DOCKETED	
Docket Number:	20-IEPR-02
Project Title:	Transportation
TN #:	233427
Document Title:	Alameda-Contra Costa Transit District Comments on IEPR Commissioner Workshop on Heavy-Duty Zero-Emission Vehicle Market Trends
Description:	N/A
Filer:	System
Organization:	Alameda-Contra Costa Transit District
Submitter Role:	Public Agency
Submission Date:	6/11/2020 12:28:45 PM
Docketed Date:	6/11/2020

Comment Received From: Alameda-Contra Costa Transit District
Submitted On: 6/11/2020
Docket Number: 20-IEPR-02

Alameda-Contra Costa Transit District Comments on IEPR Commissioner Workshop on Heavy-Duty Zero-Emission Vehicle Market Trends

Additional submitted attachment is included below.

Alameda-Contra Costa Transit District

June 11, 2020

California Energy Commission
Docket Unit, MS-4
Re: Docket No. 20-IEPR-02
1516 Ninth Street
Sacramento, California 95814-5512

Re: Alameda-Contra Costa Transit District Comments on IEPR Commissioner Workshop on Heavy-Duty Zero-Emission Vehicle Market Trends

The Alameda-Contra Costa Transit District (AC Transit) appreciates the opportunity to submit comments on the California Energy Commission (CEC) Integrated Energy Policy Report (IEPR) Commissioner Workshop on Heavy-Duty Zero-Emission Vehicle Market Trends. Fossil fuel heavy-duty vehicles are a significant contributor to GHG emissions and criteria air pollutants, and are anticipated to play a major role in California's energy future. With this being the case, we greatly appreciate the California Energy Commission (CEC) holding this series of workshops on heavy-duty zero-emission vehicles and their inclusion in the IEPR 2020 update.

Since 2000, AC Transit has been building the most comprehensive zero emission bus (ZEB) program in the United States, initially focused on hydrogen fuel cell electric bus (FCEB) technology and most recently expanded to include battery electric buses (BEB). AC Transit deployed four generations of hydrogen fuel cell buses, each phase teaching us how to improve procurement, operation and performance of ZEB technology. During the demonstration period we logged over 3.2 million zero emission miles, while exceeding many performance targets established by the Federal Transit Administration (FTA) and Department of Energy (DOE). We operated a fuel cell for more than 32,000 hours and maintained the 13-bus fleet at performance levels equal to or above that of diesel buses. One significant accomplishment was when our team spent weeks disassembling two of the end of life fuel cell stacks and rebuilt them into a fully functional fuel cell stack which is currently powering one of our buses. Since the beginning, the National Renewable Energy Laboratory (NREL) conducted an independent, comprehensive, and unbiased evaluation of AC Transit's fuel cell bus program. Reports of NREL's evaluation can be found at the following weblink: https://www.nrel.gov/hydrogen/fuel-cell-bus-evaluation.html

Now we are operating the latest advanced ZEB technology side-by-side. ZEB Performance Evaluation 2020 is AC Transit's comprehensive analysis of public transit bus technology that will include BEB, FCEB, diesel-hybrid, conventional diesel and legacy FC bus technologies. We will assess and compare capital cost and annual operations and maintenance costs of the various bus and infrastructure technologies. Our experience has shown us that supporting both battery electric and hydrogen fuel cell technologies will be essential to California's success in meeting the State's climate action goals and ensuring that the transportation sector can remain resilient.

On June 10, 2020 AC Transit's Board of Directors approved a Zero Emissions Bus (ZEB) Rollout Plan with a commitment to transition the bus fleet to 100% zero emissions by 2040, attached is a copy of the ZEB Rollout Plan.

In public transit, each technology has a different use case. Fuel cell buses excel at longer routes that require additional range, where battery electric buses are good for shorter routes. Supporting both technologies also ensures that if there are issues with the grid or power generation, like a public safety power shutoff (PSPS), or problems with the hydrogen supply chain, fleets will still have the flexibility to operate vehicles.

While we believe that both technologies need to be supported by the State, the form the support takes differs. The resiliency of our electric infrastructure, at the utility level, needs to be improved significantly to ensure that our transportation systems remain reliable. If buses are not able to be charged, then they cannot go into service. Additionally, rate structures must be designed to be favorable to use in a large-scale transportation setting. As it stands now, demand charges make it difficult for fleets to be adaptable because DC fast charging is cost prohibitive. On the other hand, hydrogen fuel cells need an entirely different type of support. Utilities currently support battery electric installations by subsidizing charging infrastructure because there is a profit motive to get battery electric fleets online and drawing power from the grid. The hydrogen market is much less developed, so suppliers have no such motive. Fuel cell technology can be supported by promoting policies that improve the hydrogen market and reducing barriers to entry. Making more publicly available hydrogen fueling stations for private vehicles could help to spur demand, reducing the cost of fuel, as well as signaling to vehicle manufacturers that the State is committed to the technology. Policies encouraging green electrolytic hydrogen with excess solar generation capacity would make our energy system more secure and support fuel cell technology.

Workforce training support would also go a long way to advance both technologies. A major concern for fleet operators considering deployment of zero emission vehicles is the lack of a properly trained maintenance workforce. AC Transit has significant experience developing and delivering zero emission bus safety, advanced diagnostics and maintenance training. We developed a state-of-the-art training program coined Zero Emission Bus University (ZEBU) consisting of curriculum on high voltage battery, electric drive motor, fuel cell power plant, and high-pressure gaseous fuel systems. Mechanics start learning basic safety and familiarization on the zero emission propulsion systems and then progress to preventative maintenance, basic diagnostics and advanced diagnostics. Ensuring that there is a well-trained workforce is a critical component for the sustainability of zero emission technology.

AC Transit applauds the efforts of the CEC for considering the heavy-duty transportation sector in its consideration of California's energy policy. We are committed to supporting CEC's vision of a 100% clean energy future and are honored to do our part to advance that goal. We look forward to collaborating with the CEC on the IEPR 2020 update to make that happen.

Sincerely,

Michael Hursh
General Manager

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Zero-Emissions Bus Rollout Plan

VERSION 1

ALAMEDA CONTRA COSTA TRANSIT DISTRICT

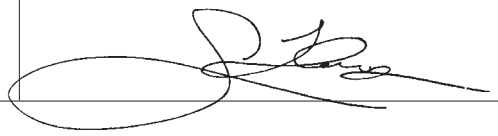
OAKLAND, CA

Leading the way to a **ZERO EMISSION FUTURE.**

DOCUMENT CONTROL HISTORY

Version	Document Title	Date	Comments
1	Zero-Emissions Bus Rollout Plan	6/10/20	AC Transit Resolution No. 20-029

AUTHORITY ACCEPTANCE

Recipient Name	Title	Signature
Salvador Llamas	Chief Operating Officer	

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Acronyms

AC	TransitAlameda-Contra Costa Transit District
API	Applications Program Interface
BAAQMD	Bay Area Quality Management District
BEB	Battery Electric Bus
BEB FCEB	Mixed Fleet
BTW	Behind the Wheel
CARB	California Air Resource Board
CMF	Central Maintenance Facility
CNG	Compressed Natural Gas
CTE	Center for Transportation & the Environment
D2	Division 2, Emeryville CA
D3	Division 3, Richmond, CA
D4	Division 4, Oakland, CA
D6	Division 6, Hayward, CA
DOE	Department of Energy
ESS	Energy Storage System
FCEB	Full Cell Electric Bus
FTA	Federal Transit Administration
GO	General Office
HVIP	Hybrid & Zero Emissions Truck & Bus Voucher Incentive Project
ICT	Innovative Clean Transit
O&M	Operations and Maintenance
OEMs	Original Equipment Manufactures
TAM	Transit Asset Management
TCP	Transit Capital Priorities
TEC	Training and Education Center
ZEB	Zero Emissions Bus

SECTION A:

Overview of AC Transit

The Alameda-Contra Costa Transit District (AC Transit) is the third-largest public bus-only transit property in California, serving 13 cities and adjacent unincorporated areas in Alameda and Contra Costa counties. Based in the San Francisco East Bay, AC Transit's General Office is located at 1600 Franklin Street, Oakland, Alameda County, 94612. Operating in the Bay Area Air Quality Management District (BAAQMD) in the Alameda County, San Francisco Bay Area Air Basin, AC Transit has been serving the East Bay since 1960, taking over from the Key System and its predecessors that carried passengers via buses, horse-drawn rail streetcars, electric streetcars, and ferries over the previous 100 years.

AC Transit has a long-standing commitment to preserving and improving the quality and quantity of transit service for 1.5 million East Bay passengers that populate our 364 square mile service area, which includes the counties of Alameda and Contra Costa covering 13 cities and adjacent unincorporated areas of the East Bay. AC Transit carries about 200,000 riders on an average weekday, along 149 service lines while generating over 20 million annual miles on its fleet of 635 public transit buses.

Since 2000, AC Transit has been building the most comprehensive zero-emission bus (ZEB) program in the United States, initially focused on hydrogen fuel cell technology and most recently expanded to include battery electric buses. From 2003 to 2018, AC Transit lead a coalition of transit agency and industry stakeholders supported by Federal, State and Local partners; AC Transit deployed three generations of ZEBs. Each phase teaching us how to improve procurement, operation and performance of ZEB technology. During the demonstration period AC Transit logged over 3.2 million zero emission miles, while exceeding many performance targets established by the Federal Transit Administration (FTA) and the Department of Energy (DOE) and creating new performance records for ZEB technology. Through trial and error and many growing pains AC Transit has improved the ZEB deployment process with enhanced project delivery methods and ongoing sustainable maintenance practices. AC Transit is now moving into the advanced stages of ZEB deployment.

AC Transit is an industry leader at providing public transit solutions that connects the East Bay communities with regional destinations. The District adopted a Strategic Plan to concentrate staff time and resources on activities that are of primary focus. Elements of the Strategic Plan consist of: Core Values, Vision and Mission Statements, Goals and Initiatives to organize the District's work effort direction.

AC Transit Core Values

Safety

Service

Environmental Sustainability

Equity

Innovation

Integrity

Trust

Mission Statement

We deliver safe, reliable, sustainable transit service that responds to the needs of our customers and communities.

Vision Statement

AC Transit is valued as a leader that helps the Bay Area thrive by connecting East Bay communities to each other and to regional destinations.

Strategic Goals and Initiatives

GOALS:

Safe and Secure Operations
Convenient and Reliable Service
Financial Stability and Resiliency
High-Performing Workforce
Strong Public and Policymaker Support
Environmental Improvement

INITIATIVES:

Service Quality
Infrastructure Modernization
Employee Recruitment, Training and Retention
Zero Emission Programs
Financial Efficiency and Revenue Maximization

SECTION B:

Rollout Plan General Information

Innovative Clean Transit Regulation

The Innovative Clean Transit (ICT) regulation was adopted by the California Air Resources Board (CARB) in December of 2018 and became effective October 1, 2019. Title 13 California Code of Regulations §2023 (13 CCR § 2023.1 through 2023.11) requires all public transit agencies to gradually transition their bus fleets to zero-emission technologies. The ICT regulation applies to all transit agencies that own, operate, or lease buses with a gross vehicle weight rating (GVWR) greater than 14,000 pounds. It covers standard, articulated, over-the-road, double decker, and cutaway buses. The ICT regulation requires a percentage of new bus purchases to be zero-emission buses (ZEBs). The ZEB percentage increases gradually with time. The ZEB purchase requirements begin in 2023 for large transit agencies (200 buses or more) and 2026 for small transit agencies. Starting 2029, 100 percent of all transit agencies' new bus purchases must be ZEBs, with a goal of complete transition to ZEBs by 2040.

Each transit agency must adopt and submit to the California Air Resources Board (CARB) a Zero Emission Bus Rollout Plan describing how the agency will transition to a zero-emission fleet. A large transit agency must submit this plan to CARB by July 1, 2020. Accordingly, AC Transit's Board of Directors adopted a Resolution which outlines the District's goal of full transition to zero-emission technologies by 2040 that avoids early retirement of conventional buses, and adopts a AC Transit's Zero Emission Bus Rollout Plan, and sets the direction for establishing and following through with the Rollout Plan strategies that are achievable with available funds. The Zero Emission Bus Rollout Plan is specific to AC Transit and is not part of a Joint Group.

ZEB Rollout Plan Executive Leadership Contact Information

Name	Title	Phone	Email
Michael A. Hursh	General Manager	(510) 891-4753	mhursh@actransit.org
Salvador Llamas	Chief Operating Officer	(510) 891-7215	sllamas@actransit.org

Per ICT Regulation a ZEB Rollout Plan must meet the following requirements:

a) A goal of full transition to zero-emission buses by 2040 with careful planning that avoids early retirement of conventional internal combustion engine buses

b) Identification of the types of zero-emission bus technologies a transit agency is planning to deploy, such as battery electric or fuel cell electric bus

c) A schedule for construction of facilities and infrastructure modifications or upgrades, including charging, fueling, and maintenance facilities, to deploy and maintain zero-emission buses. 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 internal combustion engine buses 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 internal combustion engine buses to zero-emission buses, if any. This schedule for bus conversion must identify number of buses, bus types, the propulsion systems being removed and converted to

f) A description on how a transit agency plans to deploy zero-emission buses in disadvantaged communities as listed in the latest version of "CalEnviroScreen"

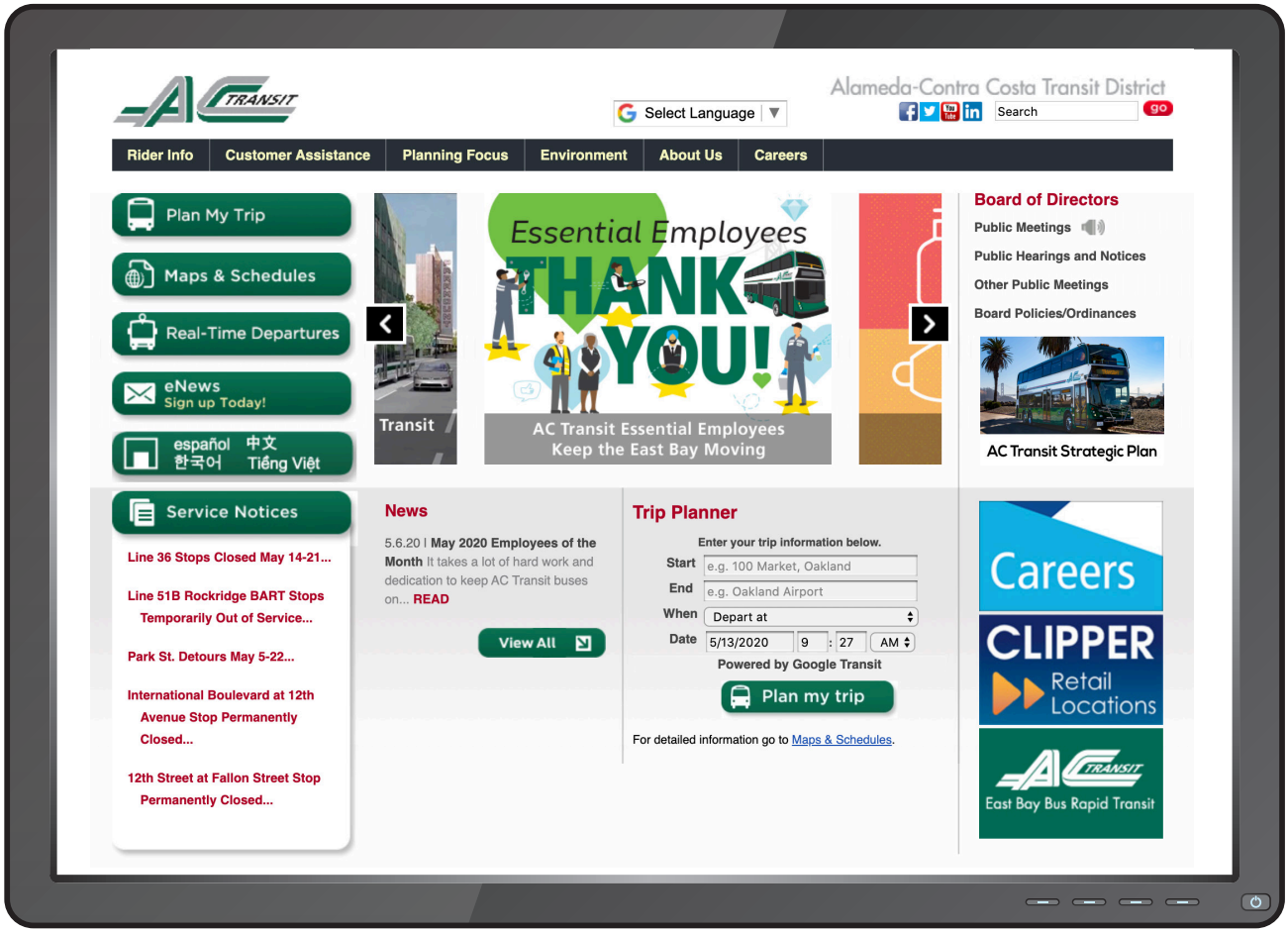
g) A training plan and schedule for zero-emission bus operators and maintenance and repair staff.

h) Identification of potential funding sources

i) Start-up and Scale-up Challenges

AC Transit's Board of Directors has approved a Strategic Plan, Clean Corridors Plan, Capital Improvement Program, Facilities Utilization Study, and Zero-Emissions Bus Study as the guiding documents to comply with the ICT Regulation requirements. The guiding documents can be found on the District's website.

AC Transit Website: www.actransit.org



SECTION C:

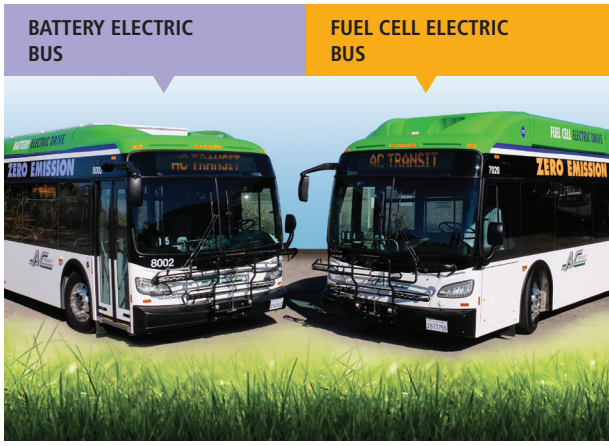
Technology Portfolio

Transition Goals and Technology Replacement

AC Transit remains committed to transition the fleet to 100% zero-emission buses. To initiate this process, AC Transit engaged the Center for Transportation & the Environment (CTE) in November 2017 to assess the applicability of zero-emission buses for AC Transit service and to develop a strategy and plan to transition AC Transit to a zero-emission fleet. The transition goal is to comply with the Innovative Clean Transit Regulation and have a 100% zero-emission fleet in place by 2040. The Zero-Emission Study developed five scenarios to inform AC Transit Board members and educate AC Transit staff of estimated cost, benefits, constraints, and risks to guide future planning and decision-making.

Zero-Emission Bus Study Scenarios

1) No changes to current fleet composition (Baseline)
2) All Battery Electric Bus Fleet (All-BEB)
   a. Technology remains at current levels
   b. Technology improves over time to maintain 1:1 replacement
3) All Fuel Cell Electric Bus Fleet (All-FCEB)
   a. Technology remains at current levels
   b. Technology improves over time to maintain 1:1 replacement
4) Mixed Fleet (BEB-FCEB)



An assessment of fleet, infrastructure, fuel, and maintenance cost estimates resulted in a total cost of ownership for each transition scenario. The table and chart below provide a side-by-side comparison of the cumulative transition costs for each scenario analyzed during this study.

Table 1: Transition cost estimates by scenario

** Note: scenario (a) technology remains at current levels, (b) technology improves over time to maintain 1:1 replacement*

	Baseline	2a: All BEB*	2b: All BEB*	3a: All FCEB*	3b: All FCEB*	4: Mixed Fleet
Fleet	$567,845,000	$1,043,085,000	$789,310,000	$1,028,160,000	$1,024,560,000	$906,635,000
Infrastructure	–	$247,896,976	$176,231,508	$45,220,000	$45,220,000	$176,231,508
Fuel	$321,283,074	$379,879,840	$284,587,189	$418,122,230	$418,122,230	$363,900,134
Maintenance	$747,680,824	$830,501,132	$699,236,568	$1,011,206,327	$1,008,915,529	$886,537,380
Totals	**$1,636,808,899**	**$2,501,362,948**	**$1,949,365,265**	**$2,502,708,557**	**$2,496,817,760**	**$2,333,304,022**
Incremental costs		$864,554,049	$312,556,367	$865,899,659	$860,008,861	$696,495,124

Zero-emission bus technologies are in a period of rapid development and change. While the technology is proven in many pilot deployments, it is not yet matured to the point where it can easily replace current diesel and CNG technologies on a large scale. Battery electric buses will require significant investment in facilities and infrastructure and may require changes to service and operations to manage their inherent constraints. On the other hand, fuel cell electric buses are believed to provide an operational equivalent to diesels and CNG, however, the incremental cost of buses, fueling infrastructure, and fuel places this technology at a serious disadvantage.

As a result, AC Transit's transition approach is as follows:

1. **Remain proactive with ZEB deployments:** AC Transit has developed a reputation as an industry leader in the deployment of developing technologies. Significantly more development, data collection, and analyses are needed before the technology is ready for fleet-wide deployment. For example, BEBs will require charge management software, hardware, and standards to manage the fleet-wide transition. FCEBs will require lower fuel and station maintenance costs that will evolve over time with the production of hydrogen at scale. Thus, AC Transit will continue with small-scale deployments of both BEBs and FCEBs, taking advantage of various grant and incentive programs to offset the incremental cost. AC Transit's Board of Directors approved a Clean Corridors Plan, which identifies Disadvantaged Communities to be prioritized for zero emission bus service. Based on this proactive and strategic approach, AC Transit was awarded funds to purchase an additional 45 ZEBs.

2. **Target specific routes and blocks for early ZEB deployments:** AC Transit should consider the strengths of given ZEB technologies and focus those technologies on routes and blocks that take advantage of their efficiencies and minimizes the impact of the constraints related to the respective technologies. For example, depot-charged BEBs for shorter routes and blocks, on-route charged BEBs for mid-range routes with layovers at a transit center, and FCEBs for long routes or routes with higher speeds and/or heavier loads. These technologies cannot follow a "one-size-fits-all" approach from either a performance or cost perspective. Matching the technology to the service will be a critical best practice.

3. **Continue with both BEBs and FCEBs:** At this stage, it is too early to tell which technology will dominate the market 10-20 years from now. Having the capability to deploy both ZEB technologies creates an opportunity for AC Transit to fully assess BEBs and FCEBs to determine which technology can best meet the operational range requirements while being financially efficient and sustainable. This approach will allow staff to report annually to the AC Transit Board of Directors providing an update on ZEB performance, operations and maintenance (O&M) costs including the cost of fuel/energy, and infrastructure O&M costs. AC Transit can then modify the ZEB Rollout Plan as needed based on results of the annual report to the Board.

Rollout Plan Timeline

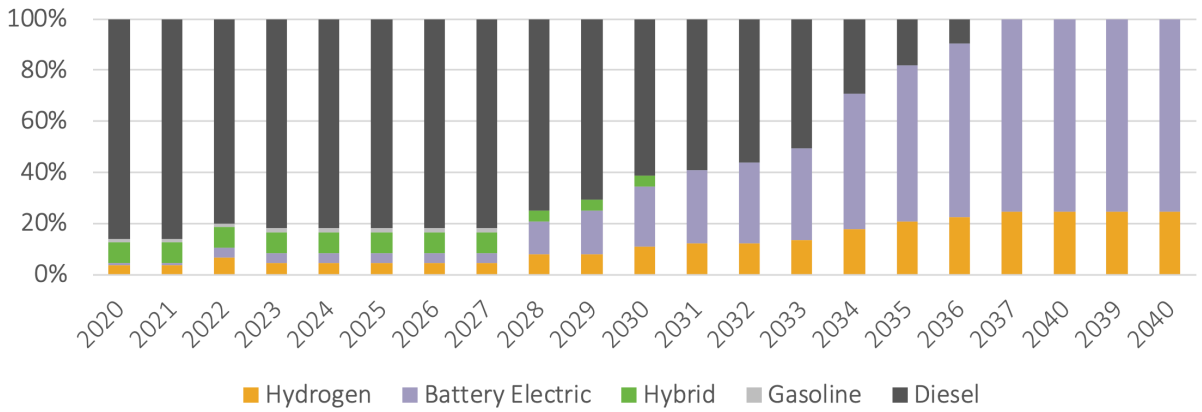
As a leader in early adoption of zero-emission bus (ZEB) technology, AC Transit (District) is in the position to fully assess which ZEB technology can best meet the service operational requirements while being financially efficient and sustainable. AC Transit's Board of Directors approved a Strategic Plan, Clean Corridors Plan, Capital Improvement Plan, Facilities Utilization Plan, and Zero-Emissions Bus Study as a foundation to forge a path towards the fleet transition and compliance with California Code of Regulations §2023.2. AC Transit's ZEB Rollout Plan serves as a blueprint for how the District is planning to achieve a full transition to zero-emission technologies by 2040, considering minimum useful life of buses.

Through more than 20-years of experience deploying ZEBs, AC Transit has learned there are still many unknowns and unexpected challenges to overcome. Both, battery electric and fuel cell electric bus technologies, have start-up and scale-up challenges as listed in Section I of the Plan. In order to successfully transition the fleet, AC Transit will need policy makers, industry original equipment manufacturers (OEMs) and energy providers to help address existing challenges and risks. As with any living document, the ZEB Rollout Plan is not binding and can be updated, adjustments will be made to the Plan as technology advances and solutions are realized.

Fleet Transition Schedule and Cost

Based on AC Transit's current fleet replacement schedule and planned procurements, the following chart depicts the annual mixed fleet composition to achieve a goal of 100% zero-emission buses by 2040. The replacement schedule is based on the District's Transit Asset Management (TAM) Plan, mandated by the Federal Transit Administration (FTA). ZEB technology mix is based on existing range capability and route block pairing where 75% of daily blocks are under a 170-mile rage.

ZEB Fleet Transition Schedule



Using cost estimates based on the District's current 45 ZEB deployment project, which assumes a 2020 year-of-expenditure, the total cost to successfully transition to a 100% ZEB fleet will reach $1.1 billion. Based on earlier studies, an incremental cost of $696 million is expected however, this may change and reduce during each procurement phase. Summarized on the chart below is the bus procurement and large-scale infrastructure cost to support each technology type. Infrastructure cost uses the current market scalability of $28 million to deploy 50 battery electric buses (BEB) and $31 million to deploy 200 fuel cell electric buses (FCEB).

ZEB Technology Cost

ZEB Technology	Fleet Qty	Bus Cost	Infrastructure Cost	Technology Total
Battery Electric Bus	530	$580,000,000	$297,000,000	$880,000,000
Fuel Cell Bus	150	$195,000,000	$31,000,000	$226,000,000
	680	$778,000,000	$328,000,000	$1,106,000,000

Information Technology Infrastructure and Data Analytics Platform

AC Transit will need to invest in its Information Technology (IT) infrastructure, security, and data integration platform, to manage the increasing amount of ZEB energy and performance data. A robust and secure data collection, integration and management platform is being envisioned to minimize manual intervention when collecting data from disparate systems in real-time.

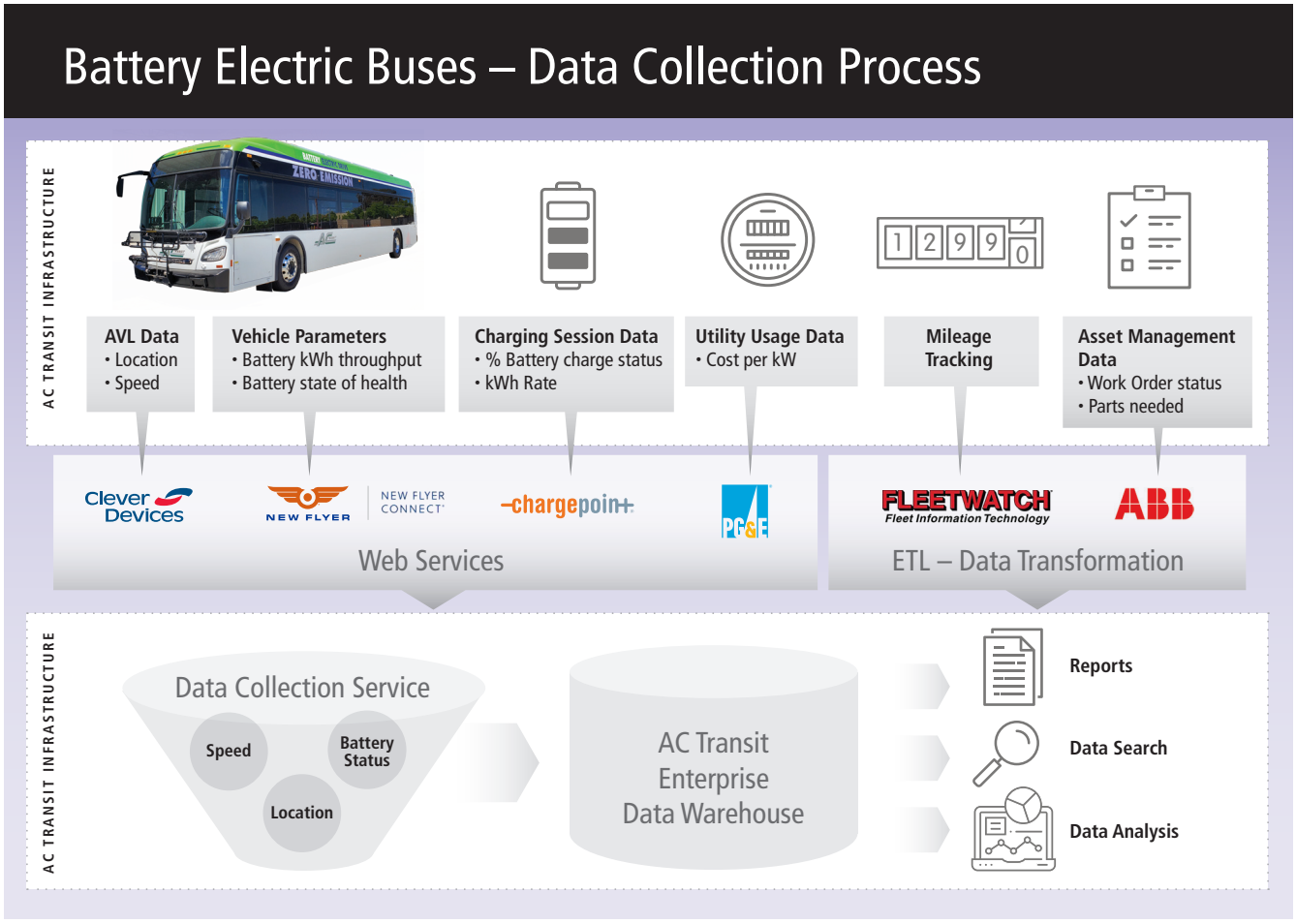
AC Transit sees tremendous value in collecting and reporting on all types of system and performance data. AC Transit will build a robust enterprise Data Analytics Platform to support the Zero Emission Buses program by optimizing energy consumption. This new Data Analytics Platform leverages the Cloud technology and includes modern database technology, Machine Learning, and enterprise Application Programming Interface (API) connectivity platform. This new platform will connect various data sources, internal and external, to acquire, store and manage the ZEB fleet related data and provide real-time reports as well as historical trends. In order to collect the data, AC Transit must have direct access to the data and the Zero Emission Bus (ZEB) equipment. Data from the ZEB equipment will be collected and uploaded to our enterprise data warehouse system using our data collection system. It will be necessary to configure and secure integrations between the ZEB data systems and our data collection system.

Robust, reliable and real-time connectivity will be a critical sub-system in assuring the timeliness and quality data collection. All ZEB equipment will be connected to our Local Area Network (LAN) or Wireless Local Area Network (WLAN). Network access switch ports will be made available to interconnect all ZEB equipment at our divisions and on our buses. Any data transmission outside of our network will utilize our secure Wide Area Network (WAN) infrastructure. Point to point secure VPN technology will be used to connect AC Transit to ZEB equipment and services providers.

Securing data, in transition or at rest, will be of the utmost importance for the success of this program. All transmitted and received data will be encrypted and scanned to ensure security compliance. Where appropriate, Virtual Local Area Networks (VLAN) and Access Control Lists (ACL) will be created to build logical segregation, isolate the touchpoints and protect all ZEB equipment. ZEB network traffic will be scanned, audited, and analyzed to detect unauthorize access using our network security tools. Direct access to any ZEB equipment from outside the company will be protected using secure user authentication tools and procedures.

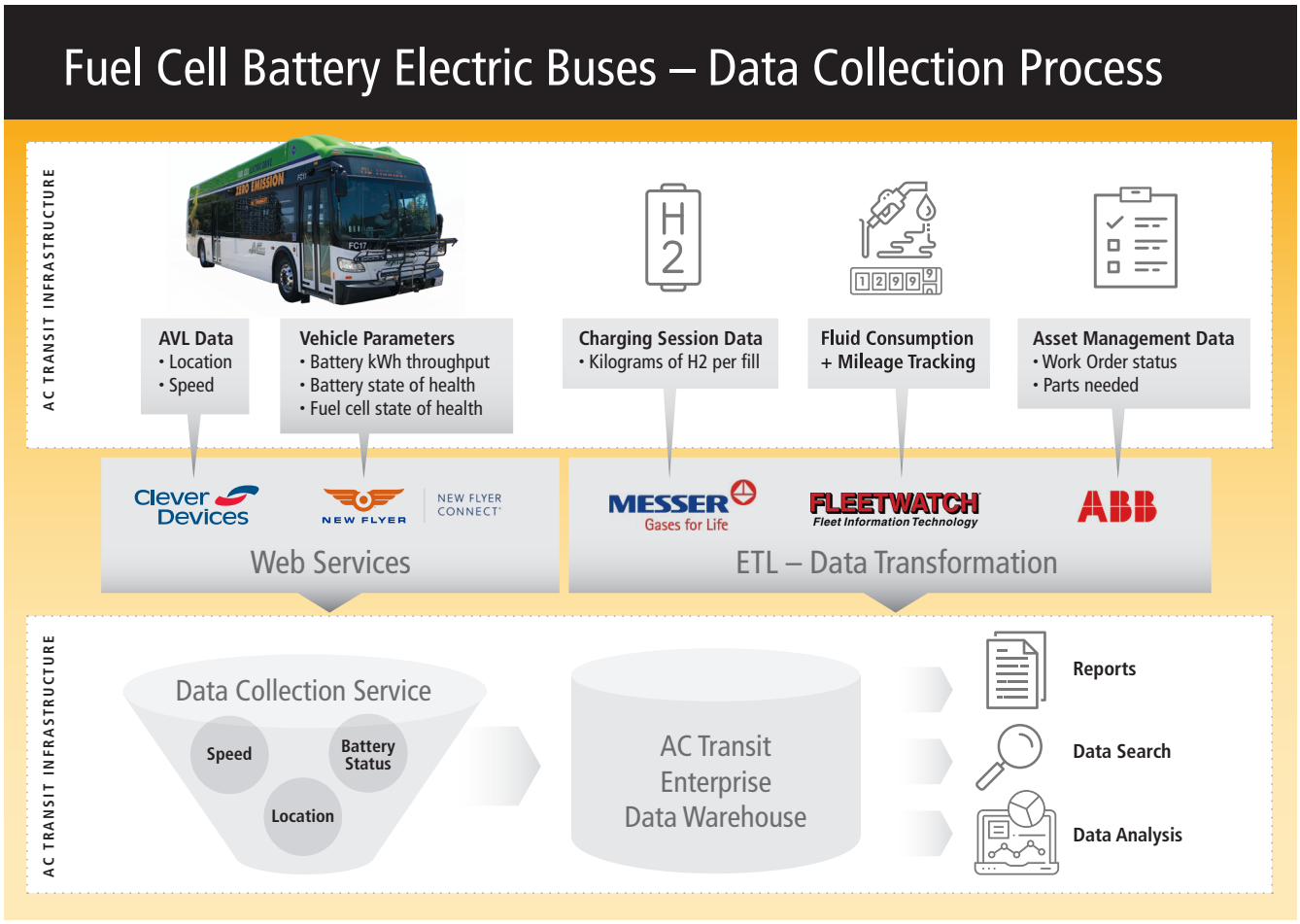
BEB Data Collection Architecture

The Battery Electric Bus data collection architecture will have a separate enterprise API module to support the collection, transformation, and analysis of electric energy and performance data due to different systems. The BEB Data Collection Architecture will use ChargePoint battery stations (% battery charge and kWh rate) and PG&E utility metering (cost per kW), Fleetwatch for mileage tracking, Vehicle Parameters from New Flyer, Clever Devices AVL for location/speed, ABB Ellipse assets and part refits for reliability and NWS for weather and environmental measurements. The Microsoft Azure Cloud software platform integrates with vendor API web services, performing data normalization and aggregation for new reports, data searches, and business intelligence/analytics, all within the AC Transit infrastructure.



FCBEB Data Collection Architecture

The Fuel Cell Battery Electric Bus data collection architecture will require a dedicated and separate enterprise API module to support the collection, transformation, and analysis of fuel-cell energy and performance data. Since the source of energy will be different; collection, transformation, and analysis of data will require a connectivity directly from various equipment and energy vendors. The FCBEB Architecture will use Messer H2 station, Fleetwatch for H2-kg per fill and mileage tracking, Vehicle Parameters from New Flyer, Clever Devices AVL for location/speed, ABB Ellipse assets and part refits for reliability and NWS for weather and environmental measurements. The Microsoft Azure cloud software platform integrates with vendor API web services, performing data normalization and aggregation for new reports, data searches, and business intelligence/analytics, all within the AC Transit infrastructure.



ZEB Performance Evaluation 2020

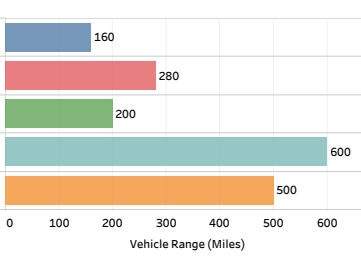
Collection, transformation, and analysis of ZEB energy, cost and performance data is currently operating within the District's on-premise servers. The retrieving feeds are used to populate reports on a set of common metrics such as mileage, road calls, fuel/energy dispensed, availability. The figure below provides an example of the District's ZEB Performance 2020 monthly report.

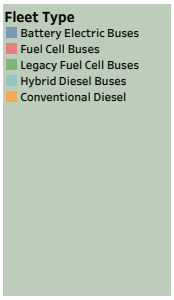
Report Example: ZEB Performance Evaluation 2020

ZEB Performance Evaluation 2020

FLEET PROFILE

Fleet Type	Fleet Series	Length (feet)	Year	Make	Bus Energy Capacity	Energy Efficiency	Qty
Battery Electric Buses	8000	40	2018	New Flyer	480 Kw	2.4 Kwh/ mile	5
Fuel Cell Buses	7000	40	2018	New Flyer	38 Kg	8.5 miles/ Kg	5
Legacy Fuel Cell Buses	FC	40	2010	Van Hool	40 Kg	4.5 miles/ Kg	5
Hybrid Diesel Buses	1550	40	2018	Gillig	120 Gal	5.5 miles/ gal	5
Conventional Diesel	1600	40	2017	Gillig	120 Gal	5 miles/ gal	5





ADVANCED TECHNOLOGY CAPITAL EXPENDITURE

Fleet Type	Infrastructure Cost Assumption	Procurement Cost/ Bus
Battery Electric Buses	$28 Million / 50 Buses	1,134,465
Fuel Cell Buses	$18 Million / 200 Buses	1,289,838

CLEAN CORRIDOR ROUTES

		Route													
	DIVISION	14	20	21	39	45	46	46L	47	51A	54	62	73	90	98	Grand Total
Blocks 150+ mi	4	4	4	3	1	1	1	1	2	4	3	4	4	4	3	39
Blocks <150 mi	4	6	0	2	1	11	0	0	0	17	2	4	2	0	0	45
Total Blocks	4	10	4	5	2	12	1	1	2	21	5	8	6	4	3	84

MONTHLY OPERATING COST AND PERFORMANCE

Fleet Type	Energy Unit	Road Calls	Veh Miles	L&M Cost	Energy Dispensed	Energy Cost/ Unit	Total Fuel Cost	L&M Cost/ Mile	Energy Cost/ Mile	Total Cost/Mile
Battery Electric Buses	Kwh*	0	4,906	$4,554	13,280	$0.19	2,523	$0.93	$0.51	$1.44
Fuel Cell Buses	Kg Hg	1	6,860	$2,012	923	$7.42	6,849	$0.29	$1.00	$1.29
Legacy Fuel Cell Buses	Kg Hg	0	8,308	$6,109	1,875	$7.42	13,913	$0.74	$1.67	$2.41
Hybrid Diesel Buses	Diesel Gal	2	14,498	$10,656	3,038	$2.15	6,532	$0.73	$0.45	$1.19
Conventional Diesel	Diesel Gal	0	22,171	$2,111	5,242	$2.15	11,270	$0.10	$0.51	$0.60
		0 1 2 3	0K 10K 20K 30K	0K 5K 10K 15K	0K 10K 20K	0 5 10	0K 10K 20K	0.0 0.5 1.0	0 1 2	0 1 2 3

Footnote:
*Fuel Cost (BEB) $0.19 assumes average of CPUC rates for PGE

REPORT PERIOD: JANUARY 2020 | **PROJECT CONTROLS & SYSTEMS ANALYSIS**

SECTION D:

Current Fleet & Future Bus Purchases

Current Bus Fleet

AC Transit has over 630 active revenue vehicles that are comprised of 24, 30, 40, 42, 45, and 60-foot buses. These vehicles are distributed throughout the system based on capacity requirements of routes and trips with the busiest service using the 60-foot articulated buses. Individual routes often use a combination of bus types due to route interlining and the varying nature. The following table identifies the quantity of buses in the current fleet based on the service type.

Current Fleet Matrix

Type	Length	Year	Bus Technology	Bus Quantity
Cutaway	24	2014	Gasoline	10
Standard 30'	30	2006	Diesel	51
		2009	Diesel	39
Standard 40'	40	2003	Diesel	36
		2008	Diesel	27
		2010	FCEB (Depot fueling)	13
		2012	Diesel	65
		2014	Diesel	68
		2016	Diesel	55
		2016	Hybrid	25
		2017	Diesel	10
		2018	Diesel	35
		2019	FCEB (Depot fueling)	10
		2019	BEB (Depot fueling)	5
		2019	Hybrid	1
		2020	BEB (Depot fueling)	2
Transbay	40	2013	Diesel	54
	42	2018	Diesel	15
	45	2002	Diesel	36
Articulated	60	2006	Diesel	5
		2009	Diesel	9
		2013	Diesel	23
		2017	Diesel	28
		2019	Hybrid	27

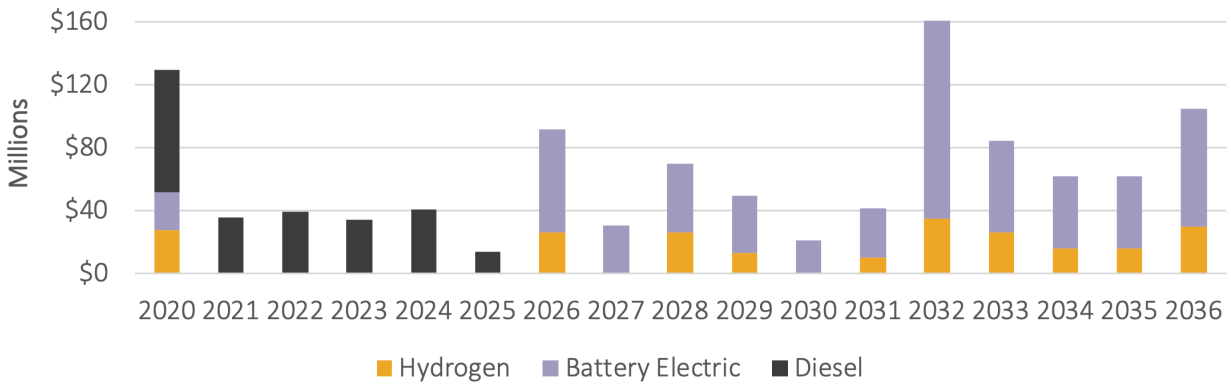
Bus Replacement Schedule

It is important to note AC Transit's priority is to deliver safe, reliable, sustainable transit service that responds to the needs of our customers and communities, as stated in our Mission Statement. Providing transit service that is both convenient and reliable is AC Transit's purpose. Our service and all the supporting functions in the District must be funded adequately to create convenient and reliable service. In order to comply with federal and state regulation while delivering AC Transit Board direction, the following ZEB transition guiding principles have been established.

1. Replace the fleet per Federal Transit Administration (FTA) mandated Transit Asset Management (TAM) Plan Performance Targets
2. Prioritize ZEB deployment per the AC Transit Board adopted Clean Corridors Plan
3. Procure ZEB's based on vehicle and infrastructure technology capabilities to meet service requirements
4. Deploy ZEB technology that is most efficient and sustainable to operate
5. Meet the 2040 ICT Goal

AC Transit's goal is to replace vehicles at the end of their useful life as defined in the Transit Asset Management (TAM) Plan. Based on the District's current fleet replacement schedule and currently planned procurements, the following chart reflects the annual cost to purchase buses to achieve a 100-percent zero-emission bus fleet by 2040. The schedule is dependent upon funding and zero-emissions technology becoming available on more fleet types, to advance deployment on blocks that operate 300 or more daily miles, in order to move completely away from conventional diesel.

Fleet Replacement Cost



AC Transit is currently working on the purchase of 45 ZEBs and supporting infrastructure, funded by various state and federal sources. With the current committed funding, AC Transit will be able to deliver the first phase including purchase of 20 FCEBs and 20 BEBs, small-scale charging infrastructure at Emeryville, Division 2 (D2) similar to the existing charging infrastructure at Oakland, Division 4 (D4), and design of a larger, scalable charging infrastructure at D4. With additional funds, staff will purchase five additional BEBs and construct the charging infrastructure at D4.

The District is able to save considerable time and effort in the procurement process for Zero Emission Buses through the use of State Cooperative Purchasing Agreements. This is essentially a method of

the District "piggybacking" off contracts developed by State Purchasing Agencies without having to engage in the highly complex and time-consuming effort of conducting its own solicitation in advance of a properly vetted contract award. The District has recently utilized such a cooperative purchasing agreement awarded by the State of Virginia to purchase 2 BEBs and plans to purchase at least 38 more under that contract. The State of California has also recently awarded contracts to a range of BEB and FCEB manufacturers that can be used the same way. While the District engages in these types of cooperative purchases, it still conducts due diligence to ensure fair and reasonable pricing and proper contracting procedures have been undertaken during the original contract process.

Fleet Replacement Plan

Year Procured	ZEB Buses				Conventional Buses			Total Buses
	Qty	Type	Technology	Req. Range	Qty	Type	Fuel	
2020	2	Standard 40'	Battery - Depot	170	36	Over-the-road	Diesel	173
	1	Standard 40'	Fuel Cell	300	60	Standard 40'	Diesel	
	20	Standard 40'	Battery - Depot	170	15	Articulated	Diesel	
	20	Standard 40'	Fuel Cell	300	5	Double-decker	Diesel	
					14	Over-the-road	Diesel	
2021					20	Standard 30'	Diesel	59
					39	Standard 40'	Diesel	
2022					47	Standard 40'	Diesel	65
					7	Over-the-road	Diesel	
2023					3	Cutaway	Gasoline	57
					57	Over-the-road	Diesel	
2024					68	Standard 40'	Diesel	91
					23	Articulated	Diesel	
2026	60	Standard 40'	Battery - Depot	200				83
	20	Standard 40'	Fuel Cell	300				
2027	28	Articulated	Battery - Depot	200				28
2028	40	Standard 40'	Battery - Depot	200				60
	5	Standard 40'	Fuel Cell	300				
	15	Double-decker	Fuel Cell	300				
2029	6	Standard 40'	Battery - Depot	200				43
	10	Standard 40'	Fuel Cell	300				
	27	BRT 60'	Battery - Depot	200				
2030	19	Standard 40'	Battery - Depot	200				19
2031	28	Over-the-road	Battery - Depot	200				36
	8	Over-the-road	Fuel Cell	300				

Year Procured	ZEB Buses				Conventional Buses			Total Buses
	Qty	Type	Technology	Req. Range	Qty	Type	Fuel	
2032	114	Standard 40’	Battery - Depot	200				141
	3	Standard 40’	Fuel Cell	300				
	5	Articulated	Fuel Cell	300				
	5	Double-decker	Fuel Cell	300				
	14	Over-the-road	Fuel Cell	300				
2033	3	Cutaway	Battery - Depot	200				73
	20	Standard 30’	Fuel Cell	300				
	39	Standard 40’	Battery - Depot	200				
	11	Articulated	Battery - Depot	200				
2034	42	Standard 30’	Battery - Depot	200				54
	5	Standard 40’	Fuel Cell	300				
	7	Over-the-road	Fuel Cell	300				
2035	42	Over-the-road	Battery - Depot	200				54
	12	Over-the-road	Fuel Cell	300				
2036	68	Standard 40’	Battery - Depot	200				91
	23	Articulated	Fuel Cell	300				

SECTION E:
Facilities and Infrastructure

AC Transit has four operating Divisions supported by a Central Maintenance Facility (CMF) and a General Office (GO). CMF, located in Oakland, provides Administration, Warehouse and Maintenance functions that support all four Divisions.

AC Transit Facilities

Name	Address	Year Built	Size (sq. ft.)
General Office	1600 Franklin St, Oakland, CA 94612	1989	100,000
Central Maintenance Facility	10626 E. 14th St, Oakland, CA 94603	1984	517,000
D2 - Emeryville Division	1177 47th St, Emeryville, CA 94608	1987	392,000
D3 - Richmond Division	2016 MacDonald Ave, Richmond, CA 94801	1989	266,000
D4 - East Oakland Division	1100 Seminary Ave, Oakland, CA 94621	1987	579,500
D6 - Hayward Division	1758 Sabre St, Hayward, CA 94545	1987	833,500
Training and Educational Center	20234 Mack St, Hayward, CA 94545	1987	29,000

To accommodate projected operational needs, address current deficiencies, and continue to provide safe, reliable transit service, the District has developed a Facilities Utilization Plan to identify the District's operations and maintenance facility needs, provide a facility master plan that outlines a road map to meet near- and long-term needs, and provide a strategy for funding and financing that is coordinated with a detailed implementation plan. The Facilities Utilization Plan assumes that the District will operate a certain percentage of battery electric buses (BEBs) and fuel cell electric buses (FCEBs) and is technology neutral that will accommodate any zero-emission bus technology. The plan accommodates footprint required for fueling/charging infrastructure, maintenance capacity for FCEBs and BEBs, and bus parking reconfiguration for allowing BEB charging infrastructure. The Plan includes space to accommodate bus technology infrastructure whether it is BEB (transformers, switchgear, etc.), FCEB (hydrogen storage, compressors, etc).

While the District is working towards addressing facilities needs holistically and preparing to redevelop a Division ready to handle ZEBs, the District must also install ZEB infrastructure incrementally at the existing divisions. The needs articulated in the Facilities Utilization Plan is inclusive of ZEB infrastructure. While AC Transit needs to address the general facility needs to accommodate ZEBs, cost associated with ZEB infrastructure is estimated with $176.2 million (2018 $) if the fleet remains at 630 buses. For both BEBs and FECBs, infrastructure and equipment shall be installed in advance of bus delivery.

With an initial BEB deployments, charging requirements are met relatively easily with a handful of plug-in pedestal chargers and small infrastructure investment. Scaling to a large BEB deployment requires a significantly different approach to charging and substantial infrastructure upgrade and smart charging software. Plug-in charging would not be practical for a large deployment as dispensers installed in the yard creates a hazard. Instead a preferred approach is to use overhead pantograph or dispensers attached to overhead structures, such as gantries and deck, installed across the yard. This would require reconfiguration of bus circulation and parking configurations at Divisions.

Currently Divisions 2 and Division 4 can accommodate fueling and maintenance of FCEBs. With the two divisions, AC Transit estimates maintenance capacity of 50 FCEBs and fueling capacity of 41 FCEBs. In order to expand FCEB infrastructure, such as canopy, fueling and maintenance bays. Canopy projects focus on building a structure that shall house the fueling islands where buses will be fueled with hydrogen. Since a canopy already exists at D2 and D4, these projects are only needed at D3 and D6. Each fueling project includes the design and construction of the hydrogen fueling station, including the installation of tanks, pumps and dispensers. Maintenance bays at each Division as well as CMF will require hydrogen detection and exhaust equipment. For a large scale FCEB deployment, it is best to allow all bays to accommodate FCEBs for maximum flexibility in operations.

ZEB Technology Cost Estimate

ZEB technology estimated costs were developed based on 2019 year-of-expenditure on the ZEB Performance 2020 bus procurements. The infrastructure costs were based on the ZEB technology preliminary engineering estimates and include the maximum vehicle deployment.

Bus and Infrastructure Estimated Capital Cost

ZEB Technology	Bus Procurement/ Unit	Infrastructure
Battery Electric Bus	$1.1M	$28M for 50 BEB Deployment
Fuel Cell Electric Bus	$1.3M	$18M for 200 FCEB Deployment

Construction Implementation

The District has four bus maintenance and operations facilities that require infrastructure modernization. Facility redevelopment project delivery methods are based on the facilities scheduled for the next ten years. Beyond these projects, the project delivery method will be evaluated based on experience with the initial projects and the District's internal expertise. The Facilities Utilization Plan focuses on deploying a large-scale and scalable zero emission infrastructure, like the one planned for Division 4. Table 5 below specifies the location of each facility, and construction timeline. AC Transit is seeking funding for a large and scalable ZEB infrastructure; however, timing for delivering the infrastructure is unknown at this time.

In addition to the existing charging capacity of 6 BEBs and fueling 41 FCEBs, AC Transit is planning to add 20 BEB charging capacity at D2 in 2021. AC Transit plans to place a scalable BEB charging for 20 BEBs with a space for expanding to 50 BEBs at D4. Beyond the planned implementation, AC Transit will delivery infrastructure improvements strategically to meet the proposed vehicle replacement schedule as well as redeveloping Divisions per the Facilities Utilization Plan.

Table 5: Facilities Information and Construction Timeline

Division/ Facility Name	Address	Main Functions	Type of Infrastructure	Service Capacity	Needs Upgrade?	Estimated Construc-tion Timeline
Division 2	1177 47th Street, Emeryville	Operating Division	BEB plug-in chargers	20	Construction	2020-2021
Division 4	1100 Seminary Ave, Oakland	Operating Division	BEB overhead chargers	25 - 50	Construction	2022-2023
Division 4	1100 Seminary Ave, Oakland	Operating Division	BEB overhead chargers	200 - 250	Construction	2023-2028
			Hydrogen storage capacity and FCEB maintenance capacity		Upgrades	
Division 2 or new Division	1177 47th Street, Emeryville	Operating Division	BEB overhead chargers	180	Construction	2025-2030
			Hydrogen storage capacity, Canopy, and FCEB maintenance capacity		Upgrades	
Division 3	2016 MacDonald Ave, Richmond	Operating Division	BEB plug-in chargers	5 - 10	Construction	2023-2025
Division 3 or new Division	2016 MacDonald Ave, Richmond	Operating Division	BEB overhead chargers	100	Construction	2032-2035
			Hydrogen storage capacity, Canopy, and FCEB maintenance capacity			
Division 6	1758 Sabre Street, Hayward	Operating Division	BEB plug-in chargers	10 -20	Construction	2023-2025
			BEB overhead chargers			
			Hydrogen storage capacity, Canopy, and FCEB maintenance capacity	180		2035-2038
CMF	11600 International Blvd, Oakland	Maintenance	BEB chargers FCEB maintenance capacity	–	Construction	2025-2030

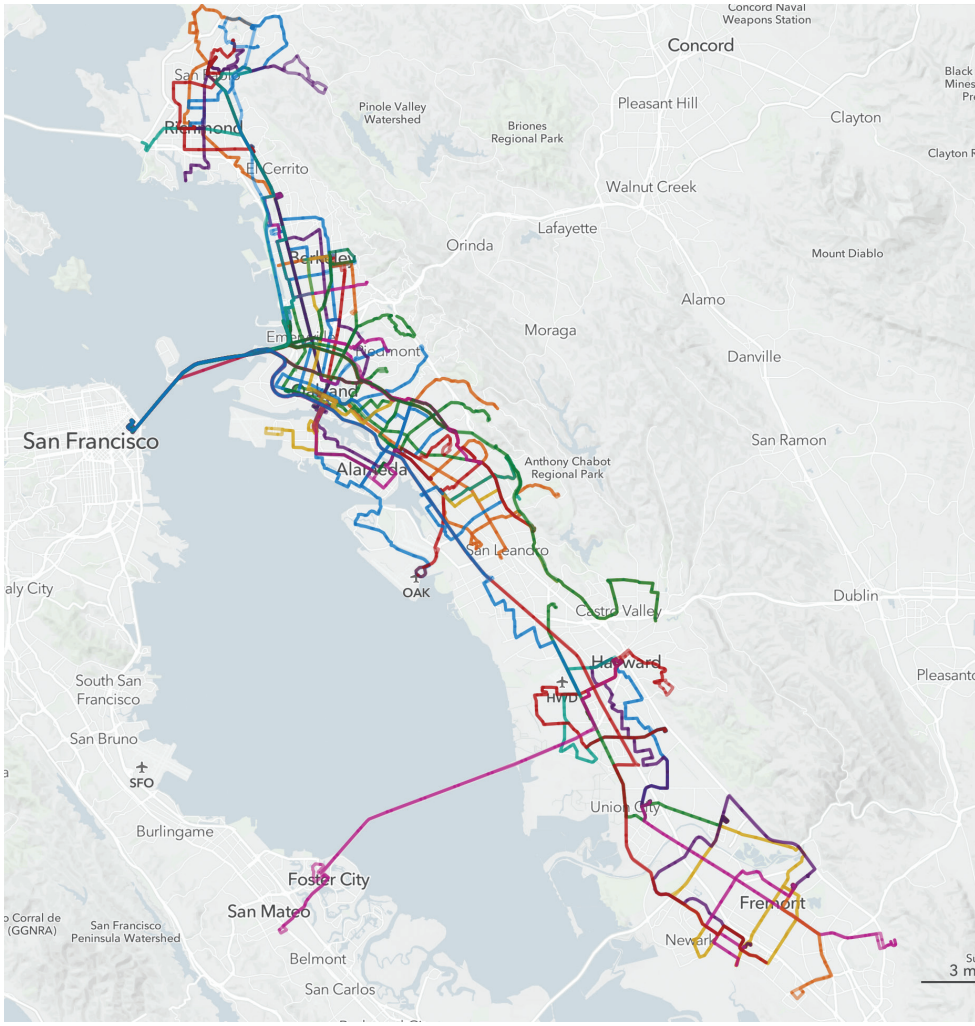
SECTION F:

Disadvantaged Communities

The District's Clean Corridors Plan identifies a series of corridors and communities to be prioritized for zero-emissions buses as the District procures more zero-emission buses. The overall goal of the plan is to have vehicles used on all lines serving these corridors and communities be completely zero-emission (whether battery-electric bus or hydrogen fuel-cell electric bus). The methodology for identifying and prioritizing the corridors and communities in that plan was as follows:

1) Evaluate existing conditions
2) Review areas identified as Disadvantaged Communities in the service area
3) Rank lines based on ridership and productivity to ensure maximum impact of the ZEB deployment
4) Consider constraints such as capacity/capability of divisions to accommodate ZEB growth
5) Scope out the number of vehicles and supporting infrastructure required to convert entire corridors/ communities into Clean Corridors
6) Forecast operating and capital costs associated with conversion to Clean Corridors

Clean Corridor Lines



The clean corridor lines are grouped into their respective service area and community ridership rankings. The number of peak vehicles per line is a key factor to determine the relative impact of converting a line or service area into a purely zero-emission Clean Corridor. The average weekday ridership is divided by the number of peak vehicles required to operate that grouping of lines. Doing so allows the District to prioritize lines where the greatest number of customers can benefit from the new lines with the fewest number of buses being converted to zero-emission.

Clean Corridor Line Group

Area	Lines	Division(s)	Weekday Ridership	Peak Vehicles	Buses/ Hour/ Direction	Riders per Vehicle
Fruitvale	19, 20, 21, 39, 47, 51A, 54, O	D2, D4	19,012	41	27	704
Macarthur-Grand	57, NL, NXs	D2, D4	11,042	34	26	425
West Berkeley	51B, 52, 80, C, F, J, Z	D2, D3	16,615	38	21	791
Richmond	70, 71, 74, 76, L, LA	D3	7,400	31	20	370
West Oakland	14, 29, 36, 62, 88	D2, D4	13,503	35	17	794
Hayward	41, 56, 60, 83, 86, 97, M, S	D6	8,859	38	16	554
Coliseum	45, 46, 46L, 73, 90, 98	D4	7,758	19	14	554
North Oakland	6, 12, 18	D2	13,282	30	13	1,022
Downtown Oakland	33, 96, BS	D2, D4	6,663	18	13	513
Fremont	200, 212, 216, 232, 251, SB	D6	3,440	24	11	313
San Pablo Ave	72, 72M, 72R	D3	12,674	31	9	1,408
International	1	D4	11,469	18	8	1,434
Foothill	40	D4	8,951	13	5	1,790

SECTION G:
Workforce Training

Trained and skilled ZEB mechanics are not readily available on the job market. This will be a big hurdle for the transit industry that will require we re-think how to package ZEB training with bus procurements. Original Equipment Manufacturers (OEMs) will need to provide the training aids and tools required to advance the skills of our workforce as ZEB technology continues to evolve.

Working with technology partners and implementing the lessons learned from more than 20 years of experience, AC Transit staff developed training curriculum to kick off an ambitious ZEB University training program. Moving to a zero-emission fleet requires changes to the District's multiple operating functions. As bus charging infrastructure or hydrogen fueling capacity increases at the bus divisions, additional mechanics will need to learn maintenance techniques on zero emission bus technology. As part of the business culture, the District has a continuous training process to ensure advanced skillsets are taught to maintain zero-emission battery and hydrogen fuel cell buses.

AC Transit training staff work closely with ZEB manufacturers to ensure that required courses are implemented for all mechanics, service employees, and bus operators. This partnership between trainers and bus manufacturers also assists in developing curricula. Trainers are able to continue teaching requisite skillsets for new hires as well as for purposes of refresher training.

The training mock up (pictured right) consists of a Ballard fuel cell, air and water cooling system along with appropriate diagnostic software. The intent is to support mechanics' abilities to perform more complex fuel cell system maintenance. Topics included preventive maintenance inspections, corrective maintenance repairs, and diagnostic and troubleshooting techniques.

Safety & Familiarization

All mechanics begin with basic safety training in high voltage awareness, personal protective equipment, pertinent safety protocols, and preventive maintenance inspections. Additional training includes orientation on air systems, brakes, steering and suspension, door operations, and electrical and computer systems, including appropriate diagnostic software. More advanced or in-depth technical training entails familiarization on four major systems to include high-voltage battery energy storage system (ESS), fuel cell power plant, electric drive systems and high-pressure gaseous fuel system. The chart on the following page lists all current ZEB-related courses.

ZEB University Course Offerings

Course	Hours	Fleet
A123 Battery Training (Vendor)	8 hrs	Gillig Hybrid New Flyer FCEB
Ballard Fuel Cell - ZEB (Vendor)	24 hrs	New Flyer FCEB
Ballard Fuel Cell 10k miles PMI - ZEB (Vendor)	32 hrs	New Flyer FCEB
Fuel Cell Power Plant - ZEB	8 hrs	New Flyer FCEB Van Hool FCEB
High Voltage Electrical Safety - ZEB (Vendor)	8 hrs	FECB/BEB
Hydrogen FC Safety and Familiarization - ZEB	8 hrs	Van Hool FCEB
Hydrogen Fuel Cell Bus Hands-On - ZEB	240 hrs	Van Hool FCEB
Lithium Ion Battery Familiarization - ZEB	8 hrs	ZEBs
New Flyer BEB Orientation - ZEB (Vendor)	3 hrs	New Flyer BEB
New Flyer BEB Srv/Maintenance - ZEB (Vendor)	24 hrs	New Flyer BEB
New Flyer FC Orientation - ZEB (Vendor)	3 hrs	New Flyer FCEB
New Flyer FCEB Maintenance - ZEB (Vendor)	32 hrs	New Flyer FCEB
New Flyer FCEB Safety & PM - ZEB (Vendor)	8 hrs	New Flyer FCEB
New Flyer Safety/Familiarization FCEB/BEB - ZEB	24 hrs	New Flyer Safety
Siemens ELFA - ZEB (Vendor)	8 hrs	VH/New Flyer FCEB and BEBs

5-Week Technical Training Program

Perhaps the most in-depth and notable course staff developed is a five-week, hands-on technical program. This program helps mechanics' understanding and retention of the training as the individual learns by working alongside a zero-emission trainer. Mechanics learn how to practice safety measures, perform preventative maintenance, advanced diagnostics and troubleshooting.

Similar to mechanics, training staff also work closely to train employees who drive zero-emission buses. Drive training is provided to both bus operators and service workers wherever a BEB or FCEB is deployed. Drive training provides each employee with both academic and behind-the-wheel drive time experiences. Topics covered include awareness of high voltage, dash controls and indicator lights, specific start-up and shut-down procedures, and defensive driving safety.

The District believes that implementing the training programs address the safety, reliability and sustainability of zero-emission buses to fully deploy this technology in public transit.

To date, AC Transit has provided mechanics with sixteen different zero-emission training programs totaling over 20,558 hours. Equally significant, staff has trained all drivers at multiple operating divisions deploying BEBs and FCEBs.

ZEB & Infrastructure Project Delivery

Operating ZEBs requires careful planning and decision making well in advance of project initiation. It takes a team of staff from many departments collaborating with precision to purchase ZEBs with timely delivery of the related infrastructure project. Training programs are being developed to provide attendees with the context and knowledge needed to understand the complexity of a ZEB deployment. Examples of topics to be covered include: ZEB procurement process, ZEB related infrastructure project delivery, the importance of pre-planning techniques, assembling a vast team of internal and external stakeholders, building and maintaining successful relationships with technology providers, regulatory compliance agencies, utility companies, fuel suppliers, contractors, first responders and other fleet operators considering electrification.

SECTION H:
Funding

Sufficient funding is critical in ensuring the District can successfully implement the Rollout Plan. Replacing nearly the entire District fleet of diesel, hybrid, and older FCEB buses with new zero-emissions buses will have a significant cost impact over replacement with standard diesel buses. The new infrastructure required for fueling/charging and reconfiguration of existing facilities adds further to the cost.

Due to the uncertain nature of transit funding over a 19-year timeframe, the District will need to constantly monitor funding and financing opportunities. Through the Metropolitan Transportation Commission's existing Transit Capital Priorities (TCP) Program, the District is eligible to receive Federal Transit Administration (FTA) funds for 70-80% of the cost of a bus replacement, with the District responsible for the remaining 20-30% local matching funds. The table below identifies the most common funding source that District could possibly utilize to fund the Rollout Plan.

The District intends to pursue funding opportunities vigorously; however, given the 2020 Pandemic and uncertain future of transit financing and ridership, it is highly likely the implementation timeline, and fleet size will change. The District will keep the Board of Directors, Funding Partners, and Regulatory Agencies apprised of this evolving situation.

Existing Funding Sources

Agency Level	Program Name
Federal	FTA Formula funds (TCP)
	FTA Low and No Emissions Program
	FTA Bus & Bus Facilities Program
State	Cap & Trade - Low Carbon Transit Operations Program (Revenue)
	Cap & Trade - Affordable Housing & Sustainable Communities
	Cap & Trade - Transit & Intercity Rail Capital Program
	SB1 Local Partnership Program (Formula and Competitive)
	SB1 State of Good Repair
Regional	Bridge Toll Capital Funds (TCP)
	Regional Measure 3
	Carl Moyer Program (CARB, BAAQMD)
	Transportation for Clean Air (BAAQMD)

SECTION I:

Start-up and Scale-up Challenges

Through more than 20-years of experience deploying ZEBs, AC Transit has learned there are still many unknowns and unexpected challenges to overcome:

- Deployment of ZEBs and infrastructure adds significant capital and operating costs
- Procurement of ZEBs now require careful timing to deliver ZEB infrastructure capital projects when ZEBs arrive on property
- Not all ZEBs are yet a one-for-one exchange of a diesel bus in terms of range and capability
- ZEB operation is vulnerable to utility company priorities and limited numbers of fuel suppliers
- ZEB technology is evolving at a rapid pace, which complicates O&M with compatibility of components and charging infrastructure.
- IT Infrastructure cost/challenges
- Funding challenges due to the uncertainty of funding availability such as the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP), and the complexities of funding matches by type and percentages.
- Unexpected short-term and long-term impacts due to an emergency such as the COVID-19 pandemic or a natural disaster.

Without a doubt, ZEBs are readily available; however, in order to successfully transition the fleet, AC Transit will need policy makers, industry OEMs and energy providers to help address the existing challenges and risks.

It is important to note, the District's ZEB Rollout Plan is a living document meant to guide the implementation of zero-emission bus fleets and help the District work through many of the potential challenges to explore solutions. The Plan provides estimated timelines based on best available information for bus purchases, infrastructure upgrades, workforce training, or any other timelines in the Plan. AC Transit may update the Plan as needed with the most current information and industry best practices.

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