Existing Conditions Report

City of Beaumont Transit System

Prepared by the Center for Transportation and the Environment
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Style Definition: Caption

Center for Transportation and the Environment

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List of Acronyms

ADA	American with Disabilities Act
AFLEET	Alternative Fuel Life-Cycle Environmental and Economic Transportation
BEB	Battery Electric Bus
CARB	California Air Resources Board
CEC	California Energy Commission
CI	Carbon Intensity
COA	Comprehensive Operations Analysis
CRT	Charge Ready Transport
CTE	Center for Transportation and the Environment
DAR	Dial-A-Ride
EV	Electric Vehicle
FCEB	Fuel Cell Electric Bus
FCEV	Fuel Cell Electric Vehicles
FTA	Federal Transit Administration
GGE	Gasoline Gallon Equivalent
GHG	Greenhouse Gas
GVWR	Gross Vehicle Weight Rating
HVAC	Heating, Ventilation, and Air Conditioning
ICE	Internal Combustion Engine
ICT	Innovative Clean Transit
kW	Kilowatt
kWh	Kilowatt Hour
kWh/mi	Kilowatt-hour/mile
LA Metro	Los Angeles County Metropolitan Transportation Authority
LCFS	Low Carbon Fuel Standard
MW	Megawatt
MWh	Megawatt-hours
NOx	Nitrogen Oxides
OCTA	Orange County Transportation Authority
OEM	Original Equipment Manufacturer
PPI	Producer Price Index
RCTC	Riverside County Transportation Commission
SCE	Southern California Edison
STA	Sunline Transit Agency
TBW	Tire and Brake Wear
TTW	Tank-To-Wheel
WTT	Well-To-Tank
WTW	Well-To-Wheel
ZEB	Zero-Emission Bus

Glossary of Terms

Auxiliary Loads: Power consumed (usually as a by time measure, such as "x" kW/hour) by support systems for non-drivetrain demands, such as HVAC and interior lighting.

Battery Electric Bus: Zero-emission bus that uses onboard battery packs to power all bus systems.

Battery Usable Capacity: The portion of the battery that is usable by the vehicle. The top 10% and the bottom 10% of a battery are typically not used to extend the life of the battery. The usable capacity therefor typically represents 80% of the nameplate capacity.

Block: Refers to a vehicle schedule, the daily assignment for an individual bus. One or more runs can work a block. A driver schedule is known as a "run."

Charging Equipment: The equipment that encompasses all the components needed to convert, control and transfer electricity from the grid to the vehicle for the purpose of charging batteries. May include chargers, controllers, couplers, transformers, ventilation, etc.

Cutaway: Cutaways are typically smaller than conventional buses, measuring less than 30 ft. long and weighing less than 30,000 lbs., seating about 15 or more passengers and may accommodate some standing passengers, while providing more space – particularly for wheelchairs – compared to other small-to-medium- sized vehicle options, forming a critical component of paratransit service in the United States.

Depot Charging: Centralized BEB charging at a transit agency's garage, maintenance facility, or transit center. With depot charging, BEBs are not limited to specific routes, but must be taken out of service to charge.

Energy: Quantity of work, measured in kWh for ZEBs.

Energy Efficiency: Metric to evaluate the performance of ZEBs. Defined in kWh/mi for BEBs, mi/kg of hydrogen for FCEBs, or miles per diesel gallon equivalent for any bus type.

Fuel Cell Electric Bus: Zero-emission bus that utilizes onboard hydrogen storage, a fuel cell system, and batteries. The fuel cell uses hydrogen to produce electricity. Its waste products are heat and water. The electricity powers the batteries, which powers the bus.

Gasoline Gallon Equivalent (GGE): A unit equal to the amount of energy contained in one gallon of gasoline that can be used to compare the fuel consumption, efficiency, and emissions across vehicles with different fuel types.

Greenhouse Gas Emissions: Common GHGs associated with diesel combustion include carbon dioxide (CO_2), carbon monoxide (CO), nitrous oxides (NO_x), volatile organic compounds (VOCs), and particulate matter (PM). These emissions negatively impact air quality and contribute to climate change impacts. Zero-emission buses have no harmful emissions that result from diesel combustion.

Gross Vehicle Weight Rating (GVWR): The maximum amount of weight that a vehicle can handle safely, which includes the vehicle weight and its payload capacity.

Hydrogen Fueling Station: The location and equipment that houses the hydrogen storage, compression, and dispensing equipment to support fuel cell electric buses. If hydrogen is produced onsite, it will also include this equipment.

Nameplate Capacity: The maximum rated output of a battery under specific conditions designated by the manufacturer. Battery nameplate capacity is commonly expressed in kWh and is usually indicated on a nameplate physically attached to the battery. It includes the unusable top and bottom portion of the battery's total energy.

Nominal Efficiency/Nominal Energy: Nominal load conditions assume average passenger loading and a moderate temperature over the course of the day, which places marginal demands on the motor and the heating, ventilation, and air conditioning (HVAC) system. These conditions are then used to define the nominal operating efficiencies in kWh/mi and energy requirements per vehicle, per route.

On-route Charging/Opportunity Charging: The behavior of using on-route located charging equipment to charge a BEB in-service. With proper planning, on-route charged BEBs can operate indefinitely, and one charger can charge multiple buses.

Operating Range: Driving range of a vehicle using only power from its electric battery pack or on-board hydrogen storage, fuel cell, and battery to travel a given driving cycle.

Route Modeling: A cost-effective method to assess the operational requirements of ZEBs by estimating the energy consumption on various routes using specific bus specifications and route features.

Strenuous Efficiency/Strenuous Energy: Strenuous load conditions assume high or maximum passenger loading and near-maximum output of the HVAC system. These strenuous loading conditions represent a hypothetical and unlikely worst-case scenario, but one that is necessary to establish an outer bound for the analysis, and are expressed as strenuous operating efficiencies in kWh/mi and energy requirements per vehicle, per route.

Tractive Efficiency: The tractive efficiency refers to the energy required to drive the motors, which can be impacted by passenger loading, topography, and speed of the cutaway.

Useful Life: FTA definition of the amount of time a transit vehicle can be expected to operate based on vehicle size and seating capacity. The useful life defined for transit buses is 12-years. For cutaways, the useful life is 7 years.

Validation Procedure: Confirms that the demonstrated bus performance is in line with expected performance. Results of validation testing can be used to refine bus modeling parameters and to inform deployment plans. Results of validation testing are typically not grounds for acceptance or non-acceptance of a bus.

Well-to-Tank (WTT) Emissions: Quantity of greenhouse gas, criteria pollutants, and/or other harmful emissions that takes into account the carbon intensity of the grid used to charge the buses. For FCEBs, well-to-tank emissions would take into account the energy to produce, transport, and deliver the hydrogen to the vehicle.

Well-to-Wheel (WTW) Emissions: Quantity of greenhouse gas, criteria pollutants, and/or other harmful emissions that includes emissions from energy use and emissions from vehicle operation. For BEBs, well-to-wheel emissions would take into account the carbon intensity of the grid used to charge the buses. For FCEBs, well-to-wheel emissions would take into account the energy to produce, transport, and deliver the hydrogen to the vehicle.

Zero-Emission Bus (ZEB): A heavy-duty bus that emits no tailpipe emissions from the onboard source of power.

Zero-Emission Vehicle: A vehicle that emits no tailpipe emissions from the onboard source of power. This is used to reference battery-electric and fuel cell electric vehicles, exclusively, in this report.

Introduction

Executive Summary

Riverside County Transportation Commission (RCTC) awarded a contract to the Center for Transportation and the Environment (CTE) to develop the Riverside County Zero-Emission Bus Rollout and Implementation plans on behalf of transit agencies and municipal transportation services in the cities of Banning, Beaumont, Corona and Riverside; and the Palo Verde Valley Transit Agency. The **Zero-Emission Bus** (ZEB) rollout plans must be compliant with the California Air Resources Board (CARB) Innovative Clean Transit (ICT) Regulation and also with Federal Transit Administration (FTA) requirements in applying for federal grant funds.

CTE is a non-profit zero-emission transportation planning and engineering firm that has partnered with IBI Group, a leading international architecture, planning, and engineering services company, to support planning the approach to achieve RCTC's zero-emission goals. The City of Beaumont's public transit system services the City of Beaumont and unincorporated areas of Riverside County known as Cherry Valley.

The Existing Conditions is the first step in the development of Beaumont's ZEB Rollout Plan and serves as a foundation and baseline scenario from which the transition to zero-emission buses will begin. CTE and IBI Group surveyed Beaumont's existing conditions including any relevant demographics, service area characteristics, existing fleet sizes and service conditions, and location and status of fueling and maintenance infrastructure in the project area. To process and verify this information, CTE compiled Beaumont's data into a standard template and conducted thorough reviews of its content. As a product of this effort, CTE created this comprehensive Existing Conditions Report that compiles this information and summarizes baseline conditions for the City of Beaumont.

Reverence to the state of affairs of an agency's operations is paramount for maintaining the service the agency provides to the community as well as leveraging the progress each agency has made to supply transportation services. Although Beaumont is currently in the midst of a Comprehensive Operations Analysis (COA), this report establishes detailed baseline conditions as of September 2022; any service changes as a result of the impending COA will not be reflected in the analysis in this report. This report catalogs Beaumont's existing vehicles and infrastructure assets, as well as outlines the route energy consumption and expected monetary expenditures for future procurements of the existing vehicle types. By the conclusion of this report, the project team will convey the current service provided by Beaumont, their assets, and provide a starting point for endeavoring on a zero-emission fleet transition, to comply with the ICT regulation.

The most notable findings from the analyses performed to create this report are as follows. According to CTE's models, based on a generic vehicle combining the market averages for battery **nameplate capacities**, 20~~18~~% of Beaumont Transit's fixed-route ~~and Dial A Ride (DAR)~~ service today can be performed solely by an overnight **depot-charging** a battery-electric bus. By 2040, only 25~~3~~% of Beaumont Transit's total fixed-route ~~and DAR~~ service can be performed by overnight depot-charged battery electric buses and **cutaways**. Beaumont Transit's average Dial-A-Ride (DAR) service day is infeasible in 2022, ~~however, it~~ and will become feasible by 2030. However, it is important to note that while the average service day is within the feasible range in 2030, any given day might exceed the feasible range. Thus, a transition to zero-emission sooner than 2040 would require either **on-route charging**, midday charging at the depot, or to be served by a fuel cell electric bus. Moreover, Beaumont Transit could restructure their **blocks** to accommodate zero-emission service but service restructuring is not a component of this project. According to IBI Group's in-depth analysis overlaying Beaumont Transit's fixed route service and 2021 census track data for disadvantaged communities, 15% of stops and 20% of service miles are located within disadvantaged communities. Over the transition period, Beaumont Transit would be projected to spend approximately $~~20.7M~~26.9M in bus capital costs to replace their fleet with similar CNG and gasoline vehicles. This will serve as the baseline expected expenditure from which CTE will calculate the delta cost of the zero-emission transition in later reports.

California Air Resources Board Innovative Clean Transit Regulation

On December 14, 2018, California Air Resources Board (CARB) enacted the Innovative Clean Transit (ICT) regulation as part of a statewide effort to reduce emissions from the transportation sector, which accounts for 40 percent of climate-changing gas emissions and 80-90 percent of smog-forming pollutants. The ICT regulation requires all California public transit agencies to submit a rollout plan demonstrating how it will achieve a 100% zero-emission fleet by 2040. The plans include zero-emission bus purchasing schedules, infrastructure developments, and workforce training programs and are due in 2023 for small transit agencies.

The only commercialized technologies that CARB qualifies as zero-emission are **battery-electric buses** (BEB) and **hydrogen fuel cell electric buses** (FCEBs). BEBs and FCEBs have similar electric drive systems that feature a traction motor powered by a battery. The primary differences between BEBs and FCEBs are the respective amount of battery storage and the method by which the batteries are recharged. The energy supply in a BEB comes from electricity provided by an external source, typically the local utility's electric grid, which is used to recharge the batteries. The energy supply for an FCEB is completely on-board, where hydrogen is converted to electricity within a fuel cell. The electricity from the fuel cell is used to recharge the batteries. The electric drive components and energy source for a BEB and FCEB are illustrated in **Figure 1**~~**Figure 1**~~.

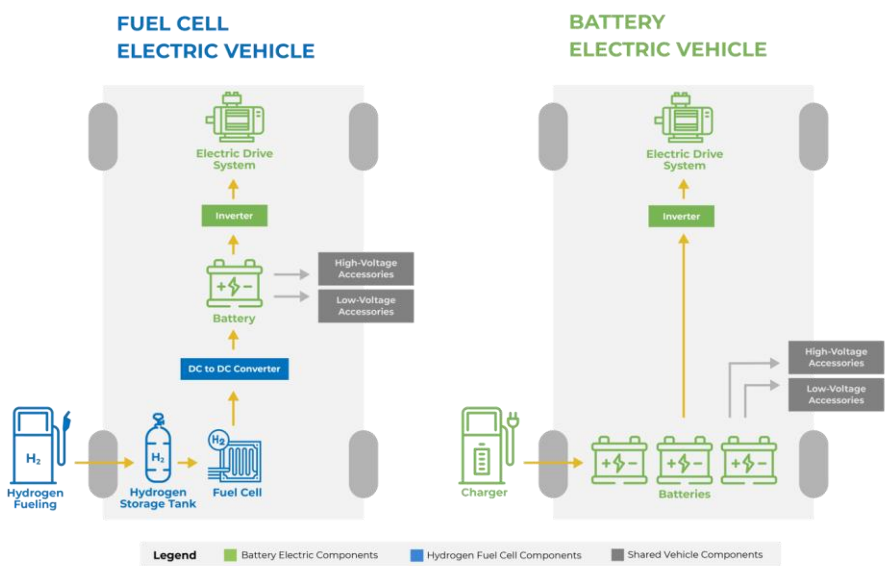

Figure 1 – Battery and Fuel Cell Electric Bus Schematic

ZEB Purchase Requirements

CARB's ICT regulation requires all transit agencies to purchase only ZEBs from 2029 onward. Partial ZEB purchasing requirements begin in 2023 for large agencies and in 2026 for small agencies with the goal of transitioning all public fleets to a 100% ZEB fleet by 2040.

CARB designates the City of Beaumont as a small fleet because the transit service operates less than 100 vehicles at peak pullout. For small agencies, the ICT regulation requires that all new bus purchases include a specified percentage of ZEBs in accordance with the following schedule in **Table 1**~~Table 1~~.

Table 1 – CARB ICT ZEB Transition Timeline for Small Agencies

Starting January 1	ZEB Percent Requirement of New Bus Purchases

2026	25%
2027	25%
2028	25%
2029	100%

Agencies can defer the purchase of a cutaway bus, over-the-road bus, double-decker bus, or articulated bus until either January 1, 2026 or until a model of a given type has passed the Altoona bus testing procedure and obtained a Bus Testing Report, regardless of purchasing milestones. At the time of writing this report, two cutaway vehicles (GreenPower's EV Star, and Forest River Bus's Ford E-450 Shuttle Bus) have passed Altoona testing, but CARB has not revised its regulation regarding cutaways. Additionally, Riverside County agencies can defer the purchase of zero-emission vehicles, based on RCTC's Capital Justification Policy that encourages agencies to consider technology retrofits prior to new procurements.

CARB offers transit agencies certain flexibility in complying with ZEB purchase requirements; two or more agencies may work together to collectively comply with the ZEB purchase requirements, so long as they share the use of infrastructure, function in the same air basin, are located in the same air district, are under the same Metropolitan Planning Organization, or are under the same Regional Transportation Planning Organization. These are referred to as Joint Groups in the regulation.

Agencies may request exemptions from ZEB purchase requirements in a given year due to circumstances beyond the transit agency's control. Acceptable circumstances include:

- Delay in bus delivery caused by setback of construction schedule of infrastructure needed for the ZEB;
- Market-available depot-charged BEBs cannot meet a transit agency's daily mileage needs;
- Market-available ZEBs do not have adequate gradeability performance (i.e., unable to climb a slope at efficient speed) to meet the transit agency's daily needs;
- When a required ZEB type for the applicable weight class based on gross vehicle weight rating (GVWR) is unavailable for purchase because the ZEB has not passed the Altoona bus test; cannot meet the Americans with Disabilities Act (ADA) requirements; or would violate any federal, state, or local regulations or ordinances;
- When a required ZEB type cannot be purchased by a transit agency due to financial hardship.

ZEB Bonus Credits

To recognize and incentivize early adopters of ZEBs, the ICT regulation has a credit system, which gives credits to agencies that deployed ZEBs before the regulation was enacted in 2018. Agencies are eligible for two credits for each fuel cell electric bus and one credit for each battery electric bus that was in their fleet as of January 1, 2018. Agencies may apply these credits to their future ZEB purchase requirements. Each credit has the same value as having one ZEB in their fleet but must be used by December 31, 2028. Given that Beaumont Transit's two (2) GreenPower EV Star vehicles entered revenue service in 2019, the City does not have any ZEB Bonus Credits available from early adoption; however, two or more agencies may share credits for joint ZEB procurements.

City of Beaumont Transit

Beaumont Transit Service Area Characteristics

The City of Beaumont operates a public transit system that provides services on five fixed routes in the city on weekdays, two of which only operate during peak service, and one weekend route. The transit system provides fixed-route, commuter link, and paratransit service to passengers across 50 square miles within Beaumont, the neighboring Cherry Valley, the commercial areas of Cabazon including Casino Morongo, and the Desert Hills Premium Outlet Malls, with connections to other regional transit providers such as Banning, Riverside Transit Authority (RTA), and the Sunline Transit Agency (STA) from one central location; the Beaumont Walmart Transit Center[1].

The agency also provides DAR service, a specialized, reservation-based, ADA-compliant paratransit service. Beaumont provides curb-to-curb transportation services to qualified individuals – seniors 65+ and persons certified under the Americans with Disabilities Act (ADA) – that live in the City of Beaumont and parts of Cherry Valley. Additionally, DAR service is provided to persons who live within ¾-of-a-mile from a fixed-route stop travelling to a destination also within an area of ¾-of-a-mile from a fixed-route stop. Beaumont's service map is illustrated in **Figure 2**~~Figure 2~~.

As a transit agency in California, the City of Beaumont is subject to the Innovative Clean Transit (ICT) regulation, requiring all California transit agencies to develop a plan to achieve a zero-emission fleet by 2040. This Existing Conditions report summarizes the service data for the agency and describes a baseline scenario that accounts for a plan without a zero-emission fleet transition.

[1] Short Range Transit Plan, City of Beaumont: https://www.beaumontca.gov/DocumentCenter/View/37026/Short-Range-Transit-Plan-FY-22

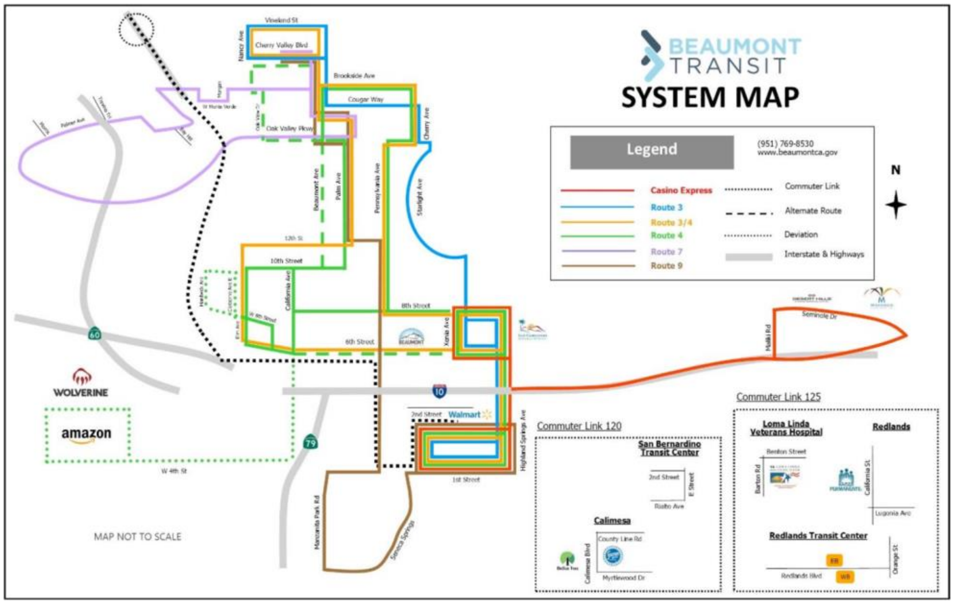

Figure 2 – Beaumont Transit Service Map

Topography and Climate

The geographical coordinates of Beaumont, California are 33.929 deg latitude, -116.929 deg longitude[2] and the city sits at 2,612 feet[3] above sea level. Beaumont Transit operates its vehicles across a mix of hilly and flat terrain through the city and the surrounding areas. CTE utilizes topography information to define the **nominal** and **strenuous energy** requirements on a vehicle in this region to inform the battery-electric bus service feasibility analysis; steeper grades and longer elevation routes will require significantly more energy, thereby defining strenuous energy requirements.

Beaumont, California experiences hot, arid, and mostly clear summers between May and October, recording an average high of 97°F in August. Beaumont experiences cold, partly cloudy winters between November and April, recording an average low of 40°F in December. These operational conditions affect the HVAC loads onboard the vehicles, particularly below 50°F and above 80°F, which in turn have a seasonal impact on the energy requirements. Energy requirements are also affected by precipitation, as regenerative braking is deactivated under slippery road conditions. Beaumont experiences minimal precipitation, recording a maximum of 4.29 inches of rain in February[4]; the lack of rain and snow implies minimal impact on the regenerative braking functionality of the vehicles.

[2] United States Geological Survey, Beaumont, California: https://store.usgs.gov/map-locator
[3] https://edits.nationalmap.gov/apps/gaz-domestic/public/summary/1660318
[4] https://www.usclimatedata.com/climate/USCA0075

Population Demographics

Located about eighty miles east of Downtown Los Angeles, Beaumont Transit serves a growing population of both residents and visitors. Demographic data for the City of Beaumont can be found in Table 2~~Table 2~~.

Table 2 – Demographics for Beaumont, CA

Metrics	Beaumont
Total Population	55,280
Population per Sq. Mile	1,749
Race	
Hispanic or Latino, percent	46.3%
White alone, Hispanic or Latino, percent	60.8%
White alone, not Hispanic or Latino, percent	33.9%
Black or African American alone, percent	9.6%
Asian Alone	7.8%

Two or More Races, percent	8.7%
Median Age	35
Median Household Income	$88,932
Average Commute Time (minutes)	36

Disadvantaged Communities Service

CalEnviroScreen is a tool created by the California Office of Environmental Health Hazard Assessment (OEHHA) to help identify communities disproportionately burdened by pollution and with population characteristics that make them more sensitive to pollution. Using this tool, specific disadvantaged communities (DACs) can be identified. DACs are classified as areas representing the 25% highest scoring census tracts in CalEnviroScreen, census tracts with high amounts of pollution and low populations, or federally recognized tribal areas as identified by the Census in the 2021[5].

DACs represent key focus areas for ZEB rollout and could be prioritized in transition planning based on their current and historical pollution burden. The Beaumont Transit service area includes four census tracts designated as DACs. **Figure 3**~~Figure 3~~ below shows Beaumont's fixed routes and fixed routes stops that are in and pass-through the DAC.

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[5]https://datacommons.org/place/geoId/4807000?utm_medium=explore&mprop=age&popt=Person&hl=en

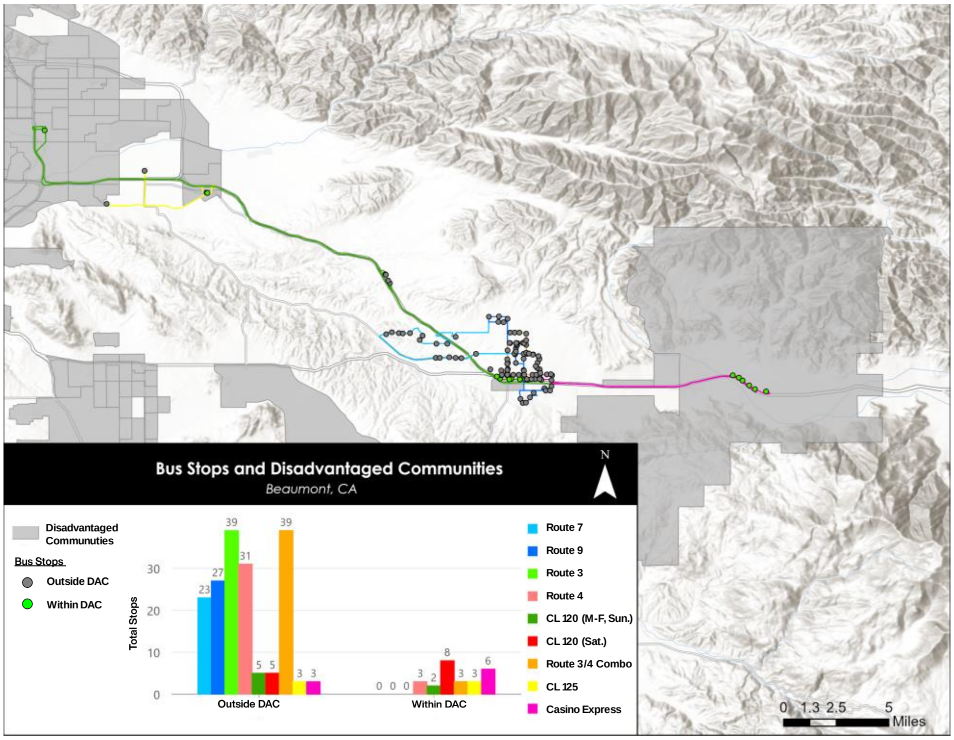

Figure 3 – Beaumont's Fixed-Route Service Relative to Disadvantaged Communities

Of Beaumont's fixed-route service, 18 stops (15%) and 41 service miles (20%) are located within DACs. A breakdown of stops and mileage within DACs by line is presented in **Table 3**~~Table 3~~ below.

Table 3 – Beaumont Transit's Fixed-Route Stops and Mileage with DAC Zones

Routes	# of stops within DAC	% of total Stops	Route mileage within DAC	% of total route mileage
Route 3	0	0%	0	0%
Route 4	3	9%	1	10%
Route 3/4	3	7%	1	7%
Weekday Commuter Link 120	2	29%	18	32%
Saturday Commuter Link 120	8	62%	8	41%
Commuter Link 125	3	50%	5	10%
Casino Express	6	66%	8	41%
Route 7	0	0%	0	0%
Route 9	0	0%	0	0%
Total	**18**	**15%**	**41**	**20%**

In addition to fixed-route service, Beaumont Transit provides a dial-a-ride (DAR) service for seniors 60 and older, persons with disabilities, and other persons certified under the Americans with Disability Act (ADA). Dial-a-ride service is provided within ¾ of a mile of fixed-route service. Some of the Beaumont dial-a-ride service area falls within the DAC zone but specific trips may start and/or end outside of the DAC designated areas. Unlike fixed-route service, dial-a-ride does not operate on a set route, so a single vehicle may provide trips both within and outside of a DAC during a single day.

Existing Fleet Overview

Beaumont's transit fleet is comprised of 22 total vehicles, including seven (7) gasoline cutaway vehicles, nine (9) CNG cutaway vehicles, one (1) CNG 32-ft. bus, three (3) CNG 40-ft. buses, and two (2) battery-electric van-style cutaways. A summary of the 2022 fleet by vehicle size, fuel type, and bus length is show in **Table 4**~~Table 4~~.

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Table 4 – Fleet Summary by Depot, Length, and Fuel Type

Depot	Vehicle Length	Fuel Type			
		Gasoline	CNG	Battery-Electric	Total
550 E 6th St.	Cutaways	7	9	2	**18**
	32'	-	1	-	**1**
	40'	-	3	-	**3**
	Total	**7**	**13**	**2**	**22**

Beaumont's transit fleet is primarily cutaway vehicles with twelve (12) manufactured by Ford Motor Company, four (4) Chevrolets and two (2) by GreenPower Motor Company. In addition, Beaumont Transit owns and operates four (4) traditional transit buses from ElDorado National. The transition to zero-emission will be agnostic to vehicle OEM, however. A summary of the 2022 fleet by bus type and OEM is shown in **Table 5**~~Table 5~~.

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Table 5 – Fleet Summary by Depot, Length, and OEM

Depot	Vehicle Length	OEM				
		Ford	Chevrolet	GreenPower	ElDorado National	Total
550 E 6th St.	Cutaways	12	4	2	-	**18**
	32'	-	-	-	1	**1**
	40'	-	-	-	3	**3**
	Total	**12**	**4**	**2**	**4**	**22**

Fleet Purchase Pricing

Recent transit vehicle capital costs reported by Beaumont Transit are listed below in **Table 6**~~Table 6~~. It is important to note that Beaumont Transit's most-recent procurements informed the projected vehicle purchase prices. CTE applied a historical cumulative inflation rate of 47%, based on the Producer Price Index (PPI) for transportation equipment[6], in order to account for pandemic pricing fluctuations between 2011 and 2022. To estimate procurement costs for the entire transition period through 2040, CTE utilized an annual inflation rate of 2% from 2022 onward, to inform vehicle pricing across the entire 18-year period.

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Table 6 – Most-Recent Fleet Costs as Reported by Agency

Reported Base Prices by Length and Fuel Type

[6] U.S Bureau of Labor Statistics, PPI Commodity Data: https://data.bls.gov/PDQWeb/wp

Length	CNG	Gasoline	Electric
Cutaway	$302,888	$247,872	$289,473
32'	$689,679	-	-
40'	$682,149	-	-

Existing Fleet Mileage and Fuel Consumption

Data on Beaumont Transit's current fuel consumption was used to estimate energy costs throughout the transition period.

It should be noted that the two (2) GreenPower EV Star electric cutaways and one (1) of the CNG cutaways are used for DAR services alone, while the remaining fleet performs fixed-route service within Beaumont Transit's service area. Average annual fleet mileage, fuel use, and calculated fuel economy is shown in respectively. The annual fleet mileage, fuel consumption, and fuel economies, are shown in **Table 7**~~**Table 7**~~, **Table 8**~~**Table 8**~~, and **Table 9**~~**Table 9**~~ respectively.

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Table 7 – Average Annual Service Miles by Bus Length

Average Annual Mileage Per Bus Type and Age (mi)			
Vehicle Length	**CNG**	**Gasoline**	**Electric**
Cutaway	19,341	20,166	851
32’	46,897	-	-
40’	8,797	-	-
Weighted Average for Total Annual Service Miles for Full Fleet	**19,030**	**20,166**	**851**

Table 8 – Annual Fuel Consumption by Bus Length

Average Annual Fuel Consumption per Bus Type and Age (GGE)			
Vehicle Length / Fuel Type	**CNG**	**Gasoline**	**Electric**
Cutaway	3,520	1,810	70
32'	8,010	-	-
40'	2,240	-	-
Weighted Average for Total Annual Fuel Consumption by Fuel Type	**3,570**	**1,810**	**70**

Table 9 – Calculated Fuel Economy by Bus Length

Calculated Fuel Economy by Vehicle Type and Age (MPGGE)			
Vehicle Length / Fuel Type	CNG	Gasoline	Electric
Cutaway	5.50	11.15	12.18
32'	5.86	-	-
40'	3.94	-	-
Weighted Average Total Fleet Fuel Economy by Fuel Type	5.34	11.15	12.18

Annual GHG Emissions

The City of Beaumont's fleet of thirteen CNG vehicles operate for approximately 247,358 miles, consuming 46,364 GGE of fuel per year. The seven gasoline vehicles operate for 141,165 miles annually and consume 12,658 gallons of fuel, while the two battery-electric vehicles operate across 1,701 miles, consuming 4,656 kWh of electricity. In order to demonstrate the benefits of transitioning from a fossil fuel fleet to a zero-emission one, CTE examined the well-to-wheel **greenhouse gas emissions** (GHG) of Beaumont Transit's existing fleet, using Argonne National Lab's Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) tool[7].

[7] AFLEET Tool: https://afleet-web.es.anl.gov/afleet

Current Well-to-Wheel Emissions

Well-to-tank (WTT) emissions are emissions associated with the production of fuel. In the case of a battery electric vehicle, this would encapsulate the carbon content of the electric grid and will vary regionally. In the case of a fuel-cell vehicle, this would factor in the hydrogen production method and feedstock. By differentiating emissions, CTE will be able to more accurately assess the criteria pollutants associated with each zero-emission bus based off of regional electricity and hydrogen supply. Tank-to-wheel (TTW) emissions are emissions associated with operating the fleet. Zero-emission vehicles will only expect emissions from particle offing at the tire-road interface whereas tradition combustion engine transit vehicles will expel pollutants directly from the tailpipe. Beaumont Transit's existing fleet is responsible for 530.41 metric tons in overall **well-to-wheel** (WTW) emissions, including 5.46 lbs. of particulate matter under 2.5 micrometers (PM2.5), which has a considerable health impact on the local community. CTE also analyzed the social costs of the greenhouse gas emissions, which capture the environmental impacts that are borne by society. The cost of each ton of GHG emissions is estimated at $40.76. The AFLEET tool estimates the total social costs of emissions from the existing fleet at $23,830 annually.

Beaumont Transit's particulate emissions are summarized in **Table 10**~~Table 10~~.

Table 10 – Annual Vehicle Operation Pollutants by Fuel Type

Overall Annual Vehicle Operation Pollutants (lbs.)									
Bus Group	CO	NOx	PM10	PM10 (TBW)	PM2.5	PM2.5 (TBW)	VOC	VOC (Evap.)	SOx
CNG	10,354.33	196.72	2.61	55.46	2.54	7.09	29.25	-	3.08
Gasoline	6,301.84	38.52	3.55	24.21	2.93	3.11	101.26	262.89	1.43
Electric	-	-	-	0.36	-	0.05	-	-	-
Total	16,656.18	235.25	6.16	80.02	5.46	10.25	130.51	262.89	4.51

Existing Facility and Infrastructure Overview

Administrative services, dispatch, and operations for Beaumont Transit are located in the heart of downtown Beaumont at the Beaumont Civic Center, 550 E 6th Street, Building D. Beaumont Transit's entire fleet of operations is domiciled at the Beaumont Civic Center, however, Beaumont Transit along with Public Works is in the process of developing a 6-acre plot of land, next to the city's Wastewater Treatment Plant, into an operations and maintenance facility for transit. The fleet maintenance operations are located at 550 California Avenue, approximately 1 mile from the administrative building.

As identified earlier, Beaumont Transit does not presently own a CNG fueling station, but is in the process of developing a CNG fueling station for both slow-fill transit buses as well as fast-fill public infrastructure on the parcel located on the corner of 4th Street and Veile Avenue in Beaumont. A map of Beaumont Transit's administrative, maintenance, and planned fueling facilities are provided below in **Figure 4**~~Figure 4~~, **Figure 5**~~Figure 5~~, and **Figure 6**~~Figure 6~~ to better understand the locations of Beaumont Transit's properties in relation to one another, as well as to routes and service areas. fueling infrastructure, chargers, and/or a **hydrogen fueling station**. These facilities offer a starting point for the

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consideration of viable locations for zero-emission fueling infrastructure, chargers, and/or a **hydrogen fueling station.**

Figure 4 – Administrative Facility Overview

Figure 5 - Maintenance Operations Facility

Figure 6 - Planned CNG Fueling Station

Transition Planning Requirements Analysis

Understanding present operations and capital costs of Beaumont Transit's service is essential to evaluating the energy requirements costs for a complete transition to a zero-emission fleet. Beginning the transition to zero with the assumption that all transit services will remain intact throughout the transition ensures that no disruptions occur for the community. City of Beaumont staff provided key data on current service including:

- Current fleet composition including vehicle propulsion types and lengths
- Route and block information including distances and trip frequency
- Nominal and strenuous passenger loading conditions
- Mileage and fuel consumption

CTE prepared the Beaumont Transit's Agency Data Collection template and distributed it to the agency to collect the aforementioned data and to begin the Requirements Analysis & Data Collection stage of the project which forms the foundation for the rest of the transition analyses.
Beaumont Transit self-assigned topography and speed characteristics to each route, which were utilized to better define block efficiencies. Quantitatively, CTE classified a route as predominantly flat if the average magnitude of the grade of the terrain was lower than 1%, and fast or slow depending on whether the route involved highway or urban (city) driving, and its average speed was over 17 mph, respectively.

CTE then used component-level specifications for a generic 30-ft. BEB with a 325-kWh nameplate capacity, and a 35/40-ft. BEB with a 450-kWh nameplate capacity, representative of the average battery-electric ~~low floor~~transit buses available in the market today, and a library of route data from years of historical deployments to develop a baseline performance model, and simulating the operation of an electric bus using Autonomie. Autonomie is a powertrain simulation software program developed by Argonne National Lab (ANL) for the heavy-duty trucking and automotive industry[8]. CTE modified pertinent software parameters in Autonomie to assess energy efficiencies, energy consumption, and range projections for several ZEBs. The energy requirements of the sample routes were then applied to all routes and blocks that share characteristics similar to Beaumont Transit's routes.

CTE also collected average data on nominal and strenuous loading conditions from Beaumont Transit. Nominal Loading conditions assume average passenger loading and a moderate temperature 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 near-maximum output of the HVAC system. These strenuous load conditions represent a hypothetical but possible worst-case scenario, and one that is necessary to establish an outer bound for the analysis. This nominal/strenuous approach offers a range of operating efficiencies—measured in kilowatt-hour/mile (kWh/mi)—to use for estimating average annual energy use (nominal) or planning maximum service demands (strenuous). The estimated **nominal** and **strenuous efficiencies** will eventually be used to predict if ZEB technologies will be able to complete all blocks in subsequent assessments.

[8] https://vms.taps.anl.gov/tools/autonomie/

Existing Service Overview

Beaumont Transit's current fixed-route service consists of eight (8) routes operated across sixteen (16) blocks on weekdays, and four (4) blocks on Saturdays. Beaumont Transit's DAR service similarly runs Mondays through Saturdays. CTE obtained service data for routes 120, 125, 3, 4, Casino Express, 7, 9, Route 3/4, as well as the DAR service, with a screening-level approach to gathering. For the purposes of this analysis, CTE considered twelve (12) independent blocks based on trip distances during the week and on weekends, the type of vehicle deployed to address routes where buses and cutaways are used interchangeably, and DAR service. Beaumont Transit self-assigned topography and speed characteristics to their routes. Quantitatively, CTE classifies a route as predominantly flat if the average grade of the terrain was lower than 1%, and fast or slow depending on whether the route involves highway or urban (city) driving, and the average speed is over or under 17 mph, respectively. Beaumont Transit's routes and corresponding characteristics are listed in **Table 11**~~Table 11~~.

Table 11 – Beaumont Transit's Routes

Route Classification	Route Number	Route Category
Commuter Link	120	Hilly, High Speed
Commuter Link	125	Hilly, High Speed
Local Fixed Route	3	Flat, Low Speed
Local Fixed Route	4	Flat, Low Speed
Local Fixed Route	Casino Express	Flat, High Speed
Peak Service	7	Flat, Low Speed
Peak Service	9	Flat, Low Speed
Weekend Service	3/4	Flat, Low Speed
~~Curb-to-Curb Service~~	~~Dial-a-Ride~~	~~Flat, Low Speed~~

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CTE collected Beaumont Transit's nominal and strenuous passenger loading data per vehicle type, as tabulated in **Table 12**~~Table 12~~ below.

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Table 12 – Nominal and Strenuous Passenger Loading by Fixed Route

Vehicle Length	Average Passenger Loading (Number of People)	
	Nominal	Strenuous
Cutaways	43	66
32'	11	17
40'	25	43

Energy efficiency and **operating range** are primarily driven by vehicle specifications. CTE's nominal and strenuous efficiency calculations for Beaumont Transit's fleet are based on 25-ft. electric cutaways, 30-ft. and 35-ft. BEB specifications, provided the lack of equivalent 30-ft. cutaways, 33-ft. cutaways, and 32-ft. BEB models that suit the input requirements of the analysis. Additionally, modeled efficiency differences between vehicles with such similar lengths are negligible for the purposes of this study. Efficiency and range metrics 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, deadhead), topography (i.e., grades), climate (i.e., temperature), driver behavior, and operational conditions (e.g., passenger loads and **auxiliary loads**). As such, the efficiency and range of a given ZEB model can vary from one agency to another. CTE utilizes 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 Beaumont Transit. This prevents an operator from assigning vehicles to a route or service day that requires more energy than the vehicle is capable of performing.

Calculated nominal and strenuous efficiencies per route have been listed in **Table 13**~~Table 13~~.

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Table 13 – Modeling Results Summary

These efficiency calculations are used to determine the total energy required per route, and subsequently each block per day. Once daily strenuous energy demand is known, it can be compared to the energy

Blocks	Bus Length	Nominal Efficiency (kWh/mi)	Strenuous Efficiency (kWh/mi)
125	Cutaway	1.30	1.50
3	Cutaway	1.55	2.53
4	Cutaway	1.55	2.53
Casino Express	Cutaway	1.30	1.71
7	40'	2.02	2.82
9	40’	2.02	2.82
3/4	Cutaway	1.55	2.53
120-SAT-1	Cutaway	1.30	1.50
120-SAT-2	Cutaway	1.30	1.50
120-1	30’	2.00	2.41
120-2	Cutaway	1.30	1.50

~~Dial-a-Ride~~	~~Cutaway~~	~~1.55~~	~~2.53~~

capacity of zero-emission transit vehicles available in the market at the time of this report. **Figure 7**~~**Figure 7**~~ below depicts how many of Beaumont Transit's blocks can be serviced by a standard battery-electric transit bus on a single overnight depot charge before pullout. Since onboard energy capacity and equipment is improving, this figure also assumes standard battery technology improvements and a 5% capacity improvement each year.

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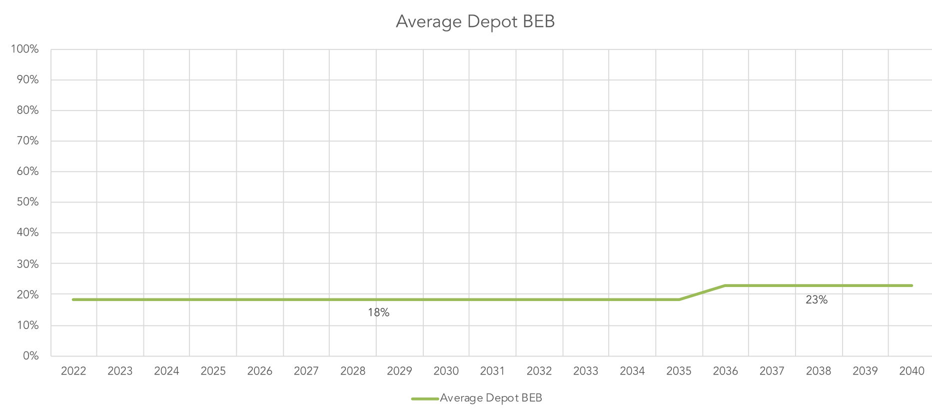

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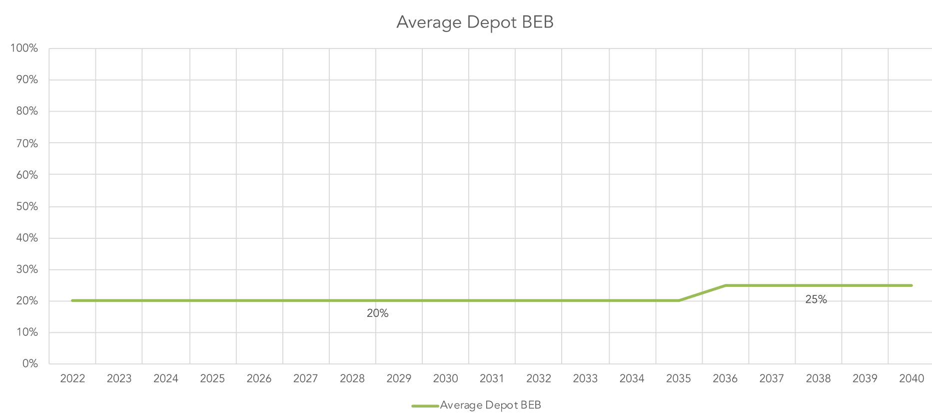

Figure 7 – Baseline Fixed Route Block Feasibility

The results indicate that 20~~18~~% of Beaumont Transit's blocks are immediately feasible in 2022, under current operating conditions; Routes 7 and 9 are feasible through the week, while none of the weekend routes are feasible. By 2040, Route 3/4's PM service becomes feasible, for a block feasibility of 25~~23~~%.

The Casino Express, Routes 3, 4, 120 and 125, 125, and Route 3/4's AM service on Saturdays, and DAR service routes will not be feasible by 2040 with solely overnight depot-charged battery-electric bus technology.

This means that Beaumont Transit will need to consider other zero-emission technology solutions to complete the agency's remaining fixed-route blocks and DAR service, which we will explore in subsequent reports. Beaumont Transit could also consider upsizing their fleet of CNG and gasoline cutaways to transit BEBs, to better meet the service requirements of the agency's more energy-intensive fixed-route blocks through the week. Beaumont Transit could also utilize equivalent battery-electric cutaways sooner, if the service days are capped by milage or duration congruent with today's battery-electric cutaway performance and the fleet is expanded. This option will not be explored in this project.

Block feasibility models are not generated for FCEBs, because it is assumed that today's transit FCEBs can accomplish any block under 350 miles. Additionally, at the time of this report, there were no comparable Altoona-tested, market-ready, transit-oriented fuel cell electric cutaways that can replace Beaumont Transit's existing fleet. If Beaumont Transit considers upsizing their entire fleet to transit FCEBs, all of the agency's DAR and fixed-route blocks ranging between 23.3 and 171.5 daily miles will be feasible.

Demand Response Service

CTE obtained information regarding Beaumont Transit's Dial-A-Ride service from the agency data collection form. Beaumont Transit operates their DAR program from 7:45 AM to 4:45 PM on the weekdays. The on-demand nature of the DAR service made it impractical to categorize the trips into discrete blocks along with the fixed route service. Instead, CTE assumed that the cutaway vehicle averaged 74 miles on weekdays, although the exact distribution of trip distances each day may vary. CTE also assumed that the service days could be classified as flat and low speed, mimicking the speed and topography of similar fixed routes. CTE used various performance data, including Altoona tests (for flat terrain), Autonomie simulations, and real-world deployments to generate a library of data, grouped by similar operating conditions (speed, terrain, and vehicle type). This data informed Beaumont Transit's vehicle efficiencies as performed by an equivalent battery-electric cutaway, specifically on flat terrain and at low speeds. The calculated nominal efficiency for Beaumont's DAR service is listed in Table below. **Table 13** below

Table 14 - Cutaway Energy Usage

Route	Bus Length	Nominal Efficiency (kWh/mi)
Dial-A-Ride	Cutaway	1.55

Once the energy demand for each service day was known, it was compared to the **usable capacity** of a market-representative battery-electric cutaway (99 kWh) to determine whether that service day would be feasible or infeasible with a single, overnight depot-charged battery-electric cutaway vehicle.

It was assumed that the observed trend of a 5% improvement on battery capacity every two years will continue, **Figure 8**~~**Figure 8**~~ shows that the average service day from 2022 would be infeasible, given available battery capacity, however, by 2030 Beaumont Transit's average day would be feasible. Assuming that the projected battery improvements continue, in 2030, service days of up to 78 miles or 120 kWh will be feasible, and by 2040, service days of up to 99 miles or 154 kWh will be feasible.

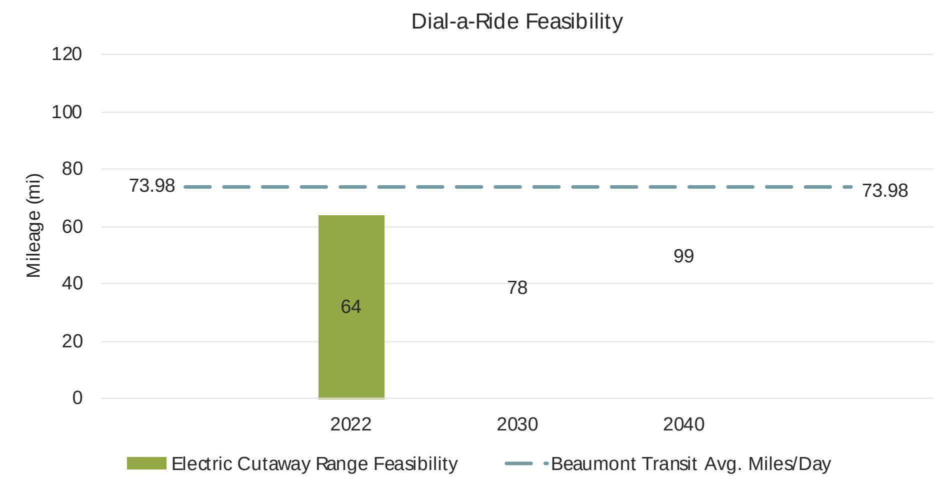

Figure 8 – Dial-a-Ride Feasibility

Baseline Vehicle Procurement Schedule

Per the City of Beaumont's 'Short Range Transit Plan', Beaumont Transit maximizes the lifetime of their fleet of predominantly cutaway vehicles, replacing them on a 12 or 14-year replacement cycle. Based on this procurement schedule, Beaumont Transit will have replaced their existing fleet of 2010 through 2016 cutaways by the year 2025. Beyond this, CTE projects Beaumont Transit will replace their ~~low-floor~~transit buses on a 12-year cycle, and cutaway vehicles on a 5-year or 7-year basis, based on FTA service-life categories determined by seating capacities, vehicle lengths, and the manufacturer's selection for federal transit bus tests[9]. While transit agencies may have their own guidelines for service life, FTA funds may not be used to procure a bus in an application requiring a higher service-life category than the highest service-life category tested by the manufacturers on a particular vehicle. Aligning procurement schedules accordingly will prove important in providing a baseline against which to compare future zero-emission capital investments in subsequent reports.

[9]Federal Transit Administration Useful Life of Transit Buses and Vans; https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/Useful_Life_of_Buses_Final_Report_4-26-07_rv1.pdf

The City of Beaumont is also subject to RCTC's Resolution No. 00-018, stating that 'all full-size urban public transit buses (as defined by CARB) purchased or leased with federal, state, or local funds granted or programmed by the Commission shall meet the urban bus optional, reduced emission standards as set by CARB for oxides of nitrogen and non-methane hydrocarbons.' This implies that the City of Beaumont will replace all existing gasoline vehicles of 'a load capacity of fifteen (15) or more passengers' with CNG equivalents per the procurement schedule, eventually phasing out gasoline technology through 2040. These considerations were taken into account when establishing a baseline scenario.

~~For the purposes of establishing a baseline scenario,~~ CTE projected vehicle procurements and costs over an 18-year period, ~~assuming there will be no changes to Beaumont Transit's fleet,~~based on the fleet composition as of September 2022. To estimate procurement costs for the entire transition period through 2040, CTE utilized an annual inflation rate of 2% to inform vehicle pricing across the entire 18-year period. **Figure 9~~Figure 9Figure 8~~** depicts the number of CNG and~~, gasoline, and~~ battery-electric through 2040 in this scenario. The subsequent graphics demonstrate a business-as-usual operation, as the foundation for understanding cost impacts to transition to zero-emission technology. Over the transition period, Beaumont Transit would spend approximately $~~20.7M~~26.9M in bus capital costs to replace their existing fleet with equivalent CNG, gasoline, and battery-electric vehicles through 2040. **Table 15** ~~**Table 15Table 14**~~ outlines the annual procurement costs, through 2040.

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Table 15 - Annual Procurements, Baseline Scenario

Purchase Year	Vehicle Lengths					
	Gasoline Cutaways	CNG Cutaways	Electric Cutaways	CNG 30'	CNG 40'	Total
2022	-	1	2	-	-	$ 881,834
2024	-	3	-	-	-	$ 945,373
2025	-	5	-	-	-	$1.61M
2026	-	4	-	-	-	$1.3M
2027	-	4	2	-	-	$2M
2028	-	0	-	-	3	$2.3M
2030	-	3	-	-	-	$1.1
2031	-	3	-	1	-	$ 1.9M
2032	-	3	2	-	-	$1.8M

2033	-	4	-	-	-	$1.5M
2034	-	3	-	-	-	$1.1M
2035	-	3	-	-	-	$1.2M
2037	-	1	2	-	-	$1.2M
2038	-	3	-	-	-	$1.2M
2039	-	2	-	-	-	$848,232
2040	-	7	-	-	3	$5.9M
Total	-	**$18.1M**	**$2.7M**	**$824,231**	**$5.2M**	**$26.9M**

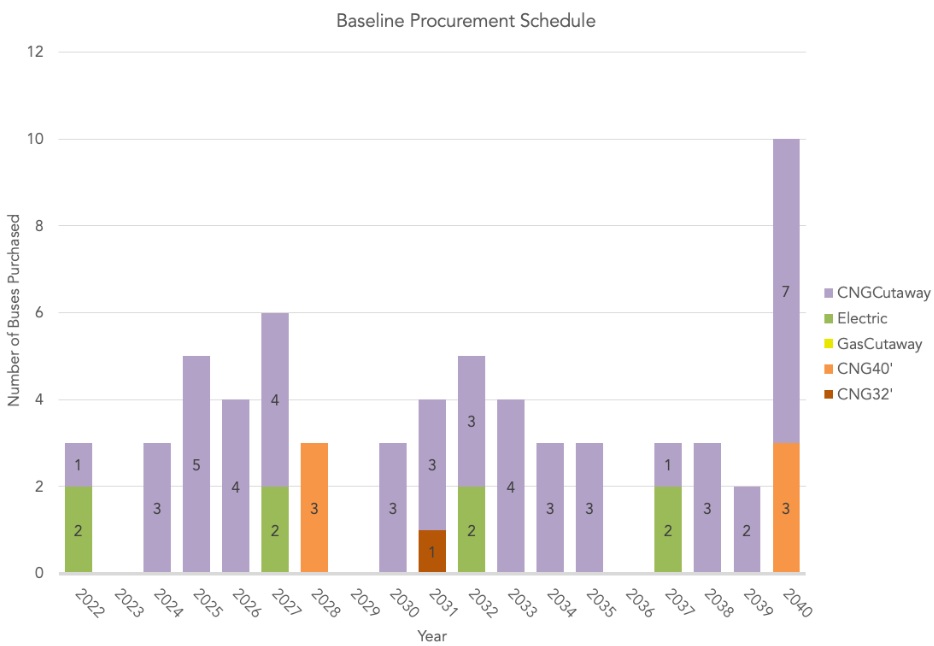

Figure 998 – Projected Bus Purchases, Baseline Scenario

Figure 10Figure 10Figure 9 depicts the annual fleet composition through 2040 for the *Baseline Scenario*; composed of CNG, gasoline, and battery-electric vehicles over the 18-year period.

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Commented [SG1]: Update to replace gas with CNGs

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Figure 10109 – Annual Fleet Composition, Baseline Scenario

Figure 11Figure 11Figure 10 shows the annual total bus capital costs for the CNG, gasoline, and battery-purchased in each year of the *Baseline Scenario*.

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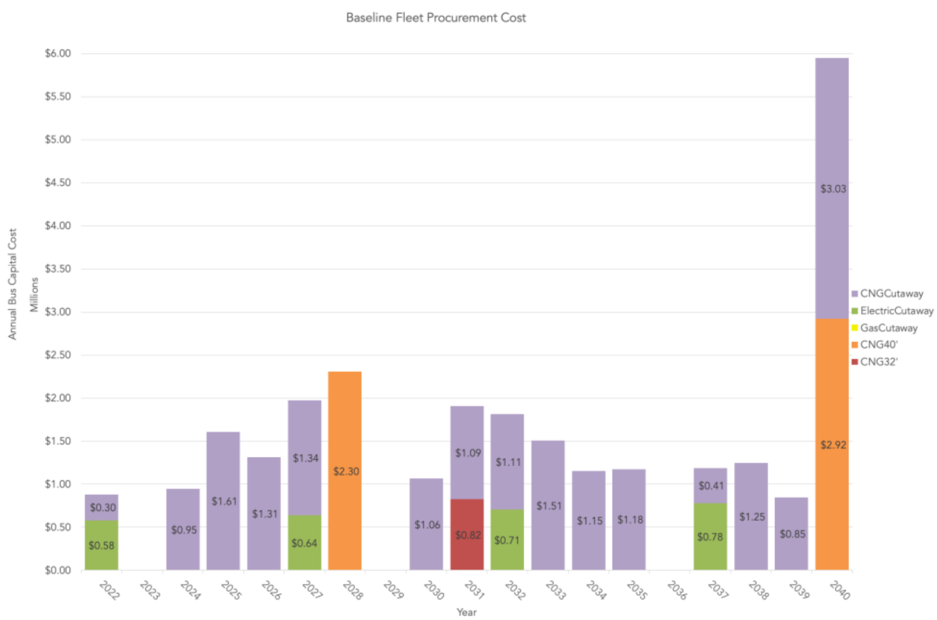

Figure 111110 – Annual Capital Costs, Baseline Scenario

City of Beaumont's Sustainability Goals

The City of Beaumont is committed to providing a more livable, equitable, and economically vibrant community through the incorporation of energy efficiency features and reduction of greenhouse gas (GHG) emissions. According to the City of Beaumont's Roadmap to Greenhouse Gas Reductions Report[10] from October 2015, 14% of Beaumont's municipal GHG emissions come from their vehicle fleet, thus decarbonizing their transit vehicles will be of paramount importance to reach their emission reductions goals for 2030 (160,501 metric tons of CO2 equivalents).

[10] Roadmap to Greenhouse Gas Reductions Report:
https://www.beaumontca.gov/DocumentCenter/View/27815/Beaumont-Climate-Action-Plan?bidId=

Regional Zero-Emission Market & Deployment Ecosystem

Regional Hydrogen Production and Distribution

California has one of the most mature hydrogen fueling networks in the nation. The state legislature has fostered growth in zero-emission fuels through the state's Low-Carbon Fuel Standard (LCFS) program, which incentivizes the consumption of fuels with a lower carbon intensity than traditional combustion fuels. Recently, the California Energy Commission (CEC) announced in late 2021 that $77 million in funding was allocated for hydrogen fueling infrastructure projects. The California Air Resources Board and the California Energy Commission (CEC) have set a target of 100 publicly available light-duty hydrogen fueling stations operational by 2023. Also in 2021, the CEC released a grant funding opportunity that is intended to stimulate developments in renewable hydrogen transportation fuel production[11]. Earlier this year, SoCalGas proposed the Angeles Link, a large-scale green hydrogen infrastructure system for Southern California, that is expected to utilize 25-35 GW of curtailed or new solar, wind, or battery output to power electrolyzers that produce 'clean hydrogen'. The hydrogen would then be delivered to industrial customers in California via a new hydrogen pipeline system spanning 200 to 750 miles.

California has at least seven heavy-duty and transit-operated fueling stations in operation and at least four more in development[12]. Additionally, the number of hydrogen production and distribution centers is growing to meet increased hydrogen demand as it gains popularity as a transportation fuel. At present, there are two operating heavy-duty and transit-operated hydrogen fueling station in the neighboring San Bernadino and Orange counties, and two planned transit-operated hydrogen fueling station in Los Angeles County and Pomona. In addition, private hydrogen fueling stations by First Element Fuels and Stratosfuel are in development and should be commissioned before the end of Beaumont Transit's fleet transition timeline.

In the region, Omintrans, a public transit agency serving the San Bernadino Valley recently received $9.3 million from the Federal Transit Administration (FTA) under the FY2022 Low-No Emission Vehicle Program to develop hydrogen refueling infrastructure and launch a workforce development program. Similarly Sunline Transit Agency has received $7.8 million to upgrade their liquid hydrogen refueling infrastructure. Riverside Transit Agency has also received $5.2 million to procure hydrogen fuel cell buses. The presence of hydrogen fueling infrastructure projects, especially in the counties of Riverside and San Bernadino, demonstrates the feasibility of fuel cell electric technology for transit in the region.

Regional BEB Deployments & Market Access

The BEB market has the benefit of greater maturity and more available products. Three of the major BEB OEMs manufacture buses in California with two manufacturing sites located in Southern California. Neighboring agencies such as Long Beach Transit, LA Metro, and Foothill California have some of the most mature BEB deployments in the country. This year, the FTA also awarded battery-electric bus and

[11] Hydrogen Refueling Stations in California, California Energy Commission: https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/hydrogen-refueling

charging infrastructure projects under the FY2022 Low-No Emission Vehicle Program. In Los Angeles County, Los Angeles County Metropolitan Transportation Authority (LA Metro) was awarded $104.2 million, and the City of Gardena was awarded $2.22 million to procure battery-electric buses and **charging equipment**. In Riverside County, Sunline Transit Agency was awarded an additional $7.15 million to procure battery electric buses and charging stations, and in Orange County, Orange County Transportation Authority (OCTA) was awarded $2.51 million to purchase zero-emission buses to improve air quality and paratransit service.

Utility Programs and EV Incentives

Southern California Edison (SCE) is the electricity provider, or utility, for Beaumont Transit. SCE's Charge Ready Transport (CRT) program supports both California's greenhouse gas (GHG)-reduction goal and local air-quality requirements. The Program assists customers with transitioning to cleaner fuels by reducing their cost for the purchase and installation of required battery-electric vehicle (EV) charging infrastructure, as well as providing rebates to offset the cost of charging stations for certain eligible customers[13].

Primarily, the CRT program offers low- to no-cost electrical system upgrades to support the installation of EV charging equipment for qualifying vehicles – heavy-duty vehicles weighing 6000+ lbs. In addition, participants that will be acquiring school buses or transit buses within SCE territory are also eligible for a rebate against the purchase of charging equipment.

Challenges to ZEB Transition

In addition to the uncertainty of technology improvements, there are other risks to consider in trying to estimate costs over the 18-year transition period. Although current BEB range limitations may be improved over time as a result of advancements in battery energy capacity and more efficient components, battery degradation may re-introduce range limitations, which is a cost and performance risk to an all-BEB fleet over time. While this can be mitigated by on-route charging, there may be emergency scenarios where the buses are expected to perform off-route or atypical service. In these emergency scenarios that require use of BEBs, agencies may face challenges performing emergency response roles expected of them in support of fire and police operations. Furthermore, fleetwide energy service requirements, power redundancy, and resilience may be difficult to achieve at any given depot in an all-BEB scenario. Although FCEBs may not be subject to these same limitations, higher capital equipment costs and availability of hydrogen may constrain FCEB solutions. RCTC, the City of Beaumont, CTE, and IBI Group will expand upon challenge mitigation and adaptation in the ZEB Implementation Plan deliverable component of this project.

Benefits of Zero-Emission Transition

Despite the challenges associated with zero-emission transitions, there are also a myriad of benefits that the City of Beaumont can realize. The most obvious is the reduction in greenhouse gas production

[13] Charge Ready Transport, Quick Reference Guide

associated with transitioning from ICE to zero-emission vehicles. The transportation sector is the largest contributor to greenhouse gas emissions in the United States, accounting for more than 30% of total emissions, and within this sector, 25% of these emissions come from the medium- and heavy-duty markets, yet these markets account for less than 5% of the total number of vehicles. Electrifying these vehicles can have an outsized impact on pollution, fossil-fuel dependency, and climate change.

Under-resourced urban communities often rely on transit bus systems for community mobility yet have also borne the brunt of pollution-emitting industries and local diesel pollution. Zero-emission transitions of public transit systems thus not only provide pollution reduction broadly but provide it more equitably by focusing efforts in historically overlooked communities. An increased commitment to electrifying public transit helps metropolitan areas, including under-resourced communities, meet national air quality standards by reducing overall vehicle emissions and the pollutants that create smog.

In addition to the emissions benefits, there are operational benefits to using zero-emission buses. ZEBs are four times more fuel efficient than comparable new diesel buses. Better fuel efficiency means less waste when converting the potential energy in the fuel to motive power. Less waste not only means less pollution, it results in more efficient use of natural resources. This fuel efficiency improvement also results in cost savings for operators.

Finally, support from the federal government has enabled transit agencies to successfully test new zero-emission vehicle technologies without passing the entire cost of these pilots on to the end-user. The federal government covers between 80 and 90 percent of the capital cost of a typical 40' transit bus in exchange for the transit agency agreeing to operate the bus for 12 years. Without such federal assistance, a technology shift of this scale would be financially infeasible for fleet operators.