ESTA BOARD AGENDA

Regular Meeting

Thursday, February 8, 2024 at 9:00am
City of Bishop Council Chambers
301 West Line St, Bishop, California
The Agenda is available at www.estransit.com

Chairperson: Karen Schwartz **Vice-Chairperson: Chris Bubser**

Board Members:

Chris Bubser (Mammoth Lakes)
Karen Schwartz (Bishop)
Karen Kong (Bishop)
Trina Orrill (Inyo County)
Jeff Griffiths (Inyo County)
Lynda Salcido (Mono County)
Bill Sauser (Mammoth Lakes)
Bob Gardner (Mono County)

Note: In compliance with the Americans with Disabilities Act, if an individual requires special assistance to participate in this meeting, please contact Eastern Sierra Transit at (760) 872-1901 ext. 15 or 800-922-1930. Notification 48 hours prior to the meeting will enable the Authority to make reasonable arrangements to ensure accessibility to this meeting. (28 CFR 13.102-35.104 ADA Title II)

Voice recorded public comment: To submit public comment via recorded message, please call 760-872-1901 ext. 12 by 4pm Wednesday, February 7. State your name and the item number(s) on which you wish to speak. The recordings will be limited to two minutes. These comments may be shared at the appropriate time during the board meeting.

Email public comment: To submit an emailed public comment to the Board please email pmoores@estransit.com by 4pm Wednesday, February 7, and provide your name, the number(s) on which you wish to speak, and your comment. These comments will be shared with all attending Board members.

Join the ZOOM meeting on your computer or mobile device by using this link:

https://us02web.zoom.us/j/86132395245

Remember, to eliminate feedback, use only one source of audio for the meeting, not both the phone and the computer.

Begin Recording Meeting & Call to Order

Roll Call

Pledge of Allegiance

Public Comment*: The Board reserves this portion of the agenda for members of the public to address the Eastern Sierra Transit Authority Board on any items not on the agenda and within the jurisdiction of the Board. The Board will listen to all communication, but in compliance with the Brown Act, will not take any action on items that are not on the agenda.

*Check meeting attendees. Read emails and/or phone calls submitted.

A. Consent Agenda (Board Action Required)

The following items are considered routine and non-controversial by staff and will be approved by one motion if no member of the ESTA or public wishes an item removed. If discussion is desired by anyone, the item will be removed from the consent agenda and will be considered separately. Questions of clarification may be made by ESTA Board members, without the removal of the item from the Consent Agenda.

A-1 Approval of Regular Meeting Minutes of January 11, 2024
- Meeting minutes from the last meeting of the ESTA Board of Directors

B. Information Agenda (Receive and File Only)

The following items are presented as information only. Staff is prepared to answer questions on these items, and may verbally emphasize points as necessary. Otherwise, if no member of the public or Board wishes to open a discussion, the Information Agenda will stand as presented, and the meeting will move to the next section.

B-1 Executive Director's Report
- Information on ridership, projects, performance, and ESTA activities

B-2 Financial Report for 2023/24
- Financial update on current fiscal year

B-3 FY22-23 Financial Audit and Report
- The Board will review the FY22-23 financial audit report

B-4 Zero Emissions Transition Plan
- The plan to move the fleet to zero emission vehicles is completed

C. Action Agenda

C-1 Board Election
- The election of ESTA Board officers

C-2 Bus Purchase
- The Board will consider expending reserves for the purchase and refurbishment of heavy-duty transit buses.

D. Closed Session

D-1 The Board will meet with staff in closed session without the public present. CONFERENCE WITH LEGAL COUNSEL: It is the intention of the Board to meet in closed session concerning the following item: Executive Director Performance Evaluation (Govt. Code Section 54957). CLOSED SESSION DISCUSSION/POSSIBLE ACTION Conference with Labor Negotiators. (Pursuant to Government Code Section 54957.6)

D-2 Report on Closed session as required by law.

E. Board Member Comments

- Board member comment on ESTA and home jurisdictions.

F. Adjournment

The next meeting of ESTA's board April 11, 2024 at 9:00 am, in Mammoth Lakes, CA. Check ESTA website for details on attending the meeting.

Eastern Sierra Transit Authority
Minutes of January 11, 2024 Meeting

Call to Order - 3:00 P.M. Friday, January 11, 2024

Chairperson Schwartz called The meeting of Eastern Sierra Transit Authority to order at 3:00 pm in the City of Bishop Council Chambers

ROLL CALL

A quorum was established by roll call.

PRESENT:

Chairperson Schwartz, Boardmembers Duggan, Kong, Sauser, Gardner, Orrill and Griffiths
Boardmember Bubser joined the meeting at 3:09 pm.

ABSENT:

None

Pledge of Allegiance

Jeff Griffiths led the Pleadge of Allegiance.

Public Comment: NONE

Consent Agenda

It was moved by Board Member Sauser and seconded by Board Member Orrill to approve the consent Agenda.

A-1 Approval of Regular Meeting Minutes of October 13, 2023
A-2 On Demand Software Procurement
A-3 Paid Time Off (PTO) Cap
A-4 Transit and Intercity Rail Capital Program (TIRCP)
A-5 Grant Resolution 2024-01

The motion passed 7-0 with Director Bubser absent

Information Agenda

B-1 Executive Directors Report
B-2 Financial report for 2023/24
B-3 Zero Emissions Transition Plan
  Presentation by Katrina Sutton, CALSTART
B-4 ESTA Annual Report
  Discussion among the board and Phil Moores regarding the Executive Directors report

Board Member comments:

Boardmember Sauser said the Mammoth Lakes Communit Recreation Center opened Nov. 24, 2023. The LA Kings Ice at Mammoth Lakes. Mammoth Town Council will hire permanent town manager.
Boardmember Duggan announced this would be her last board meeting due to conflicts in schedule.
Lynda Salcido has been appointed to ESTA's board.
Chairperson Schwartz commented there will be a new hotel in Bishop, near the Vons. A Hampton Inn.
Boardmember Griffiths commented that he can count on ESTA but Amtrak cancelled twice.

Boardmember Gardner thanked Boardmember Duggan for her service.

Adjournment

The meeting was adjourned at 3:58 pm to the next regular meeting scheduled to be held Februay 8, 2024 at 9:00 am in Bishop City Council Chambers at 301 West Line St. Bishop, CA

Recorded & prepared by:

____

Linda Robinson
Board Clerk
Eastern Sierra Transit Authority

Minutes approved:

February 8, 2024
Item B-1

STAFF REPORT

Subject: Executive Director’s Report
Presented by: Phil Moores, Executive Director

Staffing

We are saying goodbye to Tim Feher, Mammoth Operations Supervisor, as he prepares to retire. Tim worked at ESTA for five years as a driver, dispatcher, and supervisor in the Mammoth office. His hard work and dedication lead the way for the Mammoth team’s success. In the winter, stormy early mornings and long cold days were the norm for Tim these past years as he helped drivers install chains and prep buses for the busy days. He scheduled for the Reds Meadow Shuttle and handled charters in the summer months. He will be missed, but the new supervisor, Brian Ognisty is training to take his place. Thank you, Tim, for your years of commitment to ESTA.

Community

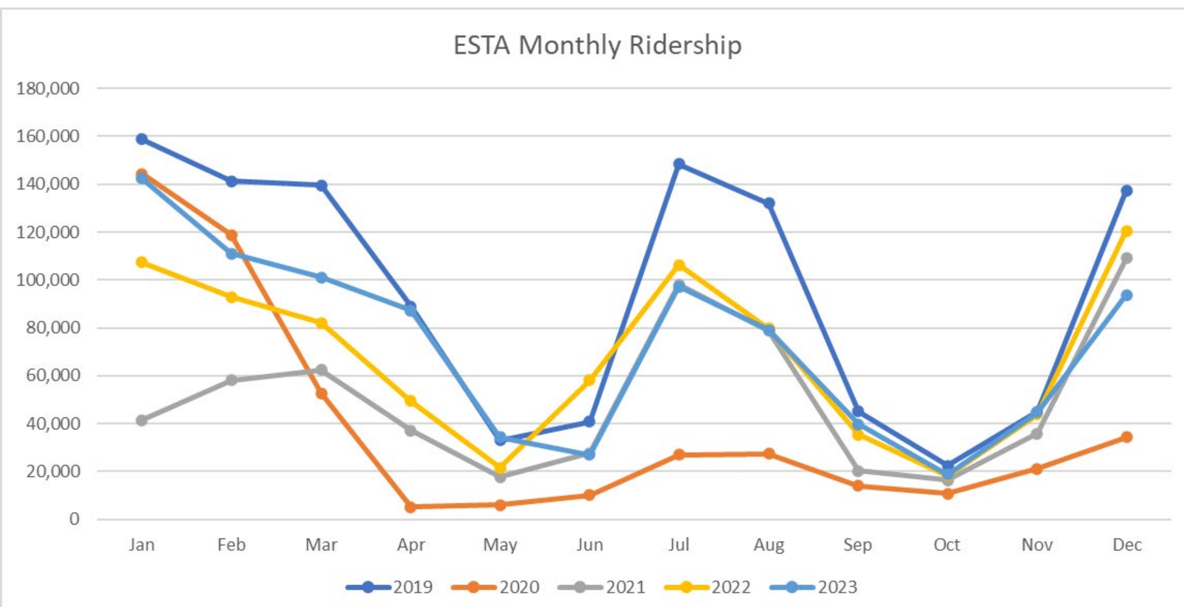
Director Jeff Griffiths connected Eastside Student Center with me to consider a vehicle transfer for the student center. ESTA had a van that fit the need and I signed over the vehicle last week. The Student Center will use the van for field trips and educational purposes. Thanks Jeff!

Ridership

ESTA’s ridership growth is slowing down and leveling off since Covid 2020. There were no significant service cancellations affecting ridership. Mountain Ski Resort ridership dropped off considerably.

December Ridership Report							
Route	**Pre-Covid 2019**	**2020**	**2021**	**2022**	**2023**	**Change Current vs. Last year**	**% Change Current vs Pre-Covid**
Benton	33.00	4.00	2.00	14.00	11.00	-3	-67%
Bishop Dial-a-Ride	3,816.00	2,284.00	2,936.00	3,354.00	3,832.00	478	0%
Bridgeport-Carson	24.00	5.00	12.00	28.00	5.00	-23	-79%
Lancaster	419.00	139.00	323.00	320.00	363.00	43	-13%
Lone Pine-Bishop	222.00	151.00	139.00	241.00	279.00	38	26%
Lone Pine Dial-a-Ride	417.00	415.00	390.00	381.00	413.00	32	-1%
Mammoth Fixed Route	24,999.00	4,565.00	15,366.00	20,326.00	18,977.00	-1,349	-24%
Mammoth Dial-a-Ride	183.00	88.00	148.00	233.00	281.00	48	54%
Mammoth Mountain Resort	105,606.00	26,001.00	88,698.00	92,360.00	67,993.00	-24,367	-36%
mammoth Express	630.00	178.00	369.00	502.00	469.00	-33	-26%
Night Rider	404.00	78.00	192.00	308.00	324.00	16	-20%
Reno	625.00	308.00	434.00	570.00	784.00	214	25%
Walker Dial-a-Ride	26.00	13.00	0.00	9.00	13.00	4	-50%
Total	137,404	34,229	109,009	118,646	93,744	-24,902	-32%

The charts below show the ridership by month and year since pre-Covid. The blue line is 2019, and the light blue line is 2023. This last December was slow.



February 8, 2024
Agenda Item #B-2

STAFF REPORT

Subject: Financial Report – FY 2023/24

Initiated by: Dawn Vidal, Administration Manager

The year-to-date roll-up and year end forecast for the 2023/24 fiscal year are included on the following pages. Reports are as of February 2,2024.

Revenue is coming in as expected. Much of ESTA's revenue is claimed on a reimbursement basis so it is normal to see low revenue amounts at this time.

Compensated Absence Expense is high for this time of year- but not unexpected as employees were encouraged to take time off during the Mammoth shoulder season. We have also had two benefitted employees retire/leave area and their accrued PTO cash out is reflected in the balance.

Fuel is budgeted at $5.38 per gallon and average price per gallon was $4.34 in December. Fuel and maintenance costs do not include invoices from The Town of Mammoth Lakes for December 2023 and January 2024.

February 8, 2024
Agenda Item #B-2

Financial information as of: 2/2/2024 % of Fiscal Year: 59%

153299 - EASTERN SIERRA TRANSIT - ROLL UP

OPERATING

Revenue		FY 23/24 Budget	YTD Actual	Balance	% of Budget	Year End Forecast	YE Forecast Variance	Comments
4061	LOCAL TRANSPORTATION TAX	1,716,105	870,047	846,058	51%	1,716,105	-	
4065	STATE TRANSIT ASST	617,902	88,043	529,859	14%	617,902	-	
4301	INTEREST FROM TREASURY	40,000	77,528	(37,528)	194%	40,000	-	
4498	STATE GRANTS	80,528	31,888	-	40%	80,528	-	
4499	STATE OTHER	83,005	27,244	55,761	33%	83,005	-	
4555	FEDERAL GRANTS	1,303,409	32,827	1,270,582	3%	1,303,409	-	
4599	OTHER AGENCIES	1,080,406	484,506	595,900	45%	1,080,406	-	
4747	INSURANCE PAYMENTS	-				-	-	
4819	SERVICES & FEES	2,052,269	1,117,152	935,117	54%	2,052,269	-	
4959	MISCELLANEOUS REVENUE	50,000	56,699	(6,699)	113%	50,000	-	Lefever Advertising
4999	PRIOR YEARS REIMBURSEMENTS	-	172	0		-	-	
	Revenue Total:	**7,023,624**	**2,786,107**	**4,189,049**	**40%**	**7,023,624**	-	

Operating Expenditure:		FY 23/24 Budget	YTD Actual	Balance	% of Budget	Year End Forecast	YE Forecast Variance	Comments
5001	SALARIED EMPLOYEES	2,060,839	1,172,827	888,012	57%			
5003	OVERTIME	133,659	125,396	8,263	94%			
5005	HOLIDAY OVERTIME	145,016	150,723	(5,707)	104%			
5012	PART TIME EMPLOYEES	558,747	364,870	193,877	65%			
	Wages subtotal	**2,898,261**	**1,813,815**	**1,084,446**	**63%**	**2,898,261**	-	
5021	RETIREMENT & SOCIAL SECURITY	71,321	36,712	34,609	51%	71,321	-	
5022	PERS RETIREMENT	234,910	127,195	107,715	54%	234,910	-	
5025	RETIREE HEALTH BENEFITS	-	-	-	0%	-		
5031	MEDICAL INSURANCE	395,470	159,365	236,105	40%	395,470	-	
5043	OTHER BENEFITS	54,582	24,558	30,024	45%	54,582	-	
5045	COMPENSATED ABSENCE EXPENSE	200,460	136,685	63,775	68%	200,460	-	Employees who retired/left PTO
5046	OPEB EXPENSE	40,000	40,000	-	100%	40,000		Prepaid
5047	EMPLOYEE INCENTIVES	7,700	6,652	1,048	86%	7,700	-	
5111	CLOTHING	4,000	5,215	(1,215)	130%	4,000	-	New Jackets
5152	WORKERS COMPENSATION	86,644	86,644	-	100%	86,644	-	Prepaid
5154	UNEMPLOYMENT INSURANCE	13,750	946	12,804	7%	13,750	-	
5158	INSURANCE PREMIUM	190,907	190,907	-	100%	190,907	-	Prepaid
5171	MAINTENANCE OF EQUIPMENT	696,120	404,549	291,571	58%	696,120	-	
5173	MAINTENANCE OF EQUIPMENT-M	-	-	-	0%	-	-	
5191	MAINTENANCE OF STRUCTURES	-	-	-	0%	-	-	

FY 23/24 % of Year End YE Forecast

Operating Expenditure:		Budget	YTD Actual	Balance	Budget	Forecast	Variance	Comments
5211	MEMBERSHIPS	1,475	1,364	111	92%	1,475	-	
5232	OFFICE & OTHER EQUIP < $5,000	19,750	13,043	6,707	66%	19,750		
5238	OFFICE SUPPLIES	9,000	2,114	6,886	23%	9,000	-	
5253	ACCOUNTING & AUDITING SERVIC	61,608	33,865	27,743	55%	61,608	-	
5260	HEALTH - EMPLOYEE PHYSICALS	7,500	1,913	5,587	26%	7,500	-	
5263	ADVERTISING	45,602	35,266	10,336	77%	45,602	-	
5265	PROFESSIONAL & SPECIAL SERVICE	525,948	286,977	238,971	55%	525,948	-	
5291	OFFICE, SPACE & SITE RENTAL	229,540	106,508	123,032	46%	224,528		
5311	GENERAL OPERATING EXPENSE	107,476	48,378	59,098	45%	107,476	-	
5326	LATE FEES & FINANCE CHARGES	125	254	(129)	203%	125	-	
5331	TRAVEL EXPENSE	11,401	2,944	8,457	26%	11,401	-	
5332	MILEAGE REIMBURSEMENT	28,000	9,341	18,659	33%	28,000	-	
5351	UTILITIES	91,250	26,866	64,384	29%	91,250	-	
5352	FUEL & OIL	700,360	304,941	395,419	44%	700,360	-	
5539	OTHER AGENCY CONTRIBUTIONS	30,000	-	30,000	0%	-		
5901	CONTINGENCIES	71,371	-	71,371	0%	71,371	-	
	Expenditure Total:	**6,834,531**	**3,907,017**	**2,927,514**	**57%**	**6,799,519**		

TRANSFERS Expenditure		FY 23/24 Budget	YTD Actual	Balance	% of Budget	Year End Forecast	YE Forecast Variance	Comments
5798	CAPITAL REPLACEMENT	145,781	-	145,781	-	145,781	-	
5801	OPERATING TRANSFERS OUT	-	-	-	-	-	-	
Expenditure Total:		145,781	-	145,781	-	145,781	-	
NET	TRANSFERS		-					

Projected Revenue less Projected Expenses:	**224,105**
Less Capital Trolley Match:	**69,000**
Less Capital Replacement Transfers:	**145,781**
Less Capital Structures & Improvements:	**22,801**
Operating Balance:	**(13,477)**

CAPITAL ACCOUNT Revenue		FY 23/24 Budget	YTD Actual	Balance	% of Budget	Year End Forecast	YE Forecast Variance	Comments
4911	Sales of Fixed Assets	-	11,000	(11,000)	#DIV/0!	-	-	
4067	STATE TRANSIT ASST-CAPITAL	170,191	-	(170,191)	0%	170,191	-	Vehicle matching funds
4495	STATE GRANTS - CAPITAL	46,548	95,224	(141,772)	205%	46,548	-	LCTOP Electric Vehicle
4557	FEDERAL GRANTS - CAPITAL	1,189,429	-	(1,189,429)	0%	1,189,429	-	Vehicles(5310, 5339a)
4911	SALE OF FIXED ASSETS						-	

Capital Expenditures

5640	STRUCTURES & IMPROVEMENTS	22,801	22,629	22,801	99%	22,801	-	
5650	EQUIPMENT	10,000	-	10,000	0%	10,000	-	Reds Radios & Electric Charger
5655	VEHICLES	1,690,600	307,127	1,525,469	18%	1,690,600	-	New Vehicles (5310, 5339(a))
	Expenditure Total:	**1,723,401**	**329,756**	**1,558,270**	**19%**	**1,723,401**	-	

Projected Capital Revenue Less Projected Expenses :	**(317,233)**
Plus Trolley Funding in Operating Revenue:	**69,000**
Plus Reds Radio Funding in Operating Revenue:	
Plus Structures & Improvements in Operating Revenue:	**22,801**
Plus LCTOP fund balance for Electric Vehicle:	**67,765**
Capital Balance:	**(157,667)**

Breakdown of 4819 Service & Fees Revenue	
MMSA Fees	367,458
Red's Revenue	409,164
All Other Passenger Fares	340,531
Total 4819	1,117,152

COUNTY OF INYO
Budget to Actuals with Encumbrances by Key/Obj
As of 2/2/2024

Ledger: GL

Object	Description	Budget	Actual	Encumbrance	Balance	%
Key: 153298 - ESTA - BUDGET						
OPERATING						
Revenue						
Expenditure						
NET OPERATING		0.00	0.00	0.00	0.00	
CAPITAL ACCOUNT						
Revenue						
NET CAPITAL ACCOUNT		0.00	0.00	0.00	0.00	
Key: 153299 - EASTERN SIERRA TRANSIT						
OPERATING						
Revenue						
4061	LOCAL TRANSPORTATION TAX	1,716,105.00	870,046.73	0.00	846,058.27	50.69
4065	STATE TRANSIT ASST	617,902.00	88,043.00	0.00	529,859.00	14.24
4301	INTEREST FROM TREASURY	40,000.00	77,528.42	0.00	(37,528.42)	193.82
4498	STATE GRANTS	80,528.00	31,888.00	0.00	48,640.00	39.59
4499	STATE OTHER	83,005.00	27,244.00	0.00	55,761.00	32.82
4555	FEDERAL GRANTS	1,303,409.00	32,826.62	0.00	1,270,582.38	2.51
4599	OTHER AGENCIES	1,080,406.00	484,506.30	0.00	595,899.70	44.84
4818	MOTOR POOL CHARGES	0.00	(6,720.00)	0.00	6,720.00	0.00
4819	SERVICES & FEES	2,052,269.00	1,117,152.39	0.00	935,116.61	54.43
4959	MISCELLANEOUS REVENUE	50,000.00	56,699.27	0.00	(6,699.27)	113.39
	Revenue Total:	7,023,624.00	2,779,214.73	0.00	4,244,409.27	39.56
Expenditure						
5001	SALARIED EMPLOYEES	2,060,839.00	1,172,826.93	0.00	888,012.07	56.91
5003	OVERTIME	133,659.00	125,395.52	0.00	8,263.48	93.81
5005	HOLIDAY OVERTIME	145,016.00	150,722.54	0.00	(5,706.54)	103.93
5012	PART TIME EMPLOYEES	558,747.00	364,870.11	0.00	193,876.89	65.30
5021	RETIREMENT & SOCIAL SECURITY	71,321.00	36,711.77	0.00	34,609.23	51.47
5022	PERS RETIREMENT	234,910.00	127,194.59	0.00	107,715.41	54.14
5031	MEDICAL INSURANCE	395,470.00	159,365.37	0.00	236,104.63	40.29
5043	OTHER BENEFITS	54,582.00	24,674.62	0.00	29,907.38	45.20
5045	COMPENSATED ABSENCE EXPENSE	200,460.00	136,684.76	0.00	63,775.24	68.18
5046	OPEB EXPENSE	40,000.00	40,000.00	0.00	0.00	100.00
5047	EMPLOYEE INCENTIVES	7,700.00	6,651.61	0.00	1,048.39	86.38
5111	CLOTHING	4,000.00	5,214.51	0.00	(1,214.51)	130.36
5152	WORKERS COMPENSATION	86,644.00	86,644.00	0.00	0.00	100.00
5154	UNEMPLOYMENT INSURANCE	13,750.00	945.94	0.00	12,804.06	6.87
5158	INSURANCE PREMIUM	190,907.00	190,907.99	0.00	(0.99)	100.00
5171	MAINTENANCE OF EQUIPMENT	696,120.00	404,548.59	0.00	291,571.41	58.11
5173	MAINTENANCE OF EQUIPMENT-	0.00	(116.30)	0.00	116.30	0.00
5211	MEMBERSHIPS	1,475.00	1,364.00	0.00	111.00	92.47
5232	OFFICE & OTHER EQUIP < $5,000	19,750.00	13,043.20	0.00	6,706.80	66.04
5238	OFFICE SUPPLIES	9,000.00	2,114.27	0.00	6,885.73	23.49
5253	ACCOUNTING & AUDITING SERVICE	61,608.00	33,865.00	0.00	27,743.00	54.96
5260	HEALTH - EMPLOYEE PHYSICALS	7,500.00	1,913.20	0.00	5,586.80	25.50
5263	ADVERTISING	45,602.00	35,266.49	0.00	10,335.51	77.33
5265	PROFESSIONAL & SPECIAL SERVICE	525,948.00	286,976.99	0.00	238,971.01	54.56
5291	OFFICE, SPACE & SITE RENTAL	229,540.00	106,507.88	0.00	123,032.12	46.40
5311	GENERAL OPERATING EXPENSE	107,476.00	48,378.24	0.00	59,097.76	45.01

COUNTY OF INYO

Budget to Actuals with Encumbrances by Key/Obj

Ledger: GL

As of 2/2/2024

Object	Description	Budget	Actual	Encumbrance	Balance	%
5326	LATE FEES & FINANCE CHARGES	125.00	253.98	0.00	(128.98)	203.18
5331	TRAVEL EXPENSE	11,401.00	2,943.97	0.00	8,457.03	25.82
5332	MILEAGE REIMBURSEMENT	28,000.00	9,341.07	0.00	18,658.93	33.36
5351	UTILITIES	91,250.00	26,866.12	0.00	64,383.88	29.44
5352	FUEL & OIL	700,360.00	304,941.46	0.00	395,418.54	43.54
5539	OTHER AGENCY CONTRIBUTIONS	30,000.00	0.00	0.00	30,000.00	0.00
5901	CONTINGENCIES	71,371.00	0.00	0.00	71,371.00	0.00
	Expenditure Total:	6,834,531.00	3,907,018.42	0.00	2,927,512.58	57.16
NET OPERATING		189,093.00	(1,127,803.69)	0.00	1,316,896.69	
NON-OPERATING						
Revenue						
NET NON-OPERATING		0.00	0.00	0.00	0.00	
CAPITAL ACCOUNT						
Revenue						
4067	STATE TRANSIT ASST-CAPITAL	170,191.00	0.00	0.00	170,191.00	0.00
4495	STATE GRANTS - CAPITAL	46,584.00	95,224.00	0.00	(48,640.00)	204.41
4557	FEDERAL GRANTS - CAPITAL	1,189,429.00	0.00	0.00	1,189,429.00	0.00
4911	SALES OF FIXED ASSETS	0.00	11,000.00	0.00	(11,000.00)	0.00
	Revenue Total:	1,406,204.00	106,224.00	0.00	1,299,980.00	7.55
Expenditure						
5640	STRUCTURES & IMPROVEMENTS	22,801.00	0.00	0.00	22,801.00	0.00
5650	EQUIPMENT	0.00	22,629.31	0.00	(22,629.31)	0.00
5655	VEHICLES	1,690,600.00	307,126.76	0.00	1,383,473.24	18.16
	Expenditure Total:	1,713,401.00	329,756.07	0.00	1,383,644.93	19.24
NET CAPITAL ACCOUNT		(307,197.00)	(223,532.07)	0.00	(83,664.93)	
TRANSFERS						
Revenue						
4998	OPERATING TRANSFERS IN	0.00	168,000.00	0.00	(168,000.00)	0.00
	Revenue Total:	0.00	168,000.00	0.00	(168,000.00)	0.00
Expenditure						
5798	CAPITAL REPLACEMENT	145,781.00	0.00	0.00	145,781.00	0.00
5801	OPERATING TRANSFERS OUT	0.00	168,000.00	0.00	(168,000.00)	0.00
	Expenditure Total:	145,781.00	168,000.00	0.00	(22,219.00)	115.24
NET TRANSFERS		0.00	168,000.00	0.00	(168,000.00)	
153299	**Total:**	(263,885.00)	(1,351,335.76)	0.00	1,087,450.76	

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Complete

COUNTY OF INYO
UNDESIGNATED FUND BALANCES
AS OF 06/30/2024

		Claim on Cash 1000	Accounts Receivable 1100,1105,1160	Loans Receivable 1140	Prepaid Expenses 1200	Accounts Payable 2000	Loans Payable 2140	Deferred Revenue 2200	Computed Fund Balance	Encumbrances	Fund Balance Undesignated
ESTA	**- EASTERN SIERRA TRANSIT AUTHORI**										
1532	EASTERN SIERRA TRANSIT	4,847,037	6,599	20,029		35,361			4,838,304		4,838,304
1533	ESTA ACCUMULATED CAPITAL	1,709,437							1,709,437		1,709,437
1534	ESTA GENERAL RESERVE	547,774							547,774		547,774
1535	ESTA BUDGET STAB RESERVE	219,108							219,108		219,108
1536	REDS MEADOW ROAD MAINTI	187,638							187,638		187,638
6809	SRTP TRANSPORT PLAN	29,491							29,491		29,491
6820	NON-EMERENCY TRAN REIM	2,793					9,178		(6,385)		(6,385)
6821	BISHOP YARD-ESTA						4,928		(4,928)		(4,928)
6822	LCTOP-ELECTRIC VEHICLE	95,836					5,923		89,913		89,913
6824	ESTA-LCTOP	34,128	3						34,131		34,131
6825	BISHOP ADMIN BUILDING	145,308							145,308		145,308
ESTA	**Totals**	7,818,550	6,602	20,029		35,361	20,029		7,789,791		7,789,791
	Grand Totals	**7,818,550**	**6,602**	**20,029**		**35,361**	**20,029**		**7,789,791**		**7,789,791**

User: DVIDAL Dawn Vidal
Report: GL8001: Undesignated Fund Balances
Page: 1
Current Date: 02/02/2024
Current Time: 08:14:09

February 8, 2024
Agenda Item B-3

STAFF REPORT

Subject: 2022/23 Audited Financial Report for the Eastern Sierra Transit Authority

Presented by: Dawn Vidal, Administration Manager

BACKGROUND:

The Transportation Development Act requires that claimants receiving funds for transit services from a County Transportation Commission submit to an annual certified fiscal audit.

ANALYSIS/DISCUSSION:

In compliance with the requirements of the Transportation Development Act, the Eastern Sierra Transit Authority has an audited financial report prepared each year for the preceding fiscal year. The audit was performed this year by the firm CliftonLarsonAllan (CLA) who was chosen to perform the audit following a procurement conducted in 2023. This was the first year of their contract with ESTA.

There were no audit findings.

The audit for the fiscal year ending June 30, 2023 including the Management Report, is included on the following pages and will be available for public viewing on ESTA's website.

RECOMMENDATION:

This item is presented for the information of the Board, which is requested to receive and file the report.

CliftonLarsonAllen LLP
CLAconnect.com

Board of Directors
Eastern Sierra Transit Authority
Bishop, California

We have audited the financial statements of the business-type activities of Eastern Sierra Transit Authority as of and for the year ended June 30, 2023, and have issued our report thereon dated January 19, 2024. We have previously communicated to you information about our responsibilities under auditing standards generally accepted in the United States of America, *Government Auditing Standards*, and Title 2 U.S. *Code of Federal Regulations* Part 200, *Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards* (Uniform Guidance), as well as certain information related to the planned scope and timing of our audit in our Statement of Work dated May 1, 2023. Professional standards also require that we communicate to you the following information related to our audit.

Significant audit findings or issues

Qualitative aspects of accounting practices

Accounting policies

Management is responsible for the selection and use of appropriate accounting policies. The significant accounting policies used by Eastern Sierra Transit Authority are described in Note 1 to the financial statements.

No new accounting policies were adopted and the application of existing policies was not changed during 2023.

We noted no transactions entered into by the entity during the year for which there is a lack of authoritative guidance or consensus. All significant transactions have been recognized in the financial statements in the proper period.

Accounting estimates

Accounting estimates are an integral part of the financial statements prepared by management and are based on management's knowledge and experience about past and current events and assumptions about future events. Certain accounting estimates are particularly sensitive because of their significance to the financial statements and because of the possibility that future events affecting them may differ significantly from those expected. The most sensitive estimates affecting the financial statements were:

- Management believes receivables are fully collectible based on historical experience. Accordingly, no allowance for doubtful accounts is included in the financial statements.

- Management's estimate of the other post-employment benefits (OPEB) liability is derived from, actuarial evaluations obtained from experts. We compared the liability reported in the financial statements to the actuarial report prepared and issued for the year under audit. Considering the total liability at year-end is based on third-party actuarial valuations, the liability amount was deemed reasonable.

- Management's estimate of pension liability is derived from actuarial valuations obtained from CalPERS. We compared the liability reported in the financial statements to the actuarial report prepared and issued for the year under audit.

We evaluated the key factors and assumptions used to develop these estimates in determining that they are reasonable in relation to the financial statements taken as a whole.

Financial statement disclosures

Certain financial statement disclosures are particularly sensitive because of their significance to financial statement users. There were no particularly sensitive financial statement disclosures.

The financial statement disclosures are neutral, consistent, and clear.

Significant unusual transactions

We identified no significant unusual transactions.

Difficulties encountered in performing the audit

We encountered no significant difficulties in dealing with management in performing and completing our audit.

Uncorrected misstatements

Professional standards require us to accumulate all misstatements identified during the audit, other than those that are clearly trivial, and communicate them to the appropriate level of management. Management did not identify and we did not notify them of any uncorrected financial statement misstatements.

Corrected misstatements

None of the misstatements detected as a result of audit procedures and corrected by management were material, either individually or in the aggregate, to the financial statements taken as a whole.

Disagreements with management

For purposes of this communication, a disagreement with management is a disagreement on a financial accounting, reporting, or auditing matter, whether or not resolved to our satisfaction, that could be significant to the financial statements or the auditors' report. No such disagreements arose during our audit.

Management representations

We have requested certain representations from management that are included in the management representation letter dated January 19, 2024.

Management consultations with other independent accountants

In some cases, management may decide to consult with other accountants about auditing and accounting matters, similar to obtaining a "second opinion" on certain situations. If a consultation involves application of an accounting principle to the entity's financial statements or a determination of the type of auditors' opinion that may be expressed on those statements, our professional standards require the consulting accountant to check with us to determine that the consultant has all the relevant facts. To our knowledge, there were no such consultations with other accountants.

Significant issues discussed with management prior to engagement

We generally discuss a variety of matters, including the application of accounting principles and auditing standards, with management each year prior to engagement as the entity's auditors. However, these discussions occurred in the normal course of our professional relationship and our responses were not a condition to our engagement.

Required supplementary information

With respect to the required supplementary information (RSI) accompanying the financial statements, we made certain inquiries of management about the methods of preparing the RSI, including whether the RSI has been measured and presented in accordance with prescribed guidelines, whether the methods of measurement and preparation have been changed from the prior period and the reasons for any such changes, and whether there were any significant assumptions or interpretations underlying the measurement or presentation of the RSI. We compared the RSI for consistency with management's responses to the foregoing inquiries, the basic financial statements, and other knowledge obtained during the audit of the basic financial statements. Because these limited procedures do not provide sufficient evidence, we did not express an opinion or provide any assurance on the RSI.

Supplementary information in relation to the financial statements as a whole

With respect to the schedule of expenditures of federal awards (SEFA) accompanying the financial statements, on which we were engaged to report in relation to the financial statements as a whole, we made certain inquiries of management and evaluated the form, content, and methods of preparing the SEFA to determine that the SEFA complies with the requirements of the Uniform Guidance, the method of preparing it has not changed from the prior period or the reasons for such changes, and the SEFA is appropriate and complete in relation to our audit of the financial statements. We compared and reconciled the SEFA to the underlying accounting records used to prepare the financial statements or to the financial statements themselves. We have issued our report thereon dated January 19, 2024.

This communication is intended solely for the information and use of the Board of Directors and management of Eastern Sierra Transit Authority and is not intended to be, and should not be, used by anyone other than these specified parties.

CliftonLarsonAllen LLP

CliftonLarsonAllen LLP

Roseville, California
January 19, 2024

EASTERN SIERRA TRANSIT AUTHORITY

FINANCIAL STATEMENTS AND SUPPLEMENTARY INFORMATION

YEAR ENDED JUNE 30, 2023

EASTERN SIERRA TRANSIT AUTHORITY
TABLE OF CONTENTS
YEAR ENDED JUNE 30, 2023

CliftonLarsonAllen LLP
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INDEPENDENT AUDITORS' REPORT

Board of Directors
Eastern Sierra Transit Authority
Bishop, California

Report on the Financial Statements

Opinion

We have audited the accompanying financial statements of Eastern Sierra Transit Authority (ESTA), which comprise the statement of net position as of June 30, 2023, and the related statements of revenues, expenses, and changes in net position, and cash flows for the year then ended, and the related notes to the financial statements.

In our opinion, the financial statements referred to above present fairly, in all material respects, the financial position of ESTA as of June 30, 2023, and the changes in its financial position and its cash flows for the year then ended in accordance with accounting principles generally accepted in the United States of America.

Basis for Opinion

We conducted our audit in accordance with auditing standards generally accepted in the United States of America (GAAS) and the standards applicable to financial audits contained in *Government Auditing Standards*, issued by the Comptroller General of the United States. Our responsibilities under those standards are further described in the Auditors' Responsibilities for the Audit of the Financial Statements section of our report. We are required to be independent of the ESTA and to meet our other ethical responsibilities, in accordance with the relevant ethical requirements relating to our audit. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Responsibilities of Management for the Financial Statements

Management is responsible for the preparation and fair presentation of the financial statements in accordance with accounting principles generally accepted in the United States of America, and for the design, implementation, and maintenance of internal control relevant to the preparation and fair presentation of financial statements that are free from material misstatement, whether due to fraud or error.

In preparing the financial statements, management is required to evaluate whether there are conditions or events, considered in the aggregate, that raise substantial doubt about the ESTA's ability to continue as a going concern for twelve months beyond the financial statement date, including any currently known information that may raise substantial doubt shortly thereafter.

Board of Directors
Eastern Sierra Transit Authority

Auditors' Responsibilities for the Audit of the Financial Statements

Our objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditors' report that includes our opinion. Reasonable assurance is a high level of assurance but is not absolute assurance and therefore is not a guarantee that an audit conducted in accordance with GAAS and *Government Auditing Standards* will always detect a material misstatement when it exists. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control. Misstatements are considered material if there is a substantial likelihood that, individually or in the aggregate, they would influence the judgment made by a reasonable user based on the financial statements.

In performing an audit in accordance with GAAS and *Government Auditing Standards*, we:

- Exercise professional judgment and maintain professional skepticism throughout the audit.
- Identify and assess the risks of material misstatement of the financial statements, whether due to fraud or error, and design and perform audit procedures responsive to those risks. Such procedures include examining, on a test basis, evidence regarding the amounts and disclosures in the financial statements.
- Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of ESTA's internal control. Accordingly, no such opinion is expressed.
- Evaluate the appropriateness of accounting policies used and the reasonableness of significant accounting estimates made by management, as well as evaluate the overall presentation of the financial statements.
- Conclude whether, in our judgment, there are conditions or events, considered in the aggregate, that raise substantial doubt about ESTA's ability to continue as a going concern for a reasonable period of time.

We are required to communicate with those charged with governance regarding, among other matters, the planned scope and timing of the audit, significant audit findings, and certain internal control related matters that we identified during the audit.

Required Supplementary Information

Accounting principles generally accepted in the United States of America require that the management's discussion and analysis, schedule of ESTA's proportionate share of the net pension liability and schedule of contributions, and other postemployment benefits (OPEB) plan schedule of changes in ESTA's net OPEB liability and related ratios be presented to supplement the basic financial statements. Such information, although not a part of the basic financial statements, is required by the Governmental Accounting Standards Board, who considers it to be an essential part of financial reporting for placing the basic financial statements in an appropriate operational, economic, or historical context. We have applied certain limited procedures to the required supplementary information in accordance with auditing standards generally accepted in the United States of America, which consisted of inquiries of management about the methods of preparing the information and comparing the information for consistency with management's responses to our inquiries, the basic financial statements, and other knowledge we obtained during our audit of the basic financial statements. We do not express an opinion or provide any assurance on the information because the limited procedures do not provide us with sufficient evidence to express an opinion or provide any assurance.

Board of Directors
Eastern Sierra Transit Authority

Supplementary Information

Our audit was conducted for the purpose of forming an opinion on the financial statements that collectively comprise the ESTA's basic financial statements. The schedule of expenditures of federal awards, as required by Title 2 U.S. *Code of Federal Regulations* Part 200, *Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards*, is presented for purposes of additional analysis and is not a required part of the basic financial statements. Such information is the responsibility of management and was derived from and relates directly to the underlying accounting and other records used to prepare the basic financial statements. The information has been subjected to the auditing procedures applied in the audit of the basic financial statements and certain additional procedures, including comparing and reconciling such information directly to the underlying accounting and other records used to prepare the basic financial statements or to the basic financial statements themselves, and other additional procedures in accordance with GAAS. In our opinion, the schedule of expenditures of federal awards is fairly stated, in all material respects, in relation to the basic financial statements as a whole.

Other Reporting Required by *Government Auditing Standards*

In accordance with *Government Auditing Standards*, we have also issued our report dated January 19, 2024, on our consideration of ESTA's internal control over financial reporting and on our tests of its compliance with certain provisions of laws, regulations, contracts, and grant agreements and other matters. The purpose of that report is solely to describe the scope of our testing of internal control over financial reporting and compliance and the results of that testing, and not to provide an opinion on the effectiveness of ESTA's internal control over financial reporting or on compliance. That report is an integral part of an audit performed in accordance with *Government Auditing Standards* in considering ESTA's internal control over financial reporting and compliance.

CliftonLarsonAllen LLP

CliftonLarsonAllen LLP

Roseville, California
January 19, 2024

EASTERN SIERRA TRANSIT AUTHORITY
MANAGEMENT'S DISCUSSION AND ANALYSIS
JUNE 30, 2023

The following Management's Discussion and Analysis (MD&A) of the Eastern Sierra Transit Authority (ESTA) financial performance provides an introduction to the financial statements for the year ended June 30, 2023. The information contained in this MD&A should be considered in conjunction with the information contained in ESTA's financial statements.

OVERVIEW OF THE FINANCIAL STATEMENTS

ESTA's financial statements are prepared on the accrual basis of accounting in accordance with accounting principles generally accepted in the United States of America promulgated by the Governmental Accounting Standards Board. ESTA is structured as an enterprise fund. ESTA's revenues are recognized when earned, not when received. Expenses are recognized when incurred, not when paid. Capital assets are capitalized and, with the exception of land, are depreciated over their useful lives. See the notes to the financial statements for a summary of ESTA's significant accounting policies.

Following this discussion and analysis are the basic financial statements of ESTA.

ESTA's basic financial statements are designed to provide readers with a broad overview of ESTA's financial status.

The statement of net position presents information on all of ESTA's assets and deferred outflows of resources and liabilities and deferred inflows of resources with the difference reported as net position. Over time, increases or decreases in net position may serve as a useful indicator of ESTA's financial position.

Net Position = (Assets + Deferred Outflows of Resources) –
(Liabilities + Deferred Inflows of Resources)

The statement of revenues, expenses, and changes in net position presents information showing the change in ESTA's net position during the fiscal year. All changes in net position are reported as soon as the underlying event occurs, regardless of timing of related cash flows. Thus, revenues and expenses are recorded and reported in this statement for some items that will result in cash flows in future periods.

The statement of cash flows relates to the flows of cash and cash equivalents. Consequently, only transactions that affect ESTA's cash accounts are recorded in this statement. A reconciliation of the statement of cash flows is provided at the bottom of the statement to assist in understanding the difference between cash flows from operating activities and operating income.

The notes to the financial statements provide additional information that is essential to a full understanding of the data provided in the basic financial statements.

EASTERN SIERRA TRANSIT AUTHORITY
MANAGEMENT'S DISCUSSION AND ANALYSIS
JUNE 30, 2023

FINANCIAL HIGHLIGHTS

On June 30, 2023, the assets and deferred outflows of ESTA exceeded its liabilities and deferred inflows by $9,693,795 (net position). Of this amount, $7,854,650 (unrestricted net position) may be used to meet ESTA's ongoing obligations to citizens and creditors, and $1,839,145 is ESTA's investment in capital assets.

ESTA's capital assets (e.g., land, infrastructure, and equipment) increased by $636,044 due to capital asset additions offset by the annual depreciation of existing assets.

Long-term liabilities increased by $405,084 due to a change from a net pension asset to net pension liability during the year offset by a decrease in other post-employment benefits and unearned revenue of $67,737 and $125,243, respectively.

FINANCIAL POSITION

Condensed Statement of Net Position

	2023	2022	Variance	Change
Assets:				
Current and Other Assets	$ 9,399,814	$ 9,043,414	3.94 %	$ 356,400
Capital Assets	1,839,145	1,203,101	52.87 %	636,044
Total Assets	11,238,959	10,246,515	9.69 %	992,444
Deferred Outflows	966,536	757,317	27.63 %	209,219
Liabilities:				
Current Liabilities	658,633	529,262	24.44 %	129,371
Long-Term Liabilities	999,428	594,344	68.16 %	405,084
Total Liabilities	1,658,061	1,123,606	47.57 %	534,455
Deferred Inflows	853,639	851,190	0.29 %	2,449
Net Position:				
Investment in Capital Assets	1,839,145	1,203,101	52.87 %	636,044
Unrestricted	7,854,650	7,825,935	0.37 %	28,715
Total Net Position	$ 9,693,795	$ 9,029,036	7.36 %	$ 664,759

As shown in the schedule above, at June 30, 2023, ESTA's total assets are $11,238,959. The total assets held increased by $992,444 from the June 30, 2022 balance of $10,246,515. The increase in total assets was due primarily to an increase in cash, and capital assets net of accumulated depreciation, offset by the change from net pension asset to a net pension liability of $598,064 in the current year. Deferred outflows of $966,536 represent contributions made by ESTA during fiscal year 2022/23 after the pension and OPEB liability measurement date of June 30, 2022 and other pension related deferred outflows.

EASTERN SIERRA TRANSIT AUTHORITY
MANAGEMENT'S DISCUSSION AND ANALYSIS
JUNE 30, 2023

The largest portion of ESTA's net position reflects its unrestricted portion. These funds may be used to meet ESTA's ongoing obligations to citizens and creditors.

Changes in Net Position
Years Ended June 30, 2023 and 2022

	2023	2022	Variance	Change
Revenues:				
Operating	$ 2,165,759	$ 2,141,316	1.14%	$ 24,443
Nonoperating	4,849,639	4,746,439	2.17%	103,200
Total Revenues	7,015,398	6,887,755	1.85%	127,643
Expenses:				
Operating Expenses	6,818,502	4,762,338	43.18 %	2,056,164
Capital Contributions	467,863	19,118	2347.24 %	448,745
Change in Net Position	664,759	2,144,535	69.00 %	(1,479,776)
Net Position - Beginning	9,029,036	6,884,501	31.15%	2,144,535
Net Position - Ending	$ 9,693,795	$ 9,029,036	7.36%	$ 664,759

Revenues – ESTA's revenues for fiscal year 2022/23 increased by 1.85% or $127,643.

Expenses – ESTA's expenses for fiscal year 2022/23 increased 43.18% or $2,056,164. Operating expenses increased primarily due to pension expense.

CAPITAL ASSETS AND DEBT ADMINISTRATION

Capital Assets – ESTA's investment in capital assets as of June 30, 2023 amounted to $1,839,145 (net of accumulated depreciation). This investment in capital assets includes land, land improvements, and equipment. The $636,044 increase is due to a large amount of capital asset additions in the current year primarily from replacing an old fleet of busses.

Additional information on ESTA's capital assets can be found in Note 3 of this report.

Long-term liabilities – At June 30, 2023, ESTA reported $999,428 related to net pension and OPEB liabilities.

Additional information on ESTA's long-term liabilities can be found in Notes 6 and 7 of this report.

EASTERN SIERRA TRANSIT AUTHORITY
MANAGEMENT'S DISCUSSION AND ANALYSIS
JUNE 30, 2023

ECONOMIC FACTORS AND NEXT YEAR'S BUDGET

Eastern Sierra Transit is slowly recovering from the negative effects of the pandemic. Ridership and revenues are approaching pre-pandemic levels. However, there is room for growth in our service.

The primary economic factors effecting ESTA are inflation, fuel prices, maintenance costs, and labor. The manpower deficiency is currently improved with ESTA being fully staffed. Inflation declined from 8% in 2022 to 2.4% in 2023. We need to keep a close eye on expenditures as we have seen 50-100% increase in prices.

ESTA's primary assets, the vehicles, are slowly being replaced. With limited infrastructure and mechanical support in the region, the transition to zero emission vehicles is happening at a slower rate. Diesel and gas vehicles are still being actively purchased.

ESTA's new Bishop facility is being planned as we wait for the Los Angeles Department of Water and Power to release the land for the project.

Finally, revenues remain strong and are expected to keep up with expenses. Federal, state, and fares are all forecasted to sufficient levels. Still, with potentially volatile economic conditions, a conservative approach to growth is advised.

REQUEST FOR INFORMATION

This financial report is designed to provide a general overview of ESTA's finances for all those with an interest in ESTA's finances. Questions concerning any of the information provided in this report or requests for additional financial information should be addressed to the Eastern Sierra Transit Authority Executive Director, at P.O. Box 1357, Bishop, CA 93515 or the Inyo County Auditor-Controller at P.O. Drawer R, Independence, CA 93526.

EASTERN SIERRA TRANSIT AUTHORITY
STATEMENT OF NET POSITION
JUNE 30, 2023

ASSETS AND DEFERRED OUTFLOWS OF RESOURCES

CURRENT ASSETS	
Cash	7,638,129
Accounts Receivable	995,078
Due From Other Governments	430,161
Interest Receivable	342
Prepaid Expenses	336,104
Total Current Assets	9,399,814
CAPITAL ASSETS, Net of Accumulated Depreciation	1,839,145
Total Assets	11,238,959
DEFERRED OUTFLOWS OF RESOURCES	
Deferred Other Postemployment Benefits	142,789
Deferred Pensions	823,747
Total Deferred Outflows of Resources	966,536

LIABILITIES, DEFERRED INFLOWS OF RESOURCES, AND NET POSITION

CURRENT LIABILITIES	
Accounts Payable and Accrued Liabilities	282,184
Salaries Payable	112,496
Compensated Absences	263,953
Total Current Liabilities	658,633
NONCURRENT LIABILITIES	
Net Other Post Employment Benefits Liability	401,364
Net Pension Liability	598,064
Total Noncurrent Liabilities	999,428
Total Liabilities	1,658,061
DEFERRED INFLOWS OF RESOURCES	
Deferred Other Postemployment Benefits	713,306
Deferred Pensions	140,333
Total Deferred Inflows of Resources	853,639
NET POSITION	
Investment in Capital Assets	1,839,145
Unrestricted	7,854,650
Total Net Position	$ 9,693,795

See accompanying Notes to Financial Statements.

EASTERN SIERRA TRANSIT AUTHORITY
STATEMENT OF REVENUES, EXPENSES, AND CHANGES IN NET POSITION
YEAR ENDED JUNE 30, 2023

OPERATING REVENUES	
Fare Revenues	$ 2,165,759
OPERATING EXPENSES	
Salaries and Benefits	4,141,355
Vehicle Maintenance	816,081
Fuel	690,677
Depreciation Expense	212,013
Professional and Other Services	239,065
Rents	201,021
Insurance	190,893
Parts and Supplies	89,817
Utilities	145,275
Advertising	38,180
Miscellaneous Expenses	54,125
Total Operating Expenses	6,818,502
OPERATING LOSS	(4,652,743)
NONOPERATING REVENUES	
Local Transportation Fund Allocation	2,001,919
State Transit Assistance Fund Allocation	835,519
Intergovernmental Revenues	1,386,209
Operating Assistance	839,974
Other Revenues	69,874
Use of Money and Property	(283,856)
Total Nonoperating Revenues	4,849,639
INCOME BEFORE CAPITAL CONTRIBUTIONS	196,896
CAPITAL CONTRIBUTIONS	467,863
CHANGE IN NET POSITION	664,759
Net Position - Beginning of Year	9,029,036
NET POSITION - END OF YEAR	$ 9,693,795

See accompanying Notes to the Financial Statements.

EASTERN SIERRA TRANSIT AUTHORITY
STATEMENT OF CASH FLOWS
YEAR ENDED JUNE 30, 2023

CASH FLOWS FROM OPERATING ACTIVITIES	
Receipts from Customers	$ 1,701,292
Cash Payments to Suppliers of Goods or Services	(2,445,695)
Cash Payments to Employees for Services	(3,420,357)
Net Cash Used by Operating Activities	(4,164,760)
CASH FLOWS FROM INVESTING ACTIVITIES	
Losses for Use of Money and Property	(283,358)
CASH FLOWS FROM NONCAPITAL FINANCING ACTIVITIES	
Local Transportation Fund Allocation	2,001,919
State Transit Assistance Allocation	835,519
Operating Grants - Federal and State	1,386,209
Operating Assistance	1,312,748
Other Revenues	69,874
Net Cash Provided by Noncapital Financing Activities	5,606,269
CASH FLOWS FROM CAPITAL AND RELATED FINANCING ACTIVITIES	
Capital Grants	467,863
Payments for Capital Asset Purchases	(848,057)
Net Cash Used by Capital and Related Financing Activities	(380,194)
NET INCREASE IN CASH AND CASH EQUIVALENTS	777,957
Cash and Cash Equivalents - Beginning of Year	6,860,172
CASH AND CASH EQUIVALENTS - END OF YEAR	$ 7,638,129

See accompanying Notes to the Financial Statements.

EASTERN SIERRA TRANSIT AUTHORITY
STATEMENT OF CASH FLOWS (CONTINUED)
YEAR ENDED JUNE 30, 2023

RECONCILIATION OF OPERATING LOSS TO NET CASH USED BY OPERATING ACTIVITIES	
Operating Income (Loss)	$ (4,652,743)
Adjustments to Reconcile Operating Loss to Net Cash Used by Operating Activities:	
Depreciation	212,013
(Increase) Decrease in Assets:	
Accounts Receivable	(339,224)
Prepaid Expense	(20,539)
Deferred Pensions	(223,148)
Deferred OPEB	13,929
Increase (Decrease) in Liabilities:	
Accounts Payable and Accrued Liabilities	39,978
Salaries Payable	89,393
Unearned Revenue	(125,243)
Net Other Postemployment Liability	(67,737)
Net Pension Liability	906,112
Deferred Pensions	13,631
Deferred Other Postemployment Benefits	(11,182)
Net Cash Used by Operating Activities	$ (4,164,760)

See accompanying Notes to the Financial Statements.

EASTERN SIERRA TRANSIT AUTHORITY
NOTES TO THE FINANCIAL STATEMENTS
JUNE 30, 2023

NOTE 1 SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES

Reporting Entity

The Eastern Sierra Transit Authority (ESTA) was established in 2007 by a joint powers agreement between Inyo County, Mono County, the City of Bishop, and the Town of Mammoth Lakes to operate a regional transportation system in the Eastern Sierra region.

Basis of Presentation

ESTA reports the activity relevant to its operations in an enterprise fund. The enterprise fund is used to account for operations that are financed and operated in a manner similar to private business enterprises, where the intent of the governing body is that the costs (expenses, including depreciation) of providing goods or services to the general public on a continuing basis be financed or recovered primarily through user charges, or where the governing body has decided that periodic determination of revenues earned, expenses incurred, and/or net income is appropriate for capital maintenance, public policy, management control, accountability, or other policies. Unrestricted net position for the enterprise fund represents the net position available for future operations.

Measurement Focus and Basis of Accounting

Accounting and financial reporting treatment applied to a fund is determined by its measurement focus. The enterprise fund is accounted for on a flow of economic resources measurement focus. This measurement focus emphasizes the determination of increased/decreased net position. The accrual basis of accounting is used for the enterprise fund. Under this method, revenues are recorded when earned and expenses are recorded at the time liabilities are incurred.

Operating Revenues – Revenues from the sale of tickets and passenger rides are recognized as income when the related service is provided.

Nonoperating Revenues – ESTA receives substantial funds that are not reported as operating revenues. For example, ESTA receives operating assistance from the Town of Mammoth Lakes. These funds are recognized as revenue when all applicable eligibility requirements are met. ESTA receives annual allocations from the Local Transportation and State Transit Assistance funds of the two counties it provides services in. These allocations are recognized as revenue when the allocations are approved. ESTA also receives a number of grants from various sources. These are recognized into income as eligibility requirements are met.

The following is a description of ESTA’s main funding sources:

Passenger Revenue

Passenger fares consist of fare charges to the users of the system. Including revenue from a contract with Mammoth Mountain Ski Resort.

EASTERN SIERRA TRANSIT AUTHORITY
NOTES TO THE FINANCIAL STATEMENTS
JUNE 30, 2023

NOTE 1 SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES (CONTINUED)

Measurement Focus and Basis of Accounting (Continued)

Operating Assistance

As mentioned above, the Town of Mammoth Lakes, a member of the Joint Powers Authority, provides operating assistance to ESTA. These revenues are not included as a component of fare revenues, but instead are reported as nonoperating revenues.

Federal Transit Administration (FTA)

FTA revenues are funded by a federal gas tax and revenues of the federal general fund. ESTA receives Section 5311 grants which are used for operations. Section 5310 funding is used for Non-Emergency Medical Program.

Local Transportation Fund (LTF)

LTF is derived from a ¼ cent of the general sales tax collected statewide. The State Board of Equalization, based on sales tax collected in each county, returns the general sales tax revenues to each county's LTF. Each county then apportions the LTF funds within the county based on population.

State Transit Assistance (STA)

STA funds are appropriated by the legislature to the State Controller's Office (SCO). The SCO then allocates the tax revenue, by formula, to planning agencies and other selected agencies. Statute requires that 50% of STA funds be allocated according to population and 50% be allocated according to transit operator revenues from the prior fiscal year.

Budgetary Information

State law requires the adoption of an annual budget for the enterprise fund, which must be approved by the Board of Directors. The budget is prepared on an accrual basis. The Board of Directors adopts an annual budget for transit operations. The executive director shall have the authority to transfer funds between line items, not to exceed $5,000 or 20% for any one line item, whichever is greater, with the limits of the overall budget. The executive director shall report, on a regular basis, any such transfers to and from budgeted line items. Budget amendments in excess of $5,000 or 20% of a line item, whichever is greater, shall require board approval.

Cash and Cash Equivalents

For purposes of the statement of cash flows, ESTA considers the cash held in the County Treasury, its only investments, to be cash and cash equivalents.

Investments

Investments consist of funds deposited in the pooled fund with Inyo County. Investments are stated at market value. Such investments are within the state statutes and ESTA's investment policy.

NOTE 1 SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES (CONTINUED)

Prepaid Items

Payments made for services that will benefit future accounting periods are recorded as prepaid items.

Capital Assets

Capital assets are stated at historical cost. The cost of normal maintenance and repairs is charged to operations as incurred. Major improvements are capitalized and depreciated over the remaining useful lives of the related properties. Depreciation is computed using the straight- line method over estimated useful lives as follows:

Buildings and Improvements	40 to 50 Years
Buses and Maintenance Vehicles	5 to 12 Years
Light-Rail Structures and Light-Rail Vehicles	25 to 45 Years
Other Operating Equipment	5 to 15 Years

It is the policy of ESTA to capitalize all capital assets with an individual cost of more than $5,000, and a useful life in excess of one year.

Compensated Absences

ESTA's policy allows employees to accumulate earned but unused comprehensive leave and compensated time off, which will be paid to employees upon separation from ESTA's service.

Pensions

For purposes of measuring the net pension liability (asset) and deferred outflows/inflows of resources related to pensions, and pension expense (credit), information about the fiduciary net position of the ESTA's California Public Employees' Retirement system (CalPERS) plan (Plan) and additions to/deductions from the Plan's fiduciary net position have been determined on the same basis as they are reported by CalPERS. For this purpose, benefit payments (including refunds of employee contributions) are recognized when due and payable in accordance with the benefit terms. Investments are reported at fair value.

Deferred Outflows/Inflows of Resources

In addition to assets, the statement of financial position reports a separate section for deferred outflows of resources. This separate financial statement element, deferred outflows of resources, represents a consumption of net position that applies to a future period and so will not be recognized as an outflow of resources (expense/expenditure) until then. ESTA has two items that qualify for reporting in this category. These items relate to the outflows from changes in the net pension liability and from other postemployment benefits (OPEB) liability and are reportable on the statement of net position.

NOTE 1 SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES (CONTINUED)

Deferred Outflows/Inflows of Resources (Continued)

In addition to liabilities, the statement of financial position reports a separate section for deferred inflows of resources. This separate financial statement element, deferred inflows of resources, represents an acquisition of net position that applies to a future period and so will not be recognized as an inflow of resources (revenue) until that time. ESTA has two types of items which qualify for reporting in this category. These items relate to inflows from changes in the net pension and OPEB liabilities and are reportable on the statement of net position.

Net Other Postemployment Benefits (OPEB)

For purposes of measuring the net OPEB liability and deferred outflows/inflows of resources related to OPEB, and OPEB expense (credit), information about the fiduciary net position of the ESTA's Public Agency Retirement Services (PARS) plan (Plan) and additions to/deductions from the Plan's fiduciary net position have been determined on the same basis as they are reported by PARS. For this purpose, benefit payments (including refunds of employee contributions) are recognized when due and payable in accordance with the benefit terms. Investments are reported at fair value.

Federal, State, and Local Grant Funds

Grants are accounted for in accordance with the purpose for which the funds are intended. Approved grants for the acquisition of land, building, and equipment are recorded as revenues as the related expenses are incurred. Approved grants for operating assistance are recorded as revenues in which the related grant conditions are met. Advances received on grants are recorded as a liability until related grant conditions are met. The Transportation Development Act (TDA) provides that any funds not earned and not used may be required to be returned to their source.

When both restricted and unrestricted resources are available for the same purpose ESTA uses restricted resources first.

Use of Estimates

The preparation of financial statements in conformity with accounting principles generally accepted in the United States of America require management to make estimates and assumptions that affect the reported amounts of assets and liabilities and disclosure of contingent assets and liabilities at the date of the financial statements and the reported amounts of revenues and expenses during the reporting period. Actual results could differ from those estimates.

Allowance for Doubtful Accounts

Accounts receivables consist entirely of amounts due from other governmental agencies for operating and capital grants. Management believes its accounts receivable to be fully collectible, and, accordingly, no allowance for doubtful accounts is required.

EASTERN SIERRA TRANSIT AUTHORITY
NOTES TO THE FINANCIAL STATEMENTS
JUNE 30, 2023

NOTE 2 CASH AND INVESTMENTS

Cash and investments consisted of the following at June 30, 2023:

Deposits Held in the County of Inyo Investment Pool	$ 7,566,736
Deposits Held in Financial Institutions	71,193
Imprest Cash	200
Total	$ 7,638,129

Custodial Credit Risk

At June 30, 2023, the carrying amount of the deposits held at banks was $71,193 and the bank balances totaled $71,193. The bank balances are insured by the FDIC up to $250,000. State law requires that the collateral be equal to or greater than 100% of all public deposit that is held with the pledging financial institution if government securities are used or 150% if mortgages are used as the collateral.

Authorized Investments

California statutes authorize ESTA to invest idle or surplus funds in a variety of credit instruments as provided for in California Government Code Section 53600, Chapter 4 – *Financial Affairs*.

The Government Code allows investments in the following instruments:

- Securities of the United States government, or its agencies
- Small Business Administration loans
- Certificates of Deposit (or Time Deposits) Negotiable Certificates of Deposit
- Commercial paper and medium-term corporate notes
- Local Agency Investment Fund (State Pool and County Pool) Demand Deposits
- Repurchase Agreements (Repos)
- Passbook Savings Account Demand Deposits
- Reverse Repurchase Agreements
- County Cash Pool

The bulk of ESTA's assets are held in an investment pool with the County of Inyo. More information about the County's investments can be found in the County's financial statements.

Cash in County Treasury

Cash in Inyo County is held by the Inyo County treasurer in an investment pool. The County maintains a cash and investment pool in order to facilitate the management of cash. Cash in excess of current requirements is invested in various interest-bearing securities. Information regarding categorization and fair value of investments can be found in the County's financial statements. The treasurer's investments and policies are overseen by the Inyo County Treasury Oversight Committee.

EASTERN SIERRA TRANSIT AUTHORITY
NOTES TO THE FINANCIAL STATEMENTS
JUNE 30, 2023

NOTE 2 CASH AND INVESTMENTS (CONTINUED)

Cash in County Treasury (Continued)

Government Accounting Standards Board Statement No. 40 requires additional disclosures about a government's deposits and investment risks that include custodial risk, credit risk, concentration risk, and interest rate. ESTA did not have a deposit or investment policy that addresses specific types of risks.

Required risk disclosures for ESTA's investment in the Inyo County Investment Pool at June 30, 2023 were as follows:

Credit Risk	Not Rated
Custodial Risk	Not Applicable
Concentration of Credit Risk	Not Applicable
Interest Rate Risk	Not Available

The fair value of ESTA's investment in the Inyo County Investment Pool is determined on an amortized cost basis which approximates fair value.

NOTE 3 CAPITAL ASSETS

Capital assets consisted of the following at June 30, 2023:

	Balance 7/1/2021	Additions	Deletions	Transfers	Balance 6/30/2022
Capital Assets, Being Depreciated:					
Structures and Improvements	$ 659,646		$ -	$ -	$ 659,646
Equipment	9,633,573	848,057	(990)	-	10,480,640
Total Capital Assets, Being Depreciated	10,293,219	848,057	(990)	-	11,140,286
Less Accumulated Depreciation for:					
Structures and Improvements	(125,701)	(19,360)	-	-	(145,061)
Equipment	(8,964,417)	(192,653)	990	-	(9,156,080)
Total Accumulated Depreciation	(9,090,118)	(212,013)	990	-	(9,301,141)
Capital Assets, Net	$ 1,203,101	$ 636,044	$ -	$ -	$ 1,839,145

Depreciation expense was $212,013 for the year ended June 30, 2023.

EASTERN SIERRA TRANSIT AUTHORITY
NOTES TO THE FINANCIAL STATEMENTS
JUNE 30, 2023

NOTE 4 FARE REVENUE RATIO

ESTA is required to maintain a fare revenue-to-operating expense ratio of 10% in accordance with the Transportation Development Act. The fare revenue-to-operating expense ratio for ESTA is calculated as follows for the year ended June 30, 2023:

Fare Revenues	$	2,165,759
Operating Expenses		6,818,502
Less Allowable Exclusions:		
Depreciation and Amortization		(212,013)
Net Operating Expenses	$	6,606,489
Fare Revenue Ratio		32.78%

NOTE 5 EMPLOYEES' RETIREMENT PLAN (DEFINED BENEFIT PLAN)

Plan Description

ESTA's defined benefit pension plan, the California Public Employee's Retirement System, provides retirement and disability annual cost of living adjustments, and death benefits to plan members and beneficiaries. The California Public Employee's Retirement System (CalPERS) is a cost sharing multiple-employer plan administered by CalPERS, which acts as a common investment and administrative agent for participating public employers within the state of California. A menu of benefit provisions as well as other requirements are established by state statutes within the Public Employee's Retirement Law. ESTA selects optional benefit provisions from the benefit menu by contract with CalPERS and adopts those benefits through local ordinance (other local methods). CalPERS issues a separate report.

Funding Policy

Active plan members in ESTA's defined pension plan are required to contribute either 8%, 7%, or 6.25% of their annual covered salary depending upon the plan in which the employee participates. ESTA is required to contribute the actuarially determined remaining amounts necessary to fund the benefits for its members. The fiscal year 2022/2023 employer rates are as follows:

Tier	Misc.	PEPRA
Tier 1	11.590 %	11.600 %
Tier 2	10.484	N/A

The actuarial methods and assumptions used are those adopted by the CalPERS Board of Administration. The contribution requirements of the plan members are established by state statute and the employer contribution rate is established and may be amended by CalPERS. ESTA pays plan members' contribution on their behalf for employees participating in the Classic plan. Contributions made to the pension plan during fiscal year 2022/2023 were $166,512.

NOTE 5 EMPLOYEES' RETIREMENT PLAN (DEFINED BENEFIT PLAN) (CONTINUED)

Actuarial Assumptions

ESTA's net pension liability is measured as its proportionate share of the total pension liability, less the proportionate share of the pension plan's fiduciary net position. The net pension liability of the cost sharing plan is measured as of June 30, 2022, using an annual actuarial valuation as of June 30, 2021, with update procedures used to roll forward the total pension liability to June 30, 2022. A summary of principal assumptions and methods used to determine the net pension liability is shown below.

- Discount Rate/Rate of Return – 6.90%
- Inflation Rate – 2.3%
- Salary increases – Varies by Entry Age and Service
- COLA Increases – up to 2.00%
- Post-Retirement Mortality – Derived using CalPERS' Membership Data for all Funds

The actuarial assumptions used in the June 30, 2021 valuation were based off on the results of an actuarial experience study completed in 2021. The Experience Study Report can be obtained at CalPERS' website under Forms and Publications.

The long-term expected rate of return on pension plan investments (6.90%) was determined using a building-block method in which best-estimate ranges of expected future real rates of return (expected returns, net of pension plan investment expense, and inflation) are developed for each major asset class. These ranges are combined to produce the long-term expected rate of return by weighting the expected future real rates of return by the target asset allocation percentage and by adding expected inflation.

Asset Class	Assumed Asset Allocation	Real Return (a), (b)
Global Equity - cap-weighted	30.00 %	4.45 %
Global equity non-cap-weighted	12.00	3.84
Private Equity	13.00	7.28
Treasury	5.00	0.27
Mortgage-backed Securities	5.00	0.50
Investment Grade Corporates	10.00	1.56
High Yield	5.00	2.27
Emerging Market Debt	5.00	2.48
Private Debt	5.00	3.57
Real Assets	15.00	3.21
Leverage	(5.00)	(0.59)
Total	100.00 %	

(a) An expected inflation of 2.30% used for this period.
(b) Figures are based on the 2021-22 Asset Liability Management study.

Detailed information about the pension fund's fiduciary net position is available in the separately issued CalPERS comprehensive annual financial report which may be obtained by contacting CalPERS.

EASTERN SIERRA TRANSIT AUTHORITY
NOTES TO THE FINANCIAL STATEMENTS
JUNE 30, 2023

NOTE 5 EMPLOYEES' RETIREMENT PLAN (DEFINED BENEFIT PLAN) (CONTINUED)

Net Pension Liability

At June 30, 2023, ESTA had a liability (asset) of $598,064 in the statement of net position for its proportionate share of the net pension liability (asset). The net pension liability (asset) was measured as of June 30, 2022 and the total pension liability used to calculate the net pension liability (asset) was determined by an actuarial valuation as of June 30, 2021. ESTA's proportion of the net pension liability (asset) was based on a projection of ESTA's long-term share of contributions to the pension plan relative to the projected contributions of all pension plan participants, which was actuarially determined. The proportionate share of the Net Pension Liability for ESTA to the total pool at June 30, 2022 was (0.02701%), an increase of 0.00397% from the prior year.

Sensitivity of Net Pension Liability to Changes in the Discount Rate

The following presents the net pension liability of ESTA's proportionate share of the Plan as of the measurement date calculated using the discount rate of 6.90%, as well as what the net pension liability would be if it were calculated using a discount rate that is one percentage point lower (5.90%) or one percentage point higher (7.90%) than the current rate.

	1% Decrease 5.90%	Discount Rate 6.90%	1% Increase 7.90%
ESTA's Proportionate Share of the Net Pension PlanLiability (Asset)	$ 1,387,838	$ 598,064	$ (51,725)

Pension Expense and Deferred Outflows/Inflows of Resources Related to Pensions

Pension expense represents the change in the net pension liability during the measurement period, adjusted by actual contributions and the deferred recognition of changes in investment gain/loss, actuarial gain/loss, actuarial assumptions or method, and plan benefits. During the year ended June 30, 2023, ESTA recognized a pension expense of $863,107. At June 30, 2023, ESTA reported deferred outflows of resources and deferred inflows of resources related to pension from the following sources.

	Deferred Outflows of Resources	Deferred Inflows of Resources
Changes in Assumptions	$ 61,284	$ -
Differences between Expected and Actual Experience	3,966	-
Net Difference between Projected and Actual Investment Earnings	109,549	-
Differences between Employer Contributions and Proportionate Share of Contributions	-	140,333
Change in Authority's Proportion	482,434	
Pension Contributions Made Subsequent to Measurement Date	166,514	-
Total	$ 823,747	$ 140,333

EASTERN SIERRA TRANSIT AUTHORITY
NOTES TO THE FINANCIAL STATEMENTS
JUNE 30, 2023

NOTE 5 EMPLOYEES' RETIREMENT PLAN (DEFINED BENEFIT PLAN) (CONTINUED)

Pension Expense and Deferred Outflows/Inflows of Resources Related to Pensions (Continued)

The $166,514 reported as deferred outflows of resources related to contributions subsequent to the June 30, 2022, measurement date will be recognized as a reduction of the net pension liability in the year ending June 30, 2024. Other amounts reported as deferred outflows of resources and deferred inflows of resources related to pensions will be recognized in pension expenses as follows:

Year Ending June 30,	Amount
2024	$ 187,728
2025	165,067
2026	97,101
2027	67,004
Total	$ 516,900

NOTE 6 OTHER POST EMPLOYMENT BENEFITS PLAN

Plan Description

Plan Administration. ESTA sponsors healthcare coverage under the California Public Employees Medical and Hospital Care Act (PEMHCA), commonly referred to as PERS Health. PEMHCA provides health insurance through a variety of Health Maintenance Organization (HMO) and Preferred Provider Organization (PPO) options.

Benefits Provided. Employees hired before January 1, 2013 are eligible for ESTA-paid retiree medical benefits upon attainment of age 50, and five years CalPERS service. Employees hired on or after January 1, 2013 are eligible for ESTA-paid retiree medical benefits upon attainment of age 52, and five years CalPERS service.

ESTA contributes the PEMHCA minimum under the unequal method (5% times number of years ESTA has been in PEMHCA). ESTA joined PEMHCA in 2007, therefore for 2022, this amount is 65% of the PEMHCA minimum ($149), or $96.85 per month. In 2023, this amount is 70% of the PEMHCA minimum ($151), or $105.70 per month. In addition to the PEMHCA minimum, ESTA pays administrative fees of 0.24% per premium. Also, survivor benefits are available.

Plan membership. At July 1, 2021, membership consisted of the following:

Inactive Plan Members or Beneficiaries Currently Receiving Benefit Payments	2
Active Plan Members	45

Contributions – ESTA made contributions of $74,054 during the year ended June 30, 2023

EASTERN SIERRA TRANSIT AUTHORITY
NOTES TO THE FINANCIAL STATEMENTS
JUNE 30, 2023

NOTE 6 OTHER POST EMPLOYMENT BENEFITS PLAN (CONTINUED)

Net OPEB Liability

ESTA's net OPEB Liability was measured as of June 30, 2022 and the net OPEB Liability used to calculate the net OPEB Liability was determined by an actuarial valuation as of July 1, 2021. Standard actuarial update procedures were used to project/discount from valuation to measurement dates.

Actuarial Assumptions

The net OPEB liability was determined using the following actuarial assumptions, applied to all periods included in the measurement, unless otherwise specified:

Salary Increases	3.00%
Medical Cost Trend Rate	5.8% (increase effective January 1, 2023 and grade down to 3.9% for years 2076 and later years
Inflation Rate	2.5%

Mortality rates were based on the CalPERS 2021 experience study adding the MacLeod Watts Scale 2022 as a mortality improvement scale.

Discount rate. GASB 75 requires a discount rate that reflects the following:

a) The long-term expected rate of return on OPEB plan investments – to the extent that the OPEB plan's fiduciary net position (if any) is projected to be sufficient to make projected benefit payments and assets are expected to be invested using a strategy to achieve that return;
b) A yield or index rate for 20-year, tax-exempt general obligation municipal bonds with an average rating of AA/Aa or higher – to the extent that the conditions in (a) are not met.

To determine a resulting single (blended) rate, the amount of the plan's projected fiduciary net position (if any) and the amount of projected benefit payments is compared in each period of projected benefit payments. The discount rate used to measure ESTA's net OPEB liability is based on these requirements and the following information:

Reporting Date	Measurement Date	Municipal Bond 20-Year High Grade Rate Index	Discount Rate
June 30, 2022	June 30, 2021	3.69%	3.75%

The discount rate was increased by 1.8% from the prior year discount rate of 1.95%.

EASTERN SIERRA TRANSIT AUTHORITY
NOTES TO THE FINANCIAL STATEMENTS
JUNE 30, 2023

NOTE 6 OTHER POST EMPLOYMENT BENEFITS PLAN (CONTINUED)

Changes in the Net OPEB Liability

The table below shows the changes in the Total OPEB Liability, the Plan Fiduciary Net Position, and the Net OPEB liability as of the measurement date June 30, 2022.

	Increase (Decrease)		
	Total OPEB Liability	Plan Fiduciary Net Position	Net OPEB Liability
Balance - July 1, 2022	$ 513,088	$ 43,987	$ 469,101
Change in the Year:			
Service Cost	112,504	-	112,504
Interest on Total OPEB Liability	12,104	-	12,104
Difference Between Expected and Actual Experience	-	(15,347)	(15,347)
Changes of Assumptions	(134,933)	-	(134,933)
Benefit Payments[1]	(9,753)	(9,753)	-
Contributions - Employer	-	69,292	(69,292)
Net Investment Income	-	3,467	3,467
Net Changes	(20,078)	47,659	(91,497)
Balance - June 30, 2023	$ 493,010	$ 91,646	$ 401,364

[1] Amount includes implicit subsidy associated with benefits paid.

Sensitivity of the Net OPEB Liability to Changes in the Discount Rate

The following presents the net OPEB liability of ESTA, as well as what ESTA's net OPEB liability would be if it were calculated using a discount rate that is one percentage point lower or one percentage point higher than the current discount rate.

	1% Decrease 2.75%	Discount Rate 3.75%	1% Increase 4.75%
Net OPEB Liability	$ 470,242	$ 401,364	$ 344,815

The following presents the net OPEB liability of ESTA, as well as what ESTA's net OPEB liability would be if it were calculated using healthcare cost trend rates that are one percentage point lower or one percentage point higher than the current healthcare cost trend rates.

	1% Decrease 4.80%	Trend Rate 5.80%	1% Increase 6.80%
Net OPEB Liability	$ 325,980	$ 401,364	$ 495,791

EASTERN SIERRA TRANSIT AUTHORITY
NOTES TO THE FINANCIAL STATEMENTS
JUNE 30, 2023

NOTE 6 OTHER POST EMPLOYMENT BENEFITS PLAN (CONTINUED)

OPEB Expense, Deferred Outflows and Deferred Inflows of Resources Related to OPEB

For the year ended June 30, 2023, ESTA recognized OPEB expense (credit) of ($92,848). OPEB expense (credit) represents the change in the net OPEB liability during the measurement period, adjusted for actual contributions and the deferred recognition of changes in actuarial assumptions or method. At June 30, 2023, ESTA reported deferred outflows of resources and deferred inflows of resources related to OPEB from the following sources:

	Deferred Outflows of Resources	Deferred Inflows of Resources
Employer Contributions Made Subsequent to the Measurement Date	$ 74,054	$ -
Change in Assumptions	56,483	328,719
Difference Between Expected and Actual Experience	-	384,587
Difference Between Projected and Actual Earnings	12,252	-
Total	$ 142,789	$ 713,306

The $74,054 reported as deferred outflows of resources related to contributions subsequent to the June 30, 2022 measurement date will be recognized as a reduction of the net OPEB liability in the fiscal year ending June 30, 2024. Other amounts reported as deferred outflows of resources and deferred inflows of resources related to OPEB will be recognized as OPEB expense as follows:

Year Ending June 30,	Amount
2023	$ (107,607)
2024	(111,227)
2025	(128,354)
2026	(132,214)
2027	(135,285)
Thereafter	(29,884)
Total	$ (644,571)

EASTERN SIERRA TRANSIT AUTHORITY
REQUIRED SUPPLEMENTARY INFORMATION
LAST TEN MEASUREMENT DATES

Other Postemployment Benefits Plan (OPEB)
Schedule of Changes in the Net OPEB Liability and Related Ratios

Last 10 Fiscal Years*

	FY2018	FY2019	FY2020	FY2021	FY2022	FY2023
Total OPEB Liability						
Service Cost	$ 74,075	$ 76,297	$ 131,215	$ 147,791	$ 174,252	$ 112,504
Interest	16,306	19,066	28,599	31,389	31,985	12,104
Actual and Expected Experience Difference	-	-	(17,416)	-	(530,397)	-
Changes of Assumptions	-	(40,212)	60,271	100,632	(292,491)	(134,933)
Benefit Payments	(2,116)	(2,294)	(8,699)	(4,151)	(3,028)	(9,753)
Net Changes in Total OPEB Liability	88,265	52,857	193,970	275,661	(619,679)	(20,078)
Total OPEB Liability - Beginning	522,014	610,279	663,136	857,106	1,132,767	513,088
Total OPEB Liability - Ending (a)	$ 610,279	$ 663,136	$ 857,106	$ 1,132,767	$ 513,088	$ 493,010
Plan Fiduciary Net Position						
Contributions - Employer	$ 2,116	$ 2,294	$ 8,699	$ 4,151	$ 46,441	$ 69,292
Difference Between Actual and Expected Experience	-	-	-	-	-	(15,347)
Net Investment Income	-	-	-	-	574	3,467
Benefit Payments	(2,116)	(2,294)	(8,699)	(4,151)	(3,028)	(9,753)
Net Change in Plan Fiduciary Net Position	-	-	-	-	43,987	47,659
Plan Fiduciary Net Position - Beginning	-	-	-	-	-	43,987
Plan Fiduciary Net Position - Ending (b)	$ -	$ -	$ -	$ -	$ 43,987	$ 91,646
ESTA's Net OPEB Liability - Ending (a) - (b)	$ 610,279	$ 663,136	$ 857,106	$ 1,132,767	$ 469,101	$ 401,364
Plan Fiduciary Net Position as a Percentage of the Total OPEB Liability	0.00%	0.00%	0.00%	0.00%	9.38%	22.83%
Covered Employee Payroll	$ 1,285,438	$ 1,469,433	$ 1,507,323	$ 1,361,712	$ 1,758,682	$ 1,729,761
ESTA's Net OPEB Liability as a Percentage of Covered Employee Payroll	47.48%	45.13%	56.86%	83.19%	26.67%	23.20%
Measurement Date	6/30/2017	6/30/2018	6/30/2019	6/30/2020	6/30/2021	6/30/2022

EASTERN SIERRA TRANSIT AUTHORITY
REQUIRED SUPPLEMENTARY INFORMATION
YEAR ENDED JUNE 30, 2023

Schedule of ESTA's Proportionate Share of the Net Pension Liability (Last 10 Measurement Periods*)

Measurement Date	ESTA's Proportion of the Net Pension Liability (Asset)	ESTA's Proportionate Share of the Net Pension Liability (Asset)	ESTA's Covered Payroll	ESTA's Net Pension Liability (Asset) as a Percentage of Covered Payroll	Plan Fiduciary Net Position as a Percentage of the Total Pension Liability
2014	Varies by plan	$ 413,616	$ 1,366,206	30.27 %	79.87 %
2015	0.0166 %	387,894	1,582,603	24.51	83.27
2016	0.0156 %	540,971	1,517,088	35.66	80.22
2017	0.0038 %	149,988	1,296,176	11.57	75.39
2018	0.0033 %	122,894	1,285,439	9.56	77.69
2019	0.0055 %	218,344	1,469,433	14.86	77.69
2020	0.0080 %	338,982	1,507,323	22.49	77.73
2021	(0.0162)%	(308,047)	1,758,682	(17.52)	90.49
2022	0.0128 %	598,064	1,793,856	33.34	78.19

CalPERS — Schedule of ESTA Contributions (Last 10 Fiscal Years*)

Fiscal Year	Actuarially Determined Contribution	Total Actual Contributions	Contribution Deficiency (Excess)	ESTA's Covered Payroll	Contributions as a Percentage of Covered Payroll
2015	$ 183,362	(183,362)	$ -	$ 1,582,603	11.59 %
2016	209,515	(209,515)	-	1,517,088	13.81
2017	227,073	(690,642)	(463,569)	1,296,176	53.28
2018	190,183	(190,183)	-	1,285,439	14.80
2019	123,337	(123,337)	-	1,469,433	8.39
2020	137,639	(137,639)	-	1,507,323	9.13
2021	134,640	(134,640)	-	1,758,682	7.66
2022	142,375	(142,375)	-	1,793,856	7.94
2023	166,512	(166,512)	-	1,729,761	9.63

*Amounts presented above were determined as of 6/30. Additional years will be presented as they become available.

EASTERN SIERRA TRANSIT AUTHORITY
SCHEDULE OF EXPENDITURES OF FEDERAL AWARDS
YEAR ENDED JUNE 30, 2023

Federal Grantor/Pass-Through Grantor/Program Title	Federal Assistance Listing Number	Pass-Through Entity Identifying Number	Disbursements/ Expenditures	Expenditures to Subrecipients
U.S. Department of Transportation				
Passed through National Rural Transit Program:				
Community Rides Grant Program	20.509	-	$ 33,303	$ -
Passed through CalTrans:				
FTA Section 5311 Formula Grants for Rural Areas	20.509	-	267,594	-
FTA Section 5311 (f) Intercity Bus Program	20.509	-	230,775	-
COVID-19 AARPA Operating Assistance(FTA 5311)	20.509	-	239,000	-
COVID-19 Relief and Economic Security Act (CARES Act) Funding (FTA 5311(f))	20.509	-	146,797	-
Subtotal ALN 20.509			917,469	-
Strategic Partnerships-Transit FTA 5304	20.505	-	60,222	-
FTA Section 5310 Enhanced Mobility of Seniors and Individuals with Disabilities	20.513	-	21,886	-
FTA Section 5339 Grants for Buses and Bus Facilities Formula Program	20.526	-	189,167	-
Total U.S. Department of Transportation			1,188,744	-
Total Expenditures of Federal Awards			$ 1,188,744	$ -

See accompanying Notes to Schedule of Expenditures of Federal Awards.

EASTERN SIERRA TRANSIT AUTHORITY
NOTES TO THE SCHEDULE OF EXPENDITURES OF FEDERAL AWARDS
YEAR ENDED JUNE 30, 2021

NOTE 1 REPORTING ENTITY

The accompanying Schedule of Expenditures of Federal Awards presents the activity of all federal awards programs of the Eastern Sierra Transit Authority (the Authority). The Authority's reporting entity is defined in Note 1 to the basic financial statements. All federal awards received directly from federal agencies as well as federal awards passed through other government agencies are included in the schedule.

NOTE 2 BASIS OF PRESENTATION

The accompanying Schedule of Expenditures of Federal Awards is prepared on the accrual basis of accounting. Such expenditures are recognized following the cost principles contained in the Uniform Guidance, wherein certain types of expenditures are not allowable or are limited to reimbursement. Because the Schedule presents only a selected portion of the operations of the Authority, it is not intended to and does not present the financial position, changes in net position, or cashflows of the Authority.

NOTE 3 INDIRECT COST RATE

The Authority elected not to use the 10% de minimis indirect cost rate as allowed in 2 CFR§200.414.

NOTE 4 PASS-THROUGH ENTITIES' IDENTIFYING NUMBER

When federal awards were received from a pass-through entity, the schedule of expenditures of federal awards shows, if available, the identifying number assigned by the pass-through entity. When no identifying number is shown, the Authority determined that no identifying number is assigned for the program or the Authority was unable to obtain an identifying number from the pass-through entity.

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INDEPENDENT AUDITORS' REPORT ON INTERNAL CONTROL OVER FINANCIAL REPORTING AND ON COMPLIANCE AND OTHER MATTERS BASED ON AN AUDIT OF FINANCIAL STATEMENTS PERFORMED IN ACCORDANCE WITH *GOVERNMENT AUDITING STANDARDS*

Board of Directors
Eastern Sierra Transit Authority
Bishop, California

We have audited, in accordance with the auditing standards generally accepted in the United States of America and the standards applicable to financial audits contained in *Government Auditing Standards* issued by the Comptroller General of the United States, the financial statements of the business-type activities of Eastern Sierra Transit Authority (ESTA), as of and for the year ended June 30, 2023, and the related notes to the financial statements, and have issued our report thereon dated January 19, 2024.

Report on Internal Control Over Financial Reporting

In planning and performing our audit of the financial statements, we considered ESTA's internal control over financial reporting (internal control) as a basis for designing audit procedures that are appropriate in the circumstances for the purpose of expressing our opinion on the financial statements, but not for the purpose of expressing an opinion on the effectiveness of ESTA's internal control. Accordingly, we do not express an opinion on the effectiveness of ESTA's internal control.

A *deficiency in internal control* exists when the design or operation of a control does not allow management or employees, in the normal course of performing their assigned functions, to prevent, or detect and correct, misstatements on a timely basis. A *material weakness* is a deficiency, or a combination of deficiencies, in internal control, such that there is a reasonable possibility that a material misstatement of the entity's financial statements will not be prevented, or detected and corrected, on a timely basis. A *significant deficiency* is a deficiency, or a combination of deficiencies, in internal control that is less severe than a material weakness, yet important enough to merit attention by those charged with governance.

Our consideration of internal control was for the limited purpose described in the first paragraph of this section and was not designed to identify all deficiencies in internal control that might be material weaknesses or significant deficiencies. Given these limitations, during our audit we did not identify any deficiencies in internal control that we consider to be material weaknesses. However, material weaknesses or significant deficiencies may exist that were not identified.

Board of Directors
Eastern Sierra Transit Authority

Report on Compliance and Other Matters

As part of obtaining reasonable assurance about whether ESTA's financial statements are free from material misstatement, we performed tests of its compliance with certain provisions of laws, regulations, contracts, and grant agreements, noncompliance with which could have a direct and material effect on the financial statements. However, providing an opinion on compliance with those provisions was not an objective of our audit, and accordingly, we do not express such an opinion. The results of our tests disclosed no instances of noncompliance or other matters that are required to be reported under *Government Auditing Standards.*

Purpose of This Report

The purpose of this report is solely to describe the scope of our testing of internal control and compliance and the results of that testing, and not to provide an opinion on the effectiveness of the entity's internal control or on compliance. This report is an integral part of an audit performed in accordance with *Government Auditing Standards* in considering the entity's internal control and compliance. Accordingly, this communication is not suitable for any other purpose.

CliftonLarsonAllen LLP

CliftonLarsonAllen LLP

Roseville, California
January 19, 2024

CliftonLarsonAllen LLP
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REPORT ON COMPLIANCE OVER FINANCIAL REPORTING BASED ON AN AUDIT OF FINANCIAL STATEMENTS PERFORMED IN ACCORDANCE WITH THE STATUTES, RULES, AND REGULATIONS OF THE CALIFORNIA TRANSPORTATION DEVELOPMENT ACT AND THE ALLOCATION INSTRUCTIONS AND RESOLUTIONS OF THE LOCAL TRANSPORTATION COMMISSION

Board of Directors
Eastern Sierra Transit Authority
Bishop, California

We have audited the financial statements of Eastern Sierra Transit Authority (ESTA) as of and for the year ended June 30, 2023 and have issued our report thereon dated January 19, 2024. We conducted our audit in accordance with auditing standards generally accepted in the United States of America and the standards applicable to financial audits contained in *Government Auditing Standards*, issued by the Comptroller General of the United States.

As part of obtaining reasonable assurance about whether ESTA's financial statements are free from material misstatement, we performed tests of its compliance with certain provisions of laws, regulations, contracts and grants, noncompliance with which could have a direct and material effect on the financial statements. Additionally, we performed tests to determine that allocations made and expenditures paid by the Mono County Local Transportation Commission and Inyo County Transportation Commission were made in accordance with the allocation instructions and resolutions of the Commission and in conformance with the California Transportation Development Act. Specifically, we performed each of the specific tasks identified in the California Code of Regulations Section 6667 that are applicable to ESTA. In connection with our audit, nothing came to our attention that caused us to believe the Eastern Sierra Transit Authority failed to comply with the Statutes, Rules, and Regulations of the California Transportation Development Act and the allocation instructions and resolutions of the Local Transportation Commission. However, providing an opinion on compliance with those provisions was not an objective of our audit and, accordingly, we do not express such an opinion.

This report is intended solely for the information and use of Eastern Sierra Transit Authority, the Mono County Local Transportation Commission, the Inyo County Local Transportation Commission, management, the California Department of Transportation, and the State Controller's Office and is not intended to be, and should not be, used by anyone other than these specified parties.

CliftonLarsonAllen LLP

CliftonLarsonAllen LLP

Roseville, California
January 19, 2024

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INDEPENDENT AUDITORS' REPORT ON COMPLIANCE FOR EACH MAJOR FEDERAL PROGRAM AND REPORT ON INTERNAL CONTROL OVER COMPLIANCE REQUIRED BY THE UNIFORM GUIDANCE

Board of Directors
Eastern Sierra Transit Authority
Bishop, California

Report on Compliance for Major Federal Program

Opinion on Each Major Federal Program

We have audited Eastern Sierra Transit Authority (ESTA) compliance with the types of compliance requirements described in the U.S. Office of Management and Budget (OMB) Compliance Supplement that could have a direct and material effect on ESTA's major federal program for the year ended June 30, 2023. ESTA's major federal program is identified in the summary of auditor's results section of the accompanying schedule of findings and questioned costs.

In our opinion, ESTA complied, in all material respects, with the compliance requirements referred to above that could have a direct and material effect on its major federal program for the year ended June 30, 2023.

Basis for Opinion on Each Major Federal Program

We conducted our audit of compliance in accordance with auditing standards generally accepted in the United States of America (GAAS); the standards applicable to financial audits contained in *Government Auditing Standards* issued by the Comptroller General of the United States; and the audit requirements of Title 2 U.S. *Code of Federal Regulations* Part 200, *Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards* (Uniform Guidance). Our responsibilities under those standards and the Uniform Guidance are further described in the Auditors' Responsibilities for the Audit of Compliance section of our report.

We are required to be independent of ESTA and to meet our other ethical responsibilities, in accordance with relevant ethical requirements relating to our audit. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion on compliance for each major federal program. Our audit does not provide a legal determination of ESTA's compliance with the compliance requirements referred to above.

Responsibilities of Management for Compliance

Management is responsible for compliance with the requirements referred to above and for the design, implementation, and maintenance of effective internal control over compliance with the requirements of laws, statutes, regulations, rules and provisions of contracts or grant agreements applicable to ESTA's federal programs.

Auditors' Responsibilities for the Audit of Compliance

Our objectives are to obtain reasonable assurance about whether material noncompliance with the compliance requirements referred to above occurred, whether due to fraud or error, and express an opinion on Eastern Sierra Transit Authority's compliance based on our audit. Reasonable assurance is a high level of assurance but is not absolute assurance and therefore is not a guarantee that an audit conducted in accordance with GAAS, *Government Auditing Standards*, and the Uniform Guidance will always detect material noncompliance when it exists. The risk of not detecting material noncompliance resulting from fraud is higher than for that resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control. Noncompliance with the compliance requirements referred to above is considered material if there is a substantial likelihood that, individually or in the aggregate, it would influence the judgment made by a reasonable user of the report on compliance about ESTA's compliance with the requirements of each major federal program as a whole.

In performing an audit in accordance with GAAS, *Government Auditing Standards*, and the Uniform Guidance, we:

- exercise professional judgment and maintain professional skepticism throughout the audit.
- identify and assess the risks of material noncompliance, whether due to fraud or error, and design and perform audit procedures responsive to those risks. Such procedures include examining, on a test basis, evidence regarding ESTA's compliance with the compliance requirements referred to above and performing such other procedures as we considered necessary in the circumstances.
- obtain an understanding of ESTA's internal control over compliance relevant to the audit in order to design audit procedures that are appropriate in the circumstances and to test and report on internal control over compliance in accordance with the Uniform Guidance, but not for the purpose of expressing an opinion on the effectiveness of ESTA's internal control over compliance. Accordingly, no such opinion is expressed.

We are required to communicate with those charged with governance regarding, among other matters, the planned scope and timing of the audit and any significant deficiencies and material weaknesses in internal control over compliance that we identified during the audit.

Report on Internal Control Over Compliance

A *deficiency in internal control over compliance* exists when the design or operation of a control over compliance does not allow management or employees, in the normal course of performing their assigned functions, to prevent, or detect and correct, noncompliance with a type of compliance requirement of a federal program on a timely basis. A *material weakness in internal control over compliance* is a deficiency, or a combination of deficiencies, in internal control over compliance, such that there is a reasonable possibility that material noncompliance with a type of compliance requirement of a federal program will not be prevented, or detected and corrected, on a timely basis. A *significant deficiency in internal control over compliance* is a deficiency, or a combination of deficiencies, in internal control over compliance with a type of compliance requirement of a federal program that is less severe than a material weakness in internal control over compliance, yet important enough to merit attention by those charged with governance.

Board of Directors
Eastern Sierra Transit Authority

Our consideration of internal control over compliance was for the limited purpose described in the Auditors' Responsibilities for the Audit of Compliance section above and was not designed to identify all deficiencies in internal control over compliance that might be material weaknesses or significant deficiencies in internal control over compliance. Given these limitations, during our audit we did not identify any deficiencies in internal control over compliance that we consider to be material weaknesses, as defined above. However, material weaknesses or significant deficiencies in internal control over compliance may exist that were not identified.

Our audit was not designed for the purpose of expressing an opinion on the effectiveness of internal control over compliance. Accordingly, no such opinion is expressed.

The purpose of this report on internal control over compliance is solely to describe the scope of our testing of internal control over compliance and the results of that testing based on the requirements of the Uniform Guidance. Accordingly, this report is not suitable for any other purpose.

CliftonLarsonAllen LLP

CliftonLarsonAllen LLP

Roseville, California
January 19, 2024

EASTERN SIERRA TRANSIT AUTHORITY
SCHEDULE OF FINDINGS AND QUESTIONED COSTS
YEAR ENDED JUNE 30, 2023

Section I – Summary of Auditors' Results

Financial Statements

1. Type of auditors' report issued: Unmodified
2. Internal control over financial reporting:
   - Material weakness(es) identified? ______ yes __x__ no
   - Significant deficiency(ies) identified? ______ yes __x__ none reported
3. Noncompliance material to financial statements noted? ______ yes __x__ no

Federal Awards

1. Internal control over major federal programs:
   - Material weakness(es) identified? ______ yes __x__ no
   - Significant deficiency(ies) identified? ______ yes __x__ none reported
2. Type of auditors' report issued on compliance for major federal programs: Unmodified
3. Any audit findings disclosed that are required to be reported in accordance with 2 CFR 200.516(a)? ______ yes __x__ no

Identification of Major Federal Programs

Assistance Listing Number	Name of Federal Program or Cluster
20.509	Formula Grants for Rural Areas

Dollar threshold used to distinguish between Type A and Type B programs: $750,000

Auditee qualified as low-risk auditee? ______ yes __x__ no

EASTERN SIERRA TRANSIT AUTHORITY
SCHEDULE OF FINDINGS AND QUESTIONED COSTS
YEAR ENDED JUNE 30, 2023

Section II – Financial Statement Findings

Our audit did not disclose any matters required to be reported in accordance with *Government Auditing Standards*.

Section III – Financial and Questioned Costs – Major Federal Programs

Our audit did not disclose any matters required to be reported in accordance with 2 CFR 200.516(a).

February 8, 2024
Item B-4

STAFF REPORT

Subject: Zero Emission Plan
Presented by: Phil Moores, Executive Director

<u>Background</u>

The **Zero Emissions Transition Plan** final draft is attahced. The report is intended to serve as guidance to comply with California's Innovative Clean Transportation (ICT) rule. An executive summary is attached. The recommendations in the study are non-binding, and as technology continues to advance, it is expected that more zero emission vehicles will come to market and suit ESTA's needs.

The report meets minimum compliance standards as mandated under ICT. Overall, the plan recommends ESTA deploys a mixed fleet of 16 battery electric vehicles and 24 hydrogen fuel cell electric vehicles. Sourcing funding will be key to ESTA's full transition of their fleet. Funding is needed for vehicles, associated infrastructure, to include upfitting existing facilities, and ensuring a stable supply of hydrogen can be procured for the ten fuel-cell vehicles recommended.

Below is the expected cost per depot; this includes vehicle procurement, charging infrastructure, electricity, hydrogen procurement, and vehicle maintenance. This does not include any potential utility infrastructure upgrades. The total cost is also shown with a Net Present Value (NPV) of 4%; this is another metric used to estimate the cost of a project over multiple years.

Depot	Total	NPV (4%)
Bishop	$10,786,008.08	$8,343,357.68
Mammoth	$24,812,208.03	$20,522,412.46
Lone Pine	$2,761,532.61	$2,260,374.08
Walker	$1,692,242.54	$1,427,874.21
Total	**$40,051,991.26**	**$32,554,018.42**

Final Report

Eastern Sierra Transit Authority Zero-Emission Bus Feasibility Study

Katrina Sutton
Bryan Lee
Mike Hynes

February 2024

Acknowledgments

The authors would like to deeply thank key CALSTART staff for their critical review of and additions to this report, including Lais Caldeira, Justin Slosky, Susan Cavan, Aditya Kushwah, Deepak Tripathi, Jared Schnader, Brian Ballschmidt, and Katrina Bayer. Any errors are the authors' own.

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Table of Contents

List of Acronyms

Acronym	Definition
AC	Alternate Current
AC Transit	Alameda-Contra Costa Transit District
AFLEET	Alternative Fuel Life-Cycle Environmental and Economic Transportation
APCD	Air Pollution Control District
AQMD	Air Quality Management District
AVTA	Antelope Valley Transit Authority
BEB	Battery-Electric Bus
BESS	Battery Energy Storage System
BTM	Behind-the-Meter
BUILD	Better Utilizing Investments to Leverage Development
CAPEX	Capital Expenditures
CARB	California Air Resources Board
CEC	California Energy Commission
CI	Carbon Intensity
CLEEN	California Lending for Energy and Environmental Needs
CCS	Combined Charging System
CMAQ	Congestion Mitigation and Air Quality
CNG	Compressed Natural Gas
CO	Carbon Monoxide

Acronym	Definition
CO2	Carbon Dioxide
CTTC	California Energy Commission
DAC	Disadvantaged Community
DAR	Dial-A-Ride
DC	Direct Current
DCFC	Direct Current Fast Charger
DEM	Digital Elevation Model
DER	Distributed Energy Resources
DGS	California Department of General Services
DOT	U.S. Department of Transportation
EnergIIZE	Energy Infrastructure Incentives for Zero-Emission Commercial Vehicles
ESTA	Eastern Sierra Transit Authority
EV	Electric Vehicle
EVITP	Electric Vehicle Infrastructure Training Program
EVSE	Electric Vehicle Supply Equipment
FCEB	Fuel Cell Electric Bus
FTA	Federal Transit Administration
FTM	Front-of-the-Meter
GBUAPCD	Great Basin Unified Air Pollution Control District
GGRF	Greenhouse Gas Reduction Fund
GHG	Greenhouse Gas

Acronym	Definition
GIS	Geographic Information System
GO-Biz	California Governor's Office of Business and Economic Development
GREET	Greenhouse gases, Regulated Emissions, and Energy use in Technologies
GTFS	General Transit Feed Specification
GVWR	Gross Vehicle Weight Rating
HDRSAM	Heavy-Duty Refueling Station Analysis Model
HVAC	Heating, Ventilation, and Air Conditioning
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project
IAAS	Infrastructure-as-a-Service
IBank	California Infrastructure and Economic Development Bank
ICE	Internal Combustion Engine
ICT	California's Innovative Clean Transit (ICT) regulation
IIJA	Infrastructure Investment and Jobs Act
ISRF	Infrastructure State Revolving Fund
ITC	Investment Tax Credit
kWh	Kilowatt-Hour
LADWP	Los Angeles Department of Water and Power
LCFS	Low Carbon Fuel Standard
LCTOP	Low Carbon Transit Operations Program
Low-No	Low or No Emissions Program
MOVES	Motor Vehicle Emission Simulator

Acronym	Definition
NFPA	National Fire Protection Association
NOx	Nitrogen Oxide
NREL	National Renewable Energy Laboratory
OCPP	Open Charge Point Protocol
OEHHA	California Office of Environmental Health Hazard Assessment
OEM	Original Equipment Manufacturer
OpenADR	Open Automated Demand Response
OPEX	Operational Expenditures
PEM	Polymer Electrolyte Membrane
PM	Particulate Matter
PPA	Power Purchase Agreement
PV	Photovoltaic
RAISE	Rebuilding American Infrastructure with Sustainability and Equity
REM	Route Energy Modeling
RFID	Radio Frequency Identification
RFP	Request for Proposal
RNG	Renewable Natural Gas
RTC Washoe	Regional Transportation Commission of Washoe County
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SARTA	Stark Area Regional Transit Authority
SCE	Southern California Edison

Acronym	Definition
SOC	State of Charge
SOx	Sodium Oxide
STURAA	Surface Transportation and Uniform Relocation Assistance Act of 1987
TCO	Total Cost of Ownership
TIGER	Transportation Investments Generating Economic Recovery
TIRCP	Transit and Intercity Rail Capital Program
TOU	Time-of-Use
VOC	Volatile Organic Compound
VW	Volkswagen
YART	Yosemite Area Regional Transit
ZE	Zero-Emission
ZEB	Zero-Emission Bus

Figures and Tables

Figures

Tables

Executive Summary

Project Overview

Eastern Sierra Transit Authority (ESTA) provides public transportation to the cities and communities in Inyo and Mono counties in California. ESTA also provides regional transit to Reno, NV and Lancaster, CA. To roll out a zero-emission bus (ZEB) fleet that will help combat climate change and improve air quality, ESTA is preparing a Transit Fleet Electrification Plan to examine the economic and technological feasibility of this transition. The study is intended to provide transit agency personnel, elected officials, and policymakers with information needed to help make decisions to achieve full deployment of ZEBs and plan in accordance with California's Innovative Clean Transit (ICT) regulation, which commences in 2026 for ESTA and mandates that all transit fleets be 100% zero-emission by 2040.

ZEB Introduction

The deployment of a ZEB fleet generates substantial environmental and health benefits for residents within a transit agency's service areas. Two ZEB technologies currently exist: the battery-electric bus (BEB), which uses electricity from a battery to power the bus, and the hydrogen fuel cell electric bus (FCEB), which uses hydrogen to produce electricity that propels the bus.

- BEBs are propelled by an electrified drivetrain, use batteries to store electricity, produce zero tailpipe emissions, and make little noise when moving. Battery technology is expected to improve over time, and BEBs may become a drop-in replacement for all internal combustion engine (ICE) bus duty cycles in the future.
- FCEBs also have an electrified drivetrain to propel the bus but instead use hydrogen to produce electricity. FCEBs have a longer range than BEBs and are generally considered to be a drop-in replacement for an ICE bus, with a refuel time of about 15-20 minutes.

Replacement Plan

The ICT regulation does not obligate ESTA to start purchasing ZEBs until 2026, and ESTA is planning to gradually roll out ZEBs per the mandate. ESTA plans to replace the current ICE fleet with ZEBs as the buses reach the end of their useful life. Many of the buses are reaching or have reached the end of their useful life and need to be replaced. A 100% ZEB fleet will occur in 2037.

Route Modeling Results

Bus route modeling for ESTA's fixed-route service showed that some BEBs cannot serve as a drop-in replacement. However, it is anticipated that in coming years technological improvements may allow for BEBs to serve as a drop-in replacement for more of the fleet. On the other hand, both FCEBs used for CALSTART's route modeling can serve as a drop-in replacement for fixed-route service because their energy capacity exceeds energy demand for each shift. All routes except for 395N and 395S can be completed with FCEBs.

Charging and Fuel Cost Consideration

The utility costs for a ZEB fleet are dependent on two main factors: energy and power. There are strategies to reduce utility charges, including overnight charging during off-peak hours, sequentially charging the fleet in different batches, and managed charging. For FCEBs, the cost of hydrogen is influenced by several factors, one of which is the location of hydrogen production. It is important to remember that electricity is a required input to produce hydrogen, and the fueling station uses electricity. The use of hydrogen fuel thus entails operational costs beyond that of the hydrogen and the fueling station.

Resiliency

Installing charging infrastructure is vital for the successful deployment of a BEB fleet. Deploying BEB chargers is more than simply installing the chargers. In addition to front-of-the-meter (FTM) utility infrastructure, electrification requires the deployment of behind-the-meter (BTM) infrastructure (on the customer's side of the meter).

ESTA faces several unique resiliency risks in their region that can disrupt utility power to bus yards. An increase in harsh climate (i.e. heat waves and blizzards) is expected as climate change progresses; these events will further increase the possibility of grid outages and damage to electrical equipment used by transit agencies. Resiliency can be obtained through FTM and BTM approaches but working with Southern California Edison (SCE) and the Los Angeles Department of Water and Power (LADWP) will be critical.

Maintenance Considerations

A number of transit agencies have reported that ZEBs have fewer moving parts and therefore fewer parts to replace, meaning the main cost of preventative care is labor and time. While transit agencies have reported some issues regarding unscheduled maintenance for BEBs, which have proved to be costly, OEMs and other transit agencies in California have reported that newer generations of buses have proven to be more reliable and have had lower maintenance costs. FCEBs are unique in that energy is provided to the battery by a fuel cell. Since FCEBs use high pressure gases, many maintenance tasks are similar to that of a compressed natural gas-powered bus. However, the fuel cell and its supporting systems introduce maintenance needs that increase the amount of required maintenance tasks and the overall maintenance cost.

ZEBs have unique systems like electric drivetrains, batteries, fuel cells, and hydrogen storage tanks that require specialized training to service effectively and operate with maximum performance.

Estimated Costs and Financial Resources

Transitioning to a ZEB fleet will be more expensive than operating an ICE fleet. CALSTART calculated the total cost of ownership (TCO) for operating ESTA's ZEB fleet to be around $5.6 million (with a 2% discount factor and over a 12-year time horizon). However, due to fluctuations in the economy, hydrogen costs can impact TCO significantly.

ESTA will need a financing strategy to transition to zero-emission. Transitioning to a ZEB fleet will require substantial financial resources, but there are myriad financing options for transit agencies to deploy ZEBs. These include state and federal incentive programs and prospective financing mechanisms, in addition to traditional financing models. The purchase of the buses will need to be financed, which can be done through various grant and funding sources to cover the incremental cost of ZEBs, or the difference between the cost of a ZEB and a fossil fuel-powered bus. Using grants to cover the incremental cost of the buses would allow ESTA to purchase ZEBs with the funding sources they normally employ to purchase ICE buses.

Greenhouse Gas Emissions

Tailpipe emissions are not the only emissions associated with the operation of buses. Buses also produce upstream emissions, which are emitted during the production of the fuel that buses use. For example, diesel must be extracted, processed, and transported to buses. The production processes of electricity and hydrogen also generate emissions. As a result, even ZEBs will produce some upstream emissions. Upstream emissions are generally emitted where the fuel is produced and not in the area where the buses operate, but greenhouse gases contribute to climate change regardless of origin. CALSTART found that all electric and hydrogen pathways produce fewer emissions than diesel.

I. Introduction to Zero-Emission Buses

Project Description

The Eastern Sierra Transit Authority (ESTA) primarily serves the cities and communities in Inyo and Mono counties in California. ESTA also provides regional transit to Reno, NV and Lancaster, CA. ESTA is preparing a Transit Fleet Electrification Plan to examine the economic and technological feasibility of rolling out a zero-emission fleet. The study will examine the transit agency's needs, as well as identify potential areas for collaboration among the nearby municipalities. This study is intended to provide elected officials and policymakers with the information needed to make decisions regarding the rollout of a fully zero-emission fleet.

ESTA Overview

Overview

ESTA has serviced the Eastern Sierra region since 2006 and provides both fixed-route service and demand response service in Bishop, Mammoth Lakes, Lone Pine, and Walker. Demand response is offered in Bishop seven days a week, Lone Pines and Mammoth Lakes on weekdays, and in the Walker area on Monday, Wednesday, Thursday, and Friday. ESTA provides seasonal (summer and winter) and year-round routes. ESTA provides transit options to key locations in the region including Reno, Carson City, Reds Meadow, and Lancaster. The Purple Line, Mammoth Lake town trolley, Reds Meadow Shuttle, and Mammoth shuttle connect with Yosemite Area Regional Transit (YART). In Reno, there is a connection to the Regional Transportation Commission of Washoe County (RTC Washoe), and in Lancaster there is connection to Antelope Valley Transit Authority (AVTA).

Currently, all 54 vehicles in the fleet have internal combustion engines; the full-sized buses are fueled with diesel, and the trolleys and the Dial-A-Ride (DAR)/shuttle vehicles vary between gasoline and diesel.

The cutaway buses are often interchanged between DAR and fixed-route service, and any zero-emission (ZE) replacement must be able to handle various duty cycles. In Bishop, ESTA is also exploring the possibility of replacing some vehicles with vans to suit their ridership and reduce driver licensing needs.

ESTA currently houses vehicles at 4 locations: 565 Airport Drive, Bishop; 210 Commerce

Drive, Mammoth; 1452 S Main Street, Lone Pine; 399 Mule Deer Road, Walker.

Fixed-Route Transit Service

The fixed-route fleet consists of a total of 34 vehicles —12 cutaway buses, 13 full-sized buses, and nine trolleys. The cutaway fleet contains four Ford E-450s, four F-550 cutaways, and four Freightliner Defenders. The full-sized bus fleet contains one Blue Bird Xcel 102, three El Dorado E-Z Rider II, and nine El Dorado Axess. The trolley fleet contains four Hometown Trolleys and five Supreme Trolleys.

Dial-A-Ride Service

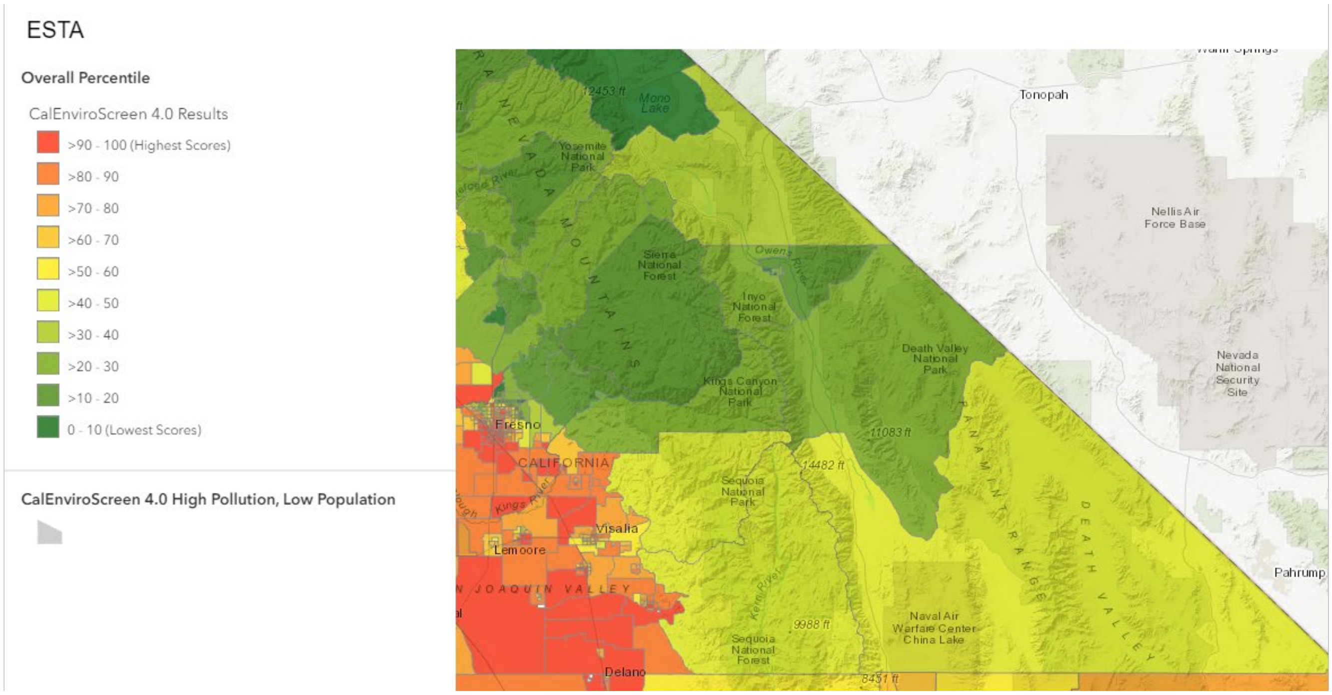
The demand response fleet consists of 10 vehicles—five Ford E-450 cutaway buses, four Daimler Sprinter vans, and one Dodge Braun van. Besides the Dodge van, the vehicles are supposed to have a useful life of seven years. At present, all of those vehicles are beyond their useful life. The fleet is reportedly larger than it needs to be, and a large spare ratio is maintained to account for additional vehicle downtime with an aging fleet and outsourced maintenance.

Overview of ZEBs

The Benefits of ZEBs

In California, most transit agencies use a fleet of buses powered by compressed natural gas (CNG). ESTA, however, uses diesel to fuel the majority of its fleet. These buses have an internal combustion engine (ICE) that burns diesel to create torque and propel the bus. The current diesel buses have proven to be reliable technology capable of handling most transit bus duty cycles. They do have several drawbacks, however, including noise pollution, tailpipe emissions, and high infrastructure costs. The diesel combustion produces carbon dioxide (CO2)—a greenhouse gas (GHG) that contributes directly to climate change—and other pollutants. One of the most potent pollutants is nitrogen oxide (NOx). NOx, when combined with heat and sunlight, produces ozone, which is harmful to the respiratory system and human health. NOx emissions are regulated by the State of California. Due to ESTA's unique region in the Sierras, it does not have a large pollution burden, as seen in the CalEnviroScreen 4.0 data (Figure 1). This designation is based on a combination of air quality, pollution, and economic metrics.

Figure 1. CalEnviroScreen 4.0 Pollution Burden Map (Source: OEHHA)



Zero-emission buses (ZEBs) are buses that produce zero tailpipe emissions and therefore do not produce any GHGs or criteria emissions during bus operations. In practical terms, a ZEB cannot use an ICE and must use an electrified drivetrain. There are currently two ZEB technologies in existence: the battery-electric bus (BEB), which uses electricity from a battery to power the bus, and the fuel cell electric bus (FCEB), which uses hydrogen to produce electricity that propels the bus. These two technologies do not produce any tailpipe GHG or Nox emissions, which helps to improve air quality. The electricity to charge the bus and the hydrogen production process do produce GHG emissions, but since the drivetrain of a ZEB is twice as efficient as that of an ICE, ZEBs produce less GHG emissions than CNG buses. ZEBs also generate less noise.

The Innovative Clean Transit Regulation

The Innovative Clean Transit (ICT) regulation issued by the California Air Resources Board (CARB) mandates that all transit agencies in California transition to ZEBs. Fleets must be 100% zero-emission by 2040, and the regulation provides a timeline for phasing in ZEB procurements. Under the ICT regulation, ESTA qualifies as a small transit agency—it operates fewer than 65 buses in annual maximum service. Small transit agencies must submit a non-binding ZEB Rollout Plan to the Executive Officer of CARB by July 1, 2023, with the following items:

a. A goal of full transition to ZEBs by 2040 with careful planning that avoids early retirement of conventional ICE buses.

b. Identification of the types of ZEB technologies a transit agency is planning to deploy, such as BEB or FCEB.

c. A schedule for construction of facilities and infrastructure modifications or upgrades, including charging, fueling, and maintenance facilities, to deploy and maintain ZEBs. This schedule must specify the general location of each facility, type of infrastructure, service capacity of infrastructure, and a timeline for construction.

d. A schedule for zero-emission and conventional ICE bus purchases and lease options. This schedule for bus purchases must identify the bus types, fuel types, and number of buses.

e. A schedule for conversion of conventional ICE buses to ZEBs, if any. This schedule for bus conversion must identify the number of buses, bus types, and the propulsion systems being removed and converted.

f. A description on how a transit agency plans to deploy ZEBs in Disadvantaged Communities (DACs) as listed in the latest version of CalEnviroScreen.[1]

g. A training plan and schedule for ZEB operators and maintenance and repair staff.

h. Identification of potential funding sources.

The ICT timeline for phasing in ZEB procurements for a small transit agency is as follows:

- By 2026: 25% of new bus purchases must be zero-emission.
- By 2029: 100% of new bus purchases must be zero-emission.

Altoona Bus Testing

The Surface Transportation and Uniform Relocation Assistance Act of 1987 (STURAA) created the Standardized Bus Testing program. The Standardized Bus Testing program, which is frequently referred to as Altoona Bus Testing, is a federal program that tests the maintainability, reliability, safety, performance, structural integrity and durability, fuel and/or energy economy, noise, and emissions from buses. Altoona Bus Testing is intended to serve as quality control and aims to ensure that new bus models can safely and reliably operate in real-world conditions. Under Altoona Bus Testing, buses are scored on a scale of 1–100 based on their performance in each of the testing categories. A bus must receive a score of 70 to pass testing. STURAA mandates that no new bus model can be acquired with federal funding without having received a passing score during Altoona Bus Testing.

[1] View the latest version of CalEnviroScreen at https://oehha.ca.gov/calenviroscreen.

Since ESTA may use federal funding toward the purchase of transit vehicles and operations, this study only examines buses that have already passed Altoona Bus Testing or are likely to begin testing in the near future.

BEBs

Battery-Electric Technology

BEBs are propelled by an electrified drivetrain and use batteries to store electricity. When the bus needs to move, it draws energy from the battery to power a traction motor. The traction motor uses magnets to generate torque and propel the bus. BEBs also have a regenerative braking system that can capture some energy from the bus when it decelerates and use it to recharge the battery during braking. BEBs produce no tailpipe emissions and are very quiet when moving. BEBs do suffer from some drawbacks, mainly that their range is constrained by how much energy can be stored in the battery. Batteries are heavy and require a lot of space. This factor puts constraints on how many batteries can be placed on the bus safely and may further limit the range of the bus. The range of the bus can be decreased if ridership is high, which increases the weight of the bus, or if the bus must gain elevation on its routes. The heating, ventilation, and air conditioning (HVAC) systems are also energy intensive and in temperature extremes can consume more energy than the propulsion system itself. This can reduce the range of the bus on days that are very hot or cold. Lastly, driver behavior can have a large impact on the range of the bus. BEBs are designed to be driven in a certain manner, and bus operators must receive driver training to properly drive the buses. Deviations from this training will impact the bus's performance. Consequently, BEBs cannot serve as a "drop-in" or a one-to-one replacement for a CNG bus for some cycles/routes. This problem is exacerbated by battery charge time. While a CNG bus can be fully refueled in minutes, a BEB can take hours to fully recharge.

Appendix C: Zero-Emission Bus Specifications provides an overview of some of the relevant BEBs currently on the market, and more information on charging technology can be found in the Charging Infrastructure section and Appendix D: Charging Infrastructure Specifications.

Transit BEBs

Classified in the Federal Transit Administration's (FTA's) 12-year/500,000-mile service-life category, transit buses are Class 7 or 8 vehicles, typically used for fixed-route service, and generally range between 30 and 40 feet in length. A transit BEB is a battery-powered bus that has a length of 30 feet or more. Transit BEBs are considered a mature technology. Multiple BEB models have passed Altoona Bus Testing, and there are several original equipment manufacturers (OEMs) that produce and sell transit BEBs. Articulated 60-foot ZEB models, which have two sections connected by a joint and can be up to 60 feet in length, have also been Altoona-tested. As of September 2022, there were 5,480 transit BEBs that have been purchased, are on order, or deployed across the United States (Chard, 2023).

Transit BEBs generally have a range of up to 225 miles, depending on the duty cycle. CNG buses, on the other hand, have a range of about 350 miles. The lower range of the BEB may require additional vehicles to provide the same level of service, depending on the duty cycle. Battery technology is expected to improve over time, however, and it is possible that a BEB can become a drop-in replacement for a CNG bus in the future. BEB charging technology and infrastructure will be discussed further in the Charging Infrastructure section.

Battery-Electric Shuttle Bus and Transit Vans

A battery-electric shuttle bus (also commonly referred to as a small bus) is classified in the FTA's 5-year/150,000-mile or 7-year/200,000-mile service-life category and is defined as a battery-powered cutaway bus with a length of less than 30 feet and a gross vehicle weight rating (GVWR) of greater than 14,000 pounds (lbs.). Shuttle buses are generally medium-duty Class 4-6 buses. These buses are typically used for demand response service and have a wheelchair lift to serve disabled passengers. Most shuttle buses can carry 19-24 passengers. OEMs also have the ability to customize configurations based on transit needs, such as changing the floorplan and adding equipment such as fareboxes and wheelchair lifts. Battery-electric transit vans have recently been introduced to the market. These vehicles are smaller than shuttle buses and can typically carry fewer than 10 passengers.

A few OEMs offer electric shuttle buses of varying battery pack sizes, vehicle lengths, and options. As of September 2022, 876 battery-electric shuttle buses have been purchased, are on order, or deployed across the United States (Chard, 2023).

Battery-electric shuttle buses generally have a range of up to 150 miles, depending on the duty cycle, and cost about $275,000. Fossil fuel-powered counterparts, on average, have a range of 350 miles and cost around $75,000. Again, additional vehicles may be required to provide the same level of service, depending on the duty cycle, but battery technology continues to improve. By the time ESTA is subject to the ICT regulation, shuttle buses will likely have a longer range. The market for transit vans is expected to grow, and there will likely be more commercial offerings in the coming years.

FCEBs

Fuel Cell Electric Technology

FCEBs use an electrified drivetrain to propel the bus, but unlike BEBs, FCEBs use gaseous hydrogen to produce electricity. When the bus needs to move, hydrogen is drawn from the bus's hydrogen tank and processed through a fuel cell to produce electricity. This electricity is stored in a battery until it is sent to the traction motor to generate torque and propel the bus. Since gaseous hydrogen has low energy density per volume, hydrogen must be compressed into the storage tank. The compression process allows more hydrogen to be stored in the tank. Fuel cell electric vehicles typically store hydrogen in their tanks at a pressure of 350 bar (5,000 lbs. per square inch) or 700 bar (10,000 lbs. per square inch). FCEBs use hydrogen compressed to a pressure of 350 bar. The tanks on a bus typically store 50 kilograms (kg) of hydrogen, 90-95% of which can be used. An FCEB has the advantage of a longer range than a BEB. Since hydrogen is energy dense and lightweight, the hydrogen tanks can store more energy on the bus than a battery. FCEBs are generally considered to be a drop-in replacement for a CNG bus. In addition, an FCEB can refuel quickly in about 15-20 minutes. While FCEBs must also contend with the HVAC, ridership, and driver behavior problems that BEBs face, these tend to be less severe due to FCEBs' ability to store more energy. While FCEBs have these advantages, FCEBs currently cost more than BEBs and must use hydrogen, which is more expensive than CNG and unleaded fuel and has unique challenges in obtaining/producing it.

Transit Fuel Cell Electric Buses

A transit FCEB is a hydrogen fuel cell-powered bus that has a length of greater than 30 feet and, like transit BEBs, is a Class 7 or 8 vehicle, classified in the FTA's 12 year/500,000-mile service-life category, and typically used for fixed-route service. Most current FCEB models have a length of 35-40 feet. At the time of writing, there is no Altoona-tested 30-foot FCEB model, but 60-foot articulated models have been Altoona-tested. Transit FCEBs are considered a mature technology, but to date there are fewer commercial offerings for transit FCEBs than BEBs; however, this is anticipated to change. As of this writing, two models of FCEBs have passed Altoona Bus Testing. As of September 2022, there were 211 transit FCEBs that have been purchased, are on order, or deployed across the United States (Chard, 2023). Transit FCEBs generally have a range of up to 300 miles, depending on the duty cycle. Since transit FCEBs have a longer range, they are generally considered to be a drop-in replacement for a fossil fuel bus.

Fuel Cell Electric Shuttle Buses

A hydrogen fuel cell electric shuttle bus is defined as a hydrogen fuel cell cutaway bus with a length of less than 30 feet, a GVWR of greater than 14,000 lbs., and is classified in the FTA's 5-year/150,000 mile or 7-year/200,000-mile service-life category. Similar to shuttle BEBs, fuel cell electric shuttle buses are generally medium-duty Class 4-6 buses, typically used for demand response service, have a wheelchair lift to serve disabled passengers, and can carry 19-24 passengers, depending on the floorplan configuration.

The market for fuel cell electric shuttle buses is less developed than battery-electric shuttle buses, with fewer models of fuel cell electric shuttle buses currently available. Fuel cell electric shuttle buses are also at an earlier stage of commercialization and have a lower technology readiness level than battery-electric shuttle buses. As of September 2022, only nine fuel cell electric shuttle buses have been purchased, are on order, or deployed across the United States (Chard, 2023). It is unclear how mature this technology will be and how many vehicle options will be available by 2026, when ESTA must begin purchasing ZEBs under the ICT regulation.

Fuel cell electric shuttle buses generally have a range of 230 miles and cost around $275,000. Data on the cost of a fuel cell electric shuttle bus is scarce. However, cost data from pilot/demo fuel cell electric shuttle buses indicates that the price is approximately equal to a battery-electric shuttle bus. Fossil fuel-powered counterparts have a range of 350 miles and cost around $75,000. Since fuel cell electric buses have a longer range than BEBs, they are closer to serving as a drop-in replacement. Both full-sized and shuttle FCEBs refuel at 350 bar, but the filling speed may have to be adjusted for the shuttle buses to maintain hydrogen tank integrity. Hydrogen fueling challenges are discussed in more detail under Hydrogen Fueling Infrastructure Overview.

Charging Infrastructure for Electric Buses

Depot Plug-in Charging

Most electric buses are charged using a plug-in charger, which consists of the dispenser and a charging cabinet. The dispenser has a plug that connects with the bus to provide energy to charge the battery, and the plug connects to the dispenser via a hose. The dispenser is then connected to the charging cabinet, which contains the power electronics and communications equipment used to control charging with the bus and to communicate with the charging provider's network. The most common current technology requires workers to manually plug in the bus when it returns from its route, but wireless technology is gaining maturity and acceptance. The communications protocols between vehicle and charger can vary among BEB OEMs (see Charger Interoperability section for additional details).

Buses can be charged with Level 2 chargers or direct current fast chargers (DCFC). A Level 2 charger delivers alternate current (AC) power to the bus at voltages of up to 240 volts (V). Level 2 chargers can deliver up to 19.2 kilowatts (kW) and are typically used to charge electric cars, vans, and shuttle buses. Buses can also be charged with a DCFC. DCFCs deliver direct current (DC) power to the bus at voltages of up to 600 V. DCFCs are typically used to charge transit buses. They can also be used to quickly charge shuttle buses.

Figure 2. Plug-in Chargers Example (Source: CALSTART)

A plug-in charging system has a large physical footprint. The charging cabinet is responsible for much of the footprint and typically requires concrete pads. Bollards are also required to protect the charging cabinets from being hit by buses or other vehicles. Some flexibility in the design/layout of a charging site does exist: The charging cabinet must typically be located within a few hundred feet of the dispenser and, as a result, the charging cabinets can be put in areas of the yard with more space (e.g., the edges). Most depots are designed with the dispensers and charging cabinets adjacent to parked buses. For example, a depot might have parking spots for the buses with a dispenser for each parking spot, as illustrated above in Figure 2. In most cases, this design is the least expensive option for charging.

Since space is a major constraint, space-saving designs can be developed. A depot can also be designed whereby the buses are parked in lanes, and the dispensers and charging cabinets are located next to the buses in between the lanes, as seen in Figure 3.

Figure 3. Buses Parked in Lanes Example (Source: ABB)

Another possible design would be overhead plug-in charging. In this design, the buses are parked in lanes and a structure is built over the parking lanes, similar to the example shown in Figure 4.

A retractable spool is installed on the overhead structure, which allows the plug to be pulled down for charging. This design does not require the charging cabinets to be located next to the bus, which is advantageous when there is not enough space in between parking lanes to install the charging cabinets or dispensers. The overhead structure can also be used for other purposes, such as housing a solar photovoltaic (PV) installation. While this design does save space, the construction cost for the overhead structure is higher because a foundation needs to be laid. Foothill Transit currently uses this design.

Figure 4. Overhead Plug-in Charging Example (Source: Burns McDonnell Foothill Transit In-Depot Charging and Planning Study)

Charger Interoperability

A key factor in plug-in charging infrastructure is charger interoperability. Charger interoperability refers to a bus charger's compatibility with multiple types of buses—if a bus charger can charge buses from multiple manufacturers, it is considered interoperable. Interoperability has multiple dimensions: the charger must be able to plug into, charge, and communicate with buses from multiple manufacturers. Since transit agencies tend to phase in their fleets over time, it is possible that a fleet will consist of buses from multiple OEMs and that chargers from multiple manufacturers will be deployed. The use of a fleet with buses from multiple OEMs and multiple types of chargers increases the risk that there will be interoperability problems. To promote interoperability, charger standards have been developed. There are several different charger standards. SAE J1772 standardizes the charging plug for Level 2 charging up to 19.2 kW. The Combined Charging System (CCS) standardizes the charging plug and offers a protocol for charging communication. CHAdeMO is a competing charging standard that offers a standard for the charging plug and charging communications. The major OEMs have adopted CCS standards.

Other interoperability concerns exist, one being that the plug-in charger must be able to communicate with vehicles via a compatible communications protocol. Another concern is whether the charger can provide either AC or DC power. The type of power the plug-in charger operates on must be the same as that of the onboard charger. Before purchasing, buses and infrastructure should be tested to ensure interoperability. For example, charging infrastructure for the shuttle BEBs and transit vans can vary. Most shuttle buses and transit vans can charge with a Level 2 charger, though many of these vehicles can also charge faster with a DCFC. The type of charger required for DC fast charging varies by OEM, and some buses must use a high voltage DCFC. It is important to purchase charging equipment that is compatible with the specific bus purchased.

Depot Overhead Charging

Buses can also be charged with an overhead pantograph charger, which is placed over the bus. When the bus parks, a radio frequency identification (RFID) sensor on the bus signals to the charger, the charger and the bus make contact, and charging begins. There are two types of pantograph chargers: a top-down charger, in which the pantograph lowers itself down to the bus to initiate charging, and a bottom-up charger, in which the pantograph is mounted on the bus and raises itself to the charger to begin charging. Pantograph chargers tend to charge at a higher power level than plug-in charging. Most overhead chargers charge at 150-200 kW, though some can charge at 450-600 kW. Most depot overhead chargers charge in the 150-200 kW range to manage utility demand chargers.

Figure 5. In-Depot Overhead Charging Example (Source: CALSTART)

An overhead pantograph charger requires an overhead structure to be built in order to mount the charger above the bus parking spots. At a very minimum, a steel structure is required. Typically, the installation of a steel structure involves building a foundation to anchor the structure. Installing the structure itself is one of the most expensive parts of the construction process, but adding additional features to the structure can be done at a relatively low incremental cost. As a result, solar panels are often installed on the structure, which provides the benefit of providing power for the facility and sheltering the bus from sunlight (to prevent heat gain) and rain. Parking lanes are also built underneath the structure, and a curb is necessary to guide the buses to align with the charger and protect the charging cabinet from collisions.

The main advantage of depot pantograph charging is that the pantographs can automatically charge the bus without workers present to manage plugs. Smart charging software can be used to control when to start and stop charging, which means that some charging operations can be automated, thereby saving labor costs. However, overhead pantograph charging, as depicted above in Figure 5 and below in Figure 6, is more expensive than regular plug-in charging. The pantographs add about 30% to the cost of the charger (per correspondence with Amply Power), but this amount excludes the construction/installation costs. Since construction/installation comprise the majority of the cost, the overall incremental cost of the pantograph is relatively small. An overhead structure is expensive, but this solution, which becomes economical when installed to charge at least 30 buses, is not much more expensive than overhead plug-in charging. For example, the Los Angeles Department of Transportation is currently planning to deploy a depot overhead charging solution for some of their yards to charge a total of 104 buses.

Figure 6. In-Depot Overhead Charging Example (Source: CALSTART)

SAE J3105 is the standard by which conductive automated connection charging devices for electric vehicles (EVs) are designed. It supports a DC power output of up to 1.2 MW. There are multiple types of chargers that are governed by this standard, including overhead pantograph chargers. SAE J3105 provides standards for both top-down and bottom-up chargers. SAE J3105/1: Infrastructure-Mounted Cross Rail Connection is the portion of SAE J3105 that governs top-down chargers. SAE J3105/2: Vehicle-Mounted Pantograph Connection is the part of SAE J3105 that governs bottom-up chargers. Top-down chargers that comply with SAE J3105/1 will be interoperable with each other whereas bottom-up chargers that comply with SAE J3105/2 will be interoperable with each other. A SAE J3105/1-compliant top-down charger will not be interoperable with a SAE J3105/2-compliant bottom-up charger.

On-route Charging

Most transit agencies use depot charging as the primary method of charging their buses. However, buses are sometimes deployed on routes that they cannot serve on a single charge. This issue can occur if the bus is on a lengthy or high-grade route, or alternatively, on days with extreme weather that increases the energy consumption of the bus's HVAC system. This is highly problematic, as the bus will run out of battery before it finishes the route.

Overhead on-route charging is one way to address this problem. On-route charging occurs during a gap in service—the bus will typically drive underneath an overhead on-route charger and the bus and the charger will interface and connect in a similar manner as depot overhead charging. Most buses have only short breaks during their schedule. To charge as much of the battery as possible during a break, these overhead chargers usually charge at high power levels. The typical on-route overhead charger will charge at power levels of 450-600 kW. These chargers are commonly built at a bus stop or a bus terminus to use when the bus is on a scheduled break.

Figure 7. On-route Overhead Charging (Source: ABB)

One major issue with an overhead charger is that the driver needs to align the bus with the pantograph. To achieve this, transit agencies will add markings to the ground underneath the charger to assist the driver. See Figure 7 as an example of this setup. In-ground inductive charging can also be used for on-route charging. Inductive charging can charge a bus at a power level up to 250kW. The benefit of in-ground charging is that it has no moving parts and is less impactful visually to the cityscape.

Hydrogen Fueling Infrastructure Overview

FCEBs utilize hydrogen to produce electricity to power the vehicle. To fuel a fleet of FCEBs, a transit agency needs to obtain and dispense hydrogen to the buses. Currently, FCEBs have a hydrogen tank that receives hydrogen at a pressure of 350 bar. Most FCEBs store 35-50 kg of hydrogen in the tank. One kg of hydrogen has approximately 33.33 kilowatt-hours (kWh) of usable energy (diesel has about 12 kWh/kg). Transit agencies have several options for obtaining hydrogen. A transit agency can either produce the hydrogen onsite or buy hydrogen from a fuel provider and have it delivered to the fueling site. Since the transportation of hydrogen is expensive, onsite hydrogen production is usually the less expensive option. However, onsite hydrogen production requires installing fueling infrastructure (similar to CNG), which can present challenges depending on the space available.

Hydrogen is a flammable gas, and as a result, hydrogen infrastructure, as with other types of propulsion infrastructure, must comply with fire safety standards, especially the prominent National Fire Protection Association (NFPA) codes. Hydrogen infrastructure installations often have a lead time of ten months to two years, including the permitting process. A number of safety sensors and training required as well.

Onsite Steam Methane Reforming

Hydrogen can be produced using steam methane reforming (SMR). SMR requires a reformer that combines natural gas and steam at high temperatures to produce hydrogen. SMR uses little electricity, using instead a catalyst to produce hydrogen. However, SMR does require the use of natural gas and water.

An onsite SMR system would need a minimum of 60 feet by 60 feet, or 3,600 square feet. The system can also be split into two 60-foot by 30-foot rectangles, as long as the two areas can be placed near each other. Typically, the SMR comes in two parts. One part is a container that houses the SMR modules, the electronics, and hydrogen compression equipment. The second part is the fueling station and storage. An onsite SMR system also requires a compressor to compress the hydrogen in order to dispense at a pressure of 350 bar.

Since this process produces GHGs, the State of California requires that 33% of the natural gas comes from renewable sources. SMR also consumes about 4.6 gallons of water per kg of hydrogen produced (Webber, 2007). Still, SMR can produce hydrogen in a less expensive manner. However, SMR production does require investment in production equipment. See page 28 for more information on hydrogen fueling cost considerations.

Onsite Electrolysis

Hydrogen can also be produced via onsite electrolysis. Electrolysis produces hydrogen by running an electrical current through pure water to split the water into hydrogen and oxygen. The hydrogen is then captured, compressed, and stored until it is dispensed into the bus. Electrolysis uses approximately 2.4 gallons of water per kg of hydrogen (Webber, 2007). An electrolyzer has a similar footprint as an SMR system and comes in two containers, with one container housing the electrolyzer and compression equipment and the second container housing storage and fueling equipment. An onsite electrolyzer system also requires a compressor to compress the hydrogen to dispense at a pressure of 350 bar.

Electrolysis is considered the cleanest method of producing hydrogen, as it does not produce any direct GHG emissions. In using electricity, indirect GHG emissions are generated when producing the electricity. However, these emissions can be mitigated if the electricity is produced from renewable sources. Electrolysis is currently an expensive method of producing hydrogen and is energy intensive.

Delivered Gaseous Hydrogen

Hydrogen can be produced offsite at a centralized location and then delivered to the bus fueling location. Gaseous hydrogen is typically produced at a central production facility at low pressures of 20-30 bar, then compressed to a higher pressure. The hydrogen is stored in cylindrical tubes that are then loaded onto a truck trailer and transported to the bus fueling location. Once the tube trailer arrives at the location, the hydrogen is delivered to the fueling station. A compressor is used to increase the pressure of the hydrogen in the tube trailer. This compressed hydrogen is then delivered to storage tanks where it can be dispensed to the buses.

These tube trailers can carry only a limited amount of hydrogen, however. U.S. Department of Transportation (DOT) regulations limit compression pressures to 250 bar. Furthermore, truck payload weight restrictions effectively limit a tube trailer to delivering a maximum of 320 kg of hydrogen (U.S. Department of Energy Hydrogen and Fuel Cells Technology Office, n.d.). As a result, this option is more advantageous for fleets that require relatively low volumes of hydrogen.

Delivered Liquid Hydrogen

To be delivered in liquid form, hydrogen is produced at a centralized production facility and then liquified by reducing its temperature to -253 degrees Celsius. The liquid hydrogen is then put onto a truck for delivery. Once the truck reaches the depot, it will pump the liquid hydrogen into a liquid hydrogen storage tank. The hydrogen from the storage tank is processed by liquid compression pumps, which deliver the hydrogen to a vaporizer. The vaporizer converts the liquid hydrogen to gaseous hydrogen, which is then delivered to gaseous storage tanks. The hydrogen is subsequently dispensed to the buses.

Liquid hydrogen has economic advantages compared to gaseous hydrogen, but some drawbacks exist. Mainly, liquid hydrogen is lost if it is left in storage for a long time. As liquid hydrogen warms up, it evaporates and turns into a gas. Hydrogen systems are designed to release this gas, known as off-gassing. Off-gassing can result in losses of 1% per day, but off-gassing can be reduced if hydrogen is dispensed to vehicles on a daily basis. A system that captures off-gassed hydrogen and compresses it into the gaseous storage tanks can also be employed.

Offsite Retail Fueling

If a transit agency is unable to invest in hydrogen fueling infrastructure, they could theoretically fuel buses at offsite retail fueling stations. A retail fueling station is a privately owned station that sells hydrogen to customers and would be analogous to a gas station or a CNG station.

The market for retail hydrogen fueling is in the early stages of development. As the fuel cell electric vehicle market has matured, more retail stations have been built. While there are multiple retail stations, light-duty and heavy-duty retail fueling are distinct markets. Light-duty stations typically have 700 bar dispensers and lower levels of storage. Heavy-duty stations typically have 350 bar dispensers and require larger storage capacity. Currently, there are no heavy-duty stations near ESTA. As a result, retail fueling would not be a viable option for a fleet of transit FCEBs. As the market for hydrogen fuel increases, there may be retail fueling stations built near ESTA.

Retail fueling could potentially be appropriate for fuel cell electric shuttle buses and paratransit vehicles. Hydrogen shuttle buses use less hydrogen than a transit FCEB, and it is theoretically possible to fuel them at retail hydrogen stations. However, there were no hydrogen fueling stations in the Fresno area at this time this study was conducted.

Route Modeling

Overview of Route Energy Modeling (REM)

As part of the ESTA electrification feasibility study, CALSTART undertook the task of analyzing the electrification of bus routes. The primary objective was to identify the current and future operational needs specific to ESTA's routes. This analysis was crucial in determining suitable replacements for the existing fleet, encompassing both EV solutions and associated charging infrastructure.

To assess daily energy consumption and infrastructure requirements, CALSTART employed the Route Energy Model tool. This tool facilitated the evaluation of BEB performance and the estimation of average daily energy consumption for both fixed-route buses and dial-a-ride services. REM, a physics-based model developed by CALSTART, factors in various elements such as topography, ambient temperature, HVAC usage, passenger weight, and route characteristics to estimate energy consumption per mile and per trip. It incorporates seasonal weather data, bus specifications, route characteristics, ridership, and other operational data to gauge BEB energy consumption under different charging scenarios (depot only, on-route only, or both).

For fixed routes, the analysis utilized General Transit Feed Specification (GTFS) files to extract route characteristics and location. Digital elevation model data was also employed to extract topography, critical for accurate energy consumption estimation. To estimate the energy consumption of dial-a-ride trips, six months of dial-a-ride data was analyzed to determine the average trip distance.

To complete this comprehensive analysis, route-level data, including ridership, average speed, number of trips per day, number of stops, topography, and time in operation, was collected. CALSTART referenced the Altoona Bus Testing data to identify potential electric bus models capable of operating these routes.

Assumptions for Route Energy Calculation:

- GTFS files and daily mileage data were used to estimate energy consumption.
- Vehicle information: The model considers the specifications of the zero-emission bus, such as battery capacity, vehicle weight, overall vehicle efficiency on flat road, and usable battery capacity defined by OEM.
- Route Characteristics: REM tool extrapolates route characteristics based on the route GTFS files and Digital Elevation Model (DEM) data. The GTFS files are used to obtain geospatial information such as total distance, and stops, whereas the DEM data is used to calculate the change in elevation. All geospatial information and calculations are performed using coordinate system of NAD 1983 Equidistant Conic Contiguous USA (ESRI: 102005).
- Different types of buses were considered as replacement vehicles based on the existing type of ICE bus which includes Class 4 shuttle bus, Class 8, 40-foot transit bus, Class 8 coach bus, and electric trolley.
- Seasonality/Ambient Temperature: REM considers the impact of ambient temperature on space conditioning and heating requirements, which affect energy consumption. By default, the REM tool assumes that the vehicle does not have an external fuel-fired heater.
- To meet the daily demand, only 80% of the total battery capacity was considered as useful energy.
- A hypothetical 10-mile route was created based on previous trips within the city

limits to account for elevation and topography and estimate energy consumption for dial-a-ride buses and fixed-route buses.

- As previously mentioned, the REM analysis is used to estimate the bus performance on the route and calculate the average daily energy consumption of the ZEBs. Based on the obtained data and calculations, Refer to Table 1 below for a complete set of customizable parameters contributing to the modeling results.

Table 1. Customizable Parameters for REM

Vehicle Inputs	Route Information Inputs	Bus Charging Infrastructure Inputs
Bus type and length (feet)	Service operation times	Depot charger power & user specified output (kW)
Frontal area (square feet)	Number of passengers	Bus state of charge upper and lower bounds
Curb weight (lbs.)	Average driving speed (miles per hour)	Overnight dwelling time at depot charger
Battery-to-wheel and regenerative braking efficiencies	Number of bus stops along the route	Charging efficiency
Battery size (kWh)	Distance and slope of route topography	-
HVAC cooling and heating performance factors	Service area elevation & geographic coordinates	-
Desired cabin temperatures by season (°F)	Seasonal temperature highs, lows, and averages (°F)	-

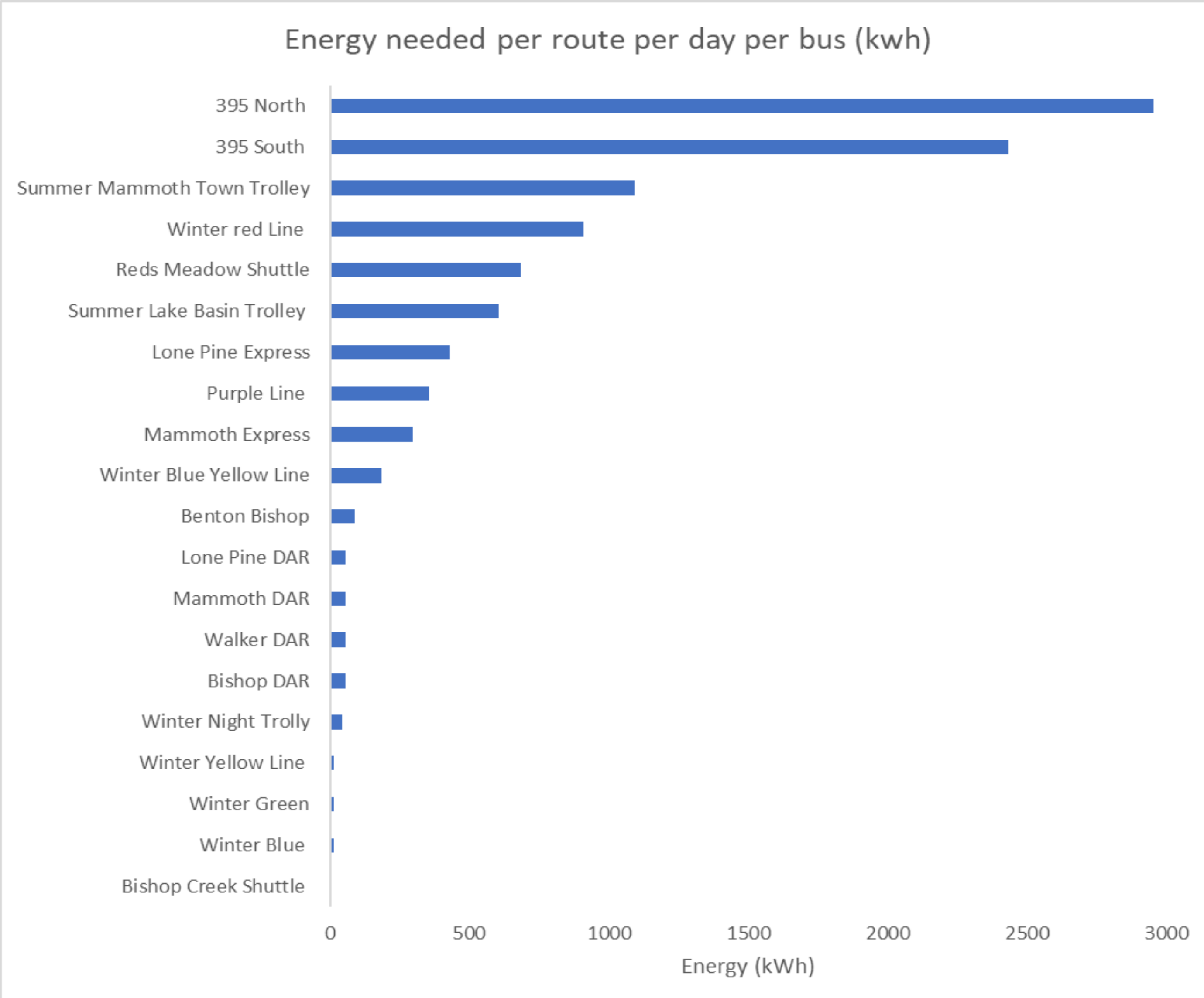
As the first step in the analysis, CALSTART interviewed ESTA's fleet manager. The purpose of this initial touchpoint was to establish a mutual understanding of the agency's goals for this analysis, as well as to gather key input parameters for the model. These meetings and subsequent follow-up communications yielded important information, such as desired electric bus model options, existing bus routes of interest for electrification, bus passenger cabin HVAC and state of charge (SOC) preferred settings, charging preferences (depot vs. on-route), and other details.

Following this level-setting step, CALSTART determined geographic information for the routes to be modeled by EBCM. For the fixed-route buses, the agencies supplied geographic information system (GIS) data that was converted into a useful format for the tool. Because the on-demand paratransit service routes vary by day and by passenger, CALSTART worked with the fleet manager to determine a hypothetical route with similar mileage and topography to some of the usual service routes. CALSTART then traced these routes on Google Earth to collect topographical inputs for distance and slope to input in the model. The electric bus performance modeled in EBCM was also based on battery-to-wheel and regenerative braking efficiencies from published Altoona Bus Testing reports. The aim of using Altoona data is to ensure that the model is operating on verifiable third-party data, rather than relying exclusively on marketing materials from bus manufacturers.

The next step in the process is gathering locational (longitude, latitude, elevation, and time zone) and seasonal weather inputs. This step is essential for the customization of bus performance specifications for a particular agency's needs. It is also noteworthy that in the California context, extreme heatwaves are increasing in frequency and intensity. More instances of fluctuations in temperature are projected to have a significant impact on vehicle HVAC energy consumption, especially air conditioning. Air conditioning is a very energy intensive auxiliary function that can, in some cases, dramatically reduce the overall range of the electric bus. To account for these challenges, the EBCM analysis included a temperature maximum parameter of 120 degrees Fahrenheit (°F) for the summer season forecast.

The analysis yielded kWh energy consumption outputs by bus subsystem, which is divided into dynamic, heating, and auxiliary sources, and the average expected energy consumption by season. Additionally, the model estimates the remaining SOC per lap on a given route to give an approximation of how much of the regular service day can be covered by a single electric bus. The energy consumption outputs from this analysis were used to inform the development of charging schedules, costs, and location(s) for the future electric buses. The summarized result for each route is shown in the Figure 8 below. The detailed route specific energy consumption results are discussed in Section II. Eastern Sierra Transit Authority.

Figure 8. ESTA Route Energy Needs



Charging and Fueling Cost Considerations

Charging Cost Considerations

Energy and Power

The utility costs for a ZEB fleet are dependent on two main factors: energy and power. Energy represents the total amount of electrical fuel consumed by the bus. Energy is denoted in units of kWh. The battery of a BEB has capacity limits and can only store a certain amount of kWh of energy. The energy capacity of the battery is analogous to the number of gallons that can be stored in a gas tank. Utility companies typically sell energy by kWh. The price of kWh can also change depending on how much demand occurs during the day. Energy is usually most expensive in the afternoon when demand is high and costs less at night when demand is lower. As a result, transit agencies typically schedule their charging to coincide with the lowest energy rates.

Power represents the rate at which energy is consumed and is typically measured in kW. Utilities care about power; if there is too much aggregate demand, it can overwhelm the grid and cause a blackout. As a result, utilities incentivize lower power demand from their customers by charging per kW. Customers are usually charged for the maximum amount of power they demand over the course of the month, regardless of how long they draw power at that level. For example, if a transit agency normally has a power demand of 50 kW but experiences a surge in demand and consumes 100 kW for 15 minutes over the course of a month, they would be charged for demanding 100 kW. Charges for power demand are typically high and can be extremely costly. These charges are typically responsible for most of the utility bill.

Utility Rate Structures

ESTA has 4 locations where the fleet is housed. These locations are in three different utility districts —Southern California Edison, LADWP, and Liberty Utilities.

Southern California Edison

SCE is the utility for the depots in Bishop and Mammoth.

SCE's EV-8 commercial EV charging rate is applicable for fleets with up to 500 kW charging demand. Energy is charged on a $/kWh basis with seasonal and hourly variations. There is a monthly meter charge.

LADWP

ESTA's Lone Pine location falls in LADWP's service territory.

LADWP's A-1 Small Commercial rate is applicable for customers up to 30 kW charging demand. Energy is charged on a $/kWh basis with seasonal variations. There is a monthly meter charge.

Liberty Utilities

Liberty serves ESTA's Walker location. No electric vehicles are expected to charge at this location, so the utility rates were not examined.

Strategies for Managing Utility Costs

Utility charges are determined by a variety of factors such as energy and power demand, which have a major impact on the utility charges that a transit agency must pay to charge their buses. However, there are strategies to reduce utility charges. This section will discuss some of the strategies that transit agencies can employ to minimize this cost.

Overnight Charging

Transit agencies are charged for the energy they consume. Transit agencies are typically charged by the kWh, and utilities usually have different rate structures that their customers can use. Most transit agencies use time-of-use (TOU) tariffs. Under a TOU tariff, energy charges vary throughout the day. Energy charges are typically lowest during times of low energy demand (off-peak rates) at night and are highest during the day in the late afternoon/evening hours—solar production decreases as the sun begins to set, and energy consumption increases as air conditioning loads come online. As a result, peak energy charges usually occur from approximately 4:00 to 8:00 p.m. Some utilities also offer flat rate tariffs, where the cost per kWh is constant throughout the day.

Transit agencies aim to reduce the energy costs associated with charging, but transit agencies cannot reduce energy costs by reducing the amount of energy they consume, which would entail cutting transit service. If a transit agency is on a TOU tariff, they can reduce energy charges by shifting the times during which they charge the buses. Since off-peak rates are lower than peak rates, energy costs can be reduced by shifting the charging schedule so that the majority of buses charge at night during off-peak hours.

Managed Charging

Another method of reducing utility costs and demand charges is the use of managed charging. Managed charging minimizes power demand by remotely monitoring the bus battery status, communicating with the chargers to prioritize which buses get charged, and regulating the amount of energy and power each bus receives. Managed charging uses algorithms to control which buses should get charged and when. Managed charging software usually avoids having all buses charge at the same time and can control the power level at which they charge, thus reducing power demand. Managed charging optimizes charging and can result in even lower power demand than sequential charging.

Many smart charging systems support the use of Open Charge Point Protocol (OCPP), which is a standard for charger-to-network communication. OCPP compliant chargers allow multiple types of chargers to be integrated by a smart charging provider. While these features are not necessary for charging electric buses, they are a useful tool for larger fleets, as they can ensure all buses charge on time while also reducing maximum power demand. Reducing maximum power demand is important—demand charges and utility interconnection charges are a function of max power demand. Smart charging systems can control charging behavior to reduce maximum power, decreasing maximum power draw by up to 31–65% and greatly reducing demand charges and the cost to operate the buses (Eichman, 2020). Sometimes the charger manufacturer (e.g., ABB and Siemens) will offer their own networked charging solution. However, there are also other companies who specialize in this space as network providers.

The most basic software solution will remotely monitor the bus battery status while charging. This usually comes in the form of a web portal or app that the fleet manager can access at any time. The web portal can integrate data from the fleet operations/dispatch control system, yard management system, and energy management/smart charging system. In addition, if a fleet purchases buses and chargers from multiple manufacturers, the web portal can integrate this data in one place. Basic analysis such as which buses use the most energy, which buses are having range problems, which buses are having a disproportionate amount of maintenance downtime, and battery state-of-charge can be regularly reported to the manager. Some smart charging companies can also integrate telematics and real-time data from the buses into their smart charging systems. This information can be used by the smart charging software to prioritize which buses should be charged first to assure that all buses are ready for their respective duty cycles.

More advanced solutions will allow the charger to communicate with the utility grid. The data could be passed through in several ways, including aggregated at a network provider's cloud service or individually sent to the utility via the Open Automated Demand Response (OpenADR) 2.0b protocol, or using the OpenADR with OCPP protocol. In this case, the utility could use OpenADR with OCPP to have open communication between the EV charging stations and central management software, enabling the charging system to serve as a demand response or excess supply asset. Demand response and excess supply programs incentivize customers to shift electricity load to different times of day to facilitate grid operations and system-wide cost savings. Using OCPP on its own is also an option. Several charging manufacturers support the OCPP standards, which allows the end user to manage various chargers with one compatible software management system.

To provide managed charging solutions, a network provider will typically need to collaborate with the utility serving the transit agency. In most cases, managed charging companies provide turnkey infrastructure construction and installation services. In doing so, the managed charging company provides the capital expenditures (CAPEX) for the chargers and then signs a power purchasing agreement to sell the electricity to the transit agency. Appendix E: Managed Storage Solutions provides details for managed/networked charging providers.

Hydrogen Fueling Cost Considerations

Onsite vs. Delivered Hydrogen vs. Retail Hydrogen

The cost of hydrogen is influenced by several factors. One key factor is the location of hydrogen production. In general, the least expensive option is to produce hydrogen onsite at the bus fueling location. Hydrogen can be produced onsite using commercialized and technologically mature equipment—see Onsite Steam Methane Reforming and Onsite Electrolysis sections for detailed descriptions of these processes. Using this technology, hydrogen can be produced relatively cheaply. Some SMR equipment manufacturers have estimated that hydrogen can be produced for as low as $6 per kg. However, onsite production requires capital investment, so it is not economically feasible to produce hydrogen onsite until a volume of 200 kg of hydrogen is reached.

Delivered hydrogen must be transported to the bus fueling location—see Delivered Gaseous Hydrogen and Delivered Liquid Hydrogen sections for descriptions of these options. The transportation of hydrogen via truck is an expensive process, and most of the cost of delivered hydrogen comes from transportation. Since delivered hydrogen requires less onsite infrastructure, this solution is more economically feasible for transit agencies that use low volumes of hydrogen. Delivered gaseous hydrogen is the best option for transit agencies that consume less than 200 kg of hydrogen per day, which is below the threshold at which onsite production is economically feasible. Liquid hydrogen has less volume than gaseous hydrogen, and therefore more liquid hydrogen can be stored on a truck than gaseous hydrogen, making liquid hydrogen delivery more economical. Due to off-gassing, delivered liquid hydrogen is most economical when a transit agency requires a large amount of hydrogen and will refuel daily.

Even though no heavy-duty stations currently exist near ESTA, retail fueling could be appropriate for fuel cell electric shuttle buses and paratransit vehicles. Based on pricing data collected in June 2023, the at-the-pump price charged at California retail stations is about $26-$27 per kg of hydrogen. However, it might be possible to negotiate a lower fuel price with a retail fuel provider in exchange for guaranteed fuel volume. See the Offsite Retail Fueling section above for more information.

Security of Fuel Supply

Security of fuel supply is important because ZEBs cannot operate without access to fuel. For BEBs, the fuel supply is electricity. As a result, grid resiliency is extremely important for BEB fleets. For FCEBs, security of fuel supply centers around access to hydrogen. However, grid resiliency is also important because electricity is required to compress and dispense hydrogen. This section discusses security of fuel supply for both BEBs and FCEBs.

BEBs

BEBs are fundamentally reliant on electricity because they use it directly as a fuel. As a result, if there is a loss of power, transit agencies would be unable to charge. California has a relatively reliable grid. Grid reliability is traditionally measured with metrics such as System Average Interruption Duration Index (SAIDI), which measures the average minutes of grid outage experienced by customers per year, and System Average Interruption Frequency Index (SAIFI), which is the average number of grid outages that a customer can expect to experience per year. Utilities report their SAIDI and SAIFI statistics. ESTA is served by SCE (Mammoth and Bishop depots), LADWP (Lone Pine depot), and Liberty Utilities (Walker depot). The SAIDI and SAIFI statistics for these utilities is displayed below in Table 2.

Table 2. Utility Reliability Statistics

Utility	SAIDI	SAIFI
SCE (Bishop District - 2022)[2]	236.615	1.962
LADWP (2022-2023)[3]	212.95	0.81
Liberty Utilities* - (2021)[4]	916.28	4.60

* The depot served by Liberty Utilities will not be hosting electric buses, only fuel cell vans

While customers can expect to have relatively few outages, extreme events such as storms, hurricanes, natural disasters, terrorism, or cyberattacks can cause the grid to go offline for longer periods of time. For example, in 2017, the American Northeast experienced extreme winter storms which caused disruptions to power service to the region. Likewise, in 2017, states such as Florida and Georgia experienced outages from hurricanes; in the aftermath of Hurricane Maria the same year, Puerto Rico experienced the worst blackouts in American history. More recently, in February 2021, Texas experienced a lengthy grid outage following a polar vortex. Lengthy outages such as these could easily prevent transit agencies from engaging in routine charging of their buses, which would then disrupt normal service and core transit operations. Since many members of the community use public transport to get to and from work or school, access shopping centers, and travel to medical appointments, such disruptions would have major economic implications.

[2] https://www.sce.com/sites/default/files/custom-files/PDF_Files/2022_Annual_Electric_Reliability_Report.pdf
[3] https://prp.ladwp.com/
[4] https://california.libertyutilities.com/uploads/Reliability%20Reporting%202022%20Presentation.pdf

ESTA can implement measures to mitigate this risk. ESTA can obtain resiliency by deploying distributed energy resources (DER). This can include resources, such as solar panels, battery storage systems, or generators. Resiliency assets are classified as behind-the-meter or front-of-the-meter, based on where they are located in relation to the utility meter. BTM refers to resiliency solutions located on the customer's side of the meter, typically directly on the customer's site. FTM resiliency is provided on the utility's side of the meter, typically at the distribution level.

It is important to note that BEBs consume large amounts of energy. Depending on the size of the fleet, peak power draw can potentially be at the megawatt-scale. As a result, medium- and large-sized fleets will likely need significant DER capacity to provide full resiliency to the fleet. CALSTART quantified peak power demand for each of ESTA's depots to give a sense of the scale of resiliency needs. This is provided in Table 3 below. These figures represent max power draw and energy consumption for weekday service (fixed-route and paratransit). Furthermore, these figures exclude any energy or power demand from onsite buildings or maintenance bays.

Table 3. Daily Energy Consumption and Power Demand

Depot	Peak Power Demand (kW) / Daily Energy Consumption (kWh)	Utility
Bishop	117 / 152	Southern California Edison
Lone Pine	16 / 55	Los Angeles Department of Water and Power
Mammoth	315 / 687	Southern California Edison
Walker	0*	Liberty Utilities

*The Walker depot only hosts one vehicle and it is expected to be a FC van.

BTM Resiliency

A fleet can also receive BTM resiliency. BTM resiliency consists of generation and storage assets that are located on the customer's side of the meter and, in most cases, onsite at the fleet's depot. Transit agencies have multiple options for deploying BTM resiliency, such as opting to serve as the owner-operator of resiliency equipment. Under this ownership model, the transit agency provides the capital funding to purchase and install the equipment and is responsible for operating and maintaining the equipment.

Transit agencies can also engage with a third-party energy services company to purchase power. The third-party energy services company would be responsible for purchasing and installing the equipment. The energy services company would retain ownership of the equipment and would sign a power purchasing agreement with the transit agency to sell the energy produced by the equipment. There are also myriad other hybrid business models that can be used to operate BTM resiliency equipment. The following is an overview of different assets that can be used to provide BTM resiliency:

- Solar and Storage: Solar PV systems can be paired with a battery energy storage system (BESS) to provide BTM resiliency. Solar PV panels convert solar radiance from light to produce electricity. As a result, solar PV produces electricity during the day, with peak production occurring at about 1 pm. The BESS can be used to store excess solar power and discharge it at night, when buses are typically charging, or during a grid outage. Solar PV arrays can be installed anywhere with access to direct sunlight. Solar PV arrays are often installed on rooftops, but arrays can also be constructed on canopies over parking lots to maximize the solar potential of their yard and provide shade for the buses.
- Generators: A transit agency could also use a generator to provide power in the event of a grid outage. Generators typically use fossil fuels such as diesel or natural gas. These fuels are combusted in an ICE, which is used to produce electricity. Most generators are reciprocating engines. Generators are useful; they are energy dense, produce a large amount of power without having a large physical footprint, and can feasibly be sized to power a majority of or the entire fleet. Generators can also respond relatively quickly to outages and take about 10 minutes to fully ramp up to maximum power generation. In addition, generators do not have to operate at full power at all times and can run at partial capacity without major efficiency losses. However, this solution is problematic—since generators burn fossil fuels, they produce GHG emissions. In addition, they can produce criteria emissions such as particulate matter (PM) and NOx. As a result, there are environmental and air quality consequences to using generators.
- Stationary Fuel Cells: A stationary fuel cell can also be used to provide power in the event of a grid outage. Fuel cells typically consume hydrogen as a fuel where an electro-chemical reaction takes place to produce electricity. Fuel cells are most often associated with hydrogen vehicles, which use a fuel cell that oxidizes hydrogen to produce electricity to power the vehicle. However, a fuel cell, like

those designed by Bloom Energy and Doosan, can also be designed to use other hydrogen-rich fuels such as natural gas as the source of fuel. Stationary fuel cells are fuel cells deployed for non-vehicle usage and serve an equivalent function as a backup generator. Stationary fuel cells are advantageous in that they produce zero criteria emissions. However, since there is little infrastructure to deliver hydrogen and natural gas infrastructure is limited, this would likely not be a feasible resiliency option for ESTA.

- Microgrids: A microgrid is a local grid that uses distributed energy resources and energy storage assets to provide power to a specific campus or locality. In the transit context, a microgrid would consist of DERs that can provide power and resiliency services to the transit agency's depot. A microgrid can use a combination of DERs. A key feature of a microgrid is that it can disconnect from the utility grid and generate power for itself. The microgrid can also deploy DERs to reduce peak demand and reduce utility costs.

BTM resiliency measures are subject to regulations. These regulations are enforced by the utility or by governmental agencies. Utilities regulate DERs through their interconnection agreements. DERs must meet utility requirements to be connected to the grid. SCE regulates DER and microgrid interconnections through Rule 21. Rule 21 provides a streamlined process for interconnecting these assets to the grid. However, Rule 21 also imposes some constraints on the microgrid and the main constraint is that Rule 21 is designed for smaller DER installations. Rule 21 provides an easy-to-navigate pathway to interconnection for installations with DERs of up to 1 MW AC. However, Rule 21 imposes additional requirements for DER installations that exceed 1 MW AC. For installations 1 MW AC and larger, the utility will require the installation of telemetry equipment to monitor the microgrid's impact on the utility grid. The utility can also require engineering studies to analyze the impact that the microgrid will have on the grid and to ensure that proper grid protections are in place.

LADWP also allows for the deployment of BTM DERs. LADWP launched pilot rates for transit bus fleets within its territory in 2019. These rates are referred to as EV-Bus rates and are valid for five years. The key feature of these rates is that they provide a discount on the energy charges (per kWh) for bus charging. The EV Bus-1 rate is compatible with transit operators that have their own BTM storage system.

Since the depots served by Liberty Utilities will not be hosting electric buses, CALSTART did not conduct research into DER interconnection requirements for this utility.

Generators are also subject to regulations. The Great Basin Unified Air Pollution Control

District (GBUAPCD) has a mandate to regulate stationary sources of air pollution in Inyo, Mono, and Alpine counties. Since generators emit criteria emissions, they are subject to regulation by GBUAPCD. GBUAPCD regulates diesel engines above 50 horsepower (approximately 37 kW) and all such engines must have a permit. If a transit agency were to use engines of 50 horsepower or below, the generator can be installed without a permit. However, due to the high loads associated with charging buses, using engines with 50 horsepower or below is unlikely to be practical. If a diesel backup generator is used, it must be a Tier 3 Engine or higher if below 750 horsepower or a Tier 2 Engine or higher if 750 horsepower or greater.

GBUAPCD allows for the use of backup generators during an emergency, which is defined as an unforeseen power outage. Backup generators are allowed to operate during an emergency power outage, including Public Safety Power Shutoffs, and may operate for the duration of the outage (GBUAPCD, n.d.). Backup generators cannot be used to provide demand response services to utilities. Using a generator for this purpose requires a different permit. This permit has more stringent emissions limits and in many cases requires the use of exhaust treatment equipment.

To receive authorization for a backup generator, a transit agency would need to obtain an Authority to Construct permit. This permit allows the transit agency to physically install a generator. To obtain this permit, a transit agency needs to submit an Authority to Construct application form and a pay the permitting fees. GBUAPCD will then review the application. The maximum time for this period if 210 days. After GBUAPCD reviews the permit, they will determine whether the generator is considered to be a "large source." A large source is one that will emit more than 250 pounds per day of any criteria pollutant. If the generator is not a large source, then GBUAPCD can issue the Authority to Construct. If it is a large source, GBUAPCD must publish a notice of proposed action and gather public comments. After this step, the Authority to Construct can be issued. The Authority to Construct allows the transit agency to install the generator. Once the generator is installed, a startup inspection needs to be conducted. During this inspection, an inspector from GBUAPCD verifies that the installed generator is the same model as the generator that was permitted. Once the startup inspection is passed, a Permit to Operate is awarded. The Permit to Operate gives the holder the right to operate the generator (GBUAPCD, 2007).

If a transit agency wanted to avoid obtaining a backup generator permit, they theoretically could rent a backup generator during a grid outage. If a transit agency decided to do this, they would need to rent a generator that has been permitted by CARB or the Air Pollution Control District (APCD). The rented generator can only be operated during an emergency and must be removed from the site after the emergency ends. Renting a generator in the event of an outage could be beneficial as it would allow the transit agency to avoid the CAPEX associated with purchasing and installing a generator. However, it does take time to rent a generator and have it delivered to the site; the bus depot would be without power until the generator arrives. Furthermore, in the event of a grid outage, other entities would be seeking backup generators, making it difficult to find a generator during an emergency outage. It might be possible to secure a generator from a rental company. Some generator rental companies can guarantee access to a rental generator in exchange for a monthly payment.

FTM Resiliency

FTM resiliency is provided by the utility, and the utility can provide resiliency in several ways, such as installing energy storage assets or distributed generation assets at power plants or at a substation. If power is lost, the assets can be deployed and can provide power to customers downstream. Utilities typically charge for resiliency services to offset the cost of these assets. Some utilities offer special electrical tariffs to customers that opt to accept utility resiliency services. These tariffs often entail higher energy charges.

SCE serves the Bishop and Mammoth depots. SCE has deployed FTM DERs. According to the California Energy Commission (CEC)'s California Energy Storage System Survey, SCE has deployed 60 MW of FTM batteries in Inyo County. It is unclear whether they can be deployed as resiliency assets.

LADWP has multiple options for providing FTM resiliency services. The EV Bus-2 rate is used for transit operators that want LADWP to provide resiliency services. Under EV Bus-2, the utility will provide FTM storage either onsite or at the nearest substation. Transit operators have the option of obtaining 2-hour or 4-hour resiliency. The EV Bus-3 rate is similar except the storage provided is at a remote location.

Since the depots served by Liberty Utilities will not be hosting electric buses, CALSTART did not conduct research into FTM resiliency options for this utility.

FCEBs

FCEBs will need a secure supply of hydrogen. Hydrogen supply is discussed in the ESTA Evaluation of Hydrogen Vehicle Refueling Options report. This report notes that there are no hydrogen production facilities in the area. As a result, ESTA will be reliant on hydrogen that is transported from other parts of California. The nearest hydrogen production facilities are located in Lancaster, CA and Las Vegas, NV.

Disruptions to hydrogen production at these facilities can disrupt ESTA's fuel supplies. ESTA should try to pre-arrange plans with backup hydrogen suppliers to mitigate against this risk. Another potential risk would be a physical disruption SR-395 (i.e. flood, major accident, etc.), which would prevent trucks from delivering hydrogen. These risks can be partially mitigated by storing extra hydrogen so ESTA has fuel reserves in the event of an outage. However, the economic viability of this approach is unclear.

Training and Workforce Development

Many similarities exist between ZEBs and diesel buses, but ZEBs have unique systems such as electric drivetrains, batteries, fuel cells, and hydrogen storage tanks that require specific operational and maintenance needs. These systems have particular needs and require specialized training to service. In addition, ZEBs must be operated and driven differently than a fossil fuel bus to obtain the maximum performance from the buses.

Bus Operator Training

Bus operators will need training to drive and operate ZEBs. ZEBs need to be driven in a certain manner to optimize performance and bus range. Typically, electric buses maximize their range when accelerated slowly. Poor driver behavior, such as rapidly accelerating from a stop, can reduce bus energy efficiency by up to 25%. As a result, ensuring the bus operators drive the buses in the correct manner is vital to maximizing the benefits of ZEBs. Range anxiety, where the driver fears that they do not have enough charge to complete their route, has also been widely documented. This fear has resulted in operators prematurely ending their route and returning to the depot to charge the bus. To avoid this problem, bus operators need to understand the range and capabilities of the bus. Bus operators also need to learn how to correctly use technologies such as regenerative braking.

Bus Technician Training

ZEBs have different maintenance needs and operation best practices than traditional ICE buses. ZEBs replace the ICE with an electric drivetrain, which changes the maintenance needs of the bus. While maintaining a traditional bus, a maintenance technician needs to have expertise in maintaining and repairing ICEs and moving parts like belts, alternators, and pumps. In addition, expertise in mechanical systems such as steering, HVAC, and suspension is vital. However, with ZEBs, the vast majority of the moving parts are replaced with electric components, such as batteries, DC-to-DC converters, and electric motors. Since there are few moving parts on a ZEB, most of the maintenance tasks relate to preventative maintenance. As a result, the most vital skills for maintenance technicians to become proficient in are high voltage safety and proper use of personal protective equipment to minimize the risk of electrical shocks and arc flashes. Mechanics should consider obtaining the NFPA 70E: Standards for Electrical Safety in the Workplace and High Voltage OSHA 1910.269 8 Hour Qualified Training Course certificates. Maintenance technicians will also need to become proficient in bus inspection, preventative maintenance, and how to handle removed battery systems to effectively maintain the buses. Knowledge of standard bus mechanical systems is also important. If a fleet has hydrogen FCEBs, the maintenance technicians need additional skills. Hydrogen is a highly flammable gas, meaning that it requires specialized skills. Technicians working on hydrogen buses need training in high pressure gases and hydrogen safety. Local first responders need to receive training in EV and hydrogen safety so they can effectively respond in the event of an accident.

Technicians receive their training through a variety of sources, which usually starts in an automotive program at either a community college or trade school. While at community college/trade school, technicians are introduced to automotive safety, vehicle systems, engines, and mechanical systems. Many students will also learn about electric and hybrid drivetrains. Many community colleges such as Fresno City College, Kern Community College District, and San Joaquin Delta College have devoted EV Associate of Sciences programs. Cerro Coco Community College, which has a campus in Mammoth Lakes, was not found to have an automotive program.

After completing community college/trade school, technicians are then hired by a fleet or a transportation services company. Technicians usually receive on-the-job training after they are hired. Their employer often provides one-on-one training so the technician can work on real-life maintenance and repair issues. Bus OEMs also provide training to technicians. This training typically begins one week before the bus is delivered. The OEM will send a field service representative to provide bus operator training to the contractor's drivers. The field service representative provides safety, preventative maintenance, and diagnostic/troubleshooting training to the mechanics. Since this training is specific to the buses and is generally at a more advanced level, it is important that the technicians have some experience with the basics of zero-emission vehicle maintenance before attending the OEM's training.

The field service representative is also vital for training mechanics on more advanced maintenance tasks. During the warranty period, if repairs or troubleshooting beyond preventative maintenance are needed, the field service representative can be called to teach the mechanics how to fix the issue. It is important to use the warranty period to provide further training for its mechanics. If there are problems with any of the non-drivetrain components on the bus (e.g., the HVAC system), many component manufacturers offer similar services.

Workforce Development Training Plan

Since many traditional vehicle maintenance competencies (such as suspension, mechanical systems, HVAC systems, etc.) are transferable for maintaining ZEBs, the easiest way to develop a workforce is to upskill the existing bus operators and maintenance staff. CALSTART interviewed maintenance staff to better understand their expertise in maintaining zero-emission vehicles and to assess their training needs.

CALSTART recommends the following training sequence for the Journeymen and Assistant Mechanics:

1. High voltage Electrical Safety: The prerequisite knowledge required to begin ZEB maintenance training is a firm understanding of high voltage electrical systems and safety. During this training, maintenance staff learn how to use multimeters, how to identify high voltage components and cables, how to use personal protective equipment, and safety procedures for working with high voltage equipment. OEMs view high voltage electrical training as a prerequisite for OEM-provided maintenance training. As a result, maintenance staff need to receive high voltage safety training before they receive any instruction on bus maintenance. There are several options for obtaining this training:
    - The California Transit Training Consortium (CTTC) provides high voltage safety training. The prerequisite for their high voltage safety training course is a course in using a digital volt-ohm meter. CTTC provides three levels of high voltage safety training. Awareness training is a four-hour course that is offered to any employee who is on the floor of the vehicle repair workshop. Certification training is a 16-hour course that teaches workers how to use personal protective equipment, tools, and arc flash rescue equipment and procedures. Lastly, the advanced class is offered to any technicians who will physically be working on the vehicle. This training aligns with NFPA 70E and OSHA 1910.269 certification.
    - SunLine Transit's West Coast Center of Excellence has a ZEB Maintenance course that includes instruction on high voltage safety.
2. High Pressure Gases and Hydrogen Safety Training: maintenance staff will need to learn how to safely handle high pressure gases and hydrogen.
3. OEM-provided training: Bus OEMs provide training to teach maintenance staff to repair their specific system. ESTA should purchase training packages from the OEM. OEM-provided training teaches maintenance staff how to operate and maintain a

zero-emission drivetrain system. The OEM-provided training begins about a week before the delivery of the buses. The OEM sends a field service representative to provide bus operator training to the drivers and maintenance staff. Since there are few moving parts on a ZEB, most of the maintenance tasks relate to preventative maintenance. Bus OEMs also provide training on their diagnostic tools and how their bus systems function. Maintenance staff learn how to use the diagnostic tool to identify and resolve faults.

4. Warranty Period: During the warranty period, if repairs or troubleshooting beyond preventative maintenance are needed, ESTA may call out the field service representative to fix the issue and teach the mechanics how to fix it. Using the warranty period to provide on-the-job training for the mechanics is vital to developing the skills of the maintenance staff. Over time, the maintenance staff will accrue enough knowledge to work independently from the field service representative. This knowledge can be institutionalized by pairing more experienced maintenance staff with junior staff and new hires to teach them maintenance best practices.
5. Supplemental Training: ESTA can obtain additional training from SunLine Transit's West Coast Center of Excellence and CTTC. CTTC provides specialized training on topics like electronic brakes and electrical system diagnosis. Other organizations like the California Transit Association, American Public Transportation Association, CalACT, and the National Transit Institute also provide supplementary training.

Training Costs

There are costs associated with training. This section will provide an overview of these costs.

There are multiple options for obtaining training. CTTC offers training in high voltage electrical safety, as well as specialized training in bus systems. Transit agencies can access CTTC's trainings by joining the consortium as a member. Current membership fees range from $1,000 per year for small transit agencies (around 5-7 vehicle technicians) to $5,000 per year for large transit agencies (more than 100 vehicle technicians). Members of the consortium receive unlimited access to training courses. It is important to note that membership fees are subject to change. In the short term, CTTC will likely raise membership fees by 20%. Membership structure can also be changed in the future.

OEM-specific training is typically part of procurement contracts. California Department of General Services (DGS) has procurement contracts that transit agencies can use to purchase buses at a fixed price without having to issue a Request for Proposal (RFP). These

DGS contracts also include pricing for bus technician and bus operator training, as well as for maintenance manuals. See Table 4 for a breakdown of these costs.

Table 4. ZEB Maintenance and Operator Training Costs

Item	OEM 1	OEM 2	OEM 3	OEM 4
Operator Training (Total of 56 hours)	$12,940	$14,930	$14,930	$11,667.04
Technician Training (Total of 304 hours)	$51,756	$136,910	$76,310	$141,657.92
Maintenance Packages Manual (Per manual)	$580	$950	$1,045	$815.54
Preventative Maintenance and Procedure Manual (Per manual)	$120	$380	$380	$298.15
Parts Manual (Per manual)	$580	-	-	$153.46
Operator's Manual (Per manual)	$300	-	-	$87.69

Maintenance Costs

BEB Maintenance

BEBs have an electric drivetrain that is powered by electricity from an energy storage system, and consequently lack some of the components in an ICE bus, especially some of the mechanical systems in the propulsion system. The maintenance needs for the propulsion system are therefore different in BEBs than ICE buses. Despite these differences, BEBs do share many mechanical systems with ICE buses, such as brakes, suspension, door opening systems, the cab, and chassis, so some of the maintenance needs will be similar.

Those transit agencies that have already deployed BEBs can provide lessons about the maintenance needs for these vehicles. A number of these agencies reported that BEBs have fewer moving parts and therefore fewer parts to replace. BEBs do not require oil changes and do not have belts that need to be replaced. As a result, certain aspects of preventative maintenance for BEBs are lower than for fossil fuel-powered buses, with the main cost being labor and time.

Transit agencies have reported some issues regarding unscheduled maintenance for BEBs, with the earlier generation of BEBs experiencing some problems and failures with major components such as high voltage batteries and inverters. Another common issue has been the wires from the high voltage batteries. These wires are held together by connector pins. On many buses, these connector pins have corroded and come apart, preventing energy from being transferred from the battery to the drivetrain. Some BEBs have also experienced problems with the low voltage batteries. In these buses auxiliary equipment such as the security camera system continued to draw power even after the bus was turned off. This issue depletes the battery. Despite these problems, the drivetrain itself has proven to be very reliable, and most buses only experience minor problems with the drivetrain, but these problems can be costly.

The following maintenance data compares maintenance costs between CNG buses and BEBs; although ESTA uses diesel buses, there is more data available for transiting from CNG buses to BEBs. The cost of unscheduled maintenance is higher for BEBs than for CNG buses. The bus availability in a fleet of BEBs has also been significantly lower than for CNGs. One transit agency reported that the availability for CNG buses is about 95%, while BEB availability is about 70%. This low rate of availability has been caused by the fact that repairs on BEBs can take time to resolve. Some parts can be difficult to obtain, and sometimes diagnosis of a problem is not quickly resolved. As a result, BEBs can be out of service for up to 20-30 days in the event of an issue. To improve bus availability, ensuring the quick delivery of parts is vital. Transit agencies can also mitigate this problem by stocking extra parts.

Since some transit agencies have already deployed BEBs, there is data available on maintenance needs and costs. Foothill Transit has a fleet of BEBs: twelve 35-foot Model year 2014 buses and two 40-foot Model year 2016 buses (Eudy, 2020). The National Renewable Energy Laboratory (NREL) has been tracking the maintenance costs for this fleet and has compared it to the costs for the CNG fleet. NREL found that the maintenance costs for the 35-foot BEB fleet are $0.84 per mile and $0.53 per mile for the 40-foot BEB fleet. CNG buses have lower maintenance costs of $0.23-$0.42 per mile. Since all three fleets are out of warranty and Foothill Transit has taken over maintenance, these figures are comparable.

Although this data indicates that the maintenance costs are higher for the BEB fleet, there are several caveats in the data to consider. First, the BEBs had lower scheduled maintenance costs than the CNG fleet. The 35-foot and 40-foot BEB fleet had scheduled maintenance costs of $0.05 and $0.04 per mile, respectively. The CNG fleet had scheduled maintenance costs of $0.10 per mile. As a result, the main difference in cost between the BEB fleets and the CNG fleet is unscheduled maintenance. Some of the unscheduled maintenance figures were also skewed by an issue with the low voltage batteries, which had to be changed out frequently. The bus manufacturer is working to resolve these issues, and the low voltage battery problem is not expected to emerge in future generations of their bus. When the cost of the low voltage battery problem is excluded, the maintenance cost for the 35-foot and 40-foot BEBs are $0.72 and $0.48 per mile, respectively.

NREL also measures data on bus availability, which is defined as the percentage of days the bus is available for service. NREL issued a report analyzing BEB availability at Foothill Transit. This report found that Foothill Transit's CNG bus fleet had an availability of 95.1%. The fleet of 35-foot BEBs had a bus availability of 83.1%, and the 40-foot fleet had a bus availability of 81.6%. In most cases, general maintenance is the cause of bus unavailability. However, other issues such as problems with the electric drive or energy storage system can cause the buses to be unavailable. Significant variation of bus availability exists within the fleet; that is, some buses will have lower availability than others. For example, between Q3 and Q4 2019, some buses had a bus availability as high as 82% and others as low as 42%. Moreover, bus unavailability tends to increase as the buses get older, much like bus maintenance costs.

Maintenance and bus availability figures are also less common for newer generations of buses. Since buses have continued to develop and become more technologically mature, newer generations of buses are likely to have fewer problems with unscheduled maintenance and unavailability. During interviews with CALSTART, OEMs and other transit agencies in the Southern California region reported that newer generations of buses have proven to be more reliable and have had lower maintenance costs. Data from Antelope Valley Transit Authority indicates that maintenance costs for 40-foot BEBs are an average of $0.29 per mile (July 2019-March 2022). Utah Transit Authority reported maintenance costs of $0.41 per mile (April 2019-October 2021) for their 40-foot BEBs.

FCEB Maintenance

Like BEBs, FCEBs have an electric drivetrain that is powered by energy from a battery. Many of the maintenance tasks will be similar for both BEBs and FCEBs, but FCEBs are unique in that energy is provided to the battery by a fuel cell. Since FCEBs use high pressure gases, many maintenance tasks are similar to that of a CNG bus. However, the fuel cell and its supporting systems introduce maintenance needs that increase the amount of required maintenance tasks and the overall maintenance cost. NREL has been investigating the maintenance needs and costs for FCEBs. Tracking and reporting on the maintenance needs of several FCEBs deployed at SunLine Transit, NREL has compared them to the CNG buses deployed at the same agency. NREL reports that on a cost per mile basis, the FCEBs have a higher maintenance cost than the CNG buses. The maintenance cost for CNG buses has been reported at $0.23-$0.42 per mile whereas the maintenance cost for the FCEB fleet was reported at $0.56/mile (Eudy, 2020a).

It is important to note that many of the maintenance tasks are common between a CNG fleet and an FCEB fleet. Like BEBs, FCEBs still have many of the same mechanical systems as CNG buses. This includes systems such as brakes, suspension, door opening systems, the cab, and the chassis. Not surprisingly, both types of buses had to undergo maintenance on systems such as the brakes, low voltage batteries, and suspension. However, there are a couple of systems that seem to be responsible for most of the difference in cost between the two types of buses, such as the propulsion system. The maintenance cost of the propulsion system is more than three times higher for FCEBs than for CNG buses. In addition, basic preventative maintenance and inspection is also approximately twice as high for FCEBs than for CNG buses.

NREL also reports on the reliability of FCEBs. NREL uses bus availability as their metric to measure reliability. NREL's analysis of SunLine's fleet indicates that FCEBs have lower bus availability than CNG buses. SunLine's CNG fleet had an availability of 87% whereas the FCEBs had an availability of 73%. The availability for each individual bus ranged from 60% to 89% between January 2017 and July 2019. Approximately one third of bus unavailability was caused by routine problems with bus mechanical systems. However, one quarter of bus unavailability was caused by issues with the fuel cell and/or propulsion system. The FCEB's lower availability was influenced heavily by an event in 2017, where two of the older buses were both unavailable for an entire month—this outlier event lowered the availability figure for the FCEBs.

As a part of this study, CALSTART interviewed SunLine Transit to better understand their experiences with an FCEB fleet. SunLine Transit stated that their experience has been positive and that much of the maintenance for FCEBs is similar to CNG buses. Most of the maintenance work they have done has been routine maintenance. However, there are some general preventative maintenance and inspection tasks that are unique to FCEBs. For example, the fuel cell system has several components that need to be replaced regularly, such as particulate filters, deionizing filters (to deionize the water in the fuel cell coolant system), and air filters. These additional tasks increase the cost in comparison to preventative maintenance for CNG buses.

SunLine Transit also provided information about maintenance for the propulsion system. SunLine stated that they do not directly perform maintenance on the fuel cell. Instead, any fuel cell maintenance is handled by the fuel cell manufacturer. The fuel cell manufacturer has a field representative that can be onsite within one day to fix any fuel cell-related issues that arise. If there is a problem that cannot be solved quickly, the fuel cell can be removed and sent to the fuel cell manufacturer for repairs. If this occurs, the fuel cell manufacturer provides a replacement fuel cell that can be used until the issue is resolved. SunLine Transit noted that the drivetrain and fuel cell systems have been very reliable and that they have not yet needed to receive a replacement fuel cell. Instead, most of the maintenance on the propulsion system has been due to balance-of-plant components and systems that support the fuel cell, including pumps and the fuel cell cooling system. Other transit agencies have also had this experience and have reported that most bus outages result from problems with balance-of-plant components or auxiliary components such as the HVAC system, rather than from the fuel cell or the drivetrain. SunLine noted that they have been able to obtain replacement parts easily from the fuel cell manufacturer, which gets buses back in operation quickly. In addition, most of the maintenance performed on the buses to date has been through their warranty and helped to reduce the cost of maintenance. However, once the warranty is finished, the cost of maintenance is subject to increase. According to NREL's data, out of warranty, older buses have higher maintenance costs per mile than newer buses in warranty.

In addition, the amount of unscheduled maintenance for FCEBs at SunLine fell between 2017 and 2019, which implies that the buses have become more reliable. This decrease might be occurring as the buses become more technologically mature—it is possible that maintenance costs between FCEBs and CNG buses can converge in the future.

Infrastructure Maintenance Requirements

Plug-in Charging Infrastructure

Charging infrastructure requires maintenance, though most of the components are non-moving parts with fewer maintenance needs. Most maintenance tasks focus on changing air filters in the charger and performing inspections. However, components can break from time to time. Since there is an established supply chain for these components, repairs are usually routine and completed quickly. For many chargers, the biggest threat is accidentally damaging the charger receptacle by driving over it. The use of DCFC and networked chargers can increase maintenance needs; DCFCs have cooling equipment that can need maintenance and repair. Furthermore, any worker who maintains or repairs DCFCs must be a certified electrician. Networked chargers also have data and communications equipment that can potentially break.

Transit agencies can rely on their charger manufacturer to provide maintenance. The chargers usually come with a warranty during which the manufacturer is responsible for maintenance and repair tasks. If the transit agency opts to pay for networked charging services, the chargers can communicate with the network and can alert the charging company to any problems the charger is experiencing. After the warranty period expires, the transit agency can opt for an extended warranty, pay for a maintenance package, or take over maintenance with their own staff. Charging companies typically plan for up to two planned outages per year to do routine maintenance. Although the actual maintenance tasks are relatively easy to carry out, the labor costs of the maintenance can be expensive, as a certified electrician is needed to perform all maintenance tasks on DCFCs. Data from NREL indicates that maintenance costs for DCFCs are approximately $1,500 per year per charging cabinet (Johnson, 2020). In addition, if the transit agency uses overhead plug-in chargers, a manlift is required to elevate maintenance worker to the chargers.

The Electric Vehicle Infrastructure Training Program (EVITP) provides training to electricians on how to install EV charging infrastructure. Electricians who complete this program can receive EVITP certification. This certification is accepted as industry-standard, and some CEC grants even require that a certain percentage of electricians working on EV charging infrastructure have EVITP certification. EVITP also provides training on maintaining, troubleshooting, and commissioning EV chargers. It is recommended that maintenance staff who work on chargers obtain EVITP certification.

Overhead Charging Maintenance

Unlike plug-in chargers, overhead chargers have moving parts that require a prescribed set of preventative maintenance that needs to be performed regularly. Every month, the overhead charger requires an inspection to ensure that the wiring and the brushes are functioning properly. Every six months, maintenance technicians measure the energy and charging capacity to make sure the charger is outputting the correct amount of power. On a yearly basis, maintenance technicians inspect the charger to ensure that the wiring and communication systems are working properly. Maintenance is typically carried out by the OEM, and the manufacturer will normally offer a maintenance service package.

Hydrogen Production Equipment and Fueling Stations Maintenance

The type of maintenance onsite hydrogen production equipment requires depends on the type of hydrogen infrastructure in place. If hydrogen is produced onsite, the transit agency will require an electrolyzer or SMR, in addition to compression and dispensing equipment. If the transit agency receives delivered hydrogen, storage tanks and a fueling station are required.

NREL has conducted research on maintenance needs for hydrogen production equipment and fueling stations. According to NREL, the compressor is the single component most likely to fail (Eudy, 2018). The compressor is used to take hydrogen from the hydrogen production equipment and compress it to be placed in high pressure storage. Since hydrogen cannot be compressed into the dispenser without the compressor, this component is very important to ensure fuel availability. Therefore, NREL recommends that transit agencies have redundant compressors so their system can still operate if one compressor fails. NREL also notes that dispensers and the hydrogen chilling system also frequently require maintenance (Saur, 2020). CALSTART estimated this frequency by using Argonne National Laboratory's Heavy-Duty Refueling Station Analysis Model (HDRSAM). This analysis has been included in Appendix G: Evaluation of Hydrogen Vehicle Refueling Options Report.

To better understand maintenance needs for electrolyzers, CALSTART interviewed SunLine Transit. SunLine Transit has an electrolyzer and has paired the electrolyzer with a solar panel array to power it. SunLine Transit states that most of the maintenance for their electrolyzer has focused on route maintenance tasks. Maintenance workers perform a daily walk-through to inspect for safety issues or operating malfunctions. Maintenance workers also perform a weekly inspection to check water plumbing systems, compressor oil levels, and any system faults or alarms. SunLine also stated electrolyzers are more vulnerable to problems. Since SunLine Transit operates in extreme heat during the summer, cooling and chilling of the hydrogen has historically been an obstacle. However, to address this issue, SunLine Transit added auxiliary cooling systems, which has effectively eliminated this problem.

SunLine Transit reported few problems with infrastructure unavailability, partly because obtaining replacement hardware components such as compressors is relatively easy with an established supply chain. Some of the controls are manufactured in Europe and were previously difficult to obtain, but these parts are now stocked in Northern California. SunLine Transit did mention that a brief power outage prevented them from operating the electrolyzer. To mitigate this problem, SunLine Transit is building a redundant system to store and produce hydrogen in the event of an outage.

Another factor in infrastructure maintenance is hydrogen purity. It is vital that hydrogen, whether produced onsite or delivered, is pure and does not contain contaminants. Contaminants in the hydrogen, as listed in Figure 9, can reduce the performance of the fuel cell. The impact of contaminants on fuel cell performance depends on the type and concentration of the contaminant. Some contaminants will only cause the fuel cell to lose power, which will degrade the performance of the bus. This issue could be fixed by flushing out the hydrogen storage tanks and the fuel cell, which is difficult and costly. However, some contaminants can cause catastrophic damage to the fuel cell. SAE J2719 outlines the relevant contaminants. Sulfur compounds are the most serious and destructive contaminants. Carbon compounds such as carbon monoxide (CO) and CO2 block the catalyst surface on the fuel cell, which reduces efficiency. Compounds such as ammonia affect the membrane, which reduces the efficiency of the fuel cell system. Removing water from the hydrogen gas is also important because it can facilitate the infiltration of other contaminants into the system (Tiger Optics, 2020).

The hydrogen production pathway affects the types of contaminants that are likely to be present. Electrolysis is the least likely to produce contaminants, as it uses pure water for input. SMR, however, uses natural gas and is at risk of being contaminated with ammonia, sulfur compounds, CO, and CO2. After the hydrogen is produced, atmospheric compounds such as nitrogen, water, and oxygen can contaminate the hydrogen through leaks in the system (Tiger Optics, 2020).

The State of California recognizes the problem from contaminants, and the CEC requires that any hydrogen fueling station that receives grant funding must be tested for contaminants at least every three months. The CEC also requires that hydrogen quality be tested any time the hydrogen could have been exposed to contaminants during maintenance or other activities.

Figure 9. Typical Hydrogen Contaminants (CARB, 2016)

Impurity Source	Typical Contaminant
Air	N_2, NO_X, (NO, NO_2), SO_X (SO_2, SO_3), NH_3, O_3
Reformate hydrogen	CO, CO_2, H_2S, NH_3, CH_4
Bipolar metal plates (end plates)	Fe_3+, Ni_2+, Cu_2+, Cr_3+
Membranes (Nafion)	$Na+$, Ca_2+
Sealing gasket	Si
Coolants, DI water	Si,Al, S, K, Fe, Cu, Cl, V, Cr
Battlefield pollutants	SO_2, NO_2, CO, propane, benzene
Compressors	Oils

The cost of maintenance for hydrogen infrastructure can vary depending on the ownership model for the equipment. Many hydrogen infrastructure providers prefer to own the infrastructure and sign an agreement to provide hydrogen to the fleet. Under these agreements, the infrastructure provider is responsible for providing maintenance. For example, the Stark Area Regional Transit Authority (SARTA) (the transit agency serving Canton, Ohio, and the surrounding Stark County) receives delivered liquid hydrogen that is trucked from Canada. SARTA has 9,000 gallons of liquid hydrogen storage and a fueling station. The liquid hydrogen storage and fueling equipment is owned by Air Products. SARTA has a contract with Air Products, who owns, operates, and maintains the equipment. SARTA pays $10,000 per month plus the cost of fuel (Eudy, 2019). However, other hydrogen companies have a different business model and will construct the fueling station. After completing the fueling station, the hydrogen infrastructure company will provide maintenance for a fixed cost. The maintenance cost can be reduced if the transit agency's staff can carry out routine maintenance tasks, leaving major maintenance tasks to the hydrogen company.

Required Tools and Facility Upgrades

To adequately service the buses, the maintenance staff will need to have proper tools and facilities. Many of the tools used to maintain traditional ICE buses can also be used to service electric buses. However, some specialized equipment is needed to handle EV high voltage components such as batteries, inverters, and traction motors. The following are examples of necessary tools and equipment:

- OEM-specific diagnostic tools to troubleshoot problems on the bus.

- High impedance multimeters to monitor current in the electrical systems
- Insulated hand tools (wrenches, screwdrivers, pliers, etc.) to protect workers from shock
- Personal protective equipment including Class 0 rubber high voltage gloves (which need to be inspected and tested regularly), leather overgloves, insulated dielectric boots, face shield, insulating rubber apron, and insulated electrical rescue hook
- Overhead crane to lift batteries from the roof of the bus
- Forklift to remove inverters and HVAC systems from the roof of the bus
- Scaffolding with fall protection so technicians can access the roof of the bus
- Lifting jigs for batteries and inverters
- OEM-specific tools to fix bus mechanical systems
- Manlift (if using overhead plug-in or pantograph chargers) to perform routine maintenance and repairs

Although FCEBs operate in a similar manner as BEBs, they have additional maintenance and operational needs. Since hydrogen is a highly flammable gas, there are many regulations that govern the maintenance of hydrogen vehicles. NFPA has published safety standards for hydrogen facilities. These standards are published in the NFPA 2 Hydrogen Technologies Code. NFPA 2 was most recently updated in 2020. NFPA 2 has several provisions that are relevant to FCEB maintenance depots:

- Repair rooms must be separated from the rest of the building by a one-hour fire resistant wall.
- A gas detection system must be provided and ready to activate the following if hydrogen level exceeds 25% of the lower flammability limit:
    - Initiation of audible and visual signals
    - Deactivation of heating systems
    - Activation of the exhaust system (unless the exhaust system operates continuously)
- Infrared flame detectors are required to detect hydrogen fires since hydrogen burns invisibly.
- Defueling is required for all work on the fuel system or all hot works (welding or open flame) within 18 inches of vehicle fuel supply container. The maintenance garage must have equipment to defuel the bus's hydrogen tanks.

Local authorities and fire departments can impose additional fire safety requirements. Meeting these requirements can be expensive and vary depending on the type of improvements required. For example, when Alameda-Contra Costa Transit District (AC Transit) adopted FCEBs, they were required to install a two-hour fire wall, an ignition-free heating system for the garage, a hydrogen lower flammability limit detector, and Class 1 Div. 2 electrical equipment throughout the garage. AC Transit spent $1.5 million to provide these upgrades (CALSTART, 2016). SARTA, however, had an existing garage and only needed to purchase air handlers to ventilate the garage and sensors to detect the presence of hydrogen. These upgrades cost about $100,000 (Eudy, 2019).

Financing Strategies and Resources

Transit agencies have multiple options for funding the deployment of ZEBs. Bus OEMs offer several models for financing the procurement of buses and infrastructure. In addition, there are myriad governmental programs available to help fund vehicles and infrastructure. This section provides an overview of financing options.

Traditional Private Financing Models

Bus OEMs offer a variety of financing mechanisms that transit agencies can use to obtain buses. This includes capital purchases, bus/battery leasing, and infrastructure as a service.

Capital Purchases

Traditionally, buses are obtained through capital purchases. A capital purchase is a transaction in which an OEM or infrastructure provider transfers ownership of a bus or infrastructure to a transit agency in exchange for a capital payment. In a traditional capital purchase, a transit agency typically releases RFPs, in which they outline the number of buses and type of infrastructure they would like to procure and release the duty specifications the buses need to meet. OEMs and infrastructure providers are then invited to submit bids, and the transit agency selects a winning bid and awards a contract. However, several states have now issued statewide contracts for buses. Under a statewide contract, the state negotiates a contract with bus OEMs to purchase buses at a fixed price. Transit agencies can purchase buses from a statewide contract and thereby avoid the RFP process. The State of California has statewide contracts with several bus OEMs through California DGS. CalACT has also developed a statewide contract for zero-emission shuttle buses.

A capital purchase allows a transit agency to make a single payment to obtain a bus. The bus's value is then depreciated over the entire life of the bus. Capital purchases can be problematic; they require transit agencies to have access to a large amount of money. It is often difficult for transit agencies to obtain enough funding to make a lump sum payment, especially smaller transit agencies.

Battery Leasing

When compared to conventional diesel- and/or gas-powered vehicles, EVs often come at a higher upfront capital cost. In most cases, the largest cost is the battery itself, which is why some OEMs have developed battery leasing programs to lower the barrier to entry for fleets and allow the manufacturer to recoup the cost of the battery over an extended contract. In this model, the BEB can be purchased without the battery pack at a lower price that is cost competitive with conventional vehicles. The upfront cost of the battery itself is covered by a participating financial partner and enables battery warranties to be guaranteed for the duration of the lease. Under this model, the transit agency would then make monthly or annual lease payments for the battery. Battery leasing helps transit agencies because it reduces CAPEX for the buses. This model effectively shifts a large portion of the bus cost into lease payments, which allows transit agencies to finance their purchase through operational budgets, rather than CAPEX.

While this is a promising model for the acceleration of transit fleet electrification, it is a newer idea that is still in development at most OEMs. A price comparison between leasing and owning the battery remains uncertain; battery leasing is a nascent business model, and it is unclear which, if any, transit agencies have utilized this option. Table 5 provides a brief overview of BEB OEM battery leasing options.

Table 5. Battery Leasing Options

Bus OEM	Battery Leasing Options
BYD	Yes
New Flyer	Unknown
GreenPower Motor Company	No
Phoenix Motorcars	No, but considering offering battery leasing in the future

Infrastructure-as-a-Service

Like bus/battery leasing, infrastructure-as-a-service (IAAS) is another method for reducing CAPEX associated with deploying ZEBs, particularly charging and resiliency infrastructure. IAAS can also be combined with battery leasing to further reduce CAPEX. Under an IAAS model, a company will provide turnkey service, managing the construction and installation of charging infrastructure. Under this model, the infrastructure company will typically maintain ownership of the chargers and any resiliency equipment. The infrastructure company then signs a power purchase agreement (PPA) with the transit agency to sell the power produced and dispensed to the buses. IAAS companies can develop PPAs where power is sold on a per kWh basis or a per mile basis. Most IAAS companies prefer to sell power on a per kWh basis. IAAS companies typically combine the infrastructure with managed/networked charging to minimize demand charges and the cost of electricity.

The IAAS model can also provide tax benefits in some cases. Some types of infrastructure can qualify for the Investment Tax Credit (see page 57) and other tax benefits. Since a transit agency is a public agency that does not pay taxes, they cannot directly take advantage of these tax credits. However, under the IAAS model, the infrastructure provider retains ownership, and they can benefit from the tax credits. This option would allow the infrastructure provider to pass some of the tax benefits onto the transit agency in the form of lower PPA rates. In some cases, an IAAS company may also give transit agencies the option to convert the PPA to a capital purchase of the infrastructure once the tax benefits have been realized. An overview of IAAS companies can be found in Appendix F: Energy Storage Solutions.

Funding Sources and Incentives for Buses and Infrastructure

ESTA is currently funded with local and federal funds. The promising funding option that ESTA has to fund the transition to a ZEB fleet is to apply for competitive grants to pay for buses or bus facilities. Grant funding can be used to reduce CAPEX associated with purchasing buses or chargers. Alternatively, there are situations where grants can be combined with traditional financing models to fund the fleet. This section provides an overview of governmental funding opportunities.

State Funding Sources and Incentives

Clean Transportation Program - CEC

The Clean Transportation Program was created to fund projects that help transition California's fuels and vehicle types to achieve California's climate policies. The Clean Transportation Program is funded from fees levied on vehicle and vessel registrations, vehicle identification plates, and smog abatement. The Clean Transportation Program was created by Assembly Bill 118 and the collection of fees that supports the program was extended to January 1, 2024, by Assembly Bill 8. The Clean Transportation Program funds multiple classes of vehicles. Every year the CEC develops an Investment Plan Update to identify how the program's funds will be allocated. The CEC proposed $30.1 million of funding for FY 2022-23 and $13.8 million in funding for FY2023-24 for zero-emission medium-and heavy-duty vehicles and infrastructure under the Clean Transportation Program. The Clean Transportation Plan also plans to invest $30 million from zero-emission vehicles and infrastructure general funds into transit activities (CEC, 2022).

Carl Moyer Program – CARB

The Carl Moyer Program provides grant funding for engines, equipment, and other sources of air pollution that exceed CARB's regulations for on-road heavy-duty vehicles. The Carl Moyer Program is managed by CARB in collaboration with local APCDs and air quality management districts (AQMDs). ZEBs with a GVWR of greater than 14,000 lbs. are eligible for funding under Carl Moyer. The APCDs and AQMDs are the entities that issue the grants and determine funding for the program. This is a competitive funding opportunity.

Energy Infrastructure Incentives for Zero-Emission Commercial Vehicles (EnergIIZE) – CEC, CALSTART

EnergIIZE is a program that was launched by the CEC and is being managed by CALSTART. EnergIIZE will provide $50 million of funding to entities to help finance the purchase of charging and hydrogen infrastructure. EnergIIZE will fund medium- and heavy-duty infrastructure and is intended to primarily benefit communities with disproportionately high levels of air pollution. EnergIIZE program will only cover a part of the infrastructure hardware and software costs. For EV projects, charging equipment eligible for funding includes Level 2 electric vehicle supply equipment (EVSE), DCFC EVSE, charge management software, switchgear, electrical panel upgrades, wiring and conduit, and meters. For hydrogen projects, equipment that is eligible for funding includes compressors, liquid and gaseous pumps, piping and pipelines, hydrogen dispensers with hoses and nozzles, high-pressure storage, onsite production equipment, chillers, switchgear, electrical panel upgrades, wiring and conduit, and meters. Construction, labor, and utility upgrade costs are not eligible for funding under this program.

The EnergIIZE program offers four pathways to fund infrastructure. Each of these pathways has different eligibility criteria:

- EV Fast Track – for fleets that own or have a purchase order for a vehicle registered in the State of California as a result of state or federal vehicle incentive funded projects.
- EV Jump Start – for transit agencies in a designated DAC (according to CalEnviroScreen 3.0)
- EV Public Charging Stations – for public charging station developers
- Hydrogen – for the development of hydrogen refueling stations for medium- and

heavy-duty vehicles (either liquid hydrogen or gaseous hydrogen)

The pathway that a transit agency qualifies for determines the amount of funding that they can receive. Under the EV Fast Track pathway, applications are evaluated on a first-come, first-served basis. EV Fast Track will fund 50% of hardware and software costs incurred, up to a maximum of $500,000. EV Jump Start funding is awarded on a competitive basis. EV Jump Start will fund 75% of hardware and software costs incurred, up to a maximum of $750,000. Hydrogen pathway funding is awarded on a competitive basis. The Hydrogen pathway will finance 50% of hardware and software costs incurred, up to a maximum of $3,000,000 (CALSTART, 2023).

At the time of writing, CALSTART is scheduled to open the EV Fast Track in Q1 2024. The EV Jump Start track is planned to open in Q3 2024. The hydrogen pathway is scheduled to open in Q2 2024. The EV Jump Start and hydrogen tracks are expected to be open for two to four weeks. This is a competitive funding opportunity.

Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) – CARB, CALSTART

California HVIP is a program that was launched by CARB and is managed by CALSTART. HVIP provides vouchers that are used to finance the purchase of clean transportation vehicles. HVIP's vouchers are applied at the point of purchase, which reduces the purchase price of the vehicle when it is purchased. ZEBs are eligible to receive vouchers under HVIP. Vouchers are allocated on a first-come, first-serve basis. This is a competitive funding opportunity.

California Infrastructure and Economic Development Bank (IBank)

The IBank was created in 1994 to fund infrastructure and economic development projects in California. The IBank was started by the Bergeson-Peace Infrastructure and Economic Development Bank Act and is operated by the California Governor's Office of Business and Economic Development (GO-Biz). IBank can issue low-interest bonds that can be used to finance projects for public agencies or nonprofits. The IBank has programs that can be used to finance the transition to a zero-emission fleet. The Infrastructure State Revolving Fund (ISRF) program provides low-Interest financing for infrastructure projects. ISRF provides loans of $50,000 to $25 million over a term of up to 30 years at a fixed interest rate. These loans are funded through the sale of ISRF revenue bonds. Public transit projects, which include but is not limited to vehicles and maintenance and storage yards, are eligible for funding through ISRF. ISRF applicants must be a public agency, joint power authority, or nonprofit corporation formed by an eligible entity. ISRF accepts applications on an ongoing basis (California Infrastructure and Economic Development Bank, 2016).

The IBank also offers the California Lending for Energy and Environmental Needs (CLEEN) program. CLEEN provides loans from $500,000 to $30 million over a term of up to 30 years. These loans can be used to fund projects that use commercially proven technology to reduce GHG emissions or pursue other environmental objectives. Eligible projects include energy storage, renewable energy generation assets, stationary fuel cells, EVs, alternative fuel vehicles, and alternative fuel vehicles refueling stations (California Infrastructure and Economic Development Bank, n.d.).

Low Carbon Fuel Standard (LCFS) Program – CARB

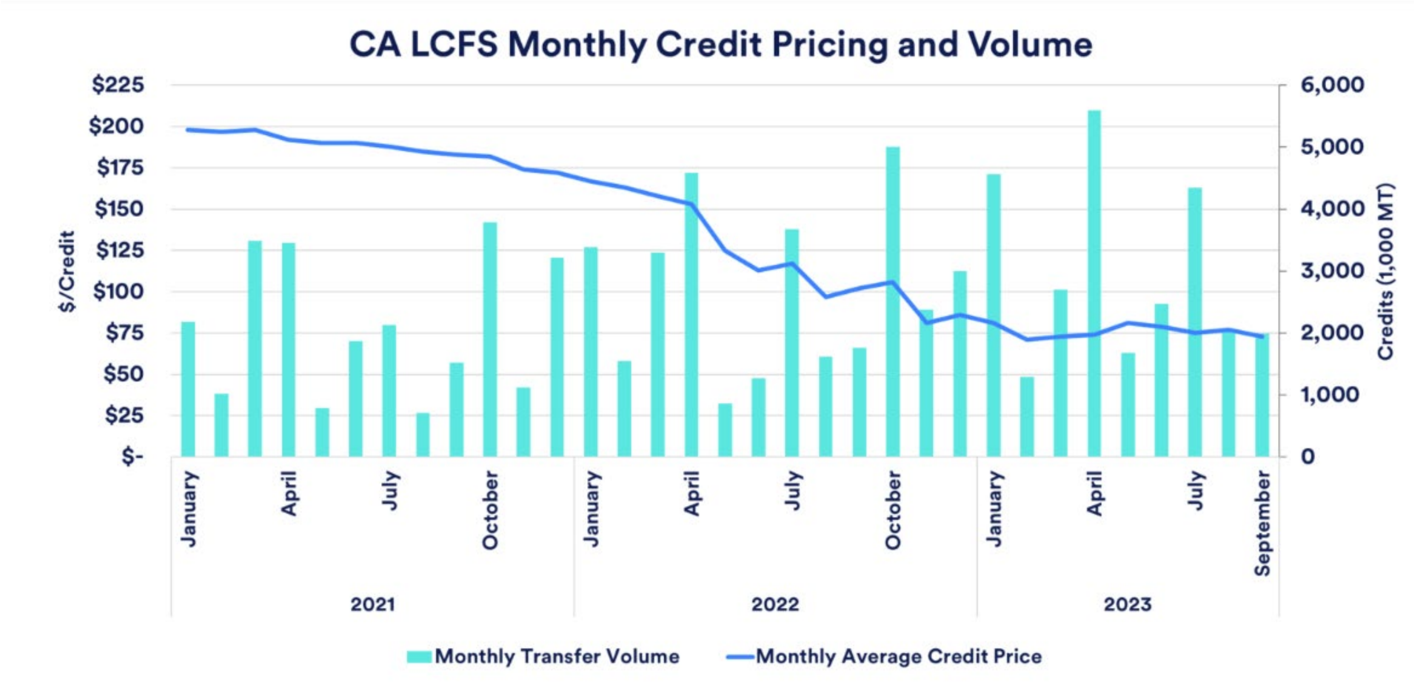
The LCFS Program is run by CARB and creates a mechanism for the users and producers of low-carbon fuels (including electricity) to generate credits for the use of these low-carbon fuels. These credits can then be sold in the LCFS market. The LCFS program sets standards for the maximum carbon intensity (CI) that a fuel can have. If an entity uses fuels that are below the CI standards, they generate LCFS credits. However, if an entity uses fuels that exceed the CI standards, they generate deficits and must purchase LCFS credits to negate their deficits.

LCFS credits are generated based on the fuel type, fuel quantity, and CI of the fuel used (in this case electricity or hydrogen). Over time, the standards for CI become more stringent, making it more difficult to earn LCFS credits. Transit agencies must comply with CARB reporting requirements to earn LCFS credits. To generate LCFS credits, the chargers or hydrogen production equipment must be registered with CARB. Once the equipment is registered, the owner of the equipment can begin generating LCFS credits.

LCFS credits can be sold to polluters that need to negate their deficits based on the going market rate. However, as of 2021, CARB has set a purchase price for LCFS credits at $221.67 per credit, effectively creating a price ceiling. The price of LCFS credits has been volatile in recent years. Prior to 2021, LCFS credits were trading at about $200 per credit. However, the price of LCFS credits has fallen substantially in 2022. At the beginning of 2022, LCFS credits traded at about $150. As of September 2023, the price has fallen to about $70 per credit. This decline in price has been attributed to increasing adoption of renewable diesel, renewable natural gas (RNG), and EVs leading to an increase in the supply of credits. However, CARB has indicated that there could be changes to the LCFS program in 2024 (SRECTrade, 2023). Changes to the LCFS program can have an effect on LCFS prices.

Sales of LCFS credits can provide a significant revenue mechanism. The profits from LCFS credits can be used to fund either vehicle purchases or charging infrastructure. Figure 10 shows historic LCFS prices from January 2021 through September 2023.

Figure 2. Historical LCFS Prices January 2021 – September 2023 (SRECTrade, 2023)



Source: California Air Resources Board

Transit and Intercity Rail Capital Program (TIRCP) – Caltrans

TIRCP provides grants to fund capital improvements that will modernize California's rail, bus, and ferry public transit facilities. The objective of the program is to reduce GHG emissions, expand transit service, increase transit ridership, and improve transit safety. Funded projects are expected to reduce GHG emissions, vehicle miles traveled, and congestion. TIRCP is funded through the Greenhouse Gas Reduction Fund (GGRF) and the Cap-and-Trade program. TIRCP funds can be used to finance site upgrades and the deployment of zero-emission infrastructure at bus depots and facilities. This is a competitive funding opportunity.

Low Carbon Transit Operations Program (LCTOP) – Caltrans

The LCTOP is one of several programs that is funded by the GGRF, which is funded by revenues from the state's Cap-and-Trade system. State law requires continual appropriation of 5% of the revenue from the GGRF to be allocated to the LCTOP. This funding is available through an allocation request. State law requires the program's funds to provide transit operating or capital assistance that meets any of the following criteria:

1. The funding can directly enhance or expand transit service by enabling new or expanded bus or rail services, water-borne transit, or expanded intermodal transit

facilities, and may include equipment acquisition, fueling, and maintenance, and other costs to operate those services or facilities.

2. The funding can fund operational expenditures (OPEX) that increase transit mode share.
3. The funding can fund the purchase of ZEBs, including electric buses, and the installation of the necessary equipment and infrastructure to operate these ZEBs.

Volkswagen (VW) Mitigation Trust – CARB

The purpose of the VW Environmental Mitigation Trust is to fully mitigate the excess NOx emissions released during the Volkswagen emission scandal. This program was established as a part of the settlement that VW reached with the EPA. The VW Mitigation Trust has allocated $423 million to the State of California to fund the deployment of clean transportation vehicles. $130 million of these funds is devoted to replacing older, high emission buses with BEBs or FCEBs. Transit, school, and shuttle buses are eligible for funding.

Federal Funding Sources and Incentives

Bus and Bus Facilities (5339) – U.S. Department of Transportation/Caltrans

The Bus and Bus Facilities program is managed by the FTA. This program provides capital funding to replace, rehabilitate, and purchase transit vehicles and construct bus-related facilities. The FTA allocates funding to states to administer these grants. The Infrastructure Investment and Jobs Act (IIJA) increased funding for the Bus and Bus Facilities program for five years between FY2022 and FY2026. Approximately $1 billion per year in both formula funding and competitive grants will be provided through the Bus and Bus Facilities program for the entire United States (FTA, 2021). In California, Caltrans has been delegated the responsibility of managing Bus and Bus Facilities formula grants. Public agencies and nonprofit organizations that are involved in public transit may apply for competitive grants.

Congestion Mitigation and Air Quality (CMAQ) Improvement Plan – DOT

CMAQ provides funds directly to states. These funds may be used to finance projects that reduce traffic congestion and improve air quality. The main objective of this program is to reduce CO, ozone, and PM emissions. This program is primarily intended to fund projects in areas that do not meet national air quality standards. The IIJA provides $13.2 billion of funding over five years. Under IIJA, there are new project types that are eligible for funding under CMAQ. The purchase of medium- or heavy-duty zero-emission vehicles and supporting infrastructure is eligible for funding under CMAQ. Shared micromobility projects are also eligible for funding. CMAQ funds can also be used to provide operating assistance for public transportation projects.

Investment Tax Credit (ITC) - IRS

Internal Revenue Code Section 48 provides a tax credit for investments in certain types of energy projects. Section 48 provides tax credits for a wide range of renewable energy investments, such as solar and energy storage. The ITC was originally scheduled to phase out over time. However, the ITC was ultimately extended by the Inflation Reduction Act. Solar and energy storage investments are eligible for an ITC of up to 30% if labor requirements are met and construction begins by 2033. The ITC begins to phase out for projects that begin construction after 2033 (Department of Energy, 2023). The ITC is useful for funding the deployment of solar and energy storage systems to support charging infrastructure.

Low or No Emissions Program (Low-No) – DOT/FTA

Low-No provides funding to state and local governmental authorities for the purchase or lease of zero-emission and low-emission transit buses. Low-No funding can also be used to acquire charging or fueling infrastructure for the buses, pay for construction costs, or obtain or lease facilities to house a fleet. In FY2021, $182 million was allocated for the Low-No program. However, the IIJA expanded funding for the Low-No program. IIJA allocates an additional $5.25 billion for the Low-No program over five years, starting in FY2022. Approximately $1.12 billion will be allocated per year (FTA, 2021). This represents a major increase in funding for ZEBs. This is a competitive funding opportunity.

To be eligible for this funding, a transit agency will need to submit a plan for transitioning to zero-emission buses. This plan must demonstrate a long-term fleet management plan that addresses how the transit agency will meet the costs of transitioning to zero-emission, the facilities and infrastructure that will be needed to be deployed to serve a zero-emission fleet, the transit agency's relationship with their utility or fuel provider, and the impact that the transition will have on the transit agency's current workforce. Under IIJA, transit agencies may apply for Low-No funding with other entities, such as an OEM, which will participate in the implementation of the project. IIJA also requires that 5% of grant funds awarded be used to fund workforce training to prepare their current workforce to maintain and operate the buses.

Rebuilding American Infrastructure with Sustainability and Equity (RAISE) grants – DOT

The RAISE grant is the latest iteration of the Better Utilizing Investments to Leverage Development (BUILD) and Transportation Investments Generating Economic Recovery (TIGER) grant program. This program is intended to invest in road, rail, transit, and port projects. The objective of this program is to fund projects that are difficult to support through traditional DOT programs. Public entities, such as municipalities, are eligible to apply for this program. RAISE is a competitive grant program. This is a competitive funding opportunity.

II. Eastern Sierra Transit Authority

ESTA Overview

Since 2006, ESTA has serviced the Eastern Sierra region and offers both demand response and fixed-route services in Bishop, Mammoth Lakes, Lone Pine, and Walker. Demand response is offered in Bishop seven days a week, Lone Pines and Mammoth Lakes on weekdays, and in the Walker area on Mondays, Wednesday, Thursday, and Friday. ESTA provides transit options to key locations in the region including Reno, Carson City, Reds Meadow, and Lancaster. The Purple Line, Mammoth Lake town trolley, Reds Meadow Shuttle, and Mammoth shuttle connect with YART. There is connection to AVTA in Lancaster, and there is a connection to Washoe RTC in Reno. ESTA provides both year-round and seasonal (winter and summer) routes.

ESTA Transit Fleet

At present, all of the fleet's 54 vehicles have internal combustion engines. The full-sized buses are fueled with diesel. The DAR/shuttle vehicles and the trolleys vary between diesel and gasoline.

The fixed-route fleet has 34 vehicles:13 full-sized buses, 12 cutaway buses, and 9 trolleys. The full-sized bus fleet consists of nine El Dorado Axess, three El Dorado E-Z Rider II, and one Blue Bird Xcel 102. The cutaway fleet contains four Ford E-450s, four F-550 cutaways, and four Freightliner Defenders. The trolley fleet has five Supreme Trolleys and four Hometown Trolleys.

There are 10 vehicles in the demand response fleet: five Ford E-450 cutaway buses, four Daimler Sprinter vans, and one Dodge Braun van. Aside from the Dodge van, the vehicles are supposed to have a useful life of seven years and those vehicles are at present beyond their useful life. The fleet is reportedly larger than it needs to be. A large spare ratio is maintained to account for additional vehicle downtime with outsourced maintenance and an aging fleet.

The cutaway buses are often interchanged between fixed-route and DAR service. A ZE replacement for these buses need to be capable of handling various duty cycles. In Bishop, ESTA is additionally looking into the possibility of using vans to replace some vehicles to lessen driver licensing needs and suit their ridership.

At present, ESTA houses vehicles at four locations: 210 Commerce Drive, Mammoth; 1452 S Main St, Lone Pine; 565 Airport Drive, Bishop; 399 Mule Deer Road, Walker.

Route Modeling

ESTA's fixed-route services vary based on the time of year. Three routes only run in the summer months, and six routes only run in the winter. Eleven routes (including DAR service) run year-round.

Due to the seasonal and route differences, the route modeling has been analyzed by season and based on the home depot for the vehicle. These results have been used to determine whether ZEBs can serve as a drop-in replacement for the current fleet and which routes are most suitable to deploy ZEBs and finally to estimate the TCO. A BEB is considered a drop-in replacement if it can complete its shift with an SOC of at least 30%. Likewise, an FCEB is considered a drop-in replacement if it can complete its shift with 10% of its hydrogen capacity remaining.

See Appendix A: ESTA Route Modeling Results for more details on ESTA's route model results.

Bishop

Bishop depot is located at East Sierra Regional Airport. This depot is assumed to house the vehicles servicing the Benton Bishop Shuttle, Bishop Creek Shuttle, Bishop Dial-a-Ride, Mammoth Express, 395 North, and 395 South routes while they are not operating in service.

The maximum load for charging battery-electric vehicles for Bishop depot is approximately 117 kW. Bishop depot requires a total of eight 19.2 kW chargers. Based on route characteristics and duty cycles, three routes are going to need hydrogen vehicles: 395N, 395S, and Mammoth Express. The expected hydrogen demand for Bishop depot is 180 kg per day.

Mammoth

Mammoth depot is located at the Town of Mammoth Lakes Fleet Maintenance building. This depot is expected to serve 11 routes while the buses are out of service.

The maximum load for Mammoth depot is approximately 150 kW. Due to the seasonality of some routes, the maximum power varies per season. Mammoth depot requires a total of six chargers: three 19.2 kW, one 50 kW, one 60 kW, and one 100 kW. Based on route characteristics and duty cycles, four routes are going to need hydrogen vehicles: Winter Red Line, Summer Town Trolley, Summer Lake Basin, and Reds Meadow. The expected hydrogen demand for the Mammoth depot is 520 kg per day.

Lone Pine

Lone Pine depot is located at Lone Pine Airport. This depot is assumed to house the vehicles servicing the Lone Pine Express and Lone Pine Dial-a-Ride routes while they are not operating.

The maximum load for Lone Pine depot is approximately 15.5 kW and will require one 19.2 kW charger. Based on route characteristics and duty cycles, one route is going to need hydrogen vehicles: Lone Pine Express. The expected hydrogen demand for the Lone Pine depot is 26 kg per day.

Walker

Walker depot is located at Walker Senior Center. This location is assumed to house the one vehicle servicing the Walker Dial-a-ride, Bridgeport to Carson City, and Walker to Mammoth Lake routes overnight while the vehicle is not operating.

Due to the charging window limits, battery size constraints, and the energy requirement of the routes serviced by Walker depot, it is recommended that the proposed vehicle is converted to a hydrogen-powered vehicle, rather than a battery-electric vehicle. The expected hydrogen demand for the Walker depot is 6 kg per day.

Fleet Replacement Plan

ESTA plans to replace the current ICE fleet with ZEBs as the buses reach the end of their useful life. Many of the buses are reaching or have reached the end of their useful life and need to be replaced. A 100% ZEB fleet will occur in 2037.

Table 6 below shows ESTA's ZEB replacement plan. Note any ICE and light-duty vehicles are not considered as they are not a part of ICT planning. Any vehicle spares were also not included in this replacement plan.

Table 6. ESTA ZEB Replacement Plan

Fleet Replacement Plan					
Year	**Depot**	**BEV**	**BEV Type(s)**	**FCEV**	**FCEV Type(s)**
2026	Bishop	2	Shuttle (1), Van (1)	1	Shuttle (1)
	Mammoth	2	40Ft Bus (1), 35Ft Bus (1)	4	40Ft Bus (4)
	Lone Pine	1	Shuttle (1)	1	Shuttle (1)
	Walker	N/A	N/A	1	Shuttle (1)
2027	Bishop	2	Van (2)	1	Coach Bus (1)
	Mammoth	2	Trolley (1), Van (1)	3	40Ft Bus (3)
	Lone Pine	N/A	N/A	N/A	N/A
	Walker	N/A	N/A	N/A	N/A
2028	Bishop	1	Van (1)	1	Coach Bus (1)
	Mammoth	1	40FT Bus (1)	3	Trolley (3)
	Lone Pine	N/A	N/A	N/A	N/A
	Walker	N/A	N/A	N/A	N/A
2029	Bishop	3	Shuttle (1), Vans (2)	N/A	N/A
	Mammoth	2	40Ft Bus (2)	9	Trolley (3), 40Ft Bus (6)
	Lone Pine	N/A	N/A	N/A	N/A
	Walker	N/A	N/A	N/A	N/A
Total	Bishop	8	Shuttles (2), Vans (6)	3	Shuttle (1), Coach Bus (2)
	Mammoth	7	40Ft Bus (4), 35Ft Bus (1), Trolley (1), Van (1)	19	40Ft Bus (13), Trolley (6)
	Lone Pine	1	Shuttle (1)	1	Shuttle (1)
	Walker	N/A	N/A	1	Shuttle (1)

Fuel Analysis

Utility Analysis

ESTA will have to purchase electricity as fuel from the utility company per depot. The electricity cost will vary per depot due to the different vehicle duty cycles and different utility rate structures. Each depot needs to be considered needs separate attention considering utility communication, upgrades, and timelines for construction.

The costs and energy demand are broken down below in Table 7. As a reference, the average annual energy consumption of a residential house uses approximately 10,000 kWh/yr (10MWh/yr).

Table 7. ESTA Energy Demand and Cost

Depot	Utility	BEV	Electricity Cost ($)	Energy Demand (kWh)	Energy Demand (MWh)
Bishop	SCE	8	$ 31,397.48	152,916.96	152.92
Mammoth	SCE	7	$ 42,877.68	246,405.45	246.41
Lone Pine	LADWP	1	$ 6,681.22	20,414.36	20.41
Walker	N/A	N/A	N/A	N/A	N/A
Total		**16**	**$ 80,956.38**	**419,736.77**	**419.74**

Hydrogen Analysis

Table 8 below show the expected demand for hydrogen based on the REM analysis. The largest demand for hydrogen is expected to come from Mammoth, followed by Bishop.

Table 8. ESTA Expected Hydrogen Demand and Cost

Depot	FCEV	Daily H2 Usage (kg)	Annual H2 Cost ($)	Annual H2 Usage (kg)
Bishop	3	189.47	$ 662,078.04	55,173.17
Mammoth	19	511.43	$ 563,098.20	46,924.85
Lone Pine	1	14.37	$ 120,860.80	15,107.60
Walker	1	6.17	$ 60,430.40	7,553.80
Total	**24**	**721.43**	**$ 1,406,467.44**	**124,759.42**

Summary from Hydrogen Report

CALSTART worked with an expert hydrogen consultant to review and propose a few options for managing the hydrogen distribution for ESTA. This section summarizes the report. Please see full report for complete details.

From the economic perspective, liquid hydrogen transportation is the most feasible. However, there needs to be enough demand for the hydrogen. Based on the cost of electricity in California, onsite hydrogen production is more expensive than delivered hydrogen. Fueling locations in the Bishop-Mammoth area are plentiful.

Installing multiple hydrogen refueling stations is impractical at this point and it is not even clear whether any hydrogen refueling station is needed for this project. The CALSTART team have identified three options for deploying hydrogen infrastructure for ESTA:

- Option 1: If the timeline for the project is far enough out that a *retail* hydrogen station in Bishop becomes a reality, then the best fueling option would be a mobile refueler capable of 350 bar fills.

- Option 2: If an intermediate location (Mammoth Airport, Crowley Lake, Tom's Place) is selected for a station to be shared by Bishop and Mammoth Lakes vehicles, then a mobile refueler probably doesn't make sense for Walker and Lone Pine. It would probably be more economical to tow the buses both ways.
    - If either Bishop or Mammoth Lakes are selected as station sites, then a mobile refueler makes sense for servicing the remaining sites.
- Option 3: Filling a mobile refueler from a tube trailer parked at Bishop Airport is probably by far the most economical approach to refueling for the project as currently conceived.

Infrastructure Analysis

To deploy a BEB fleet, ESTA will first need to design the location of charging infrastructure and funding. After funding has been secured, environmental review and a final draft of the depot will need to be completed.

Next, ESTA will need to ensure it has completed public outreach on the proposed design and develop a construction bid package. In addition, the project will go through the permitting process. Once a construction firm has been selected and permitting is complete, construction may begin. Construction is expected to take 20 months. During the construction phase, utility infrastructure will also need to be installed. After construction is complete, commissioning will take place. After commissioning, the facility will be ready for use. A Gantt chart outlining the proposed construction timeline is included below in Table 9.

Table 3. ESTA Facility Construction Timeline

	Year 1												Year 2												Year 3												Year 4											
Months from Grant Award	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
NEPA Determination	■	■	■	■	■	■	■	■																																								
Develop Final Design	■	■	■	■	■	■	■	■																																								
Public Outreach Complete									■	■																																						
Construction Bid Package									■	■																																						
Permitting											■	■	■	■	■	■	■																															
Construction Phase																		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■											
Install Utility Infrastructure																																■	■	■	■	■	■											
Commissioning																																						■	■									
Facility in Service																																								■	■	■	■	■	■	■	■	■

If the construction process adheres to the proposed timeline, construction is expected to take 39 months. The main barrier to beginning this process is obtaining land and funding to build the depot.

In addition to building a transit facility, installing charging infrastructure is vital for the successful deployment of a BEB fleet. Deploying BEB infrastructure is more than simply installing the chargers. In addition to FTM utility infrastructure, electrification requires the deployment of BTM infrastructure (on the customer's side of the meter). BTM infrastructure carries the power from the utility transformer (where the utility delivers power to the depot) to the actual chargers. BTM infrastructure upgrades entail installing appropriately sized transformers and switchgear. In addition, conduit through which the circuits can deliver power to the chargers is required. Conduit is typically underground, and the depot must be trenched to install this equipment.

The depot will need FTM equipment, mainly a transformer. ESTA will also need to deploy BTM equipment at their depot to bring power from the transformer to the chargers.

ESTA will transition to zero-emission between 2024 and 2040. To minimize the amount of construction work needed to install BTM infrastructure, it is advisable to install all BTM upgrades at the same time. To save time and reduce costs, BTM infrastructure installation should begin during the construction phase to allow the infrastructure to be installed before concrete is laid and to reduce the cost of deploying conduit by reducing the amount of trenching. In addition, ESTA will need to install conduit directly to the location where each of the chargers will be located. This strategy allows ESTA to install the infrastructure without having to do multiple rounds of trenching. The site will then be charger-ready, and as the buses are deployed, additional chargers can be added by simply running circuitry through the conduit to the chargers. To achieve this, preplanning will need to be conducted to identify where each of the chargers will be located at the depots.

Estimated Costs

The total cost of ownership for the transition of 20 routes total from the four depots, Walker, Lone Pine, Mammoth Lakes, and Bishop, is estimated with the help of CALSTART's TCO calculator. The cost includes the capital cost of buses and infrastructure, maintenance cost of buses and infrastructure, and the LCFS credits. To analysis the overall cost.

The REM analysis result indicates using battery-electric buses on 12 routes and hydrogen fuel cell buses on eight routes would be technically feasible as shown in Table 10 below.

Table 10. Feasibility of ZEB Use on ESTA Routes

Depot Name and Location	Route Name	
	BEB	FCEV
Bishop	Bishop Creek Shuttle	Mammoth Express
	Benton Bishop	395 South
	Bishop DAR	395 North
Mammoth Lakes	Winter Night Trolley	Red Meadow Shuttle
	Winter Yellow Line	Summer Lake Basin Trolley
	Winter Blue Yellow Line	Summer Mammoth Town Trolley
	Winter Blue Line	Winter Red Line
	Winter Green Line	
	Purple Line	
	Mammoth DAR	
Walker		Walker DAR/Bridgeport to Carson City/ & Walker to Mammoth Lake*
Lone Pine	Lone Pine DAR	Lone Pine Express

*Single vehicle operates on all three routes on different days.

To estimate the TCO, several assumptions have been incorporated into the calculation. These assumptions are integral to completing the comprehensive assessment, and they are outlined as follows:

1. Discount Rate: A uniform discount rate of 4% has been applied to both BEBs and FCEVs. This rate is utilized to discount future cash flows to their present value.
2. Maintenance Cost: The assumed maintenance cost is set at $0.36 per mile for both BEBs and FCEVs.
3. Number of Operation Days: The buses operate for a total of 358 days, comprising 180 winter days and 178 summer days.
4. Hydrogen Refueling Cost: The cost of hydrogen refueling is estimated at $12 per kilogram.
5. BEB Maintenance Cost: For BEBs, the maintenance cost is specified at $0.13 per mile.
6. The LCFS credits for BEBs and FCEBs in the TCO calculator are determined as $0.16/kWh and $2.14/kgs, respectively. These values are computed using the CARB LCFS calculator, considering the carbon intensity derived from utility power for BEBs and

hydrogen production for FCEBs.

7. Charger Open: A charger open rate of 2% of the charger cost is factored into the charger capital cost.
8. TCO Calculation Period: The TCO is computed by combining the vehicle capital cost with operating costs over a predetermined period of operations. In this analysis, the overall lifetime of the vehicle is considered. For transit and shuttle buses, a useful life of 12 years and seven years, respectively, is considered.

These assumptions provide a foundational framework for the TCO calculation, offering a standardized basis for evaluating the economic feasibility and comparison of BEBs and FCEVs over their respective lifetimes.

Capital cost of vehicles considered in this calculation are listed in Table 11 below.

Table 11. Vehicle Capital Cost

<table>
<tr><th>Vehicle Categories</th><th>Electric</th><th>Hydrogen</th></tr>
<tr><td>40 transit bus</td><td>$840,000</td><td rowspan="3">$900,000</td></tr>
<tr><td>35 ft transit bus</td><td>$645,000</td></tr>
<tr><td>Shuttle Vans</td><td>$159,500</td></tr>
<tr><td>Trolley</td><td>$145,000</td><td rowspan="2">$350,000</td></tr>
<tr><td>Van Transit bus</td><td>$44,500</td></tr>
</table>

Along with the vehicle cost, other general financial assumptions have been made, such as the cost of chargers, as shown in Table 12 below.

Table 12. Charger Cost by Category

Charger Category	Cost
19.2 kW	$5,000
50 kW	$32,000
60 kW	$40,000
100 kW	$56,000

The TCO offers the information to evaluate direct and indirect costs of their ZEB purchase, as well as potential savings over the life cycle of the vehicle. Based on the above-mentioned assumption the levelized cost for ($/kg), ($/kWh), and ($/mile) are shown in

Table 13 below.

Table 13. Levelized Cost for ZEB Use

Depot	Electric Buses		FCEV Buses	
Bishop	LCOE ($/kWh)	$0.55	LCOE ($/kg)	$12.60
	LCOE ($/mile)	$0.29	LCOE ($/mile)	$1.58
Mammoth	LCOE ($/kWh)	$1.45	LCOE ($/kg)	$34.57
	LCOE ($/mile)	$7.07	LCOE ($/mile)	$4.01
Walker	NA	NA	LCOE ($/kg)	$15.75[5]
			LCOE ($/mile)	$1.97[6]
Lone Pine	LCOE ($/kWh)	$0.97	LCOE ($/kg)	$11.16
	LCOE ($/mile)	$0.44	LCOE ($/mile)	$1.40

The TCO results have modeled the estimated cost of $32 million. Please see Appendix B: TCO Results for in-depth details per depot.

Financing Strategy

ESTA will need a financing strategy to transition to a zero-emission fleet. The most important step that ESTA will need to take is to plan depot and secure funding for ZEBs and fueling infrastructure. The financial resources needed for a facility may potentially be obtained by winning a competitive grant(s) that funds CAPEX. Grant programs such as Caltrans's TIRCP and the DOT's RAISE can also be used toward purchasing a bus depot or financing utility and BTM infrastructure upgrades. The DOT also provides other competitive federal grants that could potentially be used as funding. For example, the Bus and Bus Facilities grant, if awarded, could be used to help fund the purchase of buses and related equipment and the construction of bus facilities. However, grant funding should not be considered as a guaranteed source of funding as these are highly competitive programs.

Once a transit property has received infrastructure upgrades, the operational costs are expected to be covered by ESTA's operating budget. However, the purchase of the buses needs to be financed. Bus purchases can be financed with various grant and funding sources (see **Financing Strategies and Resources**). Most of these grant and finance programs will only partially finance the cost of the buses. To maximize funding for bus purchases, it would be advisable to apply for and stack multiple grants, though it is unlikely that grants will pay for the entire transition to a zero-emission fleet. The main objective when pursuing grants should be to cover the incremental cost of ZEBs, or the difference

[5] The LCOE calculations are done assuming the worst case of vehicle travelling from walker to Mammoth Lake every day.

between the cost of a ZEB and a fossil fuel-powered bus. Using grants to cover the incremental cost of the buses would allow ESTA to purchase ZEBs with the funding sources they normally employ to purchase buses.

ESTA should also consider which finance methods would be most appropriate for their agency. If ESTA is amenable to CAPEX, then traditional financing models would be the most appropriate. However, if ESTA prefers to avoid or reduce CAPEX, then financing models such as bus/battery leasing or IAAS would be more appropriate. These financing models would effectively allow ESTA to pay CAPEX from their operational budget.

There are additional financial considerations that need to be factored in when deploying resiliency assets. The most likely candidates for ESTA would be solar and storage or natural gas generators. However, there are unique financial considerations that need to be evaluated when selecting an asset. One major drawback of natural gas generators is that they are subject to air quality regulations and would likely be permitted as backup generators. As a result, they can be used only in the event of a grid outage and would remain idle for the vast majority of the time. This solution is problematic because generators have a high capital cost, meaning that the levelized cost of energy (per kWh) produced by the generator would be very high. Unlike generators, there are no restrictions on when solar and storage can be used. A solar and storage system is eligible for net metering, and excess energy produced can be exported to the grid and sold back to the utility. Furthermore, the storage system can be used to peak shave and reduce overall power draw from the grid during times of high power demand when using the battery to provide energy. This scenario is useful because it can reduce demand charges, which are a major component of utility costs. Furthermore, a solar and storage system could potentially generate revenue by providing ancillary grid services. Since solar and storage can provide a transit agency with savings and/or revenue, the levelized cost of energy would be much lower than for a natural gas generator.

In addition, solar and storage is better situated to take advantage of the ITC. The ITC provides a tax credit for investment in specific DERs. Solar is eligible for a 10%, permanent ITC. Generators are only eligible for a 10% ITC if they are used in a combined heat and power system (i.e., a system where waste heat from the generator is captured and used to provide heating for a building or industrial process). Since air quality regulations limit backup generator use to 200 hours per year, they would likely not be usable in a combined heat and power system. Furthermore, the ITC for combined heat and power systems expires at the end of 2023.

If ESTA opts to deploy DERs that are eligible for the ITC, acquiring them through a third-party ownership model, such as IAAS, would likely be the best option. The entity that owns the DER is eligible for the ITC. As a public agency, ESTA is a tax-exempt entity and would not be able to benefit from the ITC. However, if ESTA were to finance the ITC-eligible DERs through an IAAS model where a third party owns the asset, the infrastructure provider can realize the benefits of the ITC and pass the benefits on to ESTA in the form of lower PPA rates. If ESTA opts to deploy DERs that are eligible for the ITC, the use of an IAAS financing model should be seriously considered.

III. Sustainability and Environmental Impact

GHG Emissions Comparisons

ZEBs provide environmental benefits for transit service areas. As noted in detail under **Section I. Introduction to Zero-Emission Buses**, buses with an ICE produce tailpipe emissions such as GHGs, NOx, and PM during operation that drive climate change, harm air quality, and affect human health. ESTA plans to transition from fossil fuel-powered buses to ZEBs. ZEBs produce no tailpipe emissions and therefore aide in improving local air quality and residents' respiratory health.

Tailpipe emissions are not the only emissions associated with bus operations. Buses also produce upstream emissions, which are emitted during the production of fuel. For example, diesel must be extracted, processed, and transported to buses. The production processes of electricity and hydrogen also generate emissions. As a result, even ZEBs will produce some upstream emissions. Upstream emissions are generally emitted where the fuel is produced and not in the area where the buses operate, but GHGs contribute to climate change regardless of origin.

CALSTART analyzed emissions by using Argonne National Laboratory's Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) tool. AFLEET calculates GHG, PM, NOx, and volatile organic compound (VOC) emissions for diesel-, CNG-, and battery-powered buses. AFLEET uses data from Argonne National Laboratory's Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) model to calculate upstream emissions. AFLEET calculates tailpipe emissions using data from the U.S. Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES).

Users can provide customized inputs to AFLEET to generate emissions calculations. Since ESTA will deploy both electric and fuel cell buses, CALSTART modeled GHG emissions savings separate. For the electric buses, CALSTART programmed AFLEET the following assumptions detailed in Table 14 below.

Table 14. Assumptions Entered for Emissions Calculations

Parameter	Transit and Coach Buses (35' and 40')	Shuttles and Trolleys
Vehicle Type	Transit Bus	Light Commercial Truck[7]
State	California	
Gasoline/Diesel Fuel Economy	7.39 mpg (Diesel)	7.10 mpg[8] (Gasoline)
Electric Fuel Economy	21.2[9] mpg	44 mpg
Hydrogen Fuel Economy	7.4 mpg	24.8 mpg
Source of Electricity	WECC	
Average Mileage per Bus (Annual)	1728	34,427
Number of Vehicles	15	6

For the fuel cell buses, CALSTART assumed that the vehicles will use gaseous hydrogen that is produced at a centralized plant using SMR.

AFLEET calculated annual GHG emissions for an electric fleet, a hydrogen fuel cell fleet, and a diesel/gasoline powered fleet. Based on these results, an electric fleet will reduce GHG emissions by 76% as compared to a diesel/gasoline-powered fleet. A fuel cell fleet

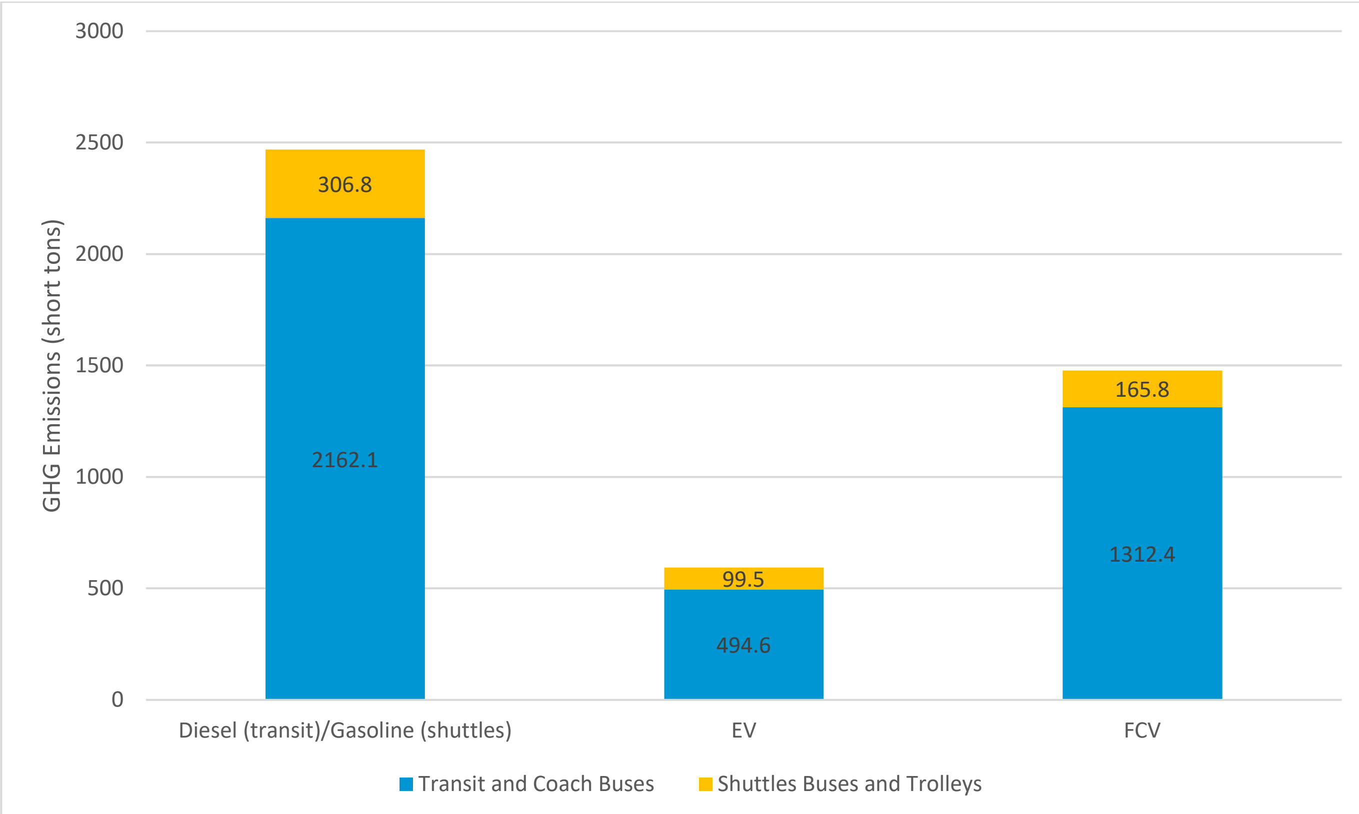
[7] The replacement buses will be electric 25-foot cutaway buses. The AFLEET tool does not have an option for shuttle buses or trolleys but there is an option for "light commercial truck." Since shuttle buses and trolleys are medium-duty vehicles, they have similar performance characteristics as a light commercial truck. CALSTART assumed that the electric shuttle buses and trolleys would have the same fuel economy as these vehicles.

[8] https://afdc.energy.gov/data/10310

[9] https://blog.ucsusa.org/jimmy-odea/electric-vs-diesel-vs-natural-gas-which-bus-is-best-for-the-climate/#:~:text=Charged%20with%20the%20national%20electricity,(4.8%20miles%20per%20gallon).

will reduce GHG emissions by 40% as compared to a diesel/gasoline-powered fleet.

Table 15. Annual GHG Emissions



Transitioning to a zero-emission fleet will also provide benefits for air quality. A fully zero-emission fleet will completely eliminate CO, NOx, VOC, and sodium oxide (SOx) emissions. Zero-emission technology will also result in small reductions in PM10 and PM2.5 emissions.

Table 16. Annual CO and NOx Emissions Comparisons

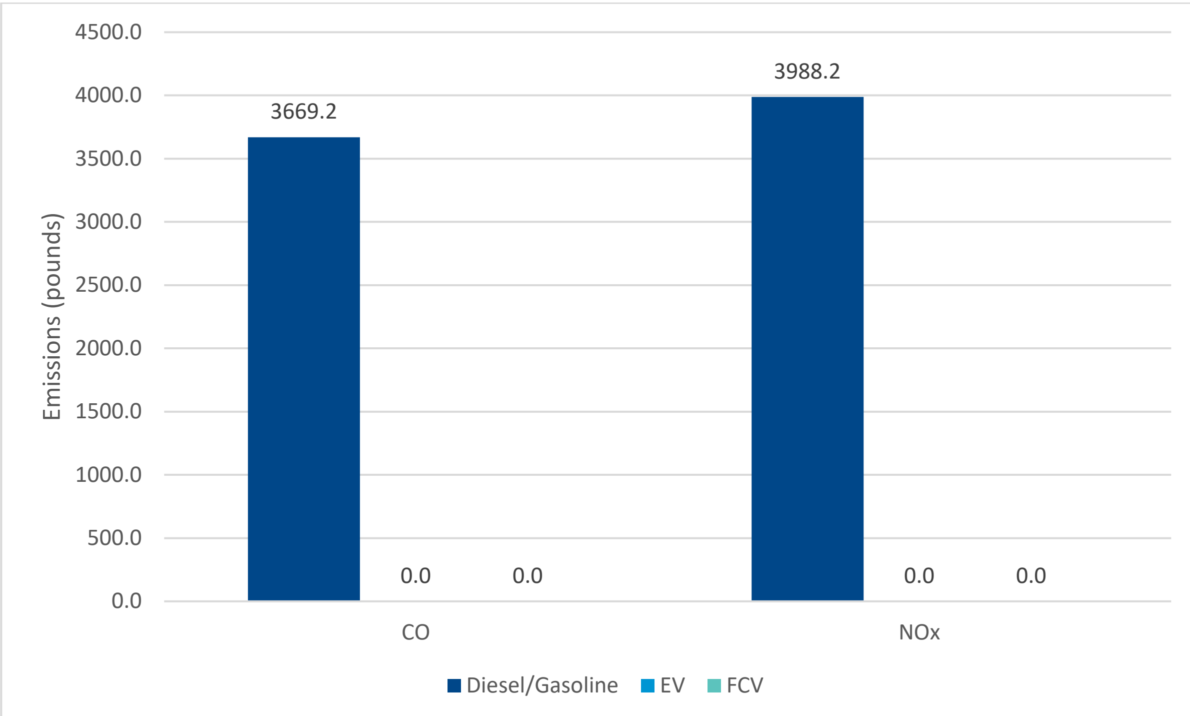
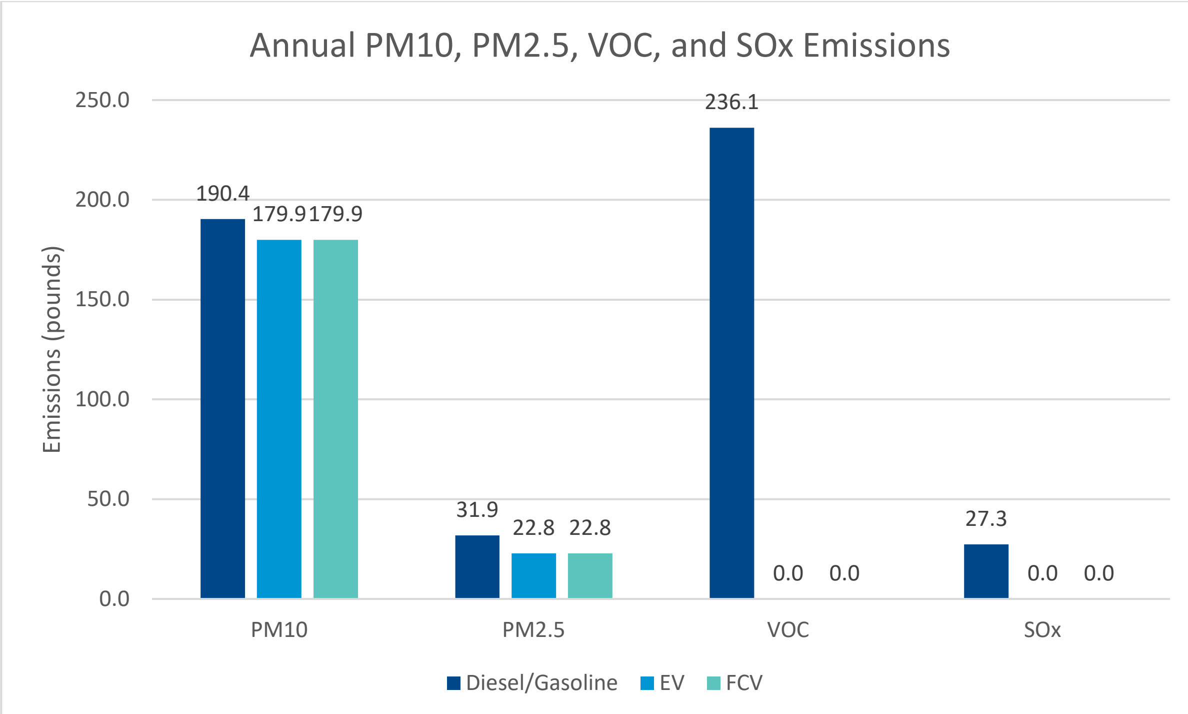


Table 17. Annual PM10, PM2.5, VOC, and SOx Emissions



Battery Recycling

As vehicle electrification expands across all market segments, the demand for batteries will increase. The growth of the EV industry and parallel renewable energy sectors has contributed to an exponentially increasing demand for critical materials such as lithium, nickel, and cobalt, among others. The extraction processes for these materials have environmental and social impacts. Furthermore, batteries degrade over time and have a finite lifespan. These factors raise questions about how to process batteries when they reach the end of their useful life and the life cycle sustainability of this technology. As demonstrated in the Emissions Comparisons section above on page 73, BEBs have a lower life cycle environmental impact than fossil fuel-powered buses. However, there are opportunities to further improve the life cycle environmental impact by recycling and re-manufacturing the materials that have been extracted. The technological benefit of EV batteries is that many of the materials used in primary production can be recycled nearly an infinite number of times and retain the same level of quality or performance. This means that recycled secondary materials maintain the same characteristics and quality as raw-earth primary materials for a fraction of the environmental, social, and economic cost. This section outlines options for recycling and reusing batteries.

Battery Recycling Companies

One of the main concerns about using battery technology is its life cycle environmental impact. The materials that are used to produce batteries have environmental and social consequences. Furthermore, as batteries reach the end of their useful life, they produce a waste stream that has environmental ramifications. Forward-thinking leaders are already developing solutions to these problems. Battery recycling companies take batteries that have reached the end of their useful life, break them down into their raw materials, and reinsert them back into the manufacturing process. These steps help to lessen the impacts of battery materials and reduce the amount of waste associated with batteries. A few companies and research teams have emerged as foundational stakeholders in battery recycling and are highlighted below.

Li-Cycle is a rapidly growing company that is focused on the mission of transforming the lithium-ion battery economy into a circular supply chain. Li-Cycle is based on a "Spoke and Hub" model where batteries are transformed into a static product at the Spoke facility and are then transferred to the Hubs where the cathode and anode materials are processed into battery-grade materials for remanufacturing or other applications. Once this process is completed, materials such as copper, aluminum, and ferrous metals are provided back to the commodity markets. Their technology can recycle any type of lithium-ion battery from all kinds of vehicle with any cathode chemistry, any SOC (meaning that batteries do not require discharging prior to recycling), any format (pack, module, battery, cell), and any condition (damaged/undamaged). Li-Cycle works with all sources of batteries, including but not limited to OEMs, fleets, battery collection organizations, and refurbishment centers. To incentivize parties to collaborate in battery sourcing, Li-Cycle offers different financial models based on the percentage of battery grade materials in collected batteries. As an additional value add, Li-Cycle offers services such as replacement kit management, logistics, and witnessed destruction. In a first for the industry, Li-Cycle is in the process of building a hydrometallurgical refinery in Rochester, NY, that will be able to take lithium, cobalt, nickel, manganese, and other materials from lithium-ion batteries and produce chemicals that can be used to make new batteries. The company currently serves the North American market (the United States, Canada, and Mexico) and expects to serve markets outside of the continent soon. In the future, Li-Cycle plans to build out a global network of recycling and refinery facilities to create a closed loop system across all markets.

RecycLiCo is a patented process of American Manganese Inc, a critical materials and metals company. In partnership with the U.S. Department of Energy, several universities, national laboratories, and research institutes, this is a research and development project in the demonstration stage that aims to target the downstream phase of battery recycling in the commercial refining process. RecycLiCo can refine materials from many types of batteries, including lithium-manganese-cobalt-oxide and lithium-manganese-oxide, with a focus on chemistries with the highest recovery rates. Since it is not yet a commercialized process, the team has relied upon OEMs and other battery collection organizations to send pre-shredded materials for recycling, but they have the goal to serve a global market in the future with Extended Producer Responsibility legislation emerging in many countries. RecycLiCo seeks a holistic approach to the battery supply chain to enable localized regions to become less reliant on raw materials from faraway places and achieve higher self-sufficiency in remanufacturing and production.

Redwood Materials is a battery materials company with a major focus on recycling as an input to produce advanced battery materials domestically while mining used products to do so. Once a battery is fully recycled, the secondary materials are funneled directly back to major battery production facilities such as Panasonic and Envision AESC. While the company recycles electronics beyond the vehicle sector, it has prioritized the EV industry as one where battery recycling can make the largest impact on sustainability, economics, and supply chain resiliency. Redwood Materials currently processes approximately 45,000 vehicle batteries per year with an estimated output of 20,000 tons of material and has built partnerships with several vehicle OEMs and fleets to source the batteries it recycles. While the batteries they process can come from anywhere, they have strategically placed their Nevada facilities in close vicinity to the largest EV market (i.e., California) to keep the logistics, economic, and environmental footprints as small as possible with plans to scale up in the future in areas where EVs become more prevalent. Their process is technology agnostic, meaning that they can process all lithium-ion battery technologies, as well as research recycling methods for future battery technologies, such as solid state. Redwood is committed to defining pathways for closing the loop to create a circular supply chain model in collaboration with its partners with the understanding that future critical material supplies will face shortages and with the goal to drive down the cost of battery production in the United States.

Second-Life Batteries

Batteries used in transportation applications have a large energy storage capacity. Many BEB OEMs install batteries in excess of 300 kWh. Batteries used in EVs are typically replaced when they degrade to 80% capacity. While these batteries are no longer suitable for transportation applications, they still retain high energy storage capacity. As a result, these batteries can theoretically be refurbished and reused in a second-life application. A second-life battery is most suited for an application where it would undergo fewer charge/discharge cycles, such as in a stationary energy storage system or a microgrid. Once the battery degrades to the point where it can no longer serve in a stationary energy storage application, the battery can be sent to a battery recycling company for disposal.

Fuel Cell Stack/Module Recycling

Similar to batteries, fuel cell manufacturers are innovating processes to optimize the usage and lifetime of the materials used in the production of fuel cell stacks and modules. Although fuel cells function like batteries in ZEVs, they are structurally different (consisting of an anode and cathode with hydrogen being supplied to the cathode to create a flow of electricity) and do not gradually degrade over time in the same way as a battery. While there is currently not a sound business model for fuel cell second-life applications, the future of recycling this hardware looks positive.

Ballard Power Systems Inc. is a manufacturer of polymer electrolyte membrane (PEM) fuel cell products for heavy-duty vehicle applications. The company supplies its FCMove module for partner transit bus OEMs New Flyer of America and ElDorado National. Ballard has operationalized its fuel cell takeback system where fleet owners assume the responsibility of returning the fuel cell module after it reaches its end of life at 20,000–30,000 hours. Once the module is sent back to the facility, it is disassembled into individual cells where some materials can be cleaned and reused up to six more times in newly produced modules. A key component of the module, platinum, is almost completely recovered during this process, which helps to reduce production costs since it is the most expensive material. Research to determine how all components of the fuel cell can be either recycled or reused is under way, but there are currently very few buses at the end of life on roads since the technology is still relatively new. (The average transit bus lifetime is 12 years.) Once the process is fully in place, Ballard will be able to serve all its global markets and is committed to making their entire value chain circular, including the production of the hydrogen that is used to fuel their modules (i.e., hydrogen produced from waste streams). Additionally, Ballard is exploring requirements that will mandate their upstream suppliers to use only recyclable components to ensure smoother and more economically viable recycling options for its customers.

References

Alternative Fuels Data Center (2020). Average Fuel Economy by Major Vehicle Category. Retrieved from: Alternative Fuels Data Center: Maps and Data - Average Fuel Economy by Major Vehicle Category (energy.gov)

California Air Resources Board (2016). 2016 Annual Evaluation of Hydrogen Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development. Retrieved from: https://ww2.arb.ca.gov/sites/default/files/2020-03/ab8_report_2016_ac.pdf

California Office of Environmental Health Hazard Assessment (2023). CalEnviroScreen 4.0. Retrieved from: https://oehha.ca.gov/calenviroscreen

CALSTART (2023). Implementation Manual for Energy Infrastructure Incentives for Zero-Emission Commercial Vehicles Project (EnergIIZE). Retrieved from: https://www.energiize.org/resources?section=irc.resources-with-tabs

Chard, Rachel, et al. (2023). CALSTART. Zeroing in on ZEBs: The Advanced Technology Transit Bus Index. Retrieved from: https://calstart.org/zeroing-in-on-zebs-2023/

Cole, Jerald A. and Katrina Sutton. Eastern Sierra Transit Authority. Eastern Sierra Transit Authority: Evaluation of Hydrogen Vehicle Refueling Options.

Department of Energy (2023). Federal Solar Tax Credits for Businesses. Retrieved from: https://www.energy.gov/eere/solar/federal-solar-tax-credits-businesses

GBUAPCD (n.d.) Emergency Generators. Retrieved from: https://www.gbuapcd.org/PermittingAndRules/PermitApplications/Generators/

GBUAPCD (2007). Permit Processing Flow Chart. Retrieved from: https://www.gbuapcd.org/PermittingAndRules/PermitApplications/FlowChart/

Hamilton, Hannah, et al. (2021). CALSTART. Zeroing in on ZEBS - The Advanced Technology Transit Bus Index: A North American ZEB Inventory Report. Retrieved from: 2021-ZIO-ZEB-Final-Report_1.3.21.pdf (calstart.org)

Liberty Utilities (2022). Liberty Utilities Reliability Reporting Workshop for 2021 Calendar Year. Retrieved from: https://california.libertyutilities.com/uploads/Reliability%20Reporting%202022%20Presentation.pdf

Los Angeles Department of Water & Power (2024). Power System Reliability Program. Retrieved from: https://prp.ladwp.com/

O'Dea, Jimmy (2018). Union of Concerned Scientists. Electric vs. Diesel vs. Natural Gas: Which Bus is Best for the Climate? Retrieved from: https://blog.ucsusa.org/jimmy-odea/electric-vs-diesel-vs-natural-gas-which-bus-is-best-for-the-climate/#:~:text=Charged%20with%20the%20national%20electricity,(4.8%20miles%20per%20gallon).

Southern California Edison (2022). Annual Electric Reliability Report: For Year 2022. Retrieved from: https://www.sce.com/sites/default/files/custom-files/PDF_Files/2022_Annual_Electric_Reliability_Report.pdf

SRECTrade (2023). Low Carbon Fuel Standard. Retrieved from: https://www.srectrade.com/blog/srec/low-carbon-fuel-standard

Tiger Optics, LLC (2020). Purity Analysis of Fuel-Cell Hydrogen. Retrieved from: https://www.tigeroptics.com/files/media/tigeroptics/technology/application-notes/AN_24_H2_Purity_Analysis.pdf

Appendix A: ESTA Route Modeling Results

A REM analysis was conducted on 20 routes under the purview of ESTA. The findings indicate that 12 vehicles are capable of fulfilling their daily mileage requirements through depot charging. However, the remaining eight routes necessitate on-route charging. Alternatively, these vehicles may need to be substituted with fuel cell electric buses to meet their operational needs. Table A1 below shows the total energy (kWh) required for each bus to complete its daily routes.

Table A1. Daily Route Energy Requirements

Single Lap	Benton Bishop	Bishop Creek Shuttle	Bishop DAR	Walker DAR	Mammoth DAR	Lone Pine DAR	Lone Pine Express	Mammoth Express	Purple Line	Reds Meadow Shuttle	Summer Lake Basin Trolley	Summer Mammoth Town Trolley	Winter Blue Yellow Line	Winter Blue	Winter Green	Winter Night Trolley	Winter Red Line	Winter Yellow Line	395 South	395 North
Bus Selection for REM	Green Power - EV Star	Green Power - EV Star	Ford eTransit	Ford eTransit	Ford eTransit	Ford eTransit	Green Power - EV Star	Green Power - EV Star	Proterra ZX5+	Proterra ZX5+	Motiv F-53	Motiv F-53	Proterra ZX5 Max	Proterra ZX5 Max	Proterra ZX5 Max	Motiv F-53	Proterra ZX5 Max	Proterra ZX5 Max	D45 CRTe	D45 CRTe
Type of Bus	Shuttle	Shuttle	Van	Van	Van	Van	Shuttle	Shuttle	35 foot Transit Bus	40 foot Transit Bus	Trolley	Trolley	40 foot Transit Bus	40 foot Transit Bus	40 foot Transit Bus	Trolley	40 foot Transit Bus	40 foot Transit Bus	Coach Bus	Coach Bus
Season	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Year-round	Summer	Summer	Summer	Winter	Winter	Winter	Winter	Winter	Winter	Year-round	Year-round
Home Depot	Bishop	Bishop	Bishop	Walker	Mammoth	Lone Pine	Lone Pine	Bishop	Mammoth	Mammoth	Mammoth	Mammoth	Mammoth	Mammoth	Mammoth	Mammoth	Mammoth	Mammoth	Bishop	Bishop
Energy needed per day per bus (kwh)	90	7	55	55	55	55	431	298	356	685	605	1092	185	14	16	45	909	16	2433	2953

Appendix B: TCO Results

The total cost of ownership for transitioning a total of 20 routes from four depots—Walker, Lone Pine, Mammoth, and Bishop is estimated to be $32 million. The TCO calculation spans 12 years and includes the LCFS credits for both BEBs and FCEVs.

In terms of the fuel cost for battery-electric vehicles, SCE EV 8 and A-1 small commercial rates from LADWP are utilized, taking into account the specific depot locations.

For hydrogen fuel, a cost of $12 per kilogram is considered. This cost encompasses both the capital and maintenance expenses associated with the hydrogen refueling station.

Table B1. TCO Breakdown

Depot	Lifetime Fuel Cost	Lifetime LCFS Credit	NPV (4%)
Bishop	$7,422,282.98	$1,524,288.73	$8,343,357.68
Mammoth	$6,186,171.45	$1,471,779.49	$20,522,412.46
Lone Pine	$1,530,504.21	$427,158.74	$2,260,374.08
Walker	$725,164.80	$193,981.58	$1,427,874.21
Total	**$15,864,123.44**	**$3,617,208.54**	**$32,554,018.43**

Appendix C: Zero-Emission Bus Specifications

Note: these are best case scenarios for vehicle ranges. Actual mileage may vary. Some of these vehicles may not be eligible for all funding opportunities.

Battery-Electric Transit Buses (BEBs)

ARBOC – Equess Charge is a low-floor shuttle/transit bus available in 30' and 35' that incorporates battery-electric technology from New Flyer®. It has capacity for up to 33 seating passengers and a range of up to 230 miles.

ARBOC SPECIALTY VEHICLES

ARBOC – Equess Charge 30' and 35' All Electric Transit Bus

SPECIFICATIONS	SPECIFICTION VALUE(S) (30' / 35')
Passenger Capacity	29 / 33
Lift Capable	Yes
Battery Size	350 kWh / 437 kWh
Approximate nameplate single-charge range	210 miles / 230 miles
Length	30 ft / 35 ft
Source	*https://arbocsv.com/site-content/uploads/2021/02/Equess-CHARGE-brochure-30-35-ft-120121.pdf*

BYD – K7M is a 30-foot plus bus that can seat up to 22 people and has a range of up to 158 miles.

BYD

BYD K7M 30'All Electric Transit Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 22 + 1
Lift Capable	Yes

Battery Size	215 kWh
Approximate nameplate single-charge range	Up to 158 miles
Length	30.7 ft
Source	*https://en.byd.com/bus/k7m/*

BYD – K7M-ER is a 30-foot bus that can seat up to 20 passengers. It has battery capacity of 313 kWh and a range of up to 196 miles.

BYD K7MER 30' All Electric Transit Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 20 + 1
Lift Capable	Yes
Battery Size	313 kWh
Approximate nameplate single-charge range	Up to 196 miles
Length	29.9 ft
Source	*https://en.byd.com/bus/k7mer/*

BYD – K8M is a 35-foot plus bus that can seat up to 32 passengers. It has battery capacity of 391 kWh and a range of up to 196 miles.

BYD K8M 35' All Electric Transit Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 32 + 1
Lift Capable	Yes
Battery Size	391 kWh
Approximate nameplate single-charge range	Up to 196 miles
Length	35.8 ft
Source	*https://en.byd.com/bus/k8m/*

BYD – K9M is a 40-foot plus bus with a 313 kWh battery. The passenger load varies on configuration and can comfortably sit 38 passengers. This Altoona-tested model can run up to 156 miles.

BYD K9M 40' All-Electric Transit Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 37+1
Lift Capable	Yes
Battery Size	313 kWh
Approximate nameplate single-charge range	Up to 156 miles
Length	40.2 ft
Source	*https://en.byd.com/bus/k9m/*

BYD – K9MD is a 40-foot plus bus with a 446 kWh battery. The passenger load can comfortably sit up to 42 passengers. This model can run up to 203 miles.

BYD K9MD 40' All-Electric Transit Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 42+1
Lift Capable	Yes
Battery Size	446 kWh
Approximate nameplate single-charge range	Up to 203 miles
Length	40.9 ft
Source	*https://en.byd.com/bus/k9md/*

BYD – K11M is a 60-foot plus bus with a 578 kWh battery, ideal for high-volume urban transit systems and BRT lines. The passenger load can comfortably sit up to 47+1 or 55+1 passengers, depending on the configuration. This model can run up to 193 miles.

BYD K11M 60' All-Electric Transit Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 47+1/ 55 + 1
Lift Capable	Yes
Battery Size	578 kWh
Approximate nameplate single-charge range	Up to 193 miles
Length	60.7 ft
Source	*https://en.byd.com/bus/k11m/*

GILLIG – Low Floor Battery Electric Bus integrates the Cummins electrified powertrain with Gillig's Low Floor platform.

Gillig Low Floor All-Electric Transit Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 38
Lift Capable	Yes
Battery Size	518 kWh
Approximate nameplate single-charge range	Up to 239 miles
Length	40 ft
Source	*https://www.altoonabustest.psu.edu/bus-details.aspx?BN=2021-12*

GreenPower – EV250 is a 30-foot bus with battery capacity of up to 260 kWh and a range of up to 163 miles.

GreenPower EV250 30' All-Electric Transit Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)

Passenger Capacity	Up to 25 + 1
Lift Capable	Yes
Battery Size	260 kWh
Approximate nameplate single-charge range	Up to 163 miles
Length	30-32 ft
Source	*https://greenpowermotor.com/wp-content/uploads/Brochures/EV250_brochure.pdf*

GreenPower – EV350 is a 40-foot plus bus with battery capacity of 400 kWh and a range of up to 212 miles.

GreenPower EV350 40' All-Electric Transit Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 39 + 1
Lift Capable	Yes
Battery Size	400 kWh
Approximate nameplate single-charge range	Up to 212 miles
Length	40.3 ft
Source	*https://greenpowermotor.com/wp-content/uploads/Brochures/EV350_brochure.pdf*

Proterra – ZX5 features faster acceleration, industry-leading gradeability, and a range of more than 125 miles per charge. The ZX5 has a capacity of up to 29 passengers.

Proterra ZX5

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	29
Lift Capable	Yes
Battery Size	225 kWh
Approximate nameplate single-charge range	95-125 miles
Length	35 Ft

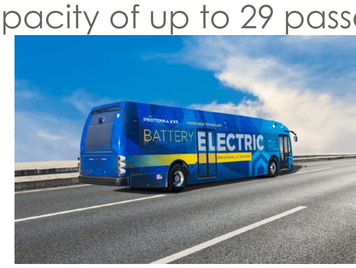
Source	*https://www.proterra.com/wp-content/uploads/2021/01/Proterra-ZX5-Spec-Sheet-35-Foot-Bus-U.S..pdf*

Proterra – ZX5 MAX is approximately five feet longer than the standard Proterra ZX5 bus model, which can accommodate 40 passengers and run up to 329 miles on a single charge.

Proterra ZX5 MAX

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	40
Lift Capable	Yes
Battery Size	675 kWh
Approximate nameplate single-charge range	221-329 miles
Length	40 Ft
Source	*https://www.proterra.com/wp-content/uploads/2021/01/Proterra-ZX5-Spec-Sheet-40-Foot-Bus-U.S..pdf*

Proterra – ZX5+ is a 35-foot bus that can run up to 240 miles on a single charge and has a capacity of up to 29 passengers.



Proterra ZX5+

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	29
Lift Capable	Yes
Battery Size	450 kWh
Approximate nameplate single-charge range	172-240 miles
Length	35 Ft
Source	*https://www.proterra.com/wp-content/uploads/2021/01/Proterra-ZX5-Spec-Sheet-35-Foot-Bus-U.S..pdf*

New Flyer – XCELSIOR XE35 is a 35-foot bus that can be configured to carry up to 35 passengers standing and 32 seating. The XCELSIOR has two battery options at 345 kWh and 435 kWh.

New Flyer XCELSIOR XE35' All-Electric Transit Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 32 seats, up to 35 standees
Lift Capable	Yes
Battery Size	345 kWh / 435 kWh
Approximate nameplate single-charge range	Up to 182 miles/ 224 miles
Length	35 ft
Source	*https://www.newflyer.com/site-content/uploads/2023/11/Xcelsior-CHARGE-NG.pdf*

New Flyer – XCELSIOR XE40, a more extended version of its 35-foot counterpart, is capable of operating with three different battery sizes (345 kWh, 435 kWh, and 520 kWh). Each battery size varies in range, going up to 258 miles on a single charge.

New Flyer XCELSIOR XE40' All-Electric Transit Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 40 seats, up to 44 standees
Lift Capable	Yes
Battery Size	345 kWh / 435 kWh / 520 kWh
Approximate nameplate single-charge range	Up to 178 / 221 / 258 miles
Length	40 ft
Source	*https://www.newflyer.com/site-content/uploads/2023/11/Xcelsior-CHARGE-NG.pdf*

New Flyer – XCELSIOR XE60, another extended version, this model is also capable of operating with three different battery sizes (520 kWh, 606 kWh, and 693 kWh). Each battery size varies in range, going up to 198 miles on a single charge.

New Flyer XCELSIOR XE60' All-Electric Transit Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 61 seats, up to 62 standees
Lift Capable	Yes
Battery Size	520 kWh / 606 kWh / 693 kWh
Approximate nameplate single-charge range	Up to 152 / 175 / 198 miles
Length	60 ft
Source	*https://www.newflyer.com/site-content/uploads/2023/11/Xcelsior-CHARGE-NG.pdf*

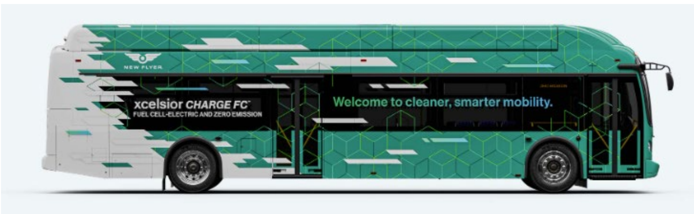
Nova Bus – LFSe+ is a 40' all electric transit bus with modular battery options capable of storing up to 564 kWh.

Gillig Low Floor All-Electric Transit Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 41
Lift Capable	Yes
Battery Size	564 kWh
Approximate nameplate single-charge range	Up to 224 miles
Length	40 ft
Source	*https://novabus.com/wp-content/uploads/2017/09/LFSe_brochure_march2021_EN.pdf and https://www.altoonabustest.psu.edu/bus-details.aspx?BN=2022-02-P*

Fuel Cell Electric Buses (FCEBs)

New Flyer – Xcelsior Charge FC XHE is a battery-electric vehicle that uses compressed hydrogen as an energy source. Fuel cell electric technology is an innovative way to obtain extended-range operation similar to existing transit vehicles with a fully zero-emission solution. This model is available in 40' and 60' with different batteries and capacities.



NEW FLYER

New Flyer Xcelsior Charge FC XHE40

SPECIFICATIONS	SPECIFICTION VALUE(S) (40' / 60')
Passenger Capacity	Up to 40 seats + 42 standees / Up to 52 seats + 73 standees
Lift Capable	Yes
Hydrogen Storage Capacity	37.5 kg / 56 kg
Approximate nameplate single-charge range	370 + miles on a single charge
Length	40' / 60'
Source	*https://www.newflyer.com/site-content/uploads/2023/12/Xcelsior-CHARGE-FC.pdf*

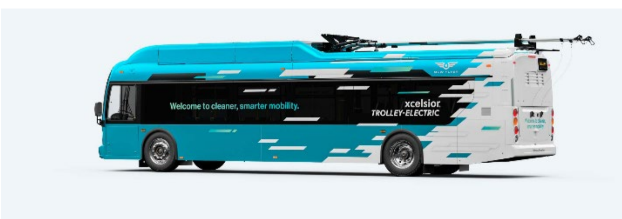
Battery-Electric Trolley

Movit – Trolley is a zero-emission trolley available in Movit's platform S and SL.

Movit Trolley

SPECIFICATIONS	SPECIFICTION VALUE(S)) (S/ SL)
Passenger Capacity	Up to 30
Lift Capable	Yes
Battery capacity	158 kWh / 237 kWh
Approximate nameplate single-charge range	Up to 150 miles / Up to 200 miles
Length	29'
Source	*https://www.motivps.com/download/17068*

New Flyer – Xcelsior Trolley is a zero-emission trolley available in 40 and 60 feet. The model provides in-motion charging, allowing for off-wire operation for up to 22.1 miles.



New Flyer Xcelsior Trolley

SPECIFICATIONS	SPECIFICTION VALUE(S)) (40' / 60')
Passenger Capacity	Up to 40 seats / Up to 60 seats
Lift Capable	Yes
Battery capacity	71 kWh
Approximate nameplate single-charge range	22.1 miles / 15.7 miles off-wire
Length	40' / 60'
Source	*https://www.newflyer.com/site-content/uploads/2023/04/Xcelsior-Trolley.pdf*

Battery-Electric Coach buses

BYD – C6M is a 23' battery-electric coach bus that can accommodate up to 16 passengers. Suited for smaller groups, this bus has a range of up to 141 miles and a battery capacity of up to 141 kWh.

BYD C6M All Electric Coach Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Seats up to 16 + 1 / 18 + 1
Battery Size	141 kWh
Approximate nameplate single-charge range	Up to 141 miles
Length	23.4 ft
Source	*https://en.byd.com/bus/bus-c6m/*

BYD – C8M is a 35' mid-size battery-electric coach bus that accommodates up to 41 passengers plus the driver. It has a range of up to 149 miles and a battery capacity of up to 313 kWh.

BYD C8M All Electric Coach Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Seats up to 41 + 1
Lift Capable	Yes
Battery Size	313 kWh
Approximate nameplate single-charge range	Up to 149 miles
Length	35.2 ft
Source	*https://en.byd.com/bus/bus-c8m/*

BYD – C8MS is a 35' double decker battery-electric coach bus. It accommodates 39 passengers in the upper level, and 12 or 8 in the lower level, depending on if the model has a restroom or not. It has a range of up to 125 miles and a battery capacity of up to 313 kWh.

BYD C8MS All Electric Coach Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Seats Up to 39 + 12 + 1 / 39 + 8 + 1 (with restroom)
Lift Capable	Yes
Battery Size	313 kWh
Approximate nameplate single-charge range	Up to 125 miles
Length	35.8 ft
Source	*https://en.byd.com/bus/bus-c8ms/*

BYD – C9M is a 40' battery-electric coach bus that comfortably accommodates up to 49 passengers. With a battery capacity of 446 kWh, it has a range of up to 186 miles. It Is has the a configuration with restroom.

BYD C9M All Electric Coach Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Seats Up to 49 + 1 / 45 + 1 (with restroom)
Lift Capable	Yes
Battery Size	446 kWh
Approximate nameplate single-charge range	Up to 186 miles
Length	40.5 ft
Source	*https://en.byd.com/bus/bus-c9m/*

BYD – C10M is BYD's longest battery-electric coach bus able to accommodate up to 57 passengers. With a battery capacity of 446 kWh, it has a range of up to 172 miles.

BYD C10M All Electric Coach Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Seats Up to 57 + 1 / 53 + 1 (with restroom)
Lift Capable	Yes
Battery Size	446 kWh
Approximate nameplate single-charge range	Up to 172 miles
Length	45.8 ft
Source	*https://en.byd.com/bus/bus-c10m/*

BYD – C10MS is the double decker version of C10M, BYD's longest battery-electric coach bus. It accommodates up to 77 seating passengers, with a battery capacity of 446 kWh, and a range of up to 159 miles.

BYD C10MS All Electric Coach Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Seats Up to 59 + 18 + 1
Lift Capable	Yes
Battery Size	446 kWh
Approximate nameplate single-charge range	Up to 159 miles
Length	45 ft
Source	*https://en.byd.com/bus/bus-c10ms/*

MCI – D45 CRT Charge is a 45' all electric high-floor commuter transit couch bus equipped with a 520 kWh battery that provides a range of up to 225 miles on a single charge.

MCI D45 CRT Charge All Electric Coach Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Seats Up to 57
Lift Capable	Yes
Battery Size	520 kWh
Approximate nameplate single-charge range	Up to 225 miles
Length	45.83 ft
Source	*https://www.mcicoach.com/site-content/uploads/2023/12/MCI-D45-CRT-CHARGE%E2%84%A2-and-D45-CRT-LE-CHARGE%E2%84%A2-brochure.pdf*

MCI – D45 CRT LE Charge is a 45' all electric couch bus that features patented low-entry vestibule, and a seating area and ramp that improves boarding and riding experience for passengers with disabilities or limited mobility. With a 520 kWh battery, it has a range of up to 225 miles on a single charge.

MCI D45 CRTLE Charge All Electric Coach Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Seats Up to 54
Lift Capable	Yes
Battery Size	520 kWh
Approximate nameplate single-charge range	Up to 225 miles
Length	45.83 ft
Source	*https://www.mcicoach.com/site-content/uploads/2023/12/MCI-D45-CRT-CHARGE%E2%84%A2-and-D45-CRT-LE-CHARGE%E2%84%A2-brochure.pdf*

MCI – J4500 Charge is a 45' all electric couch bus with a 520 kWh battery and a range of up to 230 miles on a single charge.

MCI J4500 Charge All Electric Coach Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Seats Up to 60
Lift Capable	Yes
Battery Size	520 kWh
Approximate nameplate single-charge range	Up to 230 miles
Length	45.58 ft
Source	*https://www.mcicoach.com/site-content/uploads/2023/12/MCI-J4500-CHARGE%E2%84%A2-brochure.pdf*

Van Hool – CX45E is an all-electric couch bus that complies with all specific US regulations and is developed and commercialized in close cooperation with ABC Companies, its exclusive distributor. With 45', and LTO batteries with 676 kWh it has a range of up to 260 miles.

Van Hool CX45E All Electric Coach Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Seats Up to 56
Lift Capable	Yes
Battery Size	676 kWh
Approximate nameplate single-charge range	Up to 260 miles
Length	45.58 ft
Source	*https://www.vanhool.com/en/vehicles/coaches/coaches-usa/cx45e*

Van Hool – TDX25E Astromega USA is an all-electric double decker couch bus that complies with all specific US regulations and is developed and commercialized in close cooperation with ABC Companies, its exclusive distributor. With almost 45', and batteries with 676 kWh it has a range of up to 260 miles.

Van Hool TDX25E All Electric Coach Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Seats Up to 68
Lift Capable	Yes
Battery Size	676 kWh
Approximate nameplate single-charge range	Up to 260 miles
Length	44.4 ft
Source	*https://abc-companies.com/van-hool-tdx25e/*

Battery-Electric Shuttle Buses/Vans

Endera – B Series Shuttle Bus offers multiple seating configurations and can accommodate up to 20 passengers.

Endera B Series All Electric Shuttle Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 20
Lift Capable	Yes
Battery Size	150 kWh
Approximate nameplate single-charge range	Up to 150 miles
Length	24', 26', and 28' Body Length Options
Source	*https://www.enderamotors.com/s/Endera-B-Series-Powertrain-Brochure-1.pdf*

Lightning eMotors — ZEV3 is equipped with an electric drivetrain that delivers efficiency. The Lightning ZEV3 Transit passenger van carries up to 15 passengers and can run up to 200 miles on a single charge, depending on the battery capacity.

Lightning ZEV3 Transit Passenger Van

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	15 passengers (including driver)
Lift Capable	Yes
Battery Size	80 kWh/120 kWh
Approximate nameplate single-charge range	Up to 140 miles / Up to 200 miles
Source	*https://lightningemotors.com/zev3-transit-passenger-van/*

Lightning eMotors — ZEV4 has an estimated range of over 100 miles while producing zero emissions on the road. The ZEV4 Shuttle Bus's charging capabilities are flexible, with Level 2 AC charging as standard and DC Fast Charging also being available, providing up to

80 kW.

Chevrolet Express 4500 platform with integrated Lightning ZEV4 power train

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 18 passengers with various layout options
Lift Capable	Yes
Battery Size	80 kWh/120 kWh
Approximate nameplate single-charge range	Up to 100 miles
Source	*https://lightningemotors.com//lightningelectric-class4-shuttle/*

Micro Bird – D Series Electric offers multiple seating configurations and can accommodate up to 28 passengers.

Micro Bird D Series All Electric Shuttle Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 28
Lift Capable	Yes
Approximate nameplate single-charge range	Up to 100 miles
Length	28'
Source	*https://mbcbus.com/wordpress/wp-content/uploads/2020/07/Micro_Bird_Flyer_D-Series_Electric.pdf*

Movit – Shuttle Bus offers different seating configurations that can seat up to 14 passengers. With a 127 kWh of battery capacity, it has a range of up to 105 miles.

Movit Trolley

SPECIFICATIONS	SPECIFICTION VALUE(S)) (S/ SL)
Passenger Capacity	Up to 14
Lift Capable	Yes
Battery capacity	127 kWh
Approximate nameplate single-charge range	Up to 105 miles
Length	24'
Source	*https://www.motivps.com/vehicles/shuttle-bus/*

Optimal EV – S1 is a low floor shuttle bus that provides different configurations that can accommodate up to 20 passengers. It has an estimated range of up to 125 miles.

Optimal EV S1 Battery Electric Low-Floor Bus

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 20 passengers
Lift Capable	Yes
Battery Size	113 kWh
Approximate nameplate single-charge range	Up to 125 miles
Source	*https://www.optimal-ev.com/s1*

Phoenix Motorcars — Ford E-450 Cutaway Bus: The Starcraft Allstar is powered by Phoenix Motorcars, designed to offer sustainable transportation for shared mobility and commuter transporter. The bus features seating configurations accommodating 12-20 (14 with two-seat ADA option available). Phoenix provides a five-year/60,000 drive system and provides an extended battery warranty of 8 years/300,000 miles.

Ford E-450 Cutaway Bus (Starcraft Allstar) with Phoenix Motorcars System

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	12-20 Passengers (14 with 2 seat ADA option)
Lift Capable	Yes
Battery Size	63 kWh / 94 kWh / 125 kWh / 156 kWh
Approximate nameplate single-charge range	70 miles / 100 miles / 130 miles / 160 miles
Source	*https://californiahvip.org/wp-content/uploads/2021/04/Phoenix-ZEUS-500-ZE-2021-UPDATE.pdf*

GreenPower — EV Star is a multi-purpose, zero-emission, min-E Bus with a range of up to 150 miles and offers dual charging capabilities as a standard feature. The EV Star can be used for paratransit, employee shuttles, micro-transit, and vanpool service. The EV Star is the only Buy America compliant and Altoona-tested vehicle in its class.

Green Power EV Star

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	19 FF / 21 Perimeter
Lift Capable	Yes
Battery Size	118 kWh
Approximate nameplate single-charge range	Up to 150 miles
Length	25'
Source	*https://greenpowermotor.com/gp-products/ev-star/*

GreenPower – EV Star+ is a cutaway bus with a broader body to utilize the interior space. It is designed for paratransit fleet operations—a larger seating capacity and wheelchair position options are available. The bus is ideal for hospitals, carpooling services, airport shuttles, and campus transportation.

Green Power EV Star+

SPECIFICATIONS		SPECIFICTION VALUE(S)
Passenger Capacity		24
Lift Capable		Yes
Battery Size		118 kWh
Approximate nameplate single-charge range		Up to 150 miles
Length		25'
Availability		Yes
Source		*https://greenpowermotor.com/gp-products/ev-star-plus/*

Appendix D: Charging Infrastructure Specifications

The following electrical cabinets and EVSE units were evaluated by CALSTART. The cost of the plug-in charging equipment varies depending on the manufacturer. Most plug-in chargers cost approximately $40,000 to $60,000 per bus depending on the power level. This amount includes only the cost of the charging equipment and does not include construction and installation costs, nor the cost of an overhead structure if overhead plug-in charging is deployed. This is a non-exhaustive list of charging infrastructure options.

Proterra 60 kW Power Control System

PROTERRA

Proterra 60 kW Power Control System
Proterra is a U.S. based electric bus manufacturer that builds chargers to support its heavy-duty EV product line. Proterra's 60 kW Power Control System is one of the most straightforward charging station solutions specifically designed for electric buses. The cabinet module (shown left) provides up to 60 kW of power to a single EVSE unit to charge a single electric bus. The ground level EVSE can be swapped out for an overhead pantograph connector for a more compact bus yard design. Depending on the bus, the battery can be completely recharged in approximately 6 hours. Manual labor is limited to plugging the EVSE into the bus in the evening after returning to the bus yard, then unplugging it in the morning prior to beginning daily revenue service. Existing examples can be seen at Greensboro Transit Authority.

Proterra 125 kW Power Control System

PROTERRA

Proterra 125 kW Power Control System
The 125 kW Power Control System is a simple solution with twice the power of the 60-kW version. The electrical cabinet (shown left) provides up to 125 kW of power to a single EVSE unit to charge a single electric bus. The bus's battery can be recharged in approximately three hours, which gives the fleet manager the flexibility to park two electric buses next to each other and manually transfer the plug halfway through the night.

BTC AC Chargers - Level 2

BTC POWER

BTC Power AC Chargers – Level 2
BTC Power AC-Level 2 chargers con provide power at 7-20 kW and is ideal for when longer planned downtime is available for charging. This charger is backed by the California Type Evaluation Program (CTEP), and is available in dual and single port, in the pedestal or wall mount style. The dual port models can charge two vehicles simultaneously and can provide faster charging with amperage up to 80 Amp in each port. The models and specifications available are: • L2 MaX 32, 48, 80 Amp • L2 30-40 Amp Dual Port • L2 30-70 Amp Single Port • L2 eBox 50 Amp Single Port

BTC DC Charger –
Level 3 Split System

BTC POWER

BTC Power DC Charger – Level 3 Split System
Rated 50-400 kW, DC chargers can charge vehicles more quicky and is ideal for charging larger vehicles, and vehicles that run multiple shifts or longer distances. This charger is currently available in two models: • Gen4 200, 400, 500 Amp Dispenser: Provides a continuous supply of up to 500 amperes, featuring a cutting-edge design that incorporates a maximum 950 volts DC architecture. The system is engineered for flexible configuration, enabling it to achieve power levels of up to 360 kilowatts. This ensures that every electric vehicle connected to the charging station receives the necessary energy directly to the battery, facilitating a swift charging process. • Gen2 200, 350 Amp Dispenser: With a voltage range of 200 to 950 Max DC, it accommodates various electric vehicle types offering simultaneous charging. This model requires HPCT Power Cabinet

BTC Power Cabinet

BTC Power Power Cabinet
The BTC Power Gen4 360kW Power Cabinet is part of the modular Gen 4 split system Product Line, emphasizing its flexibility, efficiency, and serviceability. When used in conjunction with a dispenser, the power cabinet can provide up to 360kW to a single vehicle. Noteworthy features include Dynamic Power Allocation, allowing simultaneous charging across multiple outputs, a wide output voltage range of 200-950VDC, and support for up to 500A max current per output simultaneously. The Gen4 360kW Power Cabinet seamlessly integrates with the Gen2 200 350 Amp dispenser, offering a comprehensive charging solution. Specifically designed for use together, these components allow for a customized setup where multiple dispensers can be connected to a single power cabinet.

Terra -
Terra DC wallbox

Terra Terra DC wallbox
The Terra DC wallbox stands as a versatile investment for fleet charging needs, with high voltage charging capabilities. Its compact design facilitates easy installation, providing space-saving benefits suitable for various fleet applications. The wallbox offers diverse connectivity options, allowing for remote software updates and ensuring safety and reliability through FCC Class A (1-Phase) and FCC Class B (3-Phase) certifications. Key features include UL standard compliance, adaptable single-phase and three-phase charging capacities, DC output of 60 A, and integrated protection features for overcurrent, overvoltage, undervoltage, ground-fault, surge protection, PE continuity monitoring, and leakage current monitoring. Charging specifications: • Single phase 19.5 kW @ 208 V, 22.5 kW @ 240 V / 100 A input • Three phase 0 – 22.5 kW, 24 kW (peak) @ 480 V / 32 A input • DC output 60 A • Charging voltage: CCS 150 – 920 V DC, CHAdeMO 150 – 500 V DC

Terra -
Terra DC Fast Chargers

Terra Terra DC Fast Chargers
The Terra series of DC fast chargers, consisting of Terra 54, Terra 94, Terra 124, and Terra 184, provides a comprehensive solution in a compact size ideal for bus depots. With a power range spanning from 50 kW to 180 kW and supporting up to 400 A charging on CCS connectors, these chargers are well-suited for depots with ample space around vehicles or those requiring vehicle authentication. • Terra 54: 50 kW DC fast charger designed for continuous charging at full capacity (50 kW) within the voltage range of 150 – 500 V, with Terra 54HV extending support up to 920 V. This versatile charger accommodates CCS, CHAdeMO, and AC functionality, featuring innovative connector holders. Compliant with international standards, including EMC Class B, it ensures safe operation in various settings such as residential, office, retail, and petrol station locations. Integrated Connected Services facilitate remote monitoring, diagnostics, statistics, and software upgrades. The Terra 54 supports fast charging technology and offers regional versions for North America (UL). Key features include a daylight-readable touchscreen display, graphic visualization of charging progress, RFID authorization, a robust stainless-steel enclosure suitable for all weather conditions, and quick, easy installation. • Terra 94: designed for retail or fleet applications, providing a quick refill. It supports up to 90 kW and can charge a 300 kWh BEB in 130 minutes. • Terra 124: for metro or fleet locations, the Terra 124 charger can simultaneously charge two vehicles. It accommodates one EV at up to 120 kW or two EVs at 60 kW each. • Terra 184: Ideal for highway or fleet sites, the Terra 184 chargers can add 100 miles of range in as little as 10 minutes or fast-charge two vehicles simultaneously in less than 20 minutes, supporting up to 90 kW for each EV or up to 180 kW for a single EV. The Terra 184 NEVI configuration provides dedicated power to 180 kW, adhering to NEVI program standards and requirements for one EV.

ABB –
HVC360 and HVC Depot Charge Box

ABB HVC360 and HVC Depot Charge Box
• HVC 360: a high-powered charging solution designed for large vehicles and heavy-duty applications. With a best-in-class power density of up to 360 kW, it supports simultaneous charging of up to four vehicles, offering flexibility in installation with a compact design. The power cabinet accommodates various charging interfaces, from CCS to pantograph, and employs a dynamic power sharing strategy for cost-effectiveness. Integrating smart energy management and a split system design, it ensures reliable and seamless charging operations for fleet electrification. • HVC Depot Charge box: suitable for wall or pedestal mounting, are tailored for efficiently charging larger fleets of electric vehicles with a limited footprint. The single CCS version supports sequential

charging for up to 3 outlets, delivering power in the range of 100 kW to 150 kW. The dual outlet CCS version allows sequential charging for up to 4 outlets, providing power in the range of 107 kW to 160 kW. Both configurations are designed to optimize the charging process for larger electric vehicle fleets.

ABB –
Celling mounting – HVC control box

ABB Celling mounting – HVC control box
Designed for overhead constructions, it is an ideal solution for sites with limited space around vehicles. An optional cable balancer is reliably designed to prevent cable drooping or lying on the ground. The cable balancer, easily installed, maintained, and available for various cable lengths, allows convenient extension and retraction from the ceiling to the vehicle's inlet using a rope, ensuring ease of use and efficient cable management.

ABB –
Pantograph down

ABB Pantograph down
The pantograph systems seamlessly integrate into existing operations and bus depots, supporting zero-emission public transport. The system ensures safe and reliable operation, employing RFID pairing technology. Additionally, it offers an optimum interface with remote diagnostics and management tools, providing flexibility as one charger can serve multiple vehicle types and brands.

Heliox – Flex 180 kW

Heliox Flex 180 kW
A highly versatile charging solution, accommodating various charging needs such as overnight or opportunity charging, dynamic or static charging, and the capability to charge from 1 to 3 vehicles. It offers versatility for any CCS-compatible electric vehicle. The Flex 180 delivers fast and highly efficient charging, able to charging three simultaneously at 60 kW. With the option for dynamic charging at 60/120/180 kW per charging connector by adding the internal power router, it ensures adaptability to different scenarios. The modular design of the Flex 180 provides optimal system redundancy and allows for future upgrades to 360 kW with parallel products, enabling the system to grow alongside evolving operations and ensuring maximum return on investment.

Heliox – Ultra-Fast 450 kW

Heliox Ultra-Fast 450 kW
Heliox's Ultra-Fast 450 kW charger, featuring the "Power Curve" technology, can optimally charge a bus in just 2-5 minutes, ensuring all-day operation and a significant increase in passenger capacity while reducing costs. The charger is straightforward to implement and future-proof, ready for Vehicle-to-Grid (V2G) and smart charging functionality. With an uptime of 96%, it provides flexibility whether stationary or on route, offering a user-friendly and reliable charging solution.

ChargePoint - Express Plus Double Stacked Power Block

ChargePoint Express Plus Double Stacked Power Block
ChargePoint is a San Francisco Bay Area-based electrical vehicle charging company. Founded in 2007, it operates over 57,000 charging stations worldwide. ChargePoint has multiple models of chargers and available for passenger vehicles, buses, and trucks. The Express Plus model is designed for ultra-fast DC charging. Thanks to its flexible modular architecture, it can expand to high charging capacity without any stranded investment by adding power modules, stations, and power blocks, per demand. Speed and dynamic power sharing are some of the many benefits of the Express Plus model. The maximum output power of the station can reach up to 500 kW for a single port, depending on the number of Power Blocks and cable amperage. The charging output voltage spans from 100 to 1000V, and each station can accommodate up to two connectors.

ChargePoint - Express 250

ChargePoint Express 250

The ChargePoint Express 250 embodies high power in a compact design, utilizing DC fast charging technology for electric cars, buses, and trucks. Featuring two easily swappable AC to DC Power Modules, the station maintains operation even if one module experiences an issue. It can be installed independently or in a paired configuration. It offers a maximum output power of 62.5 kW, supporting up to 2 connectors per station with options for CCS1, CCS2, and CHAdeMO. The paired configuration doubles the maximum output power to 125 kW, maintaining the same dimensions and voltage range. With fault-tolerant design, remote monitoring, and intelligent diagnostics, proactive alerts prevent station outages.

ChargePoint -
6000 Series

ChargePoint
6000 Series

ChargePoint offers a comprehensive electrification solution with the ChargePoint 6000 Series (CP6000), specifically well-suited for depot charging of electric vehicles in medium-duty shuttles and vans. This series provides the fastest AC charging, fleet management software, Power Management, and tailored service options, making it easy to achieve electrification goals for various fleets, including those in sales, service, delivery, or passenger transportation. With over a decade of experience, ChargePoint delivers an end-to-end solution, including fleet software, connected stations with up to 19.2 kW per port, maintenance services, and design/build and optimization services.

Siemens -
SICHARGE UC 150

Siemens
CCSSICHARGE UC 150

Siemens is a German-based industrial giant with a major footprint in the bus charging infrastructure industry, with multiple models of depot and on-route charging to choose from. SICHARGE UC offers sequential charging with up to 4 dispensers, employing a single charging center that connects to multiple vehicles. In this process, all charging power is allocated to one vehicle at a time, and charging occurs sequentially based on remaining battery levels. The benefits include delivering high power to maximize vehicle availability, reduced upfront electrical requirements for lower investment costs, faster deployment of vehicles, and minimized safety risks.

Sicharge UC 150
The SICHARGE UC 150 is a compact dispenser with an integrated cable for a straightforward connection to electric vehicles. The charging center features a high degree of protection (NEMA 3R), LED charging status indicators, an Emergency Stop button, a durable galvanized steel enclosure, large doors for easy maintenance access, an external breaker handle, and the option for side entry. It supports up to four dispensers sequentially, offers cellular and Ethernet communication, and boasts a compact size for easy installation. Manufactured in the US, the AC nominal input voltage ranges from 480 to 600 V AC, with a current of 200A per phase. The DC output has a rated power of 150 kW, voltage range from 100 to 950V, and maximum cable current of 200A, achieving an efficiency factor of 95.5% to 97% at full load. Sicharge UC Dispenser:

- The single-plug dispenser from the SICHARGE UC family boasts features such as an inclined rain protection hood, NEMA 3R dust and spray water protection, covered plug holder, multiple mounting options, 360-degree LED charging status indication, a 7-inch outdoor touchscreen display at an ergonomic height, and a convenient cable holder. With a 25-ft power cable, it can pair up to four dispensers sequentially per charging center, optimizing investment and space. The dispenser utilizes thermoelectric cooling for an extended temperature operating range and holds UL, cUL certifications while being manufactured in the US. The cable-connected dispensers are designed with a small footprint for installation near the vehicle connection.

BYD -
EVA100KS/02 and EVA200KS/01

BYD
EVA100KS/02 and EVA200KS/01

BYD is a Chinese automotive company known for building EVs. Their market consists of buses (transit and coach), vans, cars, and trucks. BYD also has a variety of chargers that it markets with its vehicles. All BYD EVs come with standard AC-DC Quick Charge Inverters. This makes for simplified fleet integration. BYD chargers are available in configurations from 40kW to 100kW per charging connector. Due to the proprietary design of the BYD charging connector and architecture, BYD buses can only be paired with BYD chargers. Each BYD bus comes with its own charger. Examples of usage are Antelope Valley Transit Authority (AVTA) in Lancaster-Palmdale, California.

Blink -
DC Fast Charger

Blink
DC Fast Charger

Blink Charging is a Florida-based charging company that produces multiple lines of charging infrastructure. Blink has a variety of business models that can work for all different types of fleets.

- 30kW DCFC: equipped with the widely used Combined Charging Systems (CCS) Plug. The station features an intuitive interface with a large LCD screen displaying pricing and relevant station information. Communication with the Blink Network is facilitated through a 4G LTE signal or an Ethernet connection. The Blink Network enables station managers to access the Built-In Electricity Metering and effectively manage costs.
- 60kW-360kW DCFC: a comprehensive charging station designed for speed and easy maintenance. With power ranging from 140 to 500 amps depending on the model, this all-in-one charger reduces installation and maintenance costs by integrating dispensers with power cabinets. Its 10-inch LCD touchscreen display offers an intuitive charging process, providing real-time feedback. Available in single or dual cable configurations with CCS1 or CHAdeMO connector options, this charger stands out for its high performance, compatibility, and serviceability when paired with the Blink Network via Wi-Fi, Ethernet, or 4G connection.
- 60kW-180kW Free Standing DCFC: Free Standing DCFC: features a modular design capable of delivering 100-300A of power, depending on the model and configuration. This comprehensive DC fast charging station is tailored for quick charging in diverse applications, including vehicle service areas, dealerships, fleets, and commercial settings where rapid recharging is essential. The user-friendly 7-inch LCD screen offers essential information to initiate a charging session and monitor its progress.

Delta -

Delta
Delta is a Taiwan-based company that provides power and thermal solutions. Delta provides AC and DC fast chargers and has 25 kW, 50 kW and 100 kW models. Their chargers are compatible with CHAdeMO and CCS-1 protocols. Delta DC chargers have two charging receptacles and can charge buses simultaneously. Delta also offers energy management software.

Efacec - QCBus

Efacec QCBus
Efacec is a Portugal-based charging company that has a variety of high-power chargers. QCBus is a user-friendly and secure method designed for charging CCS Compatible Buses. The charging station is adaptable for network integration, functioning both independently and within any network system. It provides various power levels (45, 90, and 150 kW) with a DC output up to 750 V and customizable current levels up to 200 A. The QCBus is housed in a durable enclosure, ensuring a long equipment lifespan suitable for indoor and outdoor installations. Additionally, it can be personalized with custom graphics, logos, and colors to align with a brand's overall appearance.

Efacec - HV 350 G2

Efacec HV350
The HV350 is a high-power ultra-fast charging station capable of supplying up to 350kW by connecting two HV175 G2 units to a user interface unit with the appropriate cable and connector setup. The HV350 provides a complete charging station supporting electric vehicles with battery voltages up to 920V DC and 500A DC, in compliance with the Combined Charging System (CCS) standard. Additionally, it features a second output option supporting the CHAdeMO charging system.

Tritium - RTM75

Tritium RTM75
Tritium is an Australian DC fast charger manufacturer with a large global market that is partially owned by fueling infrastructure giant Gilbarco Veeder-Root. The RTM75 from Tritium is a compact, powerful, and flexible all-in-one DC fast charger designed for convenient installation in various locations. Its reliability is underscored by its ability to withstand extreme conditions, and its modular design allows for easy field maintenance. The RTM75 ensures hassle-free charging with minimal site preparation, delivering up to 75kW. It boasts a compact size of 1998mm x 783mm x 309mm, an IP65 and NEMA 3R weather rating, and an operating temperature range of -31°F to +122°F. The charger supports CCS1/2 (up to 920V/200A DC), CHAdeMO (up to 500V/125A), and NACS (coming soon), offering simultaneous charging.

Tritium - PKM150

Tritium PKM150
The PKM150's DC power grid stands out for its superior efficiency, minimizing losses during power conversion and transmission to deliver more grid power to EVs. Additionally, the use of light-gauge DC site cabling reduces costs by 70% compared to traditional AC site cabling. Designed to endure extreme conditions, the PKM150 ensures reliability and easy field maintenance. Featuring a robust design, the PKM150 supports up to 150kW, has a compact size, and is compatible with CCS1/2 (up to 920V/350A DC), CHAdeMO (up to 500V/125A), and NACS (coming soon). Additional highlights of the PKM150 system include the capability for simultaneous charging, along with the ability to connect to four PKM chargers to a single PKM AC-to-DC power cabinet (rectifier). Tritium also offers a model compliant with NEVI requirements, assembled in the US and using many domestic materials and suppliers.

Tritium - RT50

Tritium RT50

With a lightweight yet sturdy construction, the RT50 ensures easy installation, cost-effectiveness, and is supported by 24/7 customer care. It is compatible with CHAdeMO and CCS (Type 1 or 2) connectors, provides up to 50kW, and has an operating temperature range of -31°F to +122°F. Key features include mall footprint, ease of installation without heavy equipment, ISO 15118 Plug and Charge technology, patented liquid-cooled technology for high ingress protection, a contemporary and slim design, and 3G/4G wireless communication.

Tritium - RT175-S

Tritium RT175-S
The RT175-S high-powered DC charger, designed for seamless installation, ownership, and operation, features a compact footprint and is supported by 24/7 specialist customer care. The charger employs cutting-edge technology ensuring reliability across a wide range of grid voltages, including 480V 60Hz for the US market. Thriving in temperatures from -22˚F to 122˚F, it ensures safety with standard cable management and provides real-time data access. The RT175-S is equipped with ISO 15118 Plug and Charge technology, patented liquid-cooled technology for high ingress protection, and 3G/4G wireless communication. It is compatible with CHAdeMO and CCS (Type 1 or 2) connectors and provides up to 178kW.

WAVE – Inductive Charger

WAVE Inductive Charger
WAVE delivers fast, safe, high-power charging within seconds of scheduled stops and natural dwell times. Medium- and heavy-duty EVs gain substantial range and operation time without manual plug-in operations or mechanical contact. With power ranging from 125kW to 500kW and soon higher, WAVE's high-power systems are ideal for powering EVs for mass transit, warehouse and distribution centers, shuttle services, seaports, and more. What is commercially available today is a 250-kW charger that can supply power in various configurations; where power is split down to two (2) 125 kW chargers and soon split to four (4) 62.5 kW plates with smart charging for the depot.

Enphase
Clipper Creek – CS-100

Enphase CS-100
Former Clipper Creek, Enphase offers the CS-100, the world's first UL listed EV charging station manufactured in the United States. The CS-100 is a UL Listed Level 2 EVSE offering 19.2 kW for EV charging. The CS-100 works with all SAEJ1772 compliant vehicles. This charger is ideal for vehicles that can accept high power charging, and future proofing installations. This is the recommended charger for charger for the GreenPower and Phoenix Motorcars buses. Key features include a 25 ft charging cable, a rugged fully sealed NEMA 4 enclosure suitable for indoor or outdoor installation, and an automatic circuit reclosure timer for minor power faults. In the event of a power outage, a time-delayed and randomized cold load pickup ensures seamless re-energizing. The CS-100 comes with technical specifications such as 80 A max charging power, a 208/240 V, 100 A dedicated supply circuit, and a J1772 vehicle connector type. It operates in temperatures ranging from -22°F to +122°F. Certified by cULus and cETLus, the CS-100 is backed by a 1-year limited warranty.

InductEV – Inductive charger

InductEV Inductive charger
InductEV, formerly Momentum Dynamics, provides cutting-edge wireless power charging services for commercial and passenger electric vehicles, employing a robust magnetic induction system capable of charging batteries in all weather conditions. Founded in 2009, the company is based in Malvern, Pennsylvania. The system comprises an on-vehicle receiver, a power cabinet located up to 100 feet away from the in-ground charger, and the in-ground charger itself, transferring power wirelessly from the grid to charge the vehicle. The on-vehicle receiver uses magnetic induction to receive electricity from the in-ground charger, transferring it to the battery for charging. This solution offers flexibility for electric vehicle operations, providing an interoperable, automatic, and scalable charging system. InductEV's wireless charging solutions cater to diverse needs, offering a convenient, reliable, and cost-effective option for high-utilization electric vehicle fleets. With options for 4 pads providing 300kW for buses, medium and heavy-duty trucks, and 2 pads offering 150 kW for mid-size buses and shuttles, the system ensures efficient energy distribution and management. This approach leads to higher asset utilization, reduced maintenance costs and TCO, on-route charging, more efficient CAPEX, and lower OPEX, all with a minimized real estate footprint.

Electreon – Inductive charger

Eletreon **Inductive charger**
Founded in 2013, Electreon, an Israeli company, is dedicated to accelerating carbon neutrality through its cost-effective, end-to-end wireless charging infrastructure. The technology allows electric vehicles to charge while parked, idling, or driving, reducing range anxiety and lowering operating costs for fleets. Electreon offers a revolutionary solution for fleet electrification, addressing challenges like complex charging infrastructure and limited vehicle range. The company's wireless charging system eliminates the necessity for large batteries, ensuring optimized fleet uptime and simplified operations. Embracing a Charging as a Service (CaaS) model, Electreon significantly reduces upfront costs, facilitating a seamless transition for fleet operators towards sustainable electric fleets. The company's holistic approach not only enhances the Total Cost of Ownership (TCO) but also boosts vehicle uptime through top-up charging, while supporting electric vehicle maneuverability with an 'invisible' underground charging architecture. Electreon's platform is vehicle-agnostic, offering a simplified charging solution tailored for various fleet types operating in dense urban environments. This approach aligns with the company's commitment to reducing emissions and fuel costs for fleet operators.

Power Electronics –
NB Station and NBi

POWER ELECTRONICS

Power Electronics **NB Station and NBi**
The NB Station and NBi by Power Electronics offer a cutting-edge solution for electric vehicle charging. These high-power, flexible, modular, and scalable stations are designed for durability in demanding conditions. With Smart Power Balance functionality, they intelligently distribute power based on vehicle demand, optimizing efficiency. Compatible with various dispensers and connectors, including pantographs, they support simultaneous or sequential charging for up to 24 vehicles. The power modules are easily replaceable for simplified maintenance, and the stations are power-scalable to accommodate EV fleet growth. These solutions provide a future-proof and cost-effective charging infrastructure. • NB Station: Maximum power: 300 to 1000 Vdc Simultaneous charging: Up to 24 vehicles Sequential charging: Up to 48 vehicles Power range: 840 to 1440 kW • NBi360: Maximum power: 300 to 1000 Vdc Simultaneous charging: Up to 6 vehicles Sequential charging: Up to 12 vehicles • NBi180: Maximum power: 300 to 1000 Vdc Simultaneous charging: Up to 3 vehicles Sequential charging: Up to 4 vehicles Parallel connection: Up to three power cabinets

Power Electronics –
NB Standalone

Power Electronics NB Standalone
The NB Standalone family presents a comprehensive range of versatile charging solutions, featuring the NB 120 and NB 240 models. The NB 120, the smallest of the standalone family, is designed to charge up to three vehicles simultaneously with a power scalability ranging from 60 to 120 kW and a maximum power range of 300 to 1000 Vdc. Its robust design ensures suitability for any environment. In comparison, the NB 240, the larger counterpart, has the capacity to charge up to five vehicles simultaneously (four in DC and one in AC) with a power scalability ranging from 150 to 240 kW and the same maximum power range. Both models come equipped with built-in cable management systems, accommodating 5-meter charging cables without dragging on the ground. The Standalone Line represents the market's most powerful DC chargers, scalable to support EV fleet growth, and easily maintained with replaceable power modules. The family's flexibility is further demonstrated by the option to expand charging stations by adding a Cooled or Slim dispenser as a satellite, enhancing Smart Power Balance for optimized power allocation and efficiency.

Power Electronics –
NBw30

Power Electronics NBw30
The NBw30 stands out as the smallest DC charger in its family, offering a power output of 30 kW within an extended voltage range from 300 to 1000 Vdc. Designed for both indoor and outdoor use, this versatile charger is suitable for wall or pedestal mounting, ensuring adaptability to various charging station configurations. Its lightweight and modular design not only guarantee reliable performance but also simplify transportation, installation, and maintenance processes, providing an accessible and efficient solution for electric vehicle charging.

Power Electronics –
NB Pod

Power Electronics NB Pod

The NB Pod is a small-scale lithium-ion battery storage system that offers a robust, reliable, and aesthetically pleasing solution. This Plug&Play innovation comes with integrated protections, ensuring easy integration into both new and existing EV charging installations. The NB Pod's full scalability, achieved through parallelization, allows for additional power and storage capacity to meet diverse application needs. With its Advanced Energy Management System, seamless integration with your EV charging station is facilitated, optimizing power allocation and avoiding exceeding fixed or dynamic power limitations. By supplying stored energy during peak-demand periods, NB Pod not only reduces grid strain but also significantly improves overall efficiency. Multiple NB Pods can be connected in parallel configuration, offering expanded total power and storage capacity for increased flexibility and adaptability.

Appendix E: Managed Storage Solutions

Networked or managed charging is helpful as it allows transit agencies to minimize their peak power demand. This helps to lower utility costs for transit agencies and helps utilities manage the grid. Networked and managed charging is typically a separate service from the physical hardware of the EVSE and electrical cabinets. Companies that specialize in this space call themselves "Electric Vehicle Service Providers" or simply "network providers." However, unlike the EVSEs, there are a small, but growing, number of companies that focus on charging heavy-duty vehicles, like electric buses. This section provides an overview of networked charging companies.

I/O Control Corporations offers software to inform smart systems, including remote monitoring, analytics, and prioritizing charging on specific buses. Their Electrical Load Management System (ELMS) product offering is a cloud-based application that enables remote electric bus charging management across multiple depot locations. It allows transit operators to set up their preferred parameters so that buses can be charged automatically according to specific schedules and vehicle limits. I/O Controls supplies a charging control gateway for each charging station. The pricing for the gateway includes a monthly fee for the first year with a 1 year warranty, and the transit entity is charged a yearly fee for the hardware for subsequent years of use. Currently, the ELMS and charging gateway combination is only offered for charging of BYD buses but I/O Controls can work with other vehicle manufacturers to make their hardware and software compatible with other bus technologies. I/O Controls also offers a Health Alert Management System (HAMS) which is currently being used by Antelope Valley Transit Authority in Lancaster, California. This operating system functions as a control for how much power a particular bus draws from the grid. The HAMS features AIMS (Alert, Inquire, Manage, Store) functionality. The Alert function sends a text or email message when there is an issue with the vehicle's charge cycle or during regular route service. The Inquire feature monitors the health status of the vehicle such as SOC, mileage, battery voltage, and other parameters and is updated once per minute. The Manage feature uses cloud-based software to maintain and edit information provided by the HAMS module. The Store feature allows for unlimited data uploads to the cloud for future use and analytics.

ViriCiti (now owned by ChargePoint) is a trusted solution for over 350+ operators worldwide and offers a system that is integrated with over 50 OEMs. The company is known for its telematic data logging system for buses on the road, but also offers solutions for managing electric bus chargers through their Charger Monitoring and Smart Charging packages. Both of these systems are OCPP compliant and OEM agnostic, meaning they support open standards and can communicate with a variety of charging station and vehicle types. No additional hardware is needed to monitor the chargers if they are OCPP1.6 compliant or higher. The first package offers a single dashboard view for easy visualization of vital Key Performance Indicators (KPIs) (e.g., charger status and location, connected vehicle ID and SOC, energy consumption, etc.) which serves to quickly identify and troubleshoot bugs, increase EVSE uptime, and reduce maintenance time and costs. Their new Depot View product provides a visual overview of the vehicle and chargers in the fleet's depot. It shows which vehicles are connected to which chargers and their remaining SOC. Depot View also shows the status of the chargers (available, busy, faulted). ViriCiti's data management solution can track EVSE performance and enable smart charging capabilities. ViriCiti's smart charging systems allow for fleet-wide management of charging through scheduled load balancing and can provide benefits like peak shaving, demand response, and renewables integration. Their system can also be used to track fleet data like battery SOC, bus energy efficiency, and bus downtime. ViriCiti offers modular based license subscriptions which allows customers to customize and only pay for the features they need. Licensing is offered per charger socket on a yearly subscription basis. The average cost of charger monitoring is $18 per socket/month and the average cost for smart charging is $25 per socket/month (as of Summer 2021). The ViriCiti team offers 24/7 customer support. ViriCiti was purchased by ChargePoint, which is a charging infrastructure provider, in August 2021.

Greenlots (a member of the Shell Group) is another network provider that specializes in smart charging and fleet scheduling services. Greenlots provides a turnkey solution for EV charging, which includes a site evaluation, hardware procurement and validation, engineering and construction services, and operation and maintenance services. Greenlots works closely with Shell's Solutions Development team to provide battery systems that integrate with charging stations to provide additional microgrid and energy management solutions. Their Greenlots SKY EV Charging Network Software offers real-time network management and status of EV chargers, a variable pricing engine which can set pricing based on usage, time intervals, or sessions, and a billing and payment management system through the Greenlots mobile app or charging station. Additionally, the SKY EV system provides access to advanced analytics and customizable reporting with alerts to improve EVSE uptime and access to data such as revenue, energy delivered, and avoided CO_2 emissions. The SKY EV system utilizes the OCPP standard and features a multi-layer security system to protect sensitive data. In addition to EVSE manufacturer hardware warranties, Greenlots offers a quality assurance program called "Greenlots Care" which provides trained technicians to make onsite repairs within 24-48 hours as well as a supplemental parts warranty to ensure a charger uptime guarantee of 95%. Other included services are preventative and corrective maintenance, warranty management, reporting, and performance SLAs. Finally, Greenlots offers a Charging-as-a-Service package, which is based on a recurring annual fee which aims to reduce steep upfront costs for the fleet customer. Greenlots is currently working with Foothill Transit on their electric buses.

Electriphi is a wholly owned subsidiary of Ford Motor Company that offers end-to-end fleet electrification solutions including charging management and infrastructure deployment. Electriphi works alongside fleets to simplify EV management and ease the transition from conventional to electric fleets through planning, deployment assistance, and ongoing operational services. On the implementation side, Electriphi offers testing and integration services for vehicle telematics systems prior to service deployment at the customer site. Their monthly software-as-a-service (SaaS) monitoring and management system tracks charging station status, network connectivity, and equipment fault detection, as well as offers sophisticated smart charging algorithms that ensures that vehicles are charged on time at the most optimal energy cost (while taking into account vehicle dispatch schedules, route information, TOU energy rates, demand charge windows, and more). Customers may purchase a baseline operational charging system for remote fleet control and data access and may add on managed/smart charging features which can be accessed from the same online dashboard. Electriphi also offers advanced energy services such as ESS system integration, active demand response, and V2G management. Electriphi's software compatibility is constantly evaluated based on current market offerings and is suitable for use with most major EV charging equipment manufacturers for both Level 2 and Level 3/DCFC stations. Pricing is available as an upfront, non-recurring cost or a yearly SaaS fee.

The Mobility House is a network provider that serves over 350 fleets and offers charging system management software called ChargePilot. Their software helps transit agencies engage in peak shaving and schedule charging to reduce demand charges. While their system does not connect to onboard vehicle telematics, it is compliant with multiple EVSEs at once, yielding high interoperability. To keep the fleet charged when vehicles need to be deployed and to optimize costs, the system monitors the bus SOC while plugged into the charger and calculates charge times and duration based on site-specific electricity rates. The fleet only has to supply the desired departure time and desired SOC per vehicle, and the system coordinates the rest via a local controller that is installed onsite and is connected to all the chargers. Mobility House is able to assist fleets with the charger procurement process to ensure that they are OCPP compliant, and therefore ChargePilot compliant, before purchase and installation. ChargePilot can also take solar resources and distributed generation assets into account when managing charging by integrating the data from renewables onsite into the system operations. Mobility House offers a hybrid business model with a one-time setup cost per site which includes hardware installation and commissioning, and then operates its software service on a monthly, yearly, or multi-year subscription basis according to the customer's business needs and plans. The pricing is project and volume-dependent with flexibility to operate on a Charging-as-a-Service (per mile) system. As part of this package, Mobility House provides 24/7 monitoring on all sites with quick alerts and remote fixes in the case that there is a system failure. Mobility House offers a complimentary demonstration workshop for interested customers to help calculate an individual fleet's cost savings with their managed charging solution.

bp pulse bp pulse is an EV charging business, rolling out fast, reliable charging assets to consumers and commercial fleets around the world. Entering the Americas, bp pulse focuses on providing EV charging and energy management to fleets that operate heavy-, medium- and light-duty vehicles. Globally, bp pulse is one of the United Kingdom's leading rapid and ultra-fast public EV charging networks. It also operates the largest number of sites with ultra-fast charging in Germany, with a growing footprint in China and the Netherlands. The company aims to increase its network of public EV charging assets by 2030 to over 100,000 worldwide.

bp pulse can provide Charging-as-a-Service (CaaS) to remove the burden of high capital investment and stakeholder engagement with comprehensive project management and amortized costs. bp pulse believes that the CaaS model generates the best total cost of ownership (TCO) for customers, as this ensures the customer has no upfront capital expense. The amortized capital expenses, operating expenses, and energy expenses are rolled into one monthly usage fee. CaaS terms can be between three and 15 years in length, although longer periods/extensions can be considered. In bp pulse's innovative charging and energy services agreement with Anaheim Transportation Network (ATN), the term is twenty years. This guarantees a service level of recharging vehicles for an upfront, known price per kilowatt hour (price-per-kWh).

bp pulse previously won funding from the California Energy Commission to build a microgrid for ATN. This microgrid will power 46 of ATN's electric buses. This $5 million grant will be used to deploy charging stations, battery energy storage systems, and microgrid controller units at ATN's to-be constructed depot to boost the resilience and flexibility of their zero-emission operations.

Proterra provides electric buses but also provides fleet planning and EV charging services. Through a turnkey solution, Proterra can provide an "energy delivery system" that offers a comprehensive solution for establishing EV infrastructure. This includes smart energy management, and electrical utility make-ready.

AmpUp is a software company and network provider for smart charge scheduling, dynamic access control, and energy optimization built into one platform. Their mobile app software was originally founded to offer peer-to-peer shared charging to increase charger access in residential areas and decrease the cost to EV owners. They have since expanded their product to include a solution for commercial entities and various customer types. All the charge management is facilitated through OCPP which allows the software to communicate with the hardware and means that the AmpUp solution is brand agnostic. The software determines when a charging station is on or offline, when it will become available, and when the plugged-in vehicle will charge based on customized pricing preferences. AmpUp's service is offered on a monthly or yearly software subscription basis with an additional per vehicle cost for an added telematics bundle, which offers an integration with their partner's (Smartcar) system. In California, AmpUp will also assist with fleet financing ROI by redeeming carbon credits on behalf of the customer and passing it along to them. The AmpUp system will pass on station data to the third-party carbon credit processor who will prepare and submit the required paperwork in order to receive the credit payment. These credits can be returned to the customer via check or can be directly put back into their AmpUp portal towards vehicle charge management expenses.

Appendix F: Energy Storage Solutions

Tesla – Megapack: A 1 Gigawatt hour (GWh) project provides record energy capacity—enough to power every home in San Francisco for six hours. Every Megapack arrives pre-assembled and pre-tested in one enclosure from our Gigafactory—including battery modules, bidirectional inverters, a thermal management system, an AC main breaker and controls.

Tesla Megapack

SPECIFICATIONS	SPECIFICTION VALUE(S)
Max Energy Capacity	3 MWh
Technology	Lithium-ion
Inverter Capacity	1.5 MW
Connection	AC output interface
Dimensions (L x W)	*23 ft 5 in x 5 ft 3 in (7.14 m x 1.60 m)*
Size	250 MW, 1 GWh power plant per 3 acre
Weight	51,000 lbs.
Source	*https://www.tesla.com/megapack*

BYD – Utility ESS: BYD mainly provides two kinds of indoor/outdoor solutions for on-grid, off-grid, and hybrid use. BYD energy storage systems can be fit for various needs based on its flexible and modular design.

BYD Utility ESS

SPECIFICATIONS	SPECIFICTION VALUE(S)
Max Energy Capacity	250kW/1MWh 500kW/1MWh 1MW/1MWh 1.8MW/800kWh
Technology	Lithium-ion Iron-Phosphate
Connection	AC output & DC input interface
Size	40ft Container
Source	*https://en.byd.com/energy/utility-ess/*

LG – ESS: LG Chem's L&S (Lamination & Stacking) process minimizes dead space, enables higher energy density, and enhances the sustainability of cell structures. LG Chem's SRS® (Safety Reinforced Separator) increases the mechanical and thermal stability of battery cells.

LG Energy Storage System (ESS)

SPECIFICATIONS	SPECIFICTION VALUE(S)
Max Energy Capacity	6.8MWh
Technology	Lithium-ion
Voltage Flexibility	14 Modules (~800V) 17 Modules (~1000V) 24 Modules (~1500V)
Connection	AC/DC Panel
Energy Flexibility	1) 25.8in 2) 37.4in 3) 47.2in
Size	40ft HC ISO Enclosure with HVAC
Grid Scale	Energy JH3, JH4 • Duration for ≥ 1 hour • Continuous power supply Power JP3 • Duration for < 1 hour • High power supply
Source	*https://www.lgessbattery.com/us/grid/intro.lg*

NGK Insulators – NAS Battery Cell: The NAS battery system is designed to easily expand the capacity as much as needed in one site or several separate sites. The scalability of NAS installation to many tens or hundreds of MW for durations of six to seven hours is at a scale that can defer or eliminate some transmission, distribution and generation investments especially when used in association with variable renewables for a clean solution.

NGK NAS Battery System

NGK INSULATORS
Surprising Ceramics.

SPECIFICATIONS	SPECIFICTION VALUE(S)
Energy Density	367 Wh/l 222 Wh/kg per battery cell
Power Density	36 W/kg per battery cell
Technology	Sodium-sulfur
Voltage	2V per battery cell
Connection	PCS (AC/DC power conversion system)
C-Rate	1/6 = 0.17 per battery cell
Dimensions (L x W)	9cm x 50 cm per battery cell
Weight	5 kg per battery cell
Size	Up to 50MW, 300MWh
Source	*https://www.ngk-insulators.com/en/product/nas-about.html*

NGK Insulators – NAS Container Type Unit: The NAS battery system is a "Plug and Play" design built around standard 20-foot ocean freight containers. The containerized design expedites transportation and installation and helps minimize installation costs.

NGK NAS Battery Container Type Unit

NGK INSULATORS
Surprising Ceramics.

SPECIFICATIONS	SPECIFICTION VALUE(S)
Rated Output	800 kW and 4,800 kWh
Configuration	Four container subunits, series connected. A subunit includes six NAS modules, each rated at 33 kW and 200 kWh
Dimension (W x D x H)	6.1 x 5.6 x 5.5 m
Weight	86 tonnes
Source	*https://www.ngk-insulators.com/en/product/nas-configurations.html*

NGK Insulators – NAS Package Type Unit: The enclosure package and battery modules are installed on site. This design achieves more compact system comparing with containerized design.

NGK NAS Battery Package Type Unit

NGK INSULATORS
Surprising Ceramics.

SPECIFICATIONS	SPECIFICTION VALUE(S)
Rated Output	1,200kW and 8,640kWh
Configuration	40 NAS modules, each rated at 30kW and 216kWh
Dimension (W x D x H)	10.2 x 4.4 x 4.8 m
Weight	132 tonnes
Source	*https://www.ngk-insulators.com/en/product/nas-configurations.html*

NEC - GBS-C53-LD40: Long-Duration (LD) Grid Battery Systems

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NEC - GBS-C53-LD40

SPECIFICATIONS	SPECIFICTION VALUE(S)
Energy Storage	4 MWh
Power Rating	4 MW
Technology	Nanophosphate® lithium-ion battery
DC Voltage	944V nominal (750V – 1050V DC operating range)
Connection	50Hz or 60Hz connection frequency options Optional step-up transformer to MV AC output 480VAC output (typical)
DC Efficiency	97% (C/2 rate)
Dimensions (LxWxH)	53' x 8.5' x 9.5' (16.2m x 2.6m x 2.9m)
Mass	140,000 lbs.
Source	*http://www.cls-energy.com/files/nec_grid_brochure.pdf*

NEC - GBS-C40-LD28: Long-Duration (LD) Grid Battery Systems

NEC - GBS-C40-LD28

NEC \Orchestrating a brighter world

SPECIFICATIONS	SPECIFICTION VALUE(S)
Energy Storage	2.8 MWh
Power Rating	2.8 MW
Technology	Nanophosphate® lithium-ion battery
DC Voltage	944V nominal (750V – 1050V DC operating range)
Connection	50Hz or 60Hz connection frequency options Optional step-up transformer to MV AC output 480VAC output (typical)
DC Efficiency	97% (C/2 rate)
Dimensions (LxWxH)	40' x 8.5' x 9.5' (12.2m x 2.6m x 2.9m)
Mass	100,000 lbs.
Source	*http://www.cls-energy.com/files/nec_grid_brochure.pdf*

NEC - GBS-C20-LD12: Long-Duration (LD) Grid Battery Systems

NEC - GBS-C20-LD12

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SPECIFICATIONS	SPECIFICTION VALUE(S)
Energy Storage	1.2 MWh
Power Rating	1.2 MW
Technology	Nanophosphate® lithium-ion battery
DC Voltage	944V nominal (750V – 1050V DC operating range)
Connection	50Hz or 60Hz connection frequency options Optional step-up transformer to MV AC output 480VAC output (typical)
DC Efficiency	97% (C/2 rate)
Dimensions (LxWxH)	20' x 8.5' x 9.5' (6.1m x 2.6m x 2.9m)
Mass	47,000 lbs.
Source	*http://www.cls-energy.com/files/nec_grid_brochure.pdf*

NEC - GBS-C53-HR20: High-Rate (HR) Grid Battery System

NEC - GBS-C53-HR20

SPECIFICATIONS	SPECIFICTION VALUE(S)
Energy Storage	575kWh
Power Rating	2 MW
Technology	Nanophosphate® lithium-ion battery
DC Voltage	960V nominal (750V – 1050V DC operating range)
Connection	50Hz or 60Hz connection frequency options Optional step-up transformer to MV AC output 480VAC output (typical)
DC Efficiency	96% (1C rate)
Dimensions (LxWxH)	53' x 8.5' x 9.5' (16.2m x 2.6m x 2.9m)
Mass	64,000 lbs.
Source	*http://www.cls-energy.com/files/nec_grid_brochure.pdf*

Saft – Intensium® Max 20 High Energy: Initially developed for grid installations, Intensium® Max brings rail energy-efficiency and smart-grid technologies to an aging transport infrastructure and has the potential to transform the relationship between the transport and energy industries.

Saft – Intensium® Max 20 High Energy

SPECIFICATIONS	SPECIFICTION VALUE(S)
Energy Storage	2.5 MWh
Storage Capacity	420 kWh
Voltage (V)	1000 V Class 811 1500 V Class 1216
Technology	Lithium-ion
Peak Charge	1.5 MW
Battery System	1000 V Class 9 Energy Storage System Units (ESSU) 14 battery modules in series One Battery Management Module (BMM)

	1500 V Class 6 Energy Storage System Units (ESSU) 21 battery modules One Battery Management Module (BMM)
Dimensions (LxWxH) w/o HVAC	6.1 x 2.4 x 2.9
Size	20 ft container
Weight	<30 tons
Source	*https://www.saftbatteries.com/products-solutions/products/intensium%C2%AE-max-efficient-trackside-energy-storage*

Samsung – E3-M123: To maximize economics and efficiency, the high efficiency battery solution minimizes power loss by enabling high power output and minimizes total footprint by reducing footprint of PCS and battery systems.

Samsung – E3-M123

SPECIFICATIONS	SPECIFICTION VALUE(S)
Energy Storage	6.0MWh
Cell Capacity	111 Ah
Technology	
Energy	12.3 kWh
Operating Voltage	96-126 V
Dimension (W x D x H)	344 x 160 x 1,012 mm
Weight	90 kg
Size	40 ft container
Source	*http://www.samsungsdi.com/upload/ess_brochure/201803_SamsungSDI%20ESS_EN.pdf*

Samsung – E3-R135: To maximize economics and efficiency, the high efficiency battery solution minimizes power loss by enabling high power output and minimized total footprint by reducing footprint of PCS and battery systems.

Samsung – E3-R135

SPECIFICATIONS	SPECIFICTION VALUE(S)
Energy Storage	6.0MWh
Cell Capacity	111 Ah
Energy	135 kWh
Technology	
Operating Voltage	1,056~1,386 V
Dimension (W x D x H)	415 x 1,067 x 2,124 mm
Weight	1,170 kg
Size	40 ft container
Source	*http://www.samsungsdi.com/upload/ess_brochure/201803_SamsungSDI%20ESS_EN.pdf*

Kokam by SolarEdge – KCE (Kokam Containerized ESS) 20ft.: In addition to offering customers a wide range of standard battery solutions, Kokam also works with customers to create customized solutions to address their unique needs. Compared to general system, Kokam's system saves 70% of power consumption.

Kokam by SolarEdge – KCE (Kokam Containerized ESS) 20ft

SPECIFICATIONS	SPECIFICTION VALUE(S)	
Energy Storage	1MWh	
System Configuration	1 Bank	
Technology		
Bank Configuration	10 Racks (2C5R)	
Installed Energy	Natural Air Cooling	Forced Air Cooling
Nominal Voltage	1,516kWh	1,516kWh
Operating Voltage Range	736Vdc	736Vdc
Max. Charge Power	670 ~ 826Vdc	670 ~ 826Vdc
Peak Discharge Power	1,516kW (1P)	1,516kW (1P)
Max. Discharge Power	3,032kW (2P)	4,548kW (3P)

Round Trip DC Efficiency	1,516kW (1P)	2,880kW (1.9P)
Size	20 ft container	
Source	*https://kokam.com/ess-solution*	

Kokam by SolarEdge – KCE (Kokam Containerized ESS) 40ft.: KCE racks have an extremely compact design (Max.194.3kWh per Rack) with parallel connection up to 1MWh~10MWh. They accommodate user-specific energy and voltage requirements and are equipped with multiple layers of safety mechanisms.

Kokam by SolarEdge - KCE (Kokam Containerized ESS) 40ft

Kokam by SolarEdge

SPECIFICATIONS	SPECIFICTION VALUE(S)	
Energy Storage	2MWh	
System Configuration	2 Bank	
Technology		
Bank Configuration	13 Racks (2C5R)	
Installed Energy	Natural Air Cooling	Forced Air Cooling
Nominal Voltage	3,942kWh	3,942kWh
Operating Voltage Range	736Vdc	736Vdc
Max. Charge Power	670 ~ 826Vdc	670 ~ 826Vdc
Peak Discharge Power	3,942kW (1P)	3,942kW (1P)
Max. Discharge Power	7,884kW (2P)	11,826kW (3P)
Round Trip DC Efficiency	3,942kWh	5,518kW (1.4P)
Size	40 ft container	
Source	*https://kokam.com/ess-solution*	

Hitachi ABB – Battery Energy Storage System PQpluS™: PQpluS™ is available in a wide range of power and energy ratings, making it the right choice for end users, system integrators, and aggregators, as well as users with the right control system for utility scale applications. In addition to functions like peak shaving and power quality, PQpluS™ can be managed by third party controller to perform site energy management, integration of renewables, and grid services.

HITACHI ABB

Hitachi ABB – Battery Energy Storage System PQpluS

SPECIFICATIONS	SPECIFICTION VALUE(S)
Energy Storage	68.5 kWh per rack
Electrical Grid Connection	380 VAC-415 VAC 50/60 Hz
Electrical Rated Output	30 kW / 68.5 kWh
Inverter Rated Power (at 400 V)	30 kW per module
Technology	Lithium-ion based on NMC technology
Min 30 kW power & 68.5 kWh energy to max 360 kW &411 kWh rated system	• 2 x PQstorI (30kW each) inverter and 1 x battery rack: 60 kW (max) and 68.5 kWh (max) • 9 x PQstorI (30kW each) inverter and 4 x battery racks: 270 kW (max) and 274 kWh (max)
Power/ energy requirement above 360 kW/ 411 kWh	• Up to 32 x PQstorI inverters: max power 960 kW • Up to 14 x battery racks: max energy 960 kWh Multiple modules of inverters/ batteries can operate in parallel to build storage capacity up to 1.6 MW/ 2.2 MWh. For example, a 960 kW/ 1100 kWh rated PQpluS require the following modules: • Inverter modules: 32 modules of 30 kWh PQstorI • Battery modules: 2 off 8 x battery racks
Weight	562 kg
Source	*https://www.hitachiabb-powergrids.com/offering/product-and-system/energystorage/pqplus*

Hitachi ABB – e-mesh™ PowerStore™: Hitachi ABB Power Grids e-meshTM PowerStoreTM is a scalable microgrids and energy storage solution that is designed to ensure reliable power availability, grid stability, highest possible penetration of renewable energy together with an intelligent control system for both grid-connected and off-grid systems. e-mesh™ PowerStore™ is available in two variants, Integrated and Modular, for installations across utilities, remote communities, independent power producers, commercial, and industrial establishments.

Hitachi ABB – e-mesh™ PowerStore™:

SPECIFICATIONS	SPECIFICTION VALUE(S)
Energy Storage	50kW, 250kW, up to MW scale
Variants	Integrated and Modular
Source	*https://www.hitachiabb-powergrids.com/offering/solutions/grid-edge-solutions/our-offering/e-mesh/powerstore*

STAFF REPORT

Subject: **Election of 2024 Chairperson and Vice-Chairperson**

Presented By: **Phil Moores, Executive Director**

Background:

Section 2.1 of the Joint Powers Agreement provides that the Board of Directors shall elect a Chair and Vice-Chair from among its members. The ESTA By-Laws specify that the representative elected to the Chair position shall alternate between Inyo and Mono Counties each year, and that the persons elected to the Chair and Vice-Chair positions shall not be from the same county.

Analysis/Discussion:

In keeping with the By-Laws, the Chair for 2024 should be from either Mono County or the Mammoth Lakes.

Past practice has been that the Vice-Chair has been elected to the position of Chair in the year following their term as Vice-Chair. Chris Bubser is the current Vice Chair, and her replacement should be from Bishop or Inyo County.

Recommendation:

It is recommended the Board elect a Chairperson and Vice Chairperson for 2024.

February 8, 2024
Item C-2

STAFF REPORT

Subject: Mammoth Fleet Replacement Plan

Initiated by: Phil Moores, Executive Director

BACKGROUND:

The Mammoth fleet of heavy-duty transit buses (13 buses) is in dire need of replacement. Engine failures, distressed systems, and poor appearance have increased to the point that action is in order.

ANALYSIS/DISCUSSION:

ESTA buys most of its vehicles through the California Association for Coordinated Transportation (CalACT) purchasing cooperative. The Cooperative publishes vehicle manufacturer's bids after satisfying federal procurement requirements on our behalf. Here are some conditions that support the expenditure of ESTA reserves on Mammoth's buses:

1. The contract to purchase heavy-duty diesel buses expires in April 2024.
2. Cummins Diesel engine manufacturers has declined to meet California Air Resource Board's requirements for diesel engines for next year. It is unclear when or if Cummins will make diesel engines for California buses. ESTA buses are all made by Cummins, and there are no replacement engines available at this time.
3. El Dorado National Corporation has closed its doors permanently and will no longer sell buses. Twelve of our thirteen buses are El Dorados. Some parts are difficult to impossible to get already.
4. The entire fleet is now beyond useful life limits.
5. Renewing the Mammoth fleet now with diesel buses will provide some time to observe the maturity of the alternative fuel industry which is evolving at a very fast pace.
6. ESTA has been saving for twelve years for this purchase, and reserves are sufficient to address the need.

The Plan to renew the Mammoth Lakes fleet of 13 heavy-duty transit buses is a mix of actions. All the efforts below are based on Diesel fuel vehicles.

1. 6 New – 50/50 with Mammoth Lakes/Mono LTC
2. 7 - Refurbished at Complete Coach Works

Financial Considerations

ESTA reserves are sitting around $8,000,000 to an annual operating budget of $6,000,000.

A new diesel bus costs around $775,000, compared to $1.3 million for an alternative fuel bus. Our capital replacement savings did not consider such a dramatic increase in bus prices. After the CalACT Purchasing Cooperative contract expires in April, prices for diesel buses are expected to increase.

Complete Coach Works in Riverside, CA, is a company that specializes in refurbishing used transit buses. Costs for refurbishment vary by bus depending on what is needed. An estimate of $300,000 per bus will be used in this plan.

Bus	Plan	Cost
801	buy new	$775,000
802	buy new	$775,000
803	buy new	$775,000
804	Refurb	$300,000
805	buy new	$775,000
806	Refurb	$300,000
807	Refurb	$300,000
808	Refurb	$300,000
809	buy new	$775,000
810	buy new	$775,000
811	Refurb	$300,000
812	Refurb	$300,000
706	Refurb	$300,000
	Total	$6,750,000

Obviously, we can't afford to renew the whole fleet at once. I am in negotiations with Mono LTC and Mammoth Lakes for financial assistance. If all goes according to plan, we will split the cost of purchasing new buses 50/50 up to a total of six vehicles. The remaining seven buses will be refurbished or replaced as funds become available. We will continue to pursue grant funds every year as before.

Summary

The time is right to expend reserves and purchase new buses that will give us time to evaluate zero-emission technology for the next 5-10 years. The Bishop building project is expected to cost $2,000,000 with $457,000 in grant funds available.

Recommendation

The ESTA Board is recommended to approve the expenditure of capital reserves to replace and renew the Mammoth Lakes heavy-duty transit bus fleet up to $3,000,000.