Project Zero

Zero-Emission Bus Transition Plan

pace zero emission

DECEMBER 2022

Prepared for:

Pace Suburban Bus

Prepared by:

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Agency Contact Information

Transit Agency's Name	Pace Suburban Transit
Mailing Address	550 W. Algonquin Road, Arlington Heights, IL 60005-4412
Transit Agency's Service Area	3,677 square miles, an area nearly the size state of Connecticut and about 15 times the size of the City of Chicago. Includes the six counties of Cook, DuPage, Kane, Lake, McHenry and Will, totaling 274 municipalities, including Chicago.
Population of Urbanized Area (2010)	8,608,208
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Acronyms

ATI	Advance Technical Institute
BEB	Battery Electric Bus
CaaS	Charging as a Service
CIFIA	Carbon Dioxide Transportation Infrastructure and Innovation
CIP	Capital Improvement Plan
CNG	Compressed Natural Gas
ComEd	Commonwealth Edison
DERA	Diesel Emissions Reduction Act
DFH	Diesel Fueled Heater
DRPT	Department of Rail and Public Transportation
EPA	Environmental Protection Agency
EV	Electric Vehicle
FCEB	Fuel Cell Electric Bus
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
FY	Fiscal Year
ICE	Internal Combustion Engine
IIJA	Infrastructure Investment and Jobs Act
MERIT	Making Efficient and Responsible Investments in Transit
NTD	National Transit Database
OEM	Original Equipment Manufacturer
PEER	Performance and Evaluation of Electric Bus Routes
QA/QC	Quality Assurance/Quality Control
RFP	Request for Proposal
SCIP	Smart Charging Infrastructure Pilot
SOC	State of Charge
TSP	Transit Strategic Plan
ULB	Useful Life Benchmark
ZEB	Zero-Emission Bus
ZEV	Zero-Emission Vehicle

Executive Summary

Pace Suburban Bus (Pace) offers a family of public transportation services across the six-county region of Northeast Illinois. Pace's fully accessible fleet carries millions of people annually, providing access to opportunity across 274 communities and reducing congestion throughout the region.

According to the American Public Transportation Association (APTA), the "leverage effect" of public transportation reduces the nation's carbon emissions by 37 million metric tons annually. Public transportation saves the equivalent of 900,000 automobile fill-ups every day. The typical public transit rider consumes on average one half of the oil consumed by an automobile rider.

The lesson is simple: when commuters ride public transit instead of driving their own cars, air quality improves.

By its nature, Pace services benefit the environment. However, Pace recognizes our additional responsibility for pollution reduction as an operator of hundreds of vehicles in our region. Therefore, one of Pace's top priorities is to reduce our carbon footprint and improve the quality of our community's environment ensuring our services and facilities are safe, equitable, reliable, efficient, and sustainable.

In 2021, Pace adopted a new strategic vision plan titled *Driving Innovation*. The first initiative of the plan is an Electric Bus & Zero-Emission Fleet Transition, committing Pace to a 100 percent zero-emission fleet by the year 2040. Pace has also committed to the FTA Sustainable Transit for a Healthy Planet Challenge which includes submitting a Climate Action Plan. This requirement can be satisfied with the development of a zero-emission transition plan that includes strategies with measurable goals to achieve greenhouse gas (GHG) emission targets. To achieve this challenge, the Pace Zero-Emissions Bus Transition Plan includes GHG emissions targets for each future year of BEB implementation on its fixed route fleet.

Pace's transition to lower emissions vehicles began in 2012, with Pace's first hybrid electric fleet deployed along bus routes serving Highland Park. In 2016, Pace converted its South Division garage in Markham to a compressed natural gas (CNG) facility. In November 2022, Pace took delivery of its first battery electric bus (BEB) and in 2023, Pace will take delivery of an additional 20 BEBs. The deployment of BEBs will continue in phases, supporting Pace's goals of prioritizing dependable transit services and environmental sustainability. However, securing funding to make improvements to Pace operating divisions to support zero-emission bus (ZEB) fleets is a vital first step towards a successful fleet transition. For Pace to meet the ZEB fleet transition goals, it is imperative that Pace continue to secure funding not only for ZEB vehicles, but for the garage facilities to support them.

Demand for funding and ZEBs is increasing throughout the country as the number of transit agencies choosing to transition to ZEB fleets has significantly grown in recent years. Additionally, new legislation has identified ZEBs as being required to ensure an environmentally friendly future. ZEBs offer agencies an alternative to conventional internal combustion engine (ICE) buses and provide a wide range of advantages including environmental and economic benefits. However, while the industry is moving in this direction, a broad transition to ZEBs is dependent upon bus manufacturers that satisfy the federal “Buy America” requirements, increasing their production capacity to meet demand.

In addition to the limitations presented by the bus manufacturers’ production capacity, costly modifications are needed at operation and maintenance facilities to support ZEB fleets. These facility modifications require comprehensive planning activities that impact facility designs, timing of vehicle purchases, the electrical grid, as well as operations and maintenance standard operating procedures.

To fund ZEB transitions, as outlined in the Bipartisan Infrastructure Law, the Federal Transit Administration (FTA) now requires agencies applying for Grants for Buses and Bus Facilities Competitive Program and the Low or No Emission Program to include a Zero-Emissions Transition Plan. Per FTA guidelines, these plans must include the following, which are addressed in this document:

- Demonstrate a long-term fleet management plan with a strategy for how the applicant intends to use the current request for resources and future acquisitions.
- Address the availability of current and future resources to meet costs for the transition and implementation.
- Consider policy and legislation impacting relevant technologies.
- Include an evaluation of existing and future facilities and their relationship to the technology transition.
- Describe the partnership of the applicant with the utility or alternative fuel provider.
- Examine the impact of the transition on the applicant's current workforce by identifying skill gaps, training needs, and retraining needs of the existing workers of the applicant to operate and maintain zero-emission vehicles and related infrastructure and avoid displacement of the existing workforce.

To satisfy these requirements, the Pace Zero-Emissions Transition Plan provides the following analyses of Pace-operated fixed route services:

- Current fixed route structure, service hours, costs, and ridership statistics
- Performance and Evaluation of Electric Bus Routes (PEER) analysis modeling simulation and results
- Current fleet size, technology, and infrastructure requirements
- Zero-emissions fleet maintenance needs and start-up and scale-up challenges

These considerations aided in the development of the Long-Term Fleet Management Transition Plan, that provides an actionable procurement strategy to convert Pace’s entire fixed-route fleet to 100 percent BEB by 2040. However, the timing of ZEB fleet purchases will be dictated by modifications to support facilities for ZEBs, and the availability of resources to make these upgrades.

Thus, an integral component of Pace’s ZEB transition planning effort is developing conceptual engineering plans and cost estimates for garage facilities to support ZEB fleets. Through this work Pace is identifying gaps in capital improvement budgets to strategically pursue infrastructure upgrades and funding opportunities that support the timing of ZEB vehicle purchases. Pace remains very committed to transitioning to a 100 percent zero emissions fleet by 2040, but the success of this effort is dependent upon Pace's ability to obtain sufficient facility upgrade funding to meet this goal.

Pace is also actively engaged in a partnership with the region's electric utility provider, Commonwealth Edison (ComEd) to ensure facilities are supplied with the necessary electricity from the power grid to support a ZEB fleet. This relationship is critical to establishing a charge management strategy for Pace and to ensure that the timing of ComEd upgrades to the electrical infrastructure reflects Pace's fleet and facility transition schedule. Further, Pace is working with our partners in the region and state to pursue a public utility rate for transportation providers.

Without significant, sustainable funding for infrastructure upgrades needed to operate a ZEB fleet, Pace's 2040 goal will not be realized. As part of this plan, a comprehensive database of current funding sources has been created. Additional funding sources will be incorporated into the Pace Zero-Emissions Transition Plan when they become available. An overview of policy and legislation impacting ZEB technology was also conducted to ensure Pace's transition and implementation follow current regulations.

Finally, this plan outlines Pace's commitment to retaining and training all current staff members to familiarize them with ZEB service, maintenance, and operations.

Key findings from the above analysis include:

- Converting Pace's current operating fleet of approximately 616 buses to ZEBs could eliminate more than 900,000 tons of CO_2 from the atmosphere
- Pace can achieve goal of a 1:1 replacement of internal combustion engines to ZEBs by 2040, if battery technology improves during that time
- Cost estimates for 616 ZEB acquisitions across all Pace facilities is estimated to be $1,047,163,192
- Annual bus purchases are dependent on timing of garage modifications to support BEB operations
- Substantial capital funding assistance from state, federal and regional entities is a prerequisite for modifications to Pace facilities to accommodate ZEB fleets

Transitioning to ZEBs is an iterative process, which will help to minimize risk and to accommodate new developments in a rapidly evolving market. Maintaining a vehicle replacement and facility upgrade schedule that is supportive of a 2040 fleet transition, also enables Pace to retire ICE buses at the end of their useful lives. This reduces the possibility of keeping older, higher-emissions vehicles on the street for longer, further decreasing Pace's carbon footprint. Pace will use the information outlined in this document to refine and determine the following:

- Address incomplete service blocks
- Refine infrastructure and other costs associated with the transition
- Explore collaboration opportunities
- Further engage utilities

Dependent upon facility readiness, the matrix below represents the annual fleet replacement plan based on Pace's current fleet numbers. This plan reflects Pace's goal of achieving a 100 percent zero emission Pace fixed route bus fleet by 2040. Updates to this plan will be made annually as changes in the fleet size based on service modifications are made.

Figure 1-1 Fleet Transition Timeline

ZEB Purchase Plan is generally based on 12-year ULB Replacement Timing of Existing non-ZEBs

Vehicle Config.	Orig. Non-ZEB >>	>> ZEB	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
																	100% ZEB by 2040 Final Goal				
West	40' Transit	40' Transit								24			85								
Southwest	30' Transit	35' Transit			18												RB 18				
	40' Transit	40' Transit				1			29									RB 1			RB 29
South	40' Transit CNG	40' Transit						20		55	11									RB 20	
River / East Dundee	30' Transit	35' Transit				14	14	10	Site Electrification WIP												
	40' Comm.	40' Comm.						4	13									RB 34			
Northwest	30' Transit	35' Transit				3	18	9	12		4	9				RB 8	RB 4	RB 4	RB 18	RB 9	RB 12
	40' Transit CNG	40' Transit						Site Electrification WIP					6						27	20	
North Shore	40' Transit	40' Transit						8	1	18	3					3				RB 8	RB 2
North	40' Transit	40' Transit		12	13	13	14									RB 12	RB 13	RB 13	RB 14		
					Site Electrification WIP																
Heritage / Plainfield	40' Coach	45' Coach				13		9		8				7				RB 13		RB 9	
	30' Transit	35' Transit													17	4					
Fox Valley	30' Transit	35' Transit			4									23		12	RB 4				
Annual Agency ZEB purchases (for fleet conversion, not for replacement)			0	12	35	44	46	60	55	105	18	9	91	30	17	19	0	0	27	20	0

"RB" = Replacement Buy

1 Transit Agency Overview

History

Pace was created by the 1983 RTA Act to unify the numerous disparate suburban bus agencies that existed at that time. In doing so, suburban bus fares, branding and management were integrated throughout the region. On July 1, 1984, the consolidated agency began operations as the Suburban Bus Division of the Regional Transportation Authority. A year after that, the brand name 'Pace' was established.

Pace is governed by a 13-member Board of Directors comprised of current and former suburban mayors and the Commissioner of the Mayor's Office for People with Disabilities for the City of Chicago.

For its first few years, Pace focused on the unification efforts updating and building new garages and replacement of an aging fleet. Rapid population and employment growth in the suburbs led to multiple strategic planning and long-range planning efforts that took place starting in the late 1980s and continuing through the present day. One such effort was the 2002 *Vision 2020* plan which sparked investment in many important initiatives such as the Pulse, Express Bus and Bus-on-Shoulder programs, On Demand service, Ventra farecard integration, and the Transit Signal Priority.

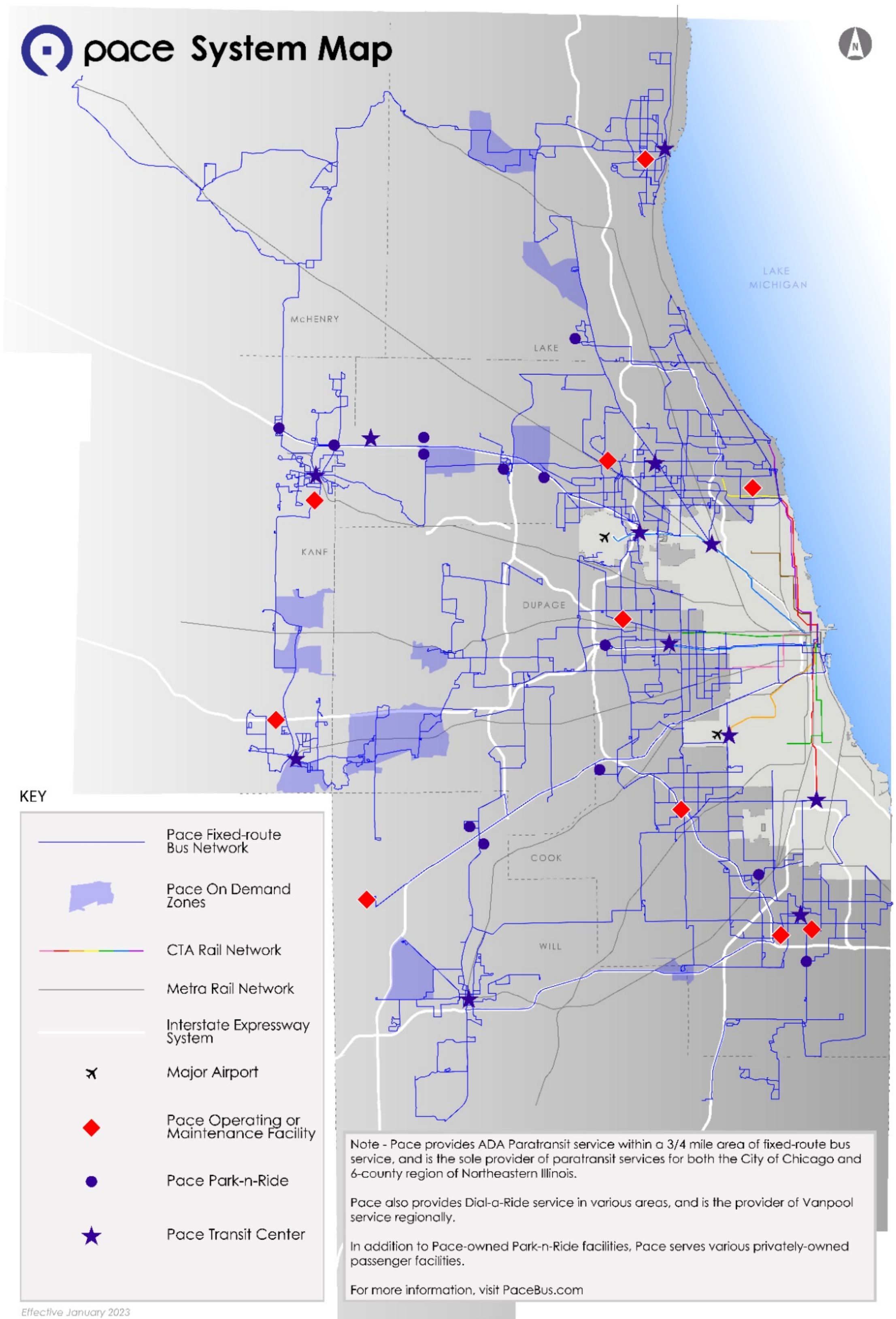
Accessibility has always been a hallmark of Pace service. Pace provided "Section 504" service to people with disabilities several years before this type of service was required by the Americans with Disabilities Act. Pace was also the first bus agency in the State of Illinois to have a fully accessible fleet. In 2006, Pace established itself as a leader in providing efficient, quality service to people with disabilities, and the Illinois legislature designated that Pace would assume responsibility for ADA paratransit in Chicago from the CTA. The move made Pace the one of the largest providers of paratransit service in the United States.

Pace established one of the largest vanpool programs in the nation and is the regional ridesharing administrator for Northeastern Illinois, bringing coordination of carpools into the program. PaceRideShare.com is the outlet for these services, offering commuters the ability to create a profile and gather information on others with similar travel patterns to form carpools or vanpools.

Since the development of *Vision 2020*, climate change, air quality, noise pollution considerations, and legislative guidelines have become more pressing. Meanwhile, available electric bus market products have become more diverse, yet domestic manufacturing capacity to support an industry-wide shift to zero emission vehicles remains limited. However, bus manufacturers are steadily increasing their product offering and assembly capacities. This will require monitoring to match the Pace fleet transition planning. Due in large part to this momentum, Pace identified the transition to a zero-emissions fleet as its top priority in its current strategic vision plan, *Driving Innovation*. To meet this challenge, Pace is taking the first steps to transition to a battery-electric bus (BEB) fleet with the arrival of the first BEB in 2022, an order of an additional 20 BEBs to be delivered in 2023, and with the development of the Pace Zero-Emissions Transition Plan to guide future investments.

Figure 1-2: Pace Transit Service Map

Source: Pace Service Area Maps, 2022



Strategic Vision Statement

Pace adopted the agency's current strategic vision plan, *Driving Innovation*, in September 2021. The document's vision statement includes the following:

"Driving Innovation *calls for innovating fixed-route transit in the highest demand markets, while concurrently harnessing technology and new mobility solutions to provide cheaper yet more effective coverage services in lower-demand areas. Furthermore, the plan advocates for and incentivizes communities to upgrade land-uses, pedestrian environments and development patterns that make public transit a more viable option. Critically, Pace is committed to becoming an agency that operates a 100 percent zero-emission fleet."*

Strategic Vision Plan Goals

Driving Innovation includes two categories of goals, one set focused on the organization itself, the other focused on the delivery of service. Among the 11 goals constituting these two categories, the following seven are directly addressed by the Pace Zero-Emission Bus Transition Plan. Each includes a goal definition, as well as description of how the goal is being addressed:

Responsiveness

- Definition: *"Provide superior experiences for all customers."*

Achievement of goal: Electric buses have fewer maintenance needs and associated costs compared to vehicles with internal combustion engines.

Safety

- Definition: *"Operate and maintain a system that prioritizes safety."*
- Achievement of goal: By upgrading its facilities and fleet to ZEB, Pace will continue ensuring a state of good repair and the highest safety standards.

Adaptability

- Definition: *"Embrace innovation to advance Pace's goals."*
- Achievement of goal: BEBs will allow Pace to replace obsolete/underused assets, in-service fleet, and operations vehicles, and bring the agency in line with rapidly emerging new industry and government standards and expectations.

Collaboration

- Definition: *"Seek creative and mutually beneficial relationships."*
- Achievement of goal: By developing pilot projects that maximize grant opportunities and funding initiatives and enable new partnerships with the public and private sectors.

Environmental Stewardship

- Definition: *"Plan and operate in a way that protects the environment."*
- Achievement of goal: Pace's pledge to become 100 percent zero emission agency by 2040 through implementing ZEB fleets is the most significant way in which it can address climate change and protect the environment.

Fiscal Solvency

- Definition: *"Deploy financial resources in a fiscally responsible way."*
- Achievement of goal: By expending resources that prioritize capital improvements that support operations.

Integrity

- Definition: *"Promote transparency in decision-making and foster a culture and practice of good governance."*
- Achievement of goal: By responsibly modernizing systems and the entire Pace organization in a transparent manner for the benefit of passengers and the air quality of the region.

Agency Core Values

In addition to the goals set forth in the *Driving Innovation* plan, Pace maintains several core values. These values not only embody and build upon the strategic plan goals and mission, but also influence the agency's desired culture and guide day-to-day business activities.

These core values include:

- Safety: Pace strives for safety excellence in all areas of our business.
- Efficiency: Pace is committed to professional, courteous, and dependable service which maximizes the value expended in delivering this vital community resource.
- Equity: Pace has established a range of different solutions to provide equal access to service for persons of all incomes and reduce financial barriers.
- Environmental Responsibility: Pace is dedicated to plan and operate in a way that protects the environment.

The transition to BEBs supports Pace core values and strategic plan goals because BEBs offer safe, smooth, and quiet rides, improving the passenger experience. BEBs reduce noise pollution compared to diesel buses, improving quality of life for residents living along bus routes, even if they do not ride the bus. BEBs do not emit greenhouse gases or particulate matter that their internal combustion engine (ICE) counterparts emit. While this improves the region's air quality for all, it can have outsized benefits for communities that primarily rely on transit. Pace is prioritizing BEBS in disadvantaged neighborhoods facing environmental justice issues. For example, the improvement in air quality can lower rates of asthma and other respiratory-related health conditions.

There are also economic benefits, as changes in bus technology provide training opportunities for vehicle manufacturers and transit agencies. Maintenance costs for transit agencies are typically lower for BEBs than ICE buses, as there are fewer parts which require maintenance on BEBs. Operational costs may be lower for BEBs than ICE buses if an energy management system is in place.

Additionally, Pace has four Action Items in Fiscal Year (FY) 2021 – FY 2022, three of which focus specifically on implementing Pace's Zero Emissions Commitment. These action items are also enshrined in the A-1 Electric Bus & Zero-Emission Fleet Transition initiative of the *Driving Innovation* plan:

- Implement 100 Percent Zero-Emission Fleet by 2040
- Implement Battery Electric Bus (BEB) Technology
- Transition Away from Diesel & Compressed Natural Gas (CNG)
- Investigate Emerging Alternative Fleets

The correlation between ZEB fleet transitioning and Pace goals is as follows:

- The BEB pilot program and transition plan are opportunities to apply the communications plan with stakeholders as the plan develops into procurement, capital upgrades, and reports on operational improvements resulting from BEB implementation.
- New vehicles and improved passenger experience on BEBs, which offer quieter and smoother rides than combustion engine buses, can improve ridership and attractiveness of service.
- Use of BEBs and potential related infrastructure such as in-route charging could be useful at high-ridership locations if required, but would be avoided as much as possible due to the additional expense and space allocation that may diminish customer accommodations.
- Qualified workforce recruitment would include BEB training.
- Transition to BEBs offers new technology possibilities, as procurement of new vehicles allows Pace to update specification requirements, so vehicles are compatible with plans to enhance customer amenities
- Operations and maintenance costs of BEBs are lower than those of ICE buses, and electricity prices are generally less volatile than oil and gas prices. As a result, Pace operational costs can be made more predictable, and lowered with BEBs.

Zero-Emission Vehicle Technology Benefits

Transitioning to zero-emission technology provides several benefits to the region as highlighted in Table 1-1.

Table 1-1: Zero Emission Vehicle Benefits

Categories		Benefits
	Economic Competitiveness	• Reduce operational costs through savings from lower fuel and maintenance costs • Advance potential workforce development • Reduced electrical energy costs resulting from off-peak charging and servicing operations in conjunction with the use of charge management
	Environmental	• Avoid carbon emissions and pounds of nitrogen oxide emissions
	Health	• Reduce noise levels • Decrease potential asthma and other air quality-related health issue exposure • Reduce dependency on fossil-based sources
	Equity	• Offer equity integration strategies
	Safety and Security	• Offer sustainable micro grid concept • Less dependence on outside energy sources
	Other	• Optimize energy consumption through regenerative braking • Improve vehicle acceleration • Enhance customer experience

2 Clean Transit Regulations

FTA Mandate

Background

On December 1, 2021, the FTA announced the Zero-Emission Plan requirement as part of the implementation of the Grants for Buses and Bus Facilities Competitive Program and the Low or No Emission Program. Under this mandate, any applications for projects related to zero-emission vehicles must include a Zero-Emission Transition Plan.

Zero-Emission Transition Plan Requirements

A Zero-Emission Transition Plan must, at a minimum:

- Demonstrate a long-term fleet management plan with a strategy for how the applicant intends to use the current request for resources and future acquisitions.
- Address the availability of current and future resources to meet costs for the transition and implementation.
- Consider policy and legislation impacting relevant technologies.
- Include an evaluation of existing and future facilities and their relationship to the technology transition.
- Describe the partnership of the applicant with the utility or alternative fuel provider.
- Examine the impact of the transition on the applicant's current workforce by identifying skill gaps, training needs, and retraining needs of the existing workers of the applicant to operate and maintain zero-emission vehicles and related infrastructure and avoid displacement of the existing workforce.

State Legislation

Within Illinois

On November 16, 2021, Governor J.B. Pritzker and the Illinois General Assembly passed the Illinois House Bill 1769, also known as the *Reimagining Electric Vehicles in Illinois Act*, into law. The new law provides various incentives for electric vehicle production across Illinois to help reach a 2030 goal of putting one million electric cars on the road. Additionally, the legislation incentivizes EV-related manufacturing facilities located in communities that have historically faced disinvestment.

The Reimagining Electric Vehicles in Illinois Act comes shortly after the General Assembly's passage of Senate Bill 2048, also known as the *Climate and Equitable Jobs Act*, which was signed into law on September 15, 2021 and requires Illinois to achieve a 100% zero-emissions power sector by 2045. Among requirements and funding directed primarily at the State's power generation, the Climate and Equitable Jobs Act ensures the availability of rebates for public and private organizations and companies installing and maintaining electric vehicle charging infrastructure.

Other States

Illinois joined Indiana, Michigan, Minnesota, and Wisconsin (Signatory States) in signing the Regional Electric Vehicle Midwest Coalition Memorandum of Understanding (MOU) to accelerate vehicle electrification in the Midwest. Signatory States are committed to:

- Accelerate medium- and heavy-duty fleet electrification
- Collaborate on regional electric vehicle supply equipment (EVSE) siting and deployment analyses with a focus on commercial routes
- Standardize regulations, messaging, and customer experience related to electric vehicles (EVs) across state lines
- Evaluate opportunities for workforce development
- Identify historically disadvantaged communities for equitable EVSE development and EV adoption; and,
- Educate consumers and fleet owners to raise EV awareness, reduce range anxiety, and increase EV adoption.

Bipartisan Infrastructure Bill

President Biden's infrastructure bill features incentives as large as $12,500 for buying electric vehicles (EVs). The bill also features an Executive Order that sets a new target of zero-emission vehicles (ZEVs) representing half of all new vehicles sold by 2030. The Executive Order also introduces long-term fuel efficiency and emissions standards. The bill sets a schedule for these standards through at least model year 2030 for light-duty vehicles and for medium- and heavy-duty vehicles starting as early as model year 2027.

3 Bus Electrification Pilot Program

Overview

Pace began a transition to low and zero emissions in 2012 with a small fleet of hybrid/electric vehicles in Highland Park. Pace continued this effort in 2016 converting the South Division fleet to CNG. In 2022, Pace took delivery of its first BEB and ordered twenty Proterra BEBs. This fleet will be distributed among various operating divisions in 2023. The Pilot Bus Electrification Program is funded through a combination of federal and state grant sources, for a combined total of $34 million of investment in:

- Twenty-one, 40-foot all electric buses, plus parts
- Charging equipment
- Retrofit infrastructure of the North Division facility and selected other facilities to accommodate operations and maintenance of pilot fleet
- Workforce training to operate and maintain the new equipment

The goals of the pilot program are to:

- Evaluate battery performance throughout Pace's operating area
- Analyze how best to deploy the buses in other Pace revenue service
- Assess the need for in-route charging (the goal being division-based charging only)
- Evaluate the overall reliability and maintenance requirements of the buses
- Assess operations service blocks completion
- Refine fleet replacement strategy
- Provide guidance on battery charging hardware infrastructure needs; facilities electrical utility power supply upgrades; existing bus garages modification to accommodate electrification and maintain operational service; and future-

proofing garage designs to facilitate long-term electrification adaptation/expansion

Once revenue service begins, Pace Operations will evaluate battery performance on various routes to gauge performance under varying conditions, with a specific interest in:

- Stopping and starting
- Power demands related to heating and air conditioning
- Doors opening and closing
- Accelerating and stopping
- Carrying large passenger loads

As part of the pilot program, Pace will be tracking key indicators of BEB performance to understand BEB operations while refining assumptions for future procurement and transition implementation.

River Division Operating Facility

Pace is renovating this facility to expand capacity and to support zero emission electrification efforts. The initial renovation scope incorporated updates to the infrastructure to support an expanded diesel bus fleet. To support Pace's commitment to transition to ZEBs, the planned improvements were modified. The planned modifications to this facility now:

- Support zero-emissions goals of a 100% BEB fleet by 2040 by future proofing for electric vehicle charging and maintenance
- Support low-emissions goals with an initial mixed fleet of BEBs and diesel buses
- Reduce energy consumption and harmful carbon emissions
- Upgrade portion of the existing structure and expand bus storage area

Northwest (Wheeling) Division Operating Facility (To replace Pace Northwest Division in Des Plaines, IL)

Pace is designing a new facility to support electrification efforts and to provide more efficient and frequent service. The new facility will be in Wheeling, IL. The new facility that is scheduled to be built will ultimately:

- Support zero-emissions goals of a 100% BEB fleet by 2040
- Support low-emissions goals with a mixed fleet of BEBs and CNG buses accounting for nearly 40% of its fleet when division opens for operations
- Accommodate expanded bus fleet in support of Pace's Pulse service to Dempster
- Reduce energy consumption and harmful carbon emissions
- Reduce deadhead miles (62,000 per year)
- Allow Pace to serve approximately 487,000 more citizens (i.e., a 169 percent increase) and over 312,000 more jobs (i.e., a 127 percent increase)

4 Description of Services

Service Standards

As stated in the Pace Suburban Bus Division – Initial Transit Asset Management Plan, 2020 Update, Pace abides by service guidelines set to ensure that service features comply with FTA circular 4702.1B (regarding requirements related to Title VI of the Civil Rights Act of 1964). The guidelines indicate that:

- Vehicle Load for most fixed bus routes should not exceed an average maximum vehicle load of 125% during peak hours and 100% during off-peak hours. For express operations, the average maximum vehicle load should not exceed 100% for both peak and off-peak hours.
- Maximum service headway on Pace's fixed routes is to operate 60 minutes or better at all times of the day (unless the route has a minimum trip-based headway standard then minimum number of trips applies).
- Pace's on-time performance goal for all fixed route service is 75%, where a bus is on-time if it is no more than one minute early and no more than five minutes late to a set timepoint.
- For fixed route buses, bus stop locations are dependent on safety considerations, ease of operation, pedestrian transfer situations, space availability, traffic operations, and location of activity generators.

These standards guide Pace's service planning and scheduling, but Pace is permitted to deviate from these standards where conditions merit. Some routes with especially strong demand may justify service beyond these standards, while others may have special circumstances that justify the opposite.

Service levels are aligned to a set of core goals, set out in the annual budget, and used by Pace to drive improvement. Schedules and routes are continuously reviewed to ensure that proper level and frequency of service is provided to each community that Pace is providing vital transportation service for.

Pace's Services[1]

Fixed Route

Pace operates 131 regular, 5 feeder, and numerous seasonal fixed routes. These routes serve 192 communities and carry over 1.06 million rides per month utilizing 480 vehicles during peak periods. All routes are fully wheelchair accessible.

Regional ADA Paratransit – Suburban and City of Chicago

The Regional ADA Paratransit Program consists of Suburban and City of Chicago services. Service delivery under both programs is largely contracted to private service operators. In addition to the city and suburban cost elements, there are regional support costs which represent the indirect overhead costs of supporting the Regional ADA Paratransit Program. Pace is also responsible for the provision of subsidized taxi

[1] Service statistics from 2022 Pace Budget Book

service to ADA eligible riders in the City of Chicago through the Taxi Access Program (TAP). This program provides subsidized taxi service to ADA eligible riders.

Suburban origin to destination service is provided by 442 lift-equipped vehicles, serving approximately 40,800 riders each month, down due to COVID-19. Prior to the pandemic, Pace provided service to 72,429 riders each month for the suburban service. For the City of Chicago, 840 vehicles, as well as taxi providers, are used to provide service to approximately 135,000 riders each month in 2022, down due to COVID-19. Prior to the pandemic, Pace provided service to 261,308 riders each month in Chicago.

Demand Response

Pace's 370 lift-equipped vehicles are also utilized to provide curb-to-curb service to approximately 48,800 riders each month, down due to COVID-19. Prior to the pandemic, Pace provided service to 80,600 riders each month. Most riders are elderly and/or people with disabilities. Pace contracts directly with private service providers for the operation of 35 demand response, Dial-a-Rides, 11 On Demand Routes, and has agreements with villages and townships for the operation of 13 other demand response services. Pace River Division operates paratransit and two On Demand routes. Pace offers these services to approximately 274 communities throughout the six-county area.

Agency Profile and Operating Costs

Service Profile

The following table provides details from the 2020 FTA National Transit Database (NTD) on the services provided by Pace:

Table 4-1: 2020 Annual Agency Profile Data

Service Metric	Fixed Route	ADA Paratransit
Annual Passenger Miles (PMT)	101,045,330	17,063,093
Annual Unlinked Trips (UPT)	14,565,492	2,150,973
Average Weekday Unlinked Trips	48,561	6,462
Average Saturday Unlinked Trips	25,160	3,487
Average Sunday Unlinked Trips	13,501	2,579
Annual Vehicle Revenue Miles (VRM)	27,737,228	21,723,273
Annual Vehicle Revenue Hours (VRH)	1,867,901	1,477,797
Vehicles Operated in Maximum Service (VOMS)	1,467	1,217
Vehicles Available for Maximum Service (VAMS)	1,803	1,524

Source: National Transit Database

Operating Costs

According to Pace's NTD 2020 Annual Profile, total operating expenses were approximately $207.7 million, consisting of $151.8 million in labor, $17 million in materials and supplies, $22.6 million in purchased transportation and $16.2 million in other operating expenses.

5 Performance Evaluation of Electrified Bus Routes

Overview

As part of the long-term fleet management plan, a Performance and Evaluation of Electric Bus Routes (PEER) analysis and modeling simulation was conducted. The PEER simulation evaluates how BEBs are expected to perform using Pace's existing block schedule and provides the agency with information about various alternative operating scenarios. The PEER model determines the total energy demand of a 100 percent BEB fleet, individual block completion rates, and the power requirements needed at each of Pace's operating facilities. The model provides critical information needed for the agency's planning, staging, and phasing of a ZEB fleet.

Purpose

The purpose of the PEER analysis is to provide an evaluation of a BEB's expected performance on every trip on each of Pace's routes to develop a real-world operating range that accounts for:

- Bus stop dwell time
- Ambient temperature
- Passenger counts
- Route grades and elevation
- Bus type and properties

Key Findings

The key findings from the PEER analysis with a diesel fired heater are:

- Using an industry-typical 40-foot BEB with a current battery capacity of 518 kWh under winter conditions with a Diesel Fueled Heater, 82 percent of the 911 currently operated weekday blocks can be completed before the battery capacity of the bus is depleted.
- After approximately six years of use (a seasoned battery), 73 percent of the blocks could be completed.
- Bus range with a new battery is modeled to between 94.16 and 226.06 miles depending on loading and the route.
- Bus range after six years is modeled to be between 75.33 and 180.85 miles.
- Block energy consumption rates range from 1.83 kWh to 4.40 kWh per mile.
- Assuming an improvement in battery technology resulting in a 54 percent increase in battery capacity, the block completion rate of each division is estimated to be as follows:
    - River Division: 88 percent of the blocks can be completed with a new battery.

    - North Shore Division: 100 percent of the blocks can be completed with a new battery
    - Southwest Division: 97 percent of the blocks can be completed with a new battery
    - North Division: 100 percent of the blocks can be completed with a new battery
    - South Division: 98 percent of the blocks can be completed with a new battery
    - West Division: 98 percent of the blocks can be completed with a new battery
    - Fox Valley Division: 100 percent of the blocks can be completed with a new battery
    - Heritage (Plainfield) Division: 97 percent of the blocks can be completed with a new battery
    - Northwest (Wheeling) Division: 97 percent of the blocks can be completed with a new battery
- After approximately six years of using the same new and improved battery technology, the battery degrades by 20% and produces the following results:
    - River Division: 77 percent of the blocks can still be completed.
    - North Shore Division: 97 percent of the blocks can still be completed
    - Southwest Division: 92 percent of the blocks can still be completed
    - North Division: 100 percent of the blocks can still be completed
    - South Division: 87 percent of the blocks can still be completed
    - West Division: 86 percent of the blocks can still be completed
    - Fox Valley Division: 98 percent of the blocks can still be completed
    - Heritage (Plainfield) Division: 93 percent of the blocks can still be completed
    - Northwest (Wheeling) Division: 87 percent of the blocks can still be completed

Block Analysis

The PEER analysis provides essential information to determine if blocks can be completed with facility-only charging, or if in-route charging is required. If in-route charging is deemed necessary, then proposed locations can be evaluated for satisfying block range needs and providing desired comfort levels in terms of block completion and remaining state of charge (SOC). Additionally, the block analysis determines the SOC remaining after each bus returns to the facility that can be used to determine a peak kW charging demand for each half-hour period throughout the night.

Blocking is used in this analysis to refer to the practice of optimizing schedules by dividing parts of scheduled routes among vehicles and drivers to optimize the schedule. Blocks are defined as paths taken by a bus from when it leaves the facility to when it returns to the facility. During this period, the bus may provide service on multiple routes. Routes are a prescribed geographical path a bus might take according to a fixed schedule.

Energy requirements for each block are determined by simulating every route on every block. Energy requirements are based upon:

- Temperature
- Route elevation profile
- Regional solar loading
- Passenger loading by route
- Bus type and properties
- Heating mechanism (diesel versus electric)

Modeling Assumptions

To model the potential variety of operating conditions in Pace's service area, a variety of ambient temperatures and bus types were simulated in PEER. The temperature and bus type assumptions are shown below and described in detail in the following sections.

- Vehicle types modeled with both new and seasoned batteries
    - A typical 35-foot BEB (440 kWh capacity)
    - A typical 40-foot BEB (518 kWh capacity)
- Ambient Temperature Profiles
    - Summer Operations: 86° F
    - Winter operation with electric heat in use: -17° F
    - Winter operation with a Diesel Fueled Heater (DFH): 0-40° F

Completion Rates Using Pace's Existing Block Schedule

The following tables show the results of the PEER simulation system-wide using Pace's 2019 block schedule. shows the number and percentage of Pace's existing block assignments that could be completed with BEBs with a new battery, under winter conditions, with a DFH. Table 5-1 represents the completion rates of all blocks using seasoned batteries, under winter conditions, with DFHs to extend battery range.

Table 5-1: Block Completion Summary – New Battery with DFH

Block Group		40-foot BEB		35-foot BEB	
	Number of Blocks	Blocks Completable	Completion Percentage	Blocks Completable	Completion Percentage
All Blocks/All Divisions	911	747	82%	713	78%
River Division	91	60	66%	55	60%
North Shore Division	71	66	93%	65	92%
Southwest Division	75	59	79%	54	72%
North Division	69	65	94%	63	91%
South Division	131	106	81%	103	79%
West Division	180	145	81%	142	79%
Fox Valley Division	58	55	95%	49	89%
Heritage (Plainfield) Division	86	77	90%	75	87%
Northwest (Wheeling) Division	150	114	76%	107	71%

Table 5-2: Block Completion Summary – Seasoned Battery with DFH

Block Group		40-foot BEB		35-foot BEB	
	Number of Blocks	Blocks Completable	Completion Percentage	Blocks Completable	Completion Percentage
All Blocks/All Divisions	911	668	73%	623	68%
River Division	91	51	56%	48	53%
North Shore Division	71	63	89%	59	83%
Southwest Division	75	53	71%	50	67%
North Division	69	57	83%	54	78%
South Division	131	97	74%	88	67%
West Division	180	134	74%	120	67%
Fox Valley Division	58	39	67%	37	64%
Heritage (Plainfield) Division	86	70	81%	66	77%
Northwest (Wheeling) Division	150	104	69%	101	67%

Future Battery Technology

From the route and block analysis data generated from PEER, the energy required to complete each block was calculated. Using these results, the minimum theoretical battery capacity needed to achieve 100 percent completion on all blocks was calculated. The results are shown in Table 5-1 and Table 5-2.

Table 5-3: Battery Capacity Needed for 100 Percent Block Completion – With DFH

Bus Type	Modeled Battey Capacity (kWh)	Battery Capacity Needed for 100% Completion (kWh)	
		New Battery	Seasoned Battery
35-foot BEB	440	1119	1399
40-foot BEB	518	1254	1568

Table 5-4: Battery Capacity Needed for 100 Percent Block Completion – Without DFH

Bus Type	Modeled Battey Capacity (kWh)	Battery Capacity Needed for 100% Completion (kWh)	
		New Battery	Seasoned Battery
35-foot BEB	440	1444	1805
40-foot BEB	518	1469	1836

As shown in Table 5-3, 100 percent of Pace's 2019 service blocks can be completed with battery capacity reaching 1568 kWh even with a seasoned battery on a 40-foot bus. This number increases to 1,836 kWh when a DFH is not used as shown in Table 5-4. These capacities are achievable but may take considerable time before they become available for commercial purposes.

The energy values for each block were also used to determine block completion based on a range of theoretical battery capacities. This analysis was done on all blocks, assuming winter conditions. The full set of results can be found in Appendix A.

Energy Consumption

Table 5-5 shows the minimum, average, and max energy consumption of each bus type on all blocks from all divisions when the buses are operated in winter with DFHs.

Table 5-5: All Facility Energy Consumption in Winter, With DFH-Equipped BEBs

Block Group	Bus Type	Minimum Energy Consumption (kWh/mi)	Average Energy Consumption (kWh/mi)	Maximum Energy Consumption (kWh/mi)
River	35-foot	1.85	2.13	2.80
	40-foot	1.99	2.32	2.94
North Shore	35-foot	1.81	2.45	4.21
	40-foot	1.92	2.58	4.40
Southwest	35-foot	1.75	2.26	2.77
	40-foot	1.83	2.34	2.85
North	35-foot	2.03	2.34	3.00
	40-foot	2.16	2.47	3.15
South	35-foot	1.78	2.30	3.24
	40-foot	1.85	2.38	3.33
West	35-foot	2.16	2.66	3.45
	40-foot	2.24	2.74	3.57
Fox Valley	35-foot	2.05	2.43	3.33
	40-foot	2.08	2.48	3.38
Heritage (Plainfield)	35-foot	1.79	2.04	3.18
	40-foot	1.91	2.19	3.33
Northwest (Wheeling)	35-foot	1.96	2.50	3.49
	40-foot	2.05	2.58	3.58

Table 5-6 shows the minimum, average, and max energy consumption of each bus type on all blocks from all divisions when the buses are operated in winter without DFHs.

Table 5-6: All Facility Energy Consumption in Winter, Without DFH-Equipped BEBs

Block Group	Bus Type	Minimum Energy Consumption (kWh/mi)	Average Energy Consumption (kWh/mi)	Maximum Energy Consumption (kWh/mi)
River	35-foot	2.49	2.93	4.52
	40-foot	2.69	3.12	4.66
North Shore	35-foot	2.65	3.85	7.10
	40-foot	2.75	3.98	7.29
Southwest	35-foot	2.44	3.44	4.44
	40-foot	2.52	3.51	4.52
North	35-foot	4.89	3.63	3.05
	40-foot	3.19	3.77	5.03
South	35-foot	2.50	3.46	5.31
	40-foot	2.57	3.54	5.40
West	35-foot	3.25	4.18	5.59
	40-foot	3.33	4.26	5.68
Fox Valley	35-foot	3.08	3.78	5.51
	40-foot	3.11	3.83	5.56
Heritage (Plainfield)	35-foot	2.34	2.88	5.28
	40-foot	2.50	3.03	5.42
Northwest (Wheeling)	35-foot	2.79	3.89	5.78
	40-foot	2.88	3.97	5.87

In general, the smaller the bus, the less energy it uses per mile. However, this can be misleading because it does not ensure that the smaller bus will go farther. Since the 35-foot bus has a significantly smaller battery, the 40-foot bus will usually have a greater range.

Total Energy Requirements

Table 5-7, Table 5-8, Table 5-9, and Table 5-10 show the total energy requirements to complete Pace's current block schedule during winter, spring and summer. The "Block Energy from Division" column represents the amount of energy required to charge the buses at the facility for every block. As noted in the previous sections, some blocks require more energy than today's batteries can store. The tables below describe the additional energy required daily from other non-maintenance facility locations (in-route chargers) to complete all of Pace's blocks. The energy needed from the in-route chargers is displayed in "Block Energy from Elsewhere" column. As battery technology improves, the amount of energy required by in-route chargers will decrease and eventually become zero. In that case, the energy required at the facility will increase by the amount found in the "Energy from Elsewhere" column. The actual energy required at the division will depend on the number of electric buses acquired and the number of blocks they are completing daily. This analysis assumes that the schedule would remain the same, with no changes in blocks. In practice the longest blocks will likely be broken up into smaller blocks, serviced by multiple vehicles. Doing so would result in more energy required at the division, and less at on-route chargers.

Table 5-7 Energy Requirements for Each Facility for 40-foot Bus in Winter – Without DFH

Block Group	Block Energy from Division [kWh]	Block Energy from Elsewhere [kWh]	Total Block Energy Required [kWh]	Number of Blocks	Blocks Completable	Completion Percentage
River	10,932	29,835	40,768	91	52	57%
North Shore	18,124	2,645	20,769	71	57	80%
Southwest	23,287	7,476	30,762	75	44	59%
North	19,452	2,363	21,815	69	49	71%
South	43,248	11,692	54,941	131	81	62%
West	55,065	18,415	73,480	180	107	59%
Fox Valley	17,134	3,648	20,781	58	37	64%
Heritage (Plainfield)	24,621	4,872	29,492	86	69	80%
Northwest (Wheeling)	44,144	16,097	60,763	150	100	67%

Table 5-8: Energy Requirements for Each Facility for 40-foot Bus in Winter – With DFH

Block Group	Block Energy from Facility [kWh]	Block Energy from Elsewhere [kWh]	Total Block Energy Required [kWh]	Number of Blocks	Blocks Completable	Completion Percentage
River	5,418	25,772	31,190	91	60	66%
North Shore	13,126	366	13,493	71	66	93%
Southwest	18,599	1,728	20,326	75	59	79%
North	14,319	49	14,368	69	65	94%
South	33,634	3,172	36,806	131	106	81%
West	42,502	4,725	47,227	180	145	81%
Fox Valley	13,127	304	13,431	58	55	95%
Heritage (Plainfield)	19,650	1,545	21,195	86	77	90%
Northwest (Wheeling)	35,164	4,409	39,914	150	113	75%

Table 5-9: Energy Requirements for Each Facility for 40-foot Bus in Spring

Block Group	Block Energy from Facility [kWh]	Block Energy from Elsewhere [kWh]	Total Block Energy Required [kWh]	Number of Blocks	Blocks Completable	Completion Percentage
River	3,461	23,025	26,486	91	68	75%
North Shore	9,910	-	9,910	71	71	100%
Southwest	14,910	290	15,200	75	70	93%
North	10,709	-	10,709	69	69	100%
South	27,503	392	27,896	131	122	93%
West	33,791	540	34,331	180	168	93%
Fox Valley	9,803	17	9,820	58	57	98%
Heritage (Plainfield)	16,792	334	17,126	86	81	94%
Northwest (Wheeling)	28,725	696	29,672	150	132	89%

Table 5-10: Energy Requirements for Each Facility for 40-foot Bus in Summer

Block Group	Block Energy from Facility [kWh]	Block Energy from Elsewhere [kWh]	Total Block Energy Required [kWh]	Number of Blocks	Blocks Completable	Completion Percentage
River	4,172	24,248	28,421	91	66	73%
North Shore	11,246	71	11,316	71	68	96%
Southwest	16,644	674	17,318	75	66	88%
North	12,216	-	12,216	69	69	100%
South	30,297	1,282	31,579	131	112	85%
West	37,762	1,893	36,655	180	154	86%
Fox Valley	11,138	92	11,230	58	57	98%
Heritage (Plainfield)	18,019	795	18,814	86	79	92%
Northwest (Wheeling)	31,609	1,996	33,893	150	127	85%

Model Recommendations

In summary the transition strategy recommendation is:

1. Sequence the procurement of BEBs over several years to match blocks that can be completed with current technology, in anticipation of future technology that will allow for most, if not all, blocks to be completed. This approach can be used to reduce or even eliminate the need for in-route charging. Coordinating the Fleet Replacement Plan with charging infrastructure installation based on the

PEER results will allow the agency to take advantage of the time required to install charging infrastructure prior to BEB deliveries. As the infrastructure and fleet installation/delivery continues, energy density increases will be realized allowing additional blocks to be completable until 100 percent fleet electrification is achieved.

2. Combine separate blocks for buses that return to the facility with significant SOC remaining. Midday charging could also be used to combine even more blocks together. However, this may increase operating costs due to higher "peak" or "demand" electricity costs during the mid-day hours.
3. Adjust or split the longest blocks, to be serviced by multiple vehicles. This option is discussed in greater detail in Appendix A.
4. Though not desirable, Pace is not precluding the possibility of implementing in-route charging to supplement electric charging equipment at its major terminal locations if warranted.
5. Install a charge management system to optimize the facility charging requirements and minimize (or eliminate) peak power demand.

In addition to the recommendations, it must also be noted that all of these are also completely dependent upon having facility modifications and charging infrastructure installed at each Division prior to receiving any ne zero emission bus.

Other Considerations

The PEER analysis simulation was conducted using pre-Covid, 2019 General Transit Feed Specification (GTFS) data. Results from the PEER simulation may differ when analyzing more recent GTFS data.

6 Technology Portfolio

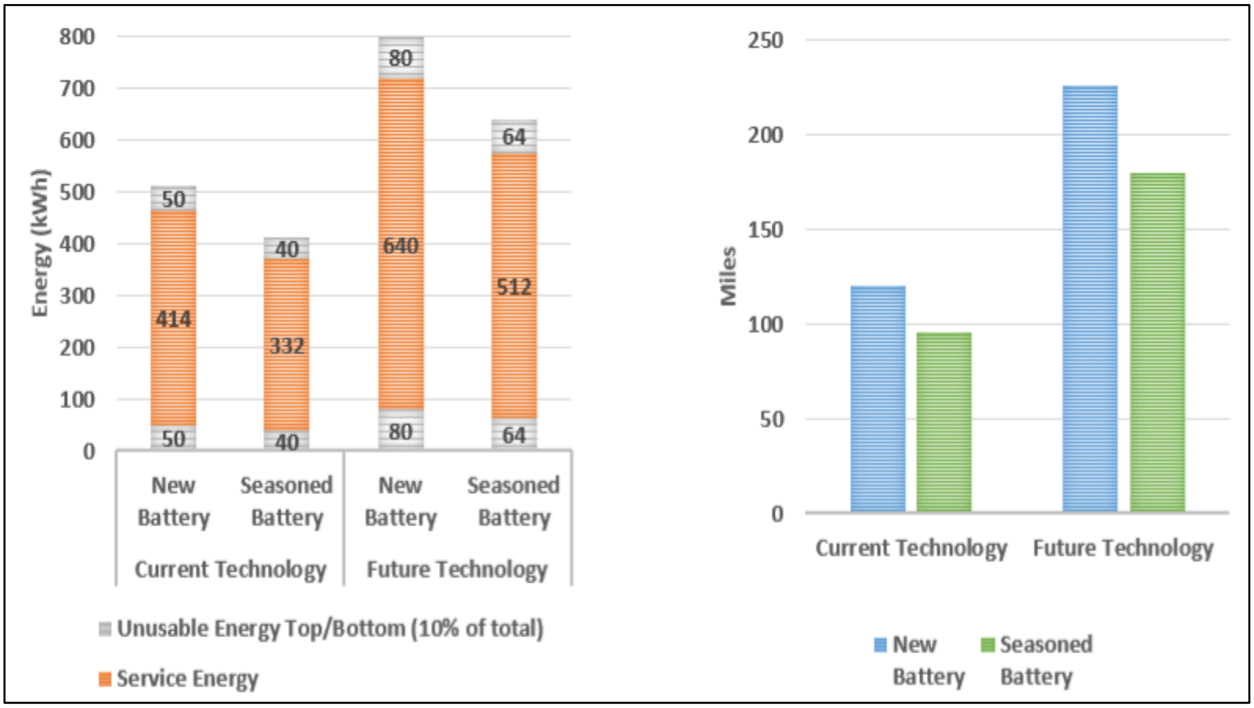
Batteries and BEB Manufacturers

The technology and market products available in the BEB industry are rapidly changing, as is battery efficiency. With so many transit agencies striving to achieve 100% zero emission fleet conversion by 2040, bus manufacturers that comply with Buy America requirements will have to increase production to meet this goal. For the purposes of this transition plan and based on anticipated market products, the analysis assumes the performance of new batteries with a battery capacity of 518 kWh and a service energy of 414 kWh will be utilized. The level of service energy is based upon maintaining a minimum SOC of 20 percent.

Service energy for a seasoned battery is further reduced by 20 percent to 332 kWh, as shown in

Figure 6-1. Estimated degradation of 20 percent is contingent upon the number of re-charging cycles and the level of battery discharge typically occurring.

Figure 6-1: Current and Future Battery Power



Note: Future advancements in energy density will result in an approximate annual 5 percent increase.

A seasoned battery faces a 20 percent performance reduction over 5 to 7 years. Average miles are an approximate number and are impacted by real world conditions including temperature, passenger load, route elevation, etc. Conventional diesel buses generally allow for 300-mile trips before needing to re-fill. Based on available BEB market products, BEBs are expected to travel for approximately 150 miles before requiring re-charging, depending on route conditions.

Bus manufacturers who may support Pace's transition plan include New Flyer, Proterra, and Gillig. BEB market products are currently expected to require approximately 20 months from order to delivery, though these durations are currently impacts by COVID-19 related supply chain impacts, and changes in nationwide BEB demand.

BEB Warranties

The cost of purchasing and maintaining BEBs will also be affected by the use of battery warranties. Factors such as the average SOC can affect the longevity of a battery's life. Therefore, the operations and standards used by transit agencies can affect battery life, and the life span of two batteries of the same type may not be the same, depending on how the buses are operated.

Batteries are one of the most expensive components of a BEB. A new battery, based on market products available today, can cost up to $200,000. A battery warranty from the BEB manufacturer can cost approximately $35,000 - $40,000 per year across a 12-year warranty, but batteries are likely to need replacement prior to the completion of a 12-year cycle. As a result, Pace will require better battery warranties and revise its capital and operating costs accordingly.

Infrastructure Concerns

While the pilot program has already begun transitioning the fleet to BEBs, transitioning the entire fleet to BEBs will require careful planning. Specific infrastructure concerns related to BEB infrastructure when transitioning to a large-scale BEB fleet are described below.

BEB Infrastructure

BEB infrastructure requires significant power supply as well as space to accommodate charging equipment. Some existing operating facilities will require redesign to hold additional required equipment. Pace must also factor in equipment availability as industry-wide supplier backlogs may worsen as more agencies begin the same zero emission transition process.

Utility Provider

ComEd is currently assisting Pace in providing energy requirements for the pilot program. There is also a potential opportunity to negotiate fixed demand charges. ComEd and Pace have established a strong partnership throughout the electric bus pilot program and development of existing Pace facilities, and both organizations anticipate a productive process toward achieving the transition plan.

7 Current Fleet and Future Acquisitions

Current Bus Fleet

The Initial Transit Asset Management Plan 2020 Update, which was released on October 15, 2021, provided an in-depth fleet asset management plan, with a detailed schedule for replacement, expansion, overhaul, and rebuild for each vehicle within the fleet. The Asset Inventory references sub-fleets of Fixed-Route Buses, Paratransit Vehicles, Vanpool Vans, Community Transit On-Demand Vehicles, and Non-Revenue Service Vehicles. The scope of this ZEB Transition Plan is limited to the Fixed-Route Buses.

Fixed-Route Bus Fleet

Pace provided updated fleet information (independent of the 2020 Update of the TAM Plan referenced above), dated October 5, 2022, which pinpoints a total bus fleet size of 726 units. This newer fleet record shows active units manufactured from 2007 through 2022, with some 2022 and 2023 model-year vehicles in the queue for delivery. From this inventory accounting, the active buses are:

- 102 El Dorado EZ 30' Diesel
  - 33 x 2007
  - 26 x 2008
  - 39 x 2010
  - 4 x 2012
- 48 El Dorado Axess 30' Diesel
  - 23 x 2020
  - 25 x 2022
- 337 El Dorado Axess 40' Diesel
  - 69 x 2013
  - 45 x 2014
  - 47 x 2015
  - 90 x 2016
  - 54 x 2017
  - 32 x 2018
  - 23 x 2020
- 108 El Dorado Axess 40' CNG
  - 20 x 2015
  - 71 x 2017
  - 11 x 2018
  - 6 x 2020
- 7 El Dorado Trolley 40' Diesel (2017)
- 37 MCI D4000 40' Diesel (over-the-road)
  - 13 x 2013
  - 9 x 2015
  - 8 x 2017
  - 7 x 2021
- 85 New Flyer XD40 40' Diesel (2020)
- 2 Orion VII 30' Hybrid-Electric Diesel (2011)

726 Total

With the following buses on order:

- 25 El Dorado Axess 30' Diesel – due in 2022-2023 (remainder of contract 228789)
- 27 40' CNG El Dorado transit buses – due in 2026-2027
- 20 40' CNG El Dorado "Pulse" buses – due in 2026-2027

However, Pace is aiming for an overall fleet size reduction to 616 total units by 2029 yet could peak at 749 units in 2024. With the diesel bus and CNG bus orders already in process, it is expected that all new bus purchase contracts will be for ZEBs, starting with 2024 deliveries.

ZEB Transition Roadmap

In April 2022, Pace purchased 20 Proterra ZX5 Max Battery Electric Buses (BEBs), due to be delivered in 2023. Pace also received their first BEB, from Gillig, in November 2022.

North Division in Waukegan, IL is planned to be the first division to be converted to 100 percent ZEB. Northwest (Wheeling) and River Divisions are the next two currently scheduled for capital improvements to support a mixed fleet of ICE and EV buses upon opening. As ICE buses are phased out over time, the facility improvements will ensure that additional charging equipment can be readily installed when needed.

Some ICE buses will need to be transferred among divisions as ZEBs are procured and put into service at the electrified divisions, before the ICE buses have reached their 12-year service life.

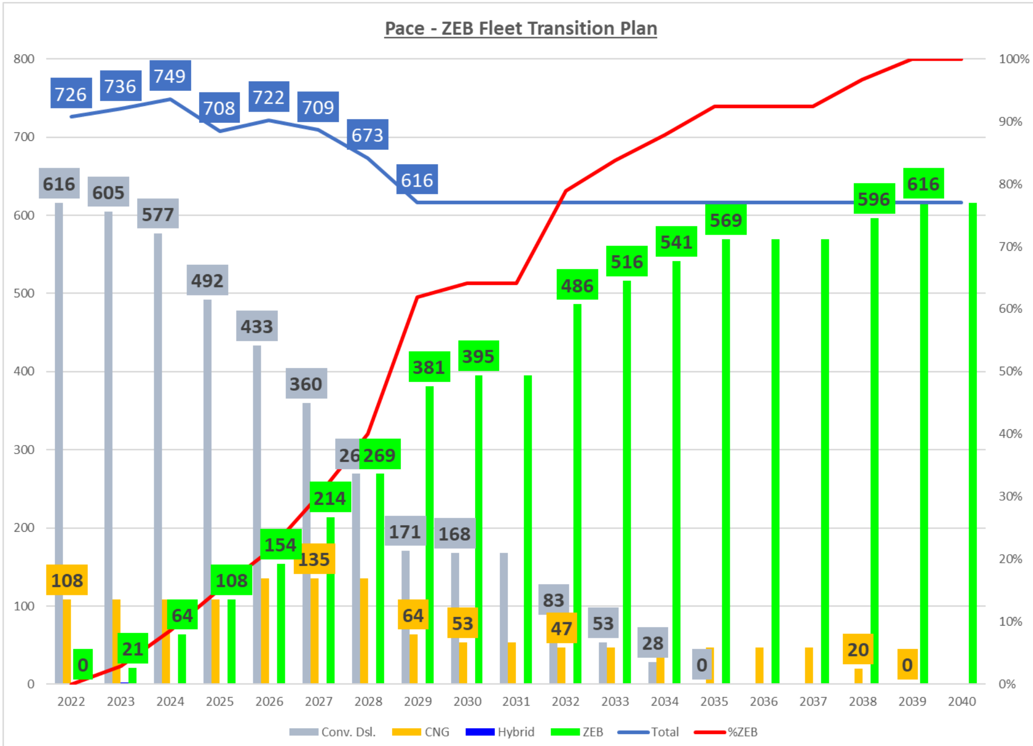
ZEBs carry with them a significantly higher capital expense compared to conventional ICE vehicles, typically about double the cost per bus. Therefore, funding for replacing ICE buses with ZEBs is higher. To help offset the higher funding levels, it is suggested to replace the ICE fleet at a steady, average rate. This approach may not be possible in all circumstances due to the FTA funding rules vs. expected useful bus life (or, Useful Life Benchmark (ULB) and facility readiness.

Bus Replacement Schedule Over 18-Year Period

A detailed layout of Pace's fleet conversion to 100 percent ZEBs is displayed in Figure 7-1. The proposed bus replacement schedule will be conducted over a 19-year period, starting in 2023. This delivery schedule is based off of Pace's master program schedule for capital projects and is entirely dependent upon the infrastructure upgrades at Pace's operating divisions being completed prior to the new fleet arriving. To meet the 2040 fleet transition goal, after the first 20 Proterras and the 1 Gillig are acquired in 2023, at least 595 additional ZEBs will need to be purchased at an average rate of about 35 buses per year (from 2024 through 2040, plus replacement ZEBs for those purchased from 2023 through 2027, which will reach their 12-year ULB before 2040). Pace is already planning for North Division to be the first fully-electric bus garage, by 2026, and from there only 52 buses are planned to be operated.

It is important to note that this replacement schedule reflects current Pace operations and it will be evaluated annually based on the changing operational demands of Pace's service area.

Figure 7-1: Future Pace Bus Fleet Composition



This schedule was developed using the assumptions shown in Figure 7-2. These assumptions include fleet additions, key events, facility upgrades, and vehicle relocations or replacements.

Figure 7-2: Pace Fleet Transition Assumptions

ZEB Purchase Plan is generally based on 12-year ULB Replacement Timing of Existing non-ZEBs

	Vehicle Config. Orig. Non-ZEB >>	>> ZEB	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
																	100% ZEB by 2040 Final Goal				
West	40' Transit	40' Transit								24			85								
Southwest	30' Transit	35' Transit			18												RB 18				
	40' Transit	40' Transit				1			29									RB 1			RB 29
South	40' Transit CNG	40' Transit						20		55	11									RB 20	
River / East Dundee	30' Transit	35' Transit				14	14	10	Site Electrification WIP												
	40' Comm.	40' Comm.						4	13									RB 34			
Northwest	30' Transit	35' Transit				3	18	9	12		4	9				RB 8	RB 4	RB 4	RB 18	RB 9	RB 12
	40' Transit CNG	40' Transit					Site Electrification WIP						6						27	20	
North Shore	40' Transit	40' Transit						8	1	18	3					3				RB 8	RB 2
North	40' Transit	40' Transit		12	13	13	14									RB 12	RB 13	RB 13	RB 14		
				Site Electrification WIP																	
Heritage / Plainfield	40' Coach	45' Coach				13		9		8				7				RB 13		RB 9	
	30' Transit	35' Transit													17	4					
Fox Valley	30' Transit	35' Transit			4									23		12	RB 4				
			0	12	35	44	46	60	55	105	18	9	91	30	17	19	0	0	27	20	0

Annual Agency ZEB purchases (for fleet conversion, not for replacement)

"RB" = Replacement Buy

Past and Future BEB Fleet Procurements

Pace will begin piloting its first BEB in its fleet in early 2023. A larger pilot deployment will occur in late 2023 when an additional 20 Proterra buses are delivered. To diversify the pilot experience among the divisions the twenty additional electric buses will be distributed among divisions which already have adequate charging power capacity from the grid and have room to accommodate the additional charger infrastructure in the short-term. To date, Pace plans for twelve (12) of the twenty (20) BEBs will operate from the North Division. The remaining eight (8) will be distributed across the region at North Shore, Southwest and Heritage (Plainfield) Divisions.

BEBs and Batteries Cost Estimates

The current cost estimate for a 40-foot BEB is $1,200,000. Pace is planning to purchase 52 BEBs for North Division which will be procured over a period of 4 years, from 2023 to 2026. The estimated total vehicle cost for BEBs at North Division is $64,898,584.

Table 7-3 provides a summary of the BEB initial buy cost estimates per Division, including the procurement periods (i.e. does not include ZEB replacements of initial ZEB buys, which will occur later in the period for ZEB initial buys early in the period, 2022-2028). Costs in this table include a 5% escalation per year beyond 2022.

Table 7-3 ZEB Cost Estimates Per Facility, 2022 - 2040

Division Name	Number of ZEBs to Purchase	Procurement Time Period	Estimated Cost ($)
North	52	2023 - 2026	$64,898,584
North Shore	33	2027 - 2035	$51,466,223
Northwest (Wheeling)	108	2023 – 2039	$199,188,218
West	109	2029 - 2032	$189,449,099
Southwest	67	2024 - 2035	$103,313,474
South	92	2027 – 2032	$141,835,685
River (+ East Dundee)	55	2025 – 2028	$74,022,811
Heritage (Plainfield)	58	2025 – 2035	$102,752,892
Fox Valley	39	2023 - 2033	$32,677,609
Contracted	28	2024 - 2035	$70,690,009
Total	**616**	**18 years**	**$1,047,163,192**

8 Facilities and Infrastructure Modifications

Facility Upgrades

Pace's transition to BEB technology will require several modifications and changes to existing infrastructure and operations. This includes the eventual decommissioning of diesel equipment, enhancements to and expansions of electrical equipment, additional electrical supply, and the installation of BEB chargers, dispensers, and other components. The Bus Replacement Schedule Over 18-Year Period

details a timeline for the needed BEB charging equipment. The expected schedule includes 40 chargers by 2025, 100 by 2030, 220 by 2035, and 340 by 2040 to accommodate Pace's BEB fleet.

Table 8-1 provides an overview of the existing and future Pace facilities which would be outfitted with electrical infrastructure to support BEB vehicles.

Table 8-1: Existing Bus Facilities Summary as of October 24, 2022

Facility Name	Address	Main Functions	Fuel Type	Total Buses	Requires Upgrades
North	1400 West 10th St, Waukegan, IL 60085	O&M	Diesel	54	Yes
North Shore	2330 Oakton St, Evanston, IL 60202	O&M	Diesel, Diesel Electric Hybrid	46	Yes
Northwest (Des Plaines)**	900 E. Northwest Highway, Des Plaines, IL 60016	O&M	Diesel	126	**Garage to be replaced with new CNG/BEB facility in Wheeling.
West	3500 West Lake St, Melrose Park, IL 60160	O&M	Diesel	139	Yes
Southwest	9889 S. Industrial Dr, Bridgeview, IL 60455	O&M	Diesel	57	Yes
South	2101 West 163rd Place, Markham, IL 60428	O&M	CNG	108	Yes
River(+ East Dundee)	975 S. State, Elgin, IL 60123	O&M	Diesel	68	Yes
Heritage (Plainfield)	14539 Depot Dr. Plainfield, IL 60544	O&M	Diesel	59	Yes
Fox Valley	1343 W Indian Trail, Aurora, IL 60505	O&M	Diesel	39	Yes

Construction Implementation

Health and safety concerns, required permits, infrastructure construction (i.e., site and building construction) and traffic management considerations will be under the responsibility of the contractor selected to complete the construction and installation of the charging infrastructure.

Requirements that are to be included in the Request for Proposal (RFP) for the construction should be:

- Detailed construction schedule
- Schedule for milestone payments
- Construction QA/QC plan including:
    - Procedures for inspection
    - Field testing
    - Documentation

The engineer of record for the construction will be licensed to practice in the state where the infrastructure will be installed (Illinois) to ensure compliance with applicable codes.

During the construction phase, the equipment supplier and design firm will be included. The responsibilities of the design firm throughout the construction process will include:

- Reviewing construction RFP responses
- Identifying solutions
- Approving any design changes

Pace will ensure that all charging and fueling infrastructure is to be installed and functional before any buses are delivered to preserve the ability to test and utilize buses.

Charging Logistics

Charging equipment will be installed in advance of all BEB deliveries. Plug-in chargers will be used inside maintenance repair facilities and the existing plug-in chargers installed as part of Pace's Bus Electrification Pilot Program will also be utilized.

Table 8-2: Proposed Number of Pantograph Chargers by Facility

Facility	Number of Pantographs
North	54
North Shore	46
Northwest (Wheeling)	126
West	139
Southwest	57
South	108
River (+ East Dundee)	68
Heritage (Plainfield)	59
Fox Valley	39

Maintenance Needs

While reduced fuel costs are the key financial benefit of electrification, reduced maintenance costs are a close second. BEBs utilize much simpler propulsion systems with fewer moving parts that require less frequent service intervals. The baseline preventive maintenance interval for a conventional ICE bus employed by Pace is 3,000 miles. This is predominantly driven by engine oil service requirements. Depending on the bus OEM and specific subcomponent supplier requirements, recommended baseline BEB service intervals are generally pushed out from 3,000 miles to 15-20,000 miles. Although BEBs have some fluid and filter replacements that are comparable to conventional ICE bus requirements, they do not require fuel filters, engine air filters, or crankcase filter replacements. The majority of BEBs available in the marketplace also use a direct-drive traction motor arrangement, which removes the need for transmissions, and the fluid, filters, and costly rebuilds associated with maintaining them. BEBs also utilize regenerative braking to increase efficiency of operation, resulting in a significant reduction of brake wear as compared to conventional buses. Factoring in these key differences in vehicle equipment and associated maintenance requirements, industry experience has shown that maintenance costs for supporting BEBs can be reduced by as much as 40 percent when compared to conventional ICE buses.

Maintenance Cost Estimates

Based on Pace's operating data from 2020 (prior to any service impacts from COVID-19) available in the FTA National Transit Database, conventional bus operating cost is calculated at $8.21 per revenue mile. A comparable fleet of BEBs requires less frequent servicing with fewer fluids and consumable items, and have longer brake life through regenerative braking reducing. Taken together this has the potential to lower daily operating costs. Over time, the reduced maintenance requirements of a BEB fleet are expected to significantly offset the large infrastructure expenditures that will be required throughout Pace's transition to electrification.

9 Service to Disadvantaged Communities

Pace facilities are either directly in, or immediately adjacent to, disadvantaged communities. This transition plan identifies disadvantaged communities as those where 50 percent or more of households are low-income, or where 50 percent or more of households consist of minority population. The conversion of existing ICE operations to BEB operations will directly benefit the communities in the vicinity of these divisions by way of a reduction in noise and emissions.

To locate disadvantaged communities, indicators, such as areas where at least 50 percent of the population earn low incomes and 50 percent or more of the population identify as minorities, are identified using the Environmental Protection Agency's EJSCREEN tool at the Census Tract level Figure 9-1. Based upon these indicators, Pace serves 153 low-income Census Tracts and 428 minority Census Tracts. Excluding trolley routes, all Pace bus routes pass through disadvantaged communities at least once during service.

Figure 9-1 Disadvantaged Communities Served by Pace Fixed-Routes

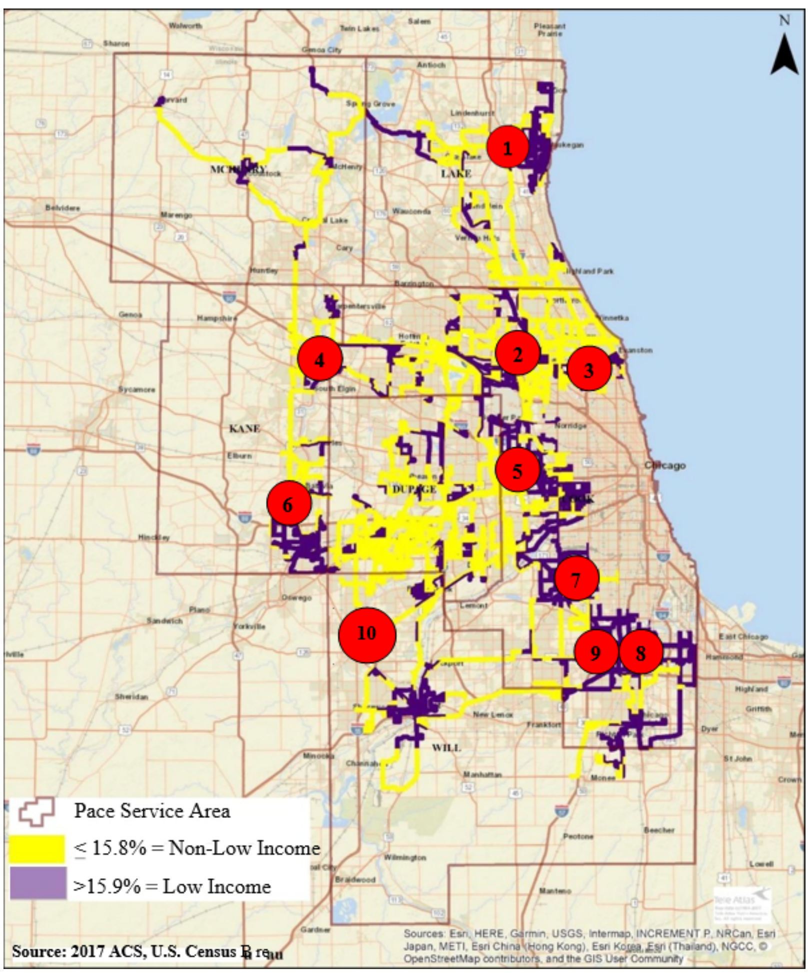


Table 9-1 Pace Division Locations

	Division Name
1	North Division
2	Northwest Division
3	North Shore Division
4	River Division
5	West Division
6	Fox Valley Division
7	Southwest Division
8	South Holland Division
9	South Division
10	Heritage (Plainfield) Division*

*Formally Heritage (Joliet). Operations moved to new location in November 2022.

Once facilities are electrified, BEBs can be prioritized for routes which primarily serve disadvantaged communities. Though all Pace bus routes pass through disadvantaged communities, not all routes pass through equal lengths or densities of disadvantaged communities, so there remains a framework for route transition prioritization.

Residents of disadvantaged communities are generally among the most vulnerable populations. They often rely on public transit, are more likely to be impoverished, and are more frequently exposed to harmful emissions and pollutants that result in negative health outcomes. Implementing BEB service in disadvantaged communities is an opportunity for Pace to help promote environmental justice and regional equity. This graphic is based upon the most recent Title VI Census Tract published in 2017.

10 Workforce Training

Workforce Development Plan

Training is required with all new and updated equipment that utilizes new technology. Pace will provide a workforce development program that equips all staff members with the necessary skills to properly use all new technology, including diagnostic software support. The labor unions representing Pace employees will also be actively involved in the transition process. To achieve this goal, Pace will identify skills and credential gaps to generate long-term support and seek to invest in a workforce development plan that will be necessary to deploy this long-term project successfully. During the pilot program, a workforce development plan will be provided by Proterra on-site. Future workforce development programs will be administered with manufacturers based on corresponding BEBs.

A detailed overview of these plans is listed in the following sections. These sections were developed in part through the FTA's workforce evaluation tool.

Required Training for Proposed Fleet

The following provides a list of personnel and positions that will need to be retrained upon further adoption of BEBs (this list is not exhaustive):

Bus Operators

Pace will provide the necessary training on ZEBs, safety, bus operations, and charging operations. Pace will train BEB operators to interpret readings such as battery SOC, remaining operating time, estimated range, and other system notifications that may occur during operation. An additional area of focus for operator training will be the use of the accelerator pedal to accelerate and to decelerate. The accelerator pedal response on ZEBs will be different than conventional ICE equipped buses and the operators can have a huge effect on energy consumption and regenerative braking efficiencies. Operator training must emphasize regenerative braking capability and its significant impact to ZEB range and performance.

Facilities Maintenance Staff and Maintenance

Facilities staff will need to be familiar with scheduled and unscheduled repairs, high-voltage systems, and the specific maintenance and repair of equipment.

First Responders

Local police and fire station staff and firefighters will need to be familiar with the new buses and supporting facilities.

Tow Truck Service Providers

Pace will provide training on proper procedures for towing BEBs to tow truck operators.

Body Repairers

Pace will provide training to body repairers on safety-related features and other components of BEBs.

Instructors

For both bus operations instruction and maintenance, instructors will need to understand all aspects of BEBs to train others.

Servicers

Bus servicers will need to be trained on proper charging and servicing protocols and procedures that are BEB-specific.

Management Staff

All management staff (supervisors, managers, etc.) will need to be train on BEB operations and safety procedures.

Technical Training (BEB and BEB Charging Infrastructure)

Pace will train BEB operators on how to interpret and use BEB readings such as battery SOC, remaining operating time, estimated range, and other system notifications that may occur during operation. Pace Operations will confirm with the OEM how SOC will be reported in monitoring services to ensure adequate charging for service. The FTA recommends training on concepts, working principles, and details of regenerative braking (specifically the differences between regenerative braking and conventional braking), mechanical braking, hill holding, and roll back.

11 Capital Improvement Plan

Pace's 2022-2026 Five-Year Capital Program (November 2021) is a component of the 2022 Final Budget document and provides blueprint for future capital investments. The program is updated annually and outlines how Pace will fund the replacement and expansion of agency infrastructure, including BEBs and charging infrastructure acquisitions. This represents a short-term forecast, but much larger funding to fulfill the facility upgrades necessary to support a 100% zero emission Pace bus fleet will need to be obtained quickly. The current five-year capital program totals $289 million and is distributed across 5 major categories:

- Rolling Stock ($172.506 Million)
    - 88 Fixed route CNG buses
    - 52 Fixed route electric buses
    - 13 Fixed route coach buses
    - 262 Paratransit vehicles
    - 69 Community Transit/On Demand vehicles

  - 68 Vanpool vehicles
  - Engine/transmission retrofits & associated capital
- Electrical/Signal/Communications ($12.799 Million)
  - Transit Signal Priority
  - Intelligent Bus System
  - Bus Security Cameras
- Support Facilities & Equipment ($51.929 Million)
  - Improve support facilities/charging infrastructure
  - Computer systems/hardware & software
  - Support equipment/non-revenue vehicles
  - Farebox system replacement
  - Fire loop system
  - Security system
- Stations & Passenger Facilities ($50.915 Million)
  - Improve passenger facilities
  - Bus stop shelters
  - Bus tracker signs
- Miscellaneous ($1.000 Million)
  - Unanticipated capital

While the Program's encompasses a wide range of agency needs and initiatives, significant increases in capital funding are required to meet the facility demands of a zero emissions fleet. A closer look at the anticipated yearly expenditures on advancing Zero-Emission initiatives are as follows ($ expressed in 000s):

Figure 11-1: Pace Five-Year Capital Program (Rolling Stock)

	2022	2023	2024	2025	2026	Total
Rolling Stock Quantities						
Fixed Route CNG Buses	51	37	0	0	0	88
Fixed Route Electric Buses	6	9	9	14	14	52
Fixed Route Coach Buses	0	0	13	0	0	13
Paratransit Vehicles	59	59	48	48	48	262
Community Transit/On Demand Vehicles	0	17	17	17	18	69
Vanpool Vehicles	0	0	0	34	34	68
Rolling Stock						
Fixed Route CNG Buses	$28,050	$20,350	$0	$0	$0	$48,400
Fixed Route Electric Buses	6,000	9,000	9,000	14,000	14,000	52,000
Fixed Route Coach Buses	0	0	9,100	0	0	9,100
Paratransit Vehicles	5,612	5,639	4,527	4,554	4,583	24,915
Community Transit/On Demand Vehicles	0	1,615	1,615	1,615	1,710	6,555
Vanpool Vehicles	0	0	0	1,360	1,360	2,720
Engine/Trans Retrofits & Associated Capital	0	6,778	6,791	7,371	7,876	28,816
Subtotal	**$39,662**	**$43,382**	**$31,033**	**$28,900**	**$29,529**	**$172,506**

Figure 11-2: Five-Year Capital Program (Support Facilities & Equipment)

Support Facilities & Equipment						
Improve Support Facilities/Charging Infrastructure	$4,000	$5,800	$5,000	$12,500	$12,000	$39,300
Computer Systems/Hardware & Software	0	1,000	1,000	1,000	1,000	4,000
Support Equipment/Non-Revenue Vehicles	0	500	500	500	500	2,000
Farebox System Replacement	3,079	0	0	0	0	3,079
Fire Loop System	2,050	0	0	0	0	2,050
Security System	1,500	0	0	0	0	1,500
Subtotal	**$10,629**	**$7,300**	**$6,500**	**$14,000**	**$13,500**	**$51,929**

12 Funding Sources

There are several potential federal, state, and regional funding and financing sources at Pace's disposal. A Table 12-1 provides a comprehensive list of current available programs.

State and Regional

The Illinois Environmental Protection Agency (IEPA) provides funding for diesel emission reduction projects through the Driving a Cleaner Illinois grant program. Projects are funded by the Illinois' portion of the Volkswagen Environmental Mitigation Trust, the U.S. Environmental Protection Agency's Diesel Emission Reduction Act (DERA) Program, and the U.S. Department of Transportation Federal Highway Administration's Congestion Mitigation and Air Quality Improvement (CMAQ) Program.

Federal

Multiple funding programs are offered by the FTA to offset the costs of transitioning. These programs include the Metropolitan & Statewide Planning and Non-Metropolitan Transportation Planning program, the Urbanized Area Formula Grants, the State of Good Repair Grants, the Flexible Funding Program – Surface Transportation Block Grant Program, the Low and No Emissions Program, the Bus & Bus Facilities Competitive Program, and the Capital Investment Grants – New/Small Starts program.

The EPA offers the Environmental Justice Collaborative Program-Solving Cooperative Agreement Program and the Diesel Emissions Reduction Act (DERA) National Grants.

The FHWA provides the Congestion Mitigation and Air Quality Improvement Program.

The USDOT offers the RAISE Grant, a competitive grant that can cover the costs associated with infrastructure. USDOT also offers two other grants, the Charging and Fueling Infrastructure Competitive Grants and the National Electric Vehicle Formula Program.

The U.S. Department of Energy provides the Energy Infrastructure Federal Financial Assistance Program, Smart Grid Matching Grants, and the Carbon Dioxide Transportation Infrastructure and Innovation (CIFIA) Loan Program.

Other Sources

Innovative financing mechanisms can also be utilized, such as Charging as a Service (CaaS). This consists of turn-key project management services for the construction and installation of infrastructure and the deployment of smart charging. The company then owns, operates, and maintains the infrastructure and the transit operator typically pays the company per kWh or per mile (ex. Amply, Invenergy, In-Charge).

Table 12-1: Funding Opportunities

Level	Agency	Name	Competitive	Vehicles	Infrastructure
Federal	FTA	Metropolitan & Statewide Planning and Non-Metropolitan Transportation Planning		X	X
		Urbanized Area Formula Grants (5307, 5339)		X	X
		State of Good Repair Grants		X	X
		Flexible Funding Program – Surface Transportation Block Grant Program			X
		Low and No Emissions Program	X	X	
		Bus & Bus Facilities Competitive Program	X	X	X
		Capital Investment Grants – New/Small Starts	X		X
	EPA	Environmental Justice Collaborative Program-Solving Cooperative Agreement Program	X	X	X
		Diesel Emissions Reduction Act (DERA) National Grants	X	X	
	FHWA	Congestion Mitigation and Air Quality Improvement Program			
	USDOT	Charging and Fueling Infrastructure Competitive Grants	X		X
		National Electric Vehicle Formula Program			X
		Rebuilding American Infrastructure with Sustainability and Equity (RAISE) Grant	X		X
	US Energy	Energy Infrastructure Federal Financial Assistance Program	X		X
		Smart Grid Matching Grants			X
		Carbon Dioxide Transportation Infrastructure and Innovation (CIFIA) Loan Program			X
State	IEPA	Driving a Cleaner Illinois grant program	X	X	X

13 Start-up and Scale-up Challenges

Pace has identified several challenges and opportunities associated with purchasing and transitioning to BEB technology, including:

- **High vehicle capital costs**: While lifecycle costs may be lower with BEBs than ICE buses, initial capital costs are high due to BEB vehicle market price. Pace will need to ensure the transition to BEBs does not affect existing service. Pace may explore the option of leasing buses or batteries, both of which are options provided by BEB manufacturers, to determine best financial practices for capital and operations costs of a BEB fleet.
- **Procurement phasing/timing**: Transition to BEBs requires careful coordination across routes and facilities to ensure new BEBs can meet service and route requirements, including having charging infrastructure in place prior to receiving BEBs for service. BEB production demand is also rising, and Pace will need to work with manufacturers to ensure delivery schedule expectations are clear and worked into Pace bus fleet management.
- **Facility infrastructure constraints, cost, and construction schedule**: Existing bus facilities must be upgraded with electric charging equipment for BEBs. The addition of pantographs, gantries, charging cabinets, and other equipment must be designed, accommodated, and built-in structures which may or may not have been designed to accommodate such features. The capital cost of this construction must be understood and planned for, and its schedule closely coordinated with ComEd and the Pace Bus Operations department.
- **Multi technology operations during transition**: Buses, which may currently be utilized flexibly across routes or housed at different facilities depending on operation's needs, will no longer be 'interchangeable" as the fleet transitions to BEBs. Pace will need to closely monitor which routes will utilize BEBs, where the garage facility of those BEBs are located, and the availability of BEB and combustion engine bus parking as each facility undergoes upgrades. This ensures BEBs do not run out of charge while away from the facilities due to service changes, deadheading, or other operation's needs. Additionally, Pace staff will need to be trained in both conventional and BEB-supportive maintenance skills while the fleet is in transition.
- **Power demand management and uncertainty**: Currently, bus operation is tailored toward service needs (e.g. AM/PM peaks). With a BEB fleet, charging costs fluctuate throughout the day based on utility provider rates, with charging costs generally higher during high-demand periods. Pace will need to consider how to manage charging to reduce peak demands and utilize power cost-efficiently. This will require close coordination with ComEd.
- **Utility company dependency & needed upgrades**: The availability, consistency, and expansion of power needs is dependent on ComEd, which is the sole utility provider in the Pace service area. The ability of Pace to upgrade facilities with charging infrastructure and operate a BEB fleet is dependent on the ability of ComEd to provide the necessary electrical connections and infrastructure required to maintain reliable BEB service. Pace may explore options to reduce dependency such as outfitting facilities with solar photovoltaic panels to generate on-site energy.

- **Technological adaptation**: The BEB market is rapidly evolving. Today's projections are based on existing BEB vehicles and battery range available, which may be outdated in the near or mid-future. Pace will need to remain alert to changes in battery technology and BEB market products while looking to meet FTA or other grant deadlines.
- **IT Infrastructure cost/challenge**: BEBs have different software requirements and outputs and will need to be integrated into existing Pace information technology systems. This will involve new partnerships, new training, and new monitoring and evaluation processes.
- **Funding challenges**: Pace may not have sufficient funds in its existing budget to implement a BEB transition on its own and will likely seek grant opportunities where possible. Successful grant applications may keep a transition on target but rejected grant applications may delay a fleet transition.
- **Resiliency and emergency response**: Pace will need to consider the different implications of running BEBs compared to combustion engine buses. This could include changes in service as a result of COVID-19, or whether there are different safety, hazards, or fire risks if a flood, tornado, excessive heat, or other natural disaster impacts a facility with large amounts of electric charging equipment.
- **Training and outreach activities**: The existing workforce will need retraining to manage BEBs, while opportunities for a new generation of BEB technicians can provide outreach and economic development opportunities to the communities of the Pace service area. However, the availability of such a workforce will be a factor in the success of the transition.
- **Public Private Partnership (PPP) opportunities**: The emergence of PPPs an increasingly common way to provide infrastructure or services will be closely monitored to identify areas which can optimize service or lower costs of purchasing and maintaining a BEB fleet.

14 Next Steps

The process to transition to BEBs will be iterative to minimize risk, and to accommodate new developments in a rapidly evolving market. It must also be acknowledged that if Pace is unable to obtain sufficient funding to convert garages to keep up with the fleet transition plan, the agency runs the risk of keeping dirtier, and older ICE buses on the road for longer. Pace will use the information outlined in this document to refine and determine the following:

- Address incomplete service blocks
- Refine costs
- Explore collaboration opportunities
- Engage utilities

This plan is a living document. It will be updated as Pace procures BEB technology, learns from the pilot program, the current roll out strategy, and designs and builds the needed infrastructure.

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