IndyGo Zero-Emission Vehicle Transition Plan

April 2024

Indianapolis Public Transportation Corporation

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Glossary

ZEV	Zero-emission vehicle
EV	Electric vehicle
ZEB	Zero-emission bus
BEB	Battery-electric bus
FCEB	Fuel cell electric bus
ICE	Internal combustion engine
OEM	Original equipment manufacturer
Green hydrogen	Hydrogen fuel produced by using zero-emission electricity to power an electrolyzer.
Gray hydrogen	Hydrogen fuel produced from natural gas using steam methane reformation.

Chapter 1. Executive Summary

The IndyGo Zero-Emission Transition Plan (ZEVTP) describes analyses that were conducted to inform IndyGo's preferred scenario to transition to a zero-emission vehicle (ZEV) fleet, including buses, paratransit vehicles and non-revenue vehicles. Analyses included a review of current and expected zero-emission vehicle technologies, an analysis of schedule compatibility of IndyGo vehicles with battery-electric and fuel cell technologies, a review of bus facility upgrades that would be needed to accommodate battery-electric bus (BEB) or fuel cell electric bus (FCEB) fleet transitions, modeling of lifecycle costs and emissions reductions for BEB or FCEB transition, and assessment of associated workforce development requirements.

The result of this analysis is that IndyGo's preferred scenario is transition to all electric vehicles, including the non-revenue fleet. This preferred scenario builds on IndyGo's existing experience and workforce training in BEBs, as well as existing infrastructure for charging at both depots and several on-route layover locations. Electricity as a power source is also widely available, whereas the hydrogen fuel supply is still being developed. In addition, based on a review of facility compatibility with BEB and FCEB infrastructure, a BEB fleet would allow more flexibility for IndyGo to decide how to house the fleet between the Corporate and East Campus locations. The summary-level findings of these analyses are described below.

The implementation plan is described in this document as a "playbook" approach, which recognizes that while technology is still rapidly evolving and IndyGo is still learning about how to operate these technologies within the local context, the transition plan will not remain static for the duration of the expected transition timeline. With a longer-term goal of full transition by the year 2040, IndyGo will remain flexible, revisiting technology choices at key milestones, making interim purchase decisions based on technology availability and cost, and incorporating new technologies and best practices as they are developed.

Federal and Local Policy Context

The Bipartisan Infrastructure Law (BIL) amended the statutory provisions for two federal discretionary funding programs, known as Bus and Bus Facilities and Low/No Emission, to include a requirement that agencies submitting projects that relate to zero-emission vehicles include a Zero-Emission Transition Plan (ZEVTP). This plan fulfills that requirement. However, there is no state or local requirement for IndyGo to transition from internal combustion engine vehicles.

Environment and Health Benefits

Compared to diesel buses, electric buses emit less local air pollution that is harmful to public health, which is particularly important in downtown neighborhoods of Indianapolis, where population density is highest and air quality is often worse. In addition, the full electrification of IndyGo's fleet is estimated to reduce the total annual CO2 emissions by approximately 82% and total PM2.5 emissions by 25% compared with maintaining a diesel fleet, accounting for power generation needed to charge buses. This could be further reduced if the mix of power generation on the regional grid shifts toward cleaner energy sources.

Technology Compatibility with IndyGo Fleet

Zero-emission vehicle technology is rapidly improving. Analysis of current bus routes and schedules showed that 83% of IndyGo's 40' bus fleet, and 89% of its 60' bus fleet would be compatible with BEB technology, assuming moderate technology improvement and use of fuel-fired heaters during adverse winter conditions. Compatibility of service with FCEB technology is slightly higher (88% of 40' buses and 100% of 60% buses) using comparable assumptions. However, BEB technology compatibility could be improved by modifying longer blocks of service to fit range constraints or simply waiting for technology to develop further.

Cutaway bus and paratransit vehicles do not currently have fuel cell offerings, and battery-electric offerings are less compatible with IndyGo service, compared to the 40' and 60' fleet. Using similar assumptions to the 40' and 60' bus analysis, only 60% and 71% of fixed route cutaway and paratransit service is compatible with EV technology, respectively.

For the non-revenue fleet, fuel cell vehicles are not readily available but many models of battery-electric vehicles exist. An analysis of operational requirements indicates that many EV models would be compatible with IndyGo's requirements.

Facility Needs

A preliminary review of support facilities was conducted to identify facility upgrades that would be needed to support zero-emission transition, for use in determining feasibility and costs for BEB and FCEB transition. The following are the key takeaways from the review of each of IndyGo's three facilities.

- A full transition to BEBs could be accommodated at West Campus and Mobility and Customer Care Center with existing site power. Power upgrades would be needed at East Campus.
- Setback requirements may hinder FCEB operations at the IndyGo Corporate Office and Mobility and Customer Care Center because of the facilities' proximity to residential neighborhoods and active railroads. Additional design work could determine whether FCEBs would be feasible at Corporate Campus.
- Due to the amount of space available at the East Campus compared to the other IndyGo locations, this location would be most suitable for FCEBs. However, the East Campus facility is located at the extreme eastern edge of IndyGo's service area, and this distance may negatively impact IndyGo operations by increasing service costs.

ZEV Scenario Development

Five ZEV transition scenarios were developed and analyzed to assess the pros, cons and tradeoffs of the above analysis for use in selecting a preferred scenario. The first is an internal combustion engine (ICE) baseline scenario for comparing against the four zero-emission transition scenarios. One zero-emission scenario transitions IndyGo's bus fleet to all BEBs and another assumes

transition all FCEBs. (All ZEV scenarios assume that paratransit vehicles and non-revenue vehicles transition to battery-electric models to the extent compatible, due to a lack of fuel cell offerings in these vehicle categories.) A fourth scenario assumes transition to 40' BEBs and 60' FCEBs and a fifth assumed 40' FCEBs and 60' BEBs. For these latter two mixed scenarios, fixed route cutaway, paratransit and non-revenue vehicles are assumed to be battery-electric to the extent compatible, as described for the FCEB scenario. Analysis of the five scenarios concluded that the all battery-electric scenario is the preferred scenario, building on existing IndyGo experience and infrastructure and taking into account other practical considerations as described in more detail in the following implementation plan document.

Implementation Plan and Next Steps

While striving toward the overall goal of a full transition to battery-electric vehicles by the year 2040, key milestones have been identified for IndyGo to confirm this technology choice ahead of significant vehicle purchases, based on technology evolution and other factors at that point in time. In addition, ahead of each annual bus purchase, a decision between battery-electric or ICE vehicles will be based on cost, as well as availability of grants to complement local funding availability. If battery-electric vehicles are prohibitively costly in some years, the date by which IndyGo would be fully transitioned to an all battery-electric fleet may be later than 2040.

- **A key decision point for the 40' bus fleet will occur in 2025**, when the future propulsion should be confirmed. This provides four years of lead time, to design and implement improvements to facilities and support equipment, before an important delivery of 40'

buses occurs in 2029. This also allows ample time to complete the bus procurement. This is the first 40' bus delivery that must be ZEBs in order to achieve a 2040 transition.[1]

- **A key decision point for the 60' bus fleet will occur in 2027**, when the future propulsion should be confirmed. This provides four years of lead time, in case any changes to facilities or support equipment are desired, before an important delivery of 60' buses occurs in 2031. This also allows ample time to complete the bus procurement. This is the first 60' bus delivery that is not already committed and that will be replacing existing BEBs.
- The key decision points for the **paratransit fleet and non-revenue vehicles are more flexible** because these vehicles have shorter replacement cycles. IndyGo could make a decision regarding its non-revenue vehicles as early as 2025, as current EVs would be suitable for most of the non-revenue fleet. However, the decision regarding IndyGo's paratransit fleet might wait longer, until 2030, to allow the cutaway EV market to develop.

A note about this report's structure

The Zero-Emission Vehicle Transition Plan document provides an overall summary of the project's key takeaways. However, much more detail and technical analysis from over a year of study can be found in the following appendices:

H. Zero Emission Vehicle Market Review
I. Service Operational Compatibility with Zero-Emission Technologies
J. Facility Review
K. Cost and Emissions Projections
L. Assessment of Workforce Capabilities
M. Recommendations Workshop Presentation (February 12, 2024)
N. Fleet Management Plan

[1] Although IndyGo's preferred scenario is to utilize BEBs, there is also interest in the performance benefits from FCEB technology. If desired, IndyGo could conduct a FCEB pilot deployment to gain further experience before making a decision regarding its 40' bus fleet. This pilot deployment would ideally occur in 2024 – however, the time window to develop this project is quite limited.

Chapter 2. Introduction

Purpose of the ZEVTP

The purpose of the Zero-Emission Vehicle Transition Plan (ZEVTP) is to set IndyGo's strategy for transitioning its fixed route, paratransit, and non-revenue fleets to zero-emission vehicles (ZEVs). To the extent feasible, IndyGo seeks to transition away from diesel powered buses to ensure a clean, sustainable, and resilient future.

This playbook summarizes the analysis and strategic planning that has been completed to inform IndyGo's fleet transition. The document is framed as a "playbook" to convey that IndyGo intends to follow an iterative process, and implementation decisions will continue to be refined over time. IndyGo's transition will include significant facility upgrades and vehicle procurements that need to be planned years in advance. However, the transition will also likely be a time of change in zero-emission bus technology, economics, and federal policy. To reflect the expected uncertainty, IndyGo needs a flexible approach that can continue to be refined over time.

The analysis presented in this playbook led to the selection of a preferred scenario for IndyGo to transition to all ZEV fleets by the year 2040. The recommendations consider the timeline of investments and decision points to advance from early deployments to a full transition. The playbook may be updated in the future to incorporate lessons learned from operational experience and to incorporate key decisions that will occur in the coming years.

Please note that this document represents an update to the Zero-Emissions Transition Plan that IndyGo completed in 2022. This plan includes more detailed evaluation of zero-emissions planning considerations and involved a more extensive planning process.

Federal Requirements for ZEVTP

The Bipartisan Infrastructure Law (BIL) amended the statutory provisions for two federal discretionary funding programs, known as Bus and Bus Facilities and Low/No Emission, to include a requirement that agencies submitting projects that relate to zero-emission vehicles include a Zero-Emission Transition Plan (ZETP). The table below lists the requirements of a ZETP and also specifies where each requirement is met in the IndyGo Zero-Emission Fleet Transition Plan.

Table 1. Summary of plan requirements and where they are addressed

Statutory Requirement	**Location in this ZEVTP**
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.	Appendix G. Fleet Management Plan
Address the availability of current and future resources to meet costs for the transition and implementation.	Appendix D. Cost and Emissions Projections
Consider policy and legislation impacting relevant technologies.	"Policy and Funding Context" section in Chapter 2

Include an evaluation of existing and future facilities and their relationship to the technology transition.	Appendix C. Facility Review
Describe the partnership of the applicant with the utility or alternative fuel provider.	"Utility/Fuel Partnership" section in Chapter 3
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.	Appendix E. Assessment of Workforce Capabilities

Existing Plans and Relationship to the ZEVTP

IndyGo has numerous other plans and policies that are related to the ZEVTP. The ZEVTP may reference the strategies outlined in each plan to show the connections between the specific efforts of transitioning to zero-emission vehicle technologies and the agency's other efforts.

- **Comprehensive Operational Analysis.** The existing Comprehensive Operational Analysis (COA) is known as IndyGo Forward and was completed in 2015. The COA outlines the goals and objectives of IndyGo's service, reviews IndyGo's existing service and service area demographics, and recommends an updated network of services. This COA informed the development of the Marion County Transit Plan in 2016 and the existing transit network. The COA is typically updated every five years, and a new COA process is currently underway. The COA is a key driver for other internal efforts, as planned service levels affect almost all aspects of IndyGo's operations, including the number of vehicles needed to operate the service levels.
- **Marion County Transit Plan.** The 2016 Marion County Transit Plan (MCTP) focused on expanding public transit services in the county. It also outlined the framework to begin studying alternative vehicle propulsion technology to reduce greenhouse gas emissions.
- **Fleet Management Plan.** The draft Fleet Management Plan outlines the plans, processes, and systematic approaches required to manage, maintain, and operate IndyGo's bus fleet. The Fleet Management Plan was approved in 2022.
- **Transit Asset Management Plan.** The Transit Asset Management Plan (TAMP) is the main asset management document for IndyGo and provides direction and information on IndyGo's asset management goals, performance measures, and performance targets for its assets, including vehicles and facilities. The TAMP was last updated in October 2022.
- **Public Transportation Agency Safety Plan.** The Public Transportation Agency Safety Plan (PTASP) is the federally-required safety plan that provides goals/objectives, performance measures, and strategies and tactics to implement and sustain a culture of safety. The addition of new zero-emission vehicle technologies to the fleet will require IndyGo to evaluate the safety protocols and ensure that sufficient steps are taken to protect the safety of riders and workers.

The following plan by the City of Indianapolis is also relevant to the ZEVTP:

- **Thrive.** Thrive is Indianapolis' comprehensive resiliency plan. It is a snapshot of current communities, social vulnerability, goals, objectives, and community partners for implementation. IndyGo is an implementation partner to reduce carbon emissions by committing to transition to a lower emission fleet.

State of the ZEV Industry

The ZEV industry is steadily growing and changing. Below is a summary of the current ZEV market for non-revenue vehicles, paratransit vehicles, and buses.

Non-revenue vehicles include common automobiles such as cars, trucks, and SUVs. Battery-electric automobiles are available from a variety of manufacturers, such as Ford, GM, BMW, Hyundai, Toyota, and Tesla. Zero-emission non-revenue vehicles are generally offered as battery-electric, with only a few manufacturers offering fuel cell powered automobiles. Market development for zero-emission vehicles is being driven by EPA standards, state clean air mandates, and automaker commitments to selling zero-emission vehicles.

Paratransit vehicles include vans, cutaway buses, and shuttle buses. Battery-electric paratransit vehicles are currently offered by several manufacturers, but fuel cell paratransit vehicles are not readily available. Overall, the market for zero-emission paratransit vehicles is less developed than it is for autos or buses, but further growth is widely expected. It also is speculated that fuel cell paratransit vehicles might become available once hydrogen infrastructure becomes more prevalent.

Zero-emission buses include BEBs and FCEBs of various sizes. The market for these technologies has been growing quickly in recent years, influenced by several factors. Across the country, federal, state, and local regulations are driving increased interest in the purchase of zero-emission buses, which supports growth in the market. The total count of ZEBs operating, funded, ordered, or delivered in each US state as of September 2022 is shown in Figure 1.

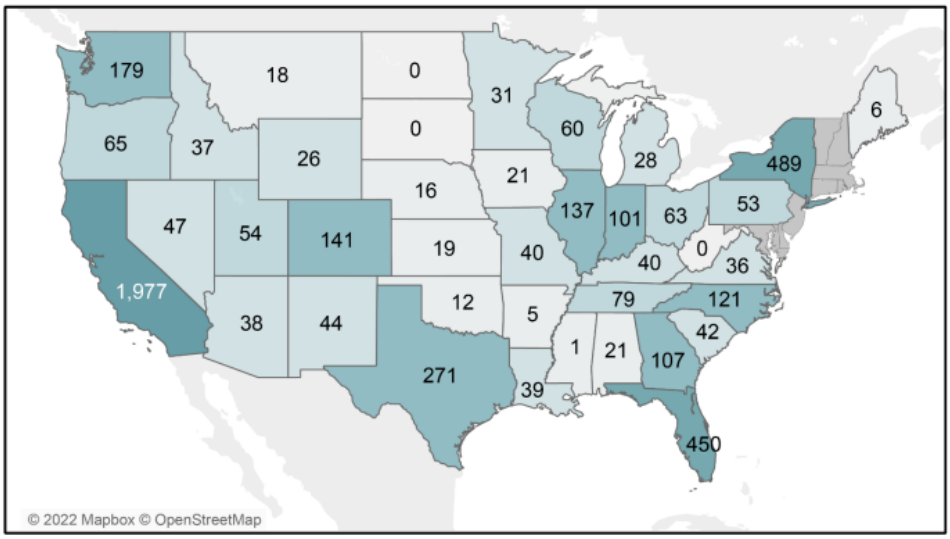

Figure 1. Full-size transit ZEBs operating, funded, ordered, or delivered as of September 2022 (source: calstart.org)

In recent years, the high demand for zero-emission buses has placed strain on OEMs that were also facing supply chain issues and labor shortages; this has led to delayed deliveries and price volatility. The challenges have been compounded by the loss of manufacturers including BYD (a 2020 defense law bars agencies from purchasing their buses with federal grants), Nova Bus (planning to exit the US market), and Proterra (filed for bankruptcy in 2023 and subsequently acquired by Phoenix Motorcars).

As of 2022, the National Transit Database (NTD) reported there were 1,467 active battery-electric buses in the United States and 89 active hydrogen fuel cell electric buses. As shown in Figure 2, the number of active BEBs operating in the US has been increasing rapidly each year. CALSTART reports that even more BEBs (3.6 times as many) were either funded, ordered, or delivered as of 2022. BEBs require charging infrastructure at depots (and sometimes at end-of-line locations), which may use plug-in, overhead pantograph, or inductive charging mechanisms. IndyGo's network already includes six planned locations for inductive on-route charging along its BRT lines.

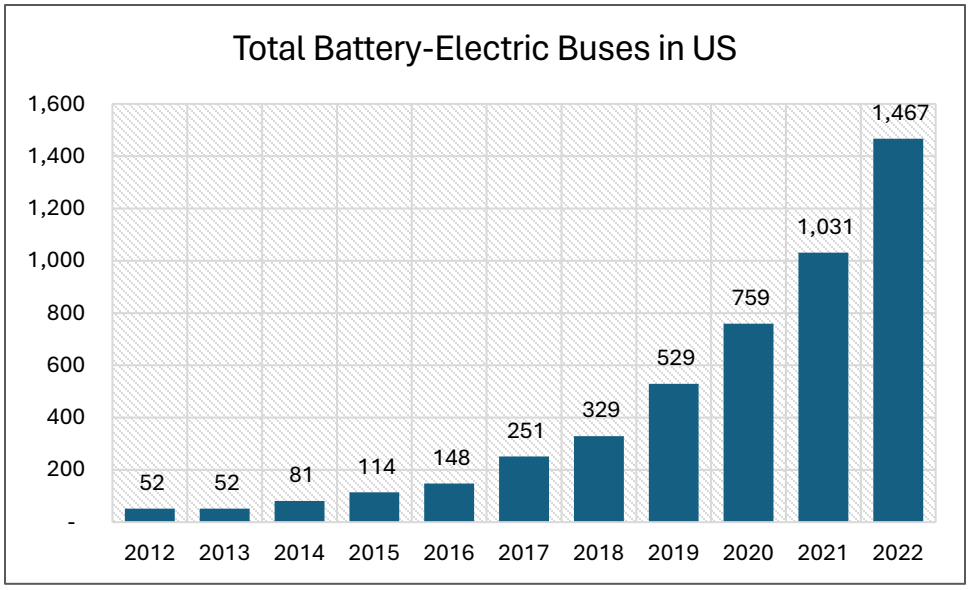

Figure 2. Total BEBs in the United States by year (source: National Transit Database)

While FCEBs are currently much less common than BEBs, these vehicles are seeing increased interest from agencies. FCEBs generally provide longer operating ranges but can require more significant initial improvements to support facilities. Smaller FCEB fleets often are supplied with gaseous hydrogen deliveries, but larger fleets tend to receive liquid hydrogen because it is more efficient for fueling operations, shipping logistics, and onsite storage. Also note that most hydrogen fuel is currently "gray" hydrogen made from natural gas; the fuel supply is expected to become cleaner over time.

IndyGo Experience with ZEVs to Date

IndyGo has been planning for ZEVs and operating them for several years. As an early adopter of BEBs, IndyGo faced some early technology challenges but gained considerable experience,

positioning the agency well to complete its long-term fleet transition. The list below summarizes IndyGo's experience as of early 2024:

- IndyGo is experienced in operating BEBs. From 2015-2021, IndyGo's fleet included 52 BEBs, including both 40' and 60' models. The 40' models were 2001 Gillig diesel buses that were repowered with Complete Coach Works (CCW) ZEPS battery-electric technology. The 60' vehicles are BYD K11 buses used for service on IndyGo's bus rapid transit line, the Red Line.
- IndyGo installed a 1 MW solar array on its headquarters at 1501 West Washington Street to offset the costs for charging its battery-electric buses.
- IndyGo established an EV maintenance team, which maintains IndyGo's fleet of battery-electric vehicles.
- IndyGo modified its main location at 1501 West Washington Street, Indianapolis, IN to charge dozens of battery-electric vehicles at once.
- IndyGo acquired 31 BEBs from BYD for the Red Line, which launched in 2019. The early operations of this service were challenging, as the vehicles did not achieve the operating range that was expected. To improve performance, IndyGo developed two end-of-the-line charging locations for the Red Line that utilize in-ground inductive charging.
- IndyGo acquired a parcel on the east end of the proposed Blue Line route (BRT) to serve as an end-of-line charging location and mobility hub.
- IndyGo acquired the East Campus property on the east side of Indianapolis to house its expanded fleet, including zero-emission vehicles, administrative staff, and a learning development center.
- IndyGo partnered with the OEM Allison Transmission to introduce the eGen Flex transmission into its diesel-hybrids. The sophisticated eGen Flex technology allows for geofencing for electric propulsion in certain areas and can allow a vehicle to run 50% of the time on electric propulsion.
- IndyGo conducted a FCEB pilot in February 2022. This involved operating a 40' New Flyer FCEB for a few days. The purpose of the pilot was for IndyGo staff to understand the safety, maintenance, and operational data of the fuel cell electric bus (FCEB).

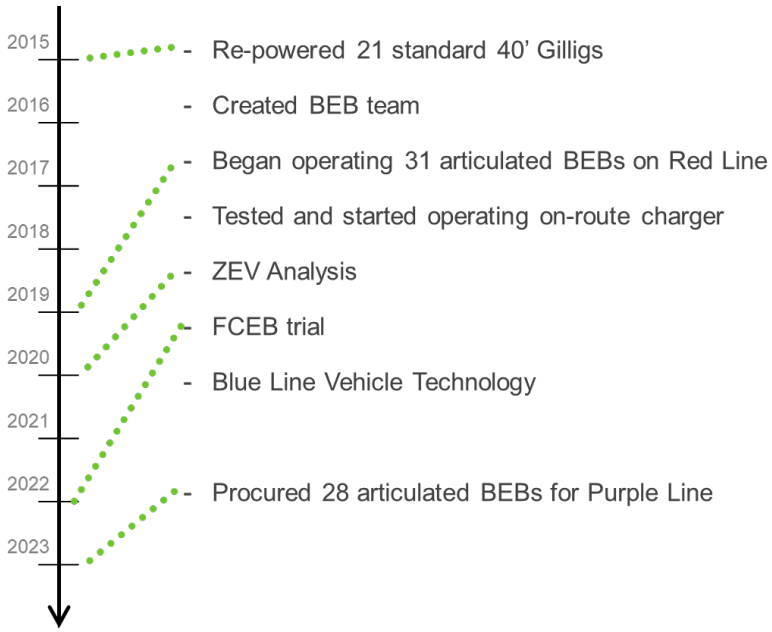

Figure 3. Timeline of IndyGo Experience with ZEBs to Date

Policy and Funding Context

Many transit agencies plan to transition to zero-emission fleets as a result of mandates from state or local governments. IndyGo has no such mandate, and thus has greater flexibility regarding whether to transition its fleets and on what timeline. However, there are still policies that incentivize IndyGo to plan for a fleet transition, such as FTA requiring a Zero-Emission Fleet Transition Plan in order to apply for the significant funding provided by the Bipartisan Infrastructure Law, including grants from the Low or No Emission Program or the Buses and Bus Facilities Competitive Program.

The fleet transition from ICE vehicles to zero-emission vehicles will add significant capital costs compared with business as usual. This is discussed more in Appendix D, with added costs including vehicle purchases, new fueling/charging infrastructure, and other costs. IndyGo will consider existing sources of funds that are used for capital projects, including FTA formula funds, locally generated funds such as property and income taxes, competitive funding opportunities such as FTA Low and No Emissions and FTA Bus and Bus Facilities program, and new sources as they become available.

Most funding sources to support a ZEV fleet transition are unreliable for long-term planning because they are discretionary grants that see competition from across the US. In addition, there is no guarantee that these grant programs will continue to be offered at existing levels beyond the current funding cycle. This is a nationwide challenge for agencies pursuing ZEV fleets. Nonetheless, IndyGo will continue to pursue competitive funding opportunities to offset additional costs. Any additional competitive grants received will allow IndyGo to utilize its existing, identified resources to advance its plans.

Finally, IndyGo advocates for supportive policies using an approach that is both collaborative and comprehensive. At the federal and state levels, IndyGo employs the use of outside government affairs firms to ensure IndyGo stays up-to-date on relevant policy from governing bodies and agencies. IndyGo also conducts routine transportation-focused discussions with the offices of elected representatives to position the agency as a community thought leader in transit-related policy discussions. The agency also has established a leadership role in national ZEV discussions and is well-equipped to work with elected officials to ensure a supportive policy landscape.

IndyGo staff and managers participate in the American Public Transportation Association (APTA) to keep abreast of relevant policy updates and peer agency best practices. Tracking industry trends and policy changes will help IndyGo adapt its transition plans over time. This approach also empowers agency leadership to participate in policy discussions regarding IndyGo's adoption of ZEVs.

Playbook Approach

IndyGo's plan for a transition to ZEVs is presented as a "playbook" in order to convey that it will be a planning process, and implementation decisions will continue to be refined over time. The 15- to 20-year transition period will include facility upgrades that need to be planned years in advance – at

the same time that the ZEV market and the federal policy landscape continue to evolve. The analysis presented in this playbook provides direction for how IndyGo can transition to all zero-emission buses by the year 2040, including next steps for implementation and future decision points.

Future iterations of this playbook can incorporate lessons learned from early deployments, new information on costs and economic trends, changes to the policy landscape, and consideration of additional technology that comes to market during the implementation period.

Preview of Preferred Alternative and Transition Guardrails

The third chapter of this plan summarizes the key takeaways from the technical analysis that was completed as part of this study. It is organized around a set of five scenarios for IndyGo's potential future fleets of buses, paratransit vehicles and non-revenue vehicles. After reviewing the advantages and disadvantages of each scenario, it recommends a scenario in which buses are all battery-electric, non-revenue vehicles are all electric, and paratransit vehicles are electric to the extent feasible operationally.

However, the fourth and final chapter also recommends a set of constraints or "guardrails" on the transition. This means that, at key decision points over the course of the transition, IndyGo should review how conditions have changed with respect to transition costs, technology development, and other factors. These evaluations will confirm whether proceeding with the next stage of the transition is justified, and whether any changed to technology or timeline are needed.

Chapter 3. Transition Scenarios and Preferred Alternative

Scenarios Considered

Five scenarios were developed to compare the various potential approaches that IndyGo could take to its fleets in the future. The first scenario is a baseline that would utilize an ICE/hybrid fleet, but the other scenarios would advance ZEV fleets in different ways. The ZEV scenarios all assume a 2040 deadline for the fleet transition. This is a common target used by other transit agencies, but because IndyGo does not have any requirement to transition its fleet, it could be adjusted over time.[2]

The fleet scenarios address IndyGo's fixed-route bus fleet, paratransit fleet, and non-revenue vehicles. All of the ZEV scenarios apply the same strategies to the paratransit fleet and non-revenue vehicles: Paratransit cutaway vehicles would become 67% EVs, while non-revenue vehicles would become all EVs. This decision was made to reflect levels of operational compatibility with battery-electric vehicles, as there are minimal fuel cell electric options for these vehicle types.

The fleet scenarios apply different approaches to the fixed-route bus fleet. IndyGo could transition to all BEBs, all FCEBs, or a mix of BEBs and FCEBs between its standard 40' buses and its articulated 60' buses. Note that some of these choices would have impacts on the bus fleet size, if operational adjustments to shorten block lengths are needed to ensure compatibility. The complete list of five fleet scenarios is below:

1. ICE/Hybrid Baseline
2. All BEBs
3. All FCEBs
4. 40' FCEBs, 60' BEBs
5. 40' BEBs, 60' FCEBs

The following sections summarize the advantages and disadvantages of each scenario, considering factors such as vehicle compatibility to operate scheduled service, facility upgrade requirements, and projected cost impacts. The detailed information supporting these findings can be found in the appendices to this report.

Scenario 1: ICE/Hybrid Baseline

The baseline scenario that uses ICE and hybrid vehicles may be the easiest path in the near term, but it carries risks for the long term. The advantages of this approach are that it does not require changes to IndyGo's current fleets, facilities, or operations. It also uses technologies that are already demonstrated to meet the agency's operational requirements. Furthermore, it has the lowest total projected cost of the scenarios studied. Scenario 1 saves $208m to $245m in capital

[2] Note that all of these scenarios build upon IndyGo's existing fleet replacement plan, and that ZEVs are only introduced as to replace other vehicles reaching the end of their useful lives.

costs compared with the ZEV scenarios, though the ZEV scenarios are expected to yield an operating cost savings over the life cycle of the vehicle.

The disadvantages of this approach are that IndyGo would not be eliminating the emissions from its fleets, which could lead to negative public perception and reduced opportunities for federal funding. It also would fail to take advantage of the zero-emission investments that IndyGo has already made at 1501 West Washington Street and at on-route charging facilities. In the long term, there is also risk as OEMs transition away from producing and supporting ICE/hybrid vehicles.

Scenario 2: All BEBs

The scenario featuring an all-BEB fleet has key advantages compared with other ZEV scenarios. First, IndyGo is already experienced operating BEBs and could leverage the existing infrastructure investments made at 1501 West Washington Street and at on-route charging facilities. Electricity to charge BEBs is readily available, and its sustainability is improving over time. Bus schedule analysis found a high level of operational compatibility with BEB technology, though modest schedule modifications would likely be needed (for 7% of 40' blocks and 1% of 60' blocks) by the end of the transition. Finally, the operating and capital costs of this scenario are projected to be the lowest of the ZEV options, though the planning-level costs identified in this study may change during more detailed design phases.

There are also disadvantages to an all-BEB fleet. Relatively long charging times (compared to fueling times) do impose constraints on the scheduling of 60' buses, leading to a need for additional vehicles. This also changes the operations of bus garages, requiring charging management systems and practices to ensure buses are properly charged before being deployed into service. Electrical infrastructure investments would also be needed, primarily at the East Campus. 1501 West Washington Street and the Mobility and Customer Care Center have sufficient electrical capacity for full vehicle electrification.

Scenario 3: All FCEBs

The scenario featuring an all-FCEB fleet yields a different set of advantages compared with other ZEV scenarios. FCEBs have short fueling times similar to a diesel bus, thus avoiding the complex impacts to garage operations that BEB charging creates. FCEBs also have longer operating ranges than BEBs – this, combined with the ability to quickly re-deploy FCEBs, minimizes their impacts on fleet size. Bus schedule analysis found a high level of operational compatibility with FCEB technology, with modest schedule modifications needed (for 12% of 40' blocks) by the end of the transition.

The downsides of an all-FCEB fleet are largely related to the less-established nature of the technology. IndyGo only has limited experience with FCEBs, so a learning curve for employees

should be expected. The supply of hydrogen fuel (especially green hydrogen[3]) is currently very limited and costly, though efforts to improve this market are underway. In addition, the facility upgrade needs would be extensive (see Appendix C for details) and would abandon the zero-emission investments that IndyGo has already made at 1501 West Washington Street and at on-route charging facilities. This is one of the reasons that the all-FCEB scenario has the highest projected operating and capital costs of any scenario.

Scenario 4: 40' FCEBs, 60' BEBs

Scenario 4 mixes the BEB and FCEB approaches described in Scenatios 2 and 3. We assume that the 60' BEBs would be based at 1501 West Washington Street (to leverage existing investments) while the 40' FCEBs would be based at the East Campus. In addition to the pros and cons already discussed, a mixed-propulsion fleet could improve resiliency by ensuring the IndyGo has experience with both competing ZEB technologies. However, a mixed fleet also has the downside of reducing IndyGo's flexibility to assign vehicles between facilities, if each garage supports one type of propulsion. This could lead to inefficient deadheads if some vehicles need to be stored far from the routes they operate.

Scenario 5: 40' BEBs, 60' FCEBs

Scenario 5 also mixes the BEB and FCEB approaches described in Scenatios 2 and 3. We assume that the 40' BEBs would be based at 1501 West Washington Street (to leverage existing investments) while the 60' FCEBs would be based at the East Campus. This approach to a mixed fleet may be more strategic because it assigns the higher-range FCEBs to the more operationally challenging 60' vehicle type, which minimizes the need for schedule modifications. As a result, this scenario's projected costs are very close to the lowest ZEV option. Like Scenatio 4, this mixed-propulsion fleet could improve resiliency by ensuring the IndyGo has experience with both competing ZEB technologies. In addition, the downside of reduced flexibility to assign vehicles in a mixed fleet also applies to this scenario.

Preferred Alternative and Rationale

The project team reviewed the advantages and disadvantages of these scenarios in great detail. Table 2 summarizes several of the key considerations that reflect IndyGo's priorities. It characterizes the projected operating costs, capital costs, emissions benefits, facility impacts, and operational impacts for each scenario. (This doesn't include every important consideration, though; factors like staff experience should also be considered.) The table suggests general trends in which the ZEV scenarios are broadly similar, with the most notable differences seen in operating

[3] "Green" hydrogen is produced by using zero-emission electricity to power an electrolyzer.

costs and facility impacts (which are most severe if the Corporate Campus needs to support FCEBs).

Table 2. Comparison of fleet scenarios according to key considerations

Scenario	Projected Operating Costs	Projected Capital Costs	Emissions Benefits	Facility Impacts	Operational Impacts
1. ICE/Hybrid Baseline	Highest	Lowest	Low	Lowest	None
2. All BEB	Lowest	High	High	Medium	Moderate
3. All FCEB	Medium	Highest	High	Highest	Moderate
4. 40' FCEBs, 60' BEBs	Medium	High	High	Medium	Moderate
5. 40' BEBs, 60' FCEBs	Low	High	High	Medium	Moderate

Based on the review of these scenarios, the IndyGo project team recommends Scenario 2: All BEBs as the preferred alternative. This decision represents a continuation of IndyGo's existing experience with and investment in BEB technology. It also reflects a sensitivity to the cost of the transition, as this scenario is projected to be the lowest-cost ZEV option overall. Pursuing an all-BEB fleet will address emissions concerns while minimizing technology risk.

Utility/Fuel Partnership

IndyGo has a longstanding relationship with its electric utility, AES Indiana. (IndyGo also works with Citizens Energy regarding water, sewer, and gas utilities.) Because IndyGo's preferred fleet scenario would use all BEBs, we anticipate continued collaboration with AES Indiana to secure necessary charging capacity and supportive infrastructure/equipment at relevant facilities.

IndyGo deployed its first battery-electric buses in 2015, and thus has been working in partnership with AES Indiana for years to successfully deploy BEB technology. Through that process, IndyGo and AES have developed a strong working relationship that extends beyond the typical commercial industrial user/utility relationship to include thought leadership as it relates to adoption of an electric fleet. IndyGo has been and remains in conversation with its Account Representative and the Consumer Programs (electric fleet adoption) to ensure that all parties are aware of emerging technologies, governmental polices and organizational capacities and plans.

AES Indiana is an active partner in IndyGo's expansion planning, including facilities, infrastructure, charging capacity and overall electrical load reliability. These expansions include BRT line implementation, on-route charging facilities, the new East Campus operations facility, and the paratransit facility. IndyGo also has worked closely with AES Indiana regarding solar arrays – both setting up and metering the existing solar array at 1501 West Washington Street and preparing for another solar array at the new East Campus.

As the ZEVTP is implemented, IndyGo and AES Indiana will continue their existing partnership to support the deployment of ZEVs. While the preferred fleet transition scenario does not involve hydrogen fuel, IndyGo staff are monitoring the development of the hydrogen fuel market and would be prepared to partner with fuel providers if needed in the future.

Chapter 4. Implementation Plan

Conditions on the Transition

While IndyGo anticipates important benefits from a ZEV fleet transition, its commitment to this transition is not open-ended. The approach recommended in this plan is for IndyGo to revisit its fleet strategies at key future decision points – to confirm that the benefits of the transition continue to justify the costs, and to consider whether any changes to technology or timeline are needed.

Providing this flexibility is important given the uncertainty around several key topics. First, the ZEV industry is changing rapidly, and it is possible that technology advances faster or slower than projected. The pricing of ZEVs and support equipment is also rather uncertain; at one point prices were expected to decline as the industry grew, but in recent years prices have been volatile (and even rising) as OEMs struggle to meet demand.[4] There are also uncertainties related to general economic conditions and federal policy. Finally, IndyGo is not constrained by any mandate to transition its fleet by a certain deadline.

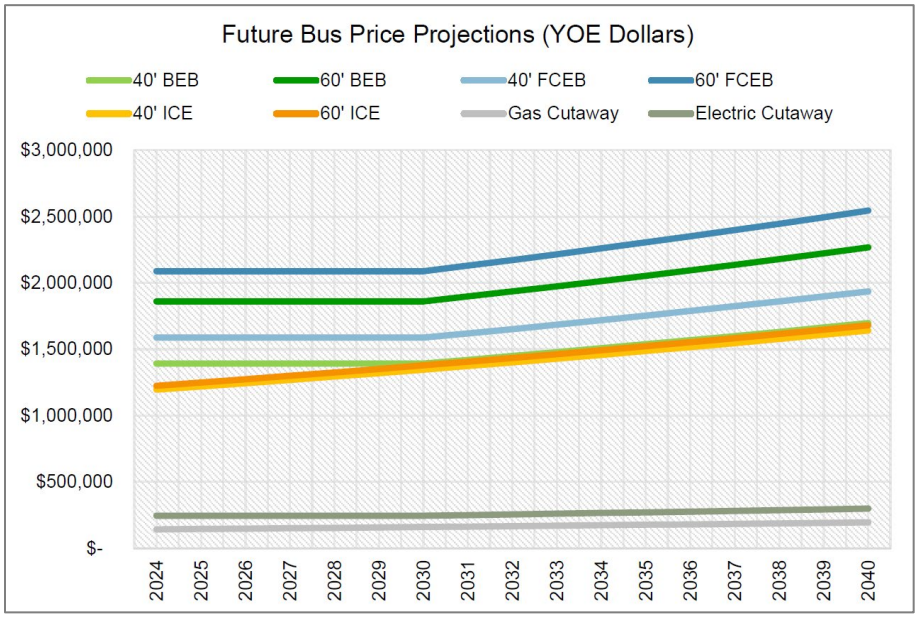

Figure 4. Bus price projections utilized in Appendix D Cost and Emissions Projections

[4] The APTA Bus Manufacturing Task Force published recommendations to better protect support OEMs in January 2024: https://www.apta.com/bus-manufacturing-task-force-recommendations/

It is recommended that IndyGo consider a set of conditions or "guardrails" when assessing its transition strategy at key decision points. These should focus on financial and operational criteria to confirm whether proceeding with the next stage of the transition is justified:[5]

- **Transition costs** must not impact IndyGo's ability to maintain transit service levels. Increased capital costs related to vehicles and facility upgrades should only be accepted so long as IndyGo can defray costs through grant funding, operating cost savings, or can otherwise absorb the cost without impact to service levels.
- ZEV **technology development** must keep pace with the projections in this plan, such that operational compatibility and reliability do not obstruct the transition. This will also minimize the need for fleet size increases. IndyGo should consider technology factors such as battery capacity, operating range, and cold-weather performance. Appendix B describes three levels of BEB technologies, from current technology to significantly improved technology. The improved operational characteristics are expected to become necessary in the later years of IndyGo's transition.

Timeline of Decision Points & Milestones

The recommended fleet transition timeline includes four key decision points when facility investment decisions would need to be made to support different fleets. There are distinct key decision points identified for 40' buses, 60' buses, paratransit cutaway vehicles, and non-revenue vehicles. The guardrails described above should be considered at these points, as well as when making significant ZEB purchases.

The timeline in Figure 5 shows when decision points and other milestones are expected for each IndyGo fleet. This was developed based on IndyGo's fleet replacement plans and the target of a 2040 transition; Figure 6 shows the transition of the fleet makeup anticipated in the recommended scenario. The timeline assumes that facility upgrades require four years of lead time to design and implement improvements and support equipment. It also assumes that vehicle procurements need at least two years of lead time. Note that the cutaway fleet and non-revenue vehicles have greater flexibility for implementation before the 2040 transition goal, due to having shorter vehicle replacement cycles.

[5] IndyGo staff are generally neutral on whether the preferred scenario will ultimately adhere to our guardrails, based on poll results during the Recommendations Workshop. On average, staff feel that ZEV technology may not be quite ready today but will be soon. Thus, it will be crucial to track future industry developments.

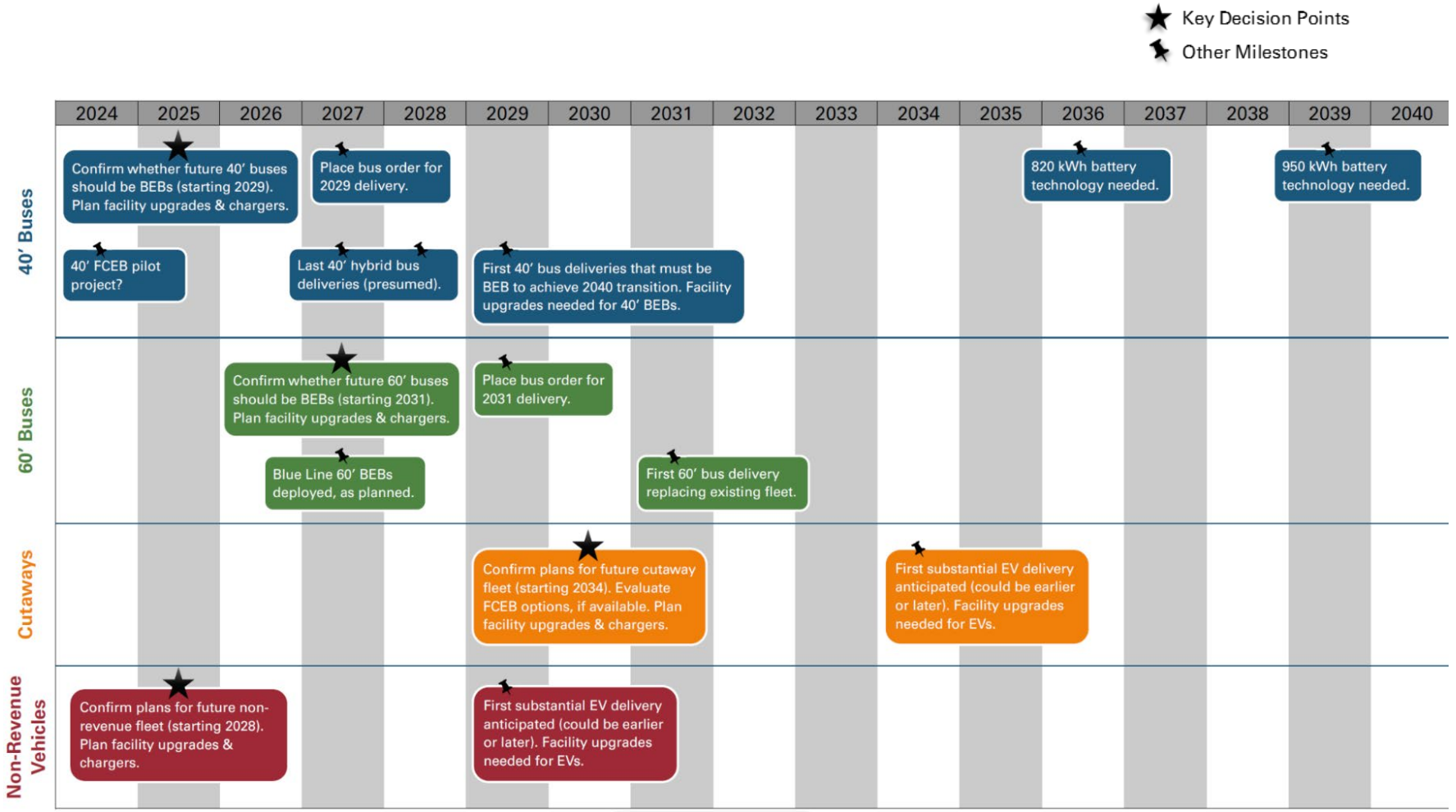

Figure 5. Draft Timeline of Decision Points and Milestones for IndyGo Fleet Transition

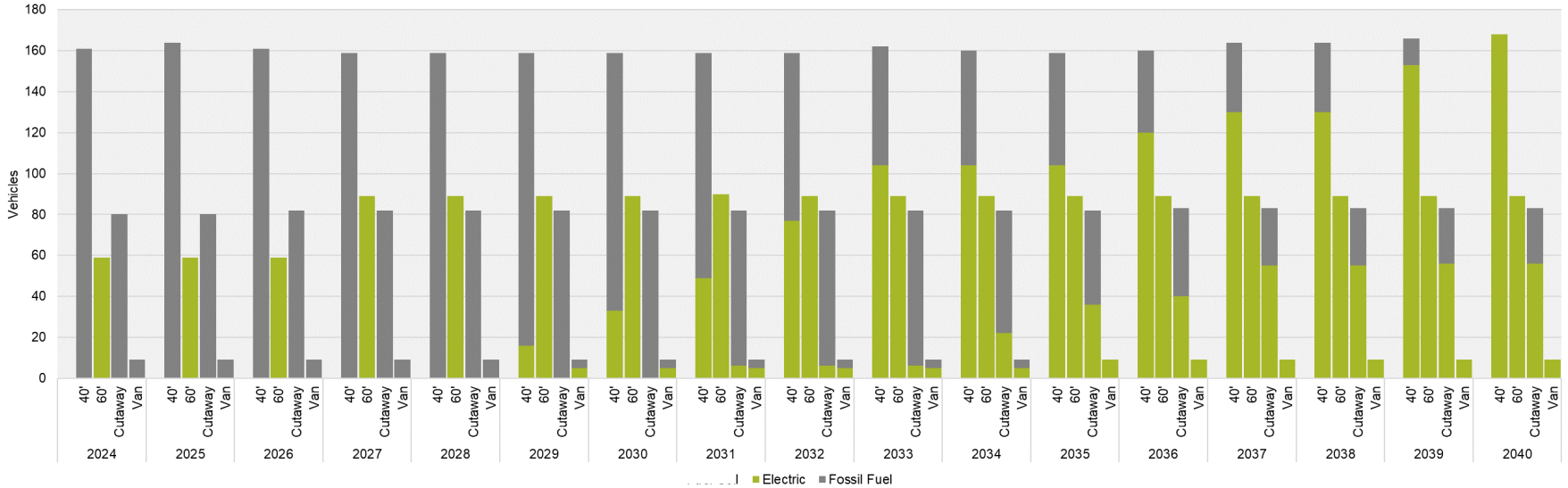

Figure 6. Graph of the fleet transition plan for the preferred fleet scenario

The following list highlights the decision points and other milestones that are anticipated in the near term (2024-2028):

2024

- A 40' FCEB pilot project could potentially be valuable to better inform decisions regarding the 40' bus fleet. However, the time window to develop this project is quite limited.

2025

- Confirm whether future 40' buses should be BEBs (starting in 2029). Plan facility upgrades and chargers.
- Confirm plans for future non-revenue fleet (starting in 2029). Plan facility upgrades and chargers. While current EVs would be suitable for the entire non-revenue fleet, this decision could also be postponed given the shorter lifetimes of these vehicles, while still adhering to the 2040 transition goal.

2027

- Place 40' bus order for 2029 delivery.
- Last 40' hybrid bus deliveries (presumed).
- Confirm whether future 60' buses should be BEBs (starting in 2031). Plan facility upgrades & chargers. The decision point for the 60' fleet comes later than the 40' fleet because 60' BEB purchases are already committed up to this point.
- Blue Line 60' BEBs deployed, as currently planned.

2028

- Last 40' hybrid bus deliveries (presumed).

Next Steps and Future Updates

This plan documents IndyGo's strategic framework for transitioning its buses, paratransit vehicles, and non-revenue vehicles to ZEVs. However, it will take a sustained agency-wide effort over the coming years to achieve the vision of a ZEV fleet. Below are several specific next steps that IndyGo should take to advance its transition plans.

Make fleet and facility decisions at key decision points. In the coming years, IndyGo will need to make key decisions about future fleet propulsion and supportive facility upgrades. The timeline in the prior section shows a decision for 40' buses being made in 2025 and a decision for 60' buses being made in 2027. Agency leadership should review the recommended conditions or "guardrails" on the fleet transition and identify any outstanding questions that need to be addressed before proceeding with facility upgrades.

To support these decisions, IndyGo should continue monitoring ZEV technology performance and costs. Tracking these trends will indicate whether technology is keeping pace with projections and whether transition costs are acceptable. Similarly, IndyGo should be prepared to adjust its plans as

operations change, as will occur when the Blue Line launches or when the East Campus begins operating as a bus depot. These changes could influence fleet sizes and energy requirements.

Continue seeking capital funding. Investments in ZEVs and support facility upgrades will require significant new capital funding. IndyGo must aggressively pursue a range of grant programs, from the federal government and other sources, to meet its capital needs. To the extent that capital funding is insufficient to cover the added costs of the fleet transition, this could result in delays or reductions in the scope of the transition. In the near term, IndyGo's capital investments for the fleet transition should continue prioritizing the facility design work and upgrades needed to support ZEVs at the East Campus, as electrical capacity upgrades at the Corporate Campus are already complete.

Continue building staff capacity around ZEV topics. Transitioning to ZEVs will impact nearly every aspect of IndyGo's operations, from scheduling to maintenance to budgeting. Not all of the impacts will be dramatic, but it will be important for staff to understand how the transition impacts their work. For staff already receiving ZEV training, such as operators and maintenance personnel, this should focus on keeping up-to-date on evolving practices, capabilities, and safety procedures. For staff involved in strategic decision-making, this should focus on the evolution of the ZEV industry and relevant policy, leveraging the experience of peer agencies and transit industry groups.

The IndyGo Zero-Emission Vehicle Transition Plan has been informed by careful analysis of vehicle technologies, operational compatibility, facility requirements, cost impacts, and workforce needs. This has facilitated a comparison of the tradeoffs related to several potential future fleet scenarios, and the recommendation of the all-BEB scenario as most feasible. While the ZEV industry is sure to continue growing and changing in the coming years, the strategic framework in this plan should give IndyGo the tools to advance its transition in line with its priorities.