and should be taken by anyone who may encounter an electric vehicle in the workplace; the second level is required for mechanics who may perform any HV preventative maintenance or repairs on the bus.

BEBs and FCEBs also have larger battery packs requiring specialized battery handling skills. Staff must be trained in OEM lock-out tag-out procedures before working on primary battery packs. Advanced staff will be required to dig deeper into the ESS and understand how to diagnose HV system issues on the ZEB using OEM-specific fault diagnostic tools and software. On ZEBs, HV batteries power the electric HVAC system, as opposed to being powered by an alternator with a static converter on a traditional ICE bus.

Fuel cells require unique maintenance with special attention to mistakes that can damage the stack. It is important to consider that FCEB training encompasses BEB training in terms of skill sets but is also more expensive given the extent of the training required.

Best Practices

Best practices include, whenever possible, allowing staff to accompany warranty technicians during warranty maintenance events. Some fleet operators have staff complete Level 1 training online and level two training in-person, whereas others require all training in-person. The project team recommends Community Transit staff attend Level 1 training in-person. Best practices also include having early discussions with the OEM regarding their training capabilities and including training and materials in procurement contracts.

CT can leverage their BEB and FCEB pilot projects to give mechanics hands-on experience before ZEBs are deployed in service. The project team recommends initially training a small group of mechanics who will become ZEB experts. CT can use their existing partnerships with local high schools and community colleges to develop ZEB training programs which will replace heavy-duty diesel programs.

If possible, it is highly beneficial to have bus or component OEM service technicians stationed onsite for an extended period of time. Other larger fleet operators have required on-site support for up to a year after initial deployment of a bus, particularly during the earliest ZEB deployments.

By Phase 4 (100% ZEB in fleet), CT will begin expanding on existing knowledge to develop in-house expertise. Other fleet operators recommend selecting staff members to become experts in certain bus subcomponents and sending staff to in-depth trainings offered by subcomponent OEMs.

Building, Utility, and Fleet Services: Facilities Maintenance

Existing Conditions

Community Transit performs the majority of their own facility maintenance but contracts out some smaller project work.

Skill Gap Assessment

In a ZEB, on-board HV batteries are recharged by direct plug-in or pantograph external power. Most in-house electricians can complete basic maintenance before the first major round of preventative maintenance. The most common charger malfunction is related to bus-charger communications and the control area network (CAN bus) communications on the ZEB. It will be crucial to assign a member of staff responsible for coordinating software updates between the charger OEM and bus OEM, as they might not be the same entity.

While fleet operators are typically able to perform fueling operations for hydrogen, hydrogen fueling stations are primarily maintained by the equipment manufacturer. Facilities for maintaining FCEBs will need to be upgraded with lighter-than-air gas detection, maintenance personnel will need to be trained on the signals and safety precautions surrounding hydrogen fuel.

Best Practices

The most important action for Community Transit is determining their desired and union-approved facility maintenance model. Some fleet operators do not plan to outsource charger maintenance once their warranty periods are over; instead, they include training hours in the charging procurement contract so they can be self-sufficient as the fleet expands. CT should begin having conversations with charger OEMs and unions to determine the proper approach.

Appendix E

Zero Emissions Program

Summary of Accomplishments

FEASIBILITY STUDY	**2021 - 2023**	**WSP Phase 1 Interim Report** This study evaluated and modeled how battery-electric buses (BEBs) would perform on CT's drafted 2024 network, a utilities and facilities assessment, and identified high-level infrastructure needs and cost estimate. The report also included an industry scan of available technologies, available grants, identifying high-level operational impacts, service + performance modeling, and a fleet replacement assessment. **WSP Phase 1.5 Report - BEBs** After the initial Phase 1 findings, WSP took a deeper dive to analyze what deploying a mixed fleet of BEBs and fuel cell electric buses (FCEBs) would look like for the agency. This report consisted of further service modeling, utility needs, charging infrastructure including opportunity charging and costs. The service modeling analysis in this report covered all of Community Transit's fixed route services that allowed the agency to review which service blocks could be completed to BEBs. **WSP Phase 1.5 Interim Report - FCEBs** This report covered the impacts and requirements associated with deploying FCEBs at one of the agency's bases – Kasch Park. This study was associated with two distinct scenarios: 1. On-site hydrogen generation via electrolysis at Kasch Park 2. Remote site hydrogen generation via hydro-electrolysis at a yet to be identified proposed site owned and operated by the agency 3. Other methods of hydrogen generation, shipping, and storage methods were further described in this report as well.
UTILITY SYSTEM IMPACT STUDY	**2022 - 2023**	**Snohomish County Utility District (PUD) Impact Study Report** Community Transit partnered with the PUD to evaluate impacts of adding load capacity for charging infrastructure and associated uses to two of the agency's bus facility bases: Kasch Park + Merrill Creek. The loads were then evaluated in two phases: 1. Phase 1 – 8MW at Kasch Park + 4MW at Merrill Creek 2. Phase 2 – 8 additional MW at Kasch Park and 4 additional MW at Merrill Creek for a total of 16 MW + 8MW at each base, respectively For this report, PUD developed these options to meet both utility and regulatory requirements, studied the projected load capacity impact to the electrical system, and provided a rough order of magnitude of costs and construction feasibility.
BETA PILOT	**2023 - 2024**	**BYD 60' K11 BEB** Community Transit conducted a one-year lease with a BYD 60' K11 BEB with a 578kWh capacity to validate its abilities on CT's network. Throughout the life of this pilot, CT tested this bus out-of-service on (2) of its bus rapid transit networks to gather data on battery efficiency, vehicle + charger performance, operator feedback, bus reliability and risks and/or challenges operating this new technology.

SIDE-BY-SIDE PILOT	**2024+**	**New Flyer 40’ FCEB x Gillig 40’ BEB** The agency is deploying one (1) 40’ Gillig BEB with a 588kWh capacity + supporting 200 kW ChargePoint charging infrastructure and one (1) 40’ New Flyer FCEB + supporting gaseous hydrogen mobile refueler into revenue service. This pilot is geared to validate service and financial modeling results, identify technology risks and mitigation strategies, create buy-in across the agency, and inform future fleet plans.
FACILITY DESIGN STUDY	**2024**	**Kimley-Horn Design Study** The agency is working with Kimley-Horn to evaluate CT’s existing bus maintenance and storage facilities to drive towards a preliminary design to include charging stations at its Merrill Creek Base and hydrogen storage at its Kasch Park Base.
NOTABLE ENGAGEMENTS	**2022+**	**Board of Director Key Dates + Milestones:** Feasibility Study + Finding’s presentation | April 2022 Service Modeling + Utility and Facility Findings presentation | October 2022 Financial Strategies + Further Service Modeling presentation | April 2023 Long Range Plan + Initial Deployment Plan adoption | July 2023 **Conferences:** Zero Emission Bus Conference | 2022, 2023 Clean Bus Conference | 2022 Washington State Spring Maintenance Forum | 2022 Hydrogen In Focus | 2022 CTE’s One-on-One Event | 2023, 2024 Advanced Clean Expo | 2023, 2024 Green H2 Summit | 2024 **Site Tours:** Link Transit | 2022, 2023 King County Metro | 2022, 2023 SunLine Transit | 2022 Foothill Transit | 2022 Everett Transit | 2022, 2023

Program Development

Governance Structure

The Zero Emissions program developed a governance charter and subcommittees. The purpose of these subcommittees is to identify and track high-level program milestones, plan for dependencies, and resource the work to support the agencies' strategic priorities of deploying a green fleet.

Zero Emissions Executive Team

As the program evolves, critical decisions are needed to empower progress to meet CT's horizon date. The following governance groups provide recommendations and decisions to be made to the Executive Team for further discussions. When this group approves the recommendation, it's then presented to the CEO who has final authority for strategic decisions that will need approval from its Board of Directors.

High-level deliverables from each governance group support the Transition Plan and agency priorities include, but not limited to:

Communications + Government Affairs

Identifying interagency, federal + state legislative, and public-private partnership engagement opportunities, develop internal communications plan, and intergovernmental agreements

Finance + Grants

Long range financial modeling + analysis to inform strategies and recommendations, grant inventory + strategy + application(s) support, and policies related to finance + grants

IT Product Suite

Identifying and managing new IT product suite applications and develop Concept of Operations

Operations

Develop deployment strategies, determine union impacts, develop Concept of Operations for Transportation + Maintenance, and maintaining safety + security throughout

Planning + Capital Development

Facility Design Study, Phase 1 + Phase 2 deployments, Long Range planning, and Utility integration

Workforce Development

Training program development, Union impacts, change management plan + deliverables, and identification + job descriptions for new positions