BLOOMINGTON • MONROE COUNTY

POLICY COMMITTEE

Meeting Agenda
September 9, 2022
1:30 – 3:00 p.m.
City Hall Council Chambers
Hybrid Meeting Location via Zoom:
Join Zoom Meeting
https://bloomington.zoom.us/j/84188592548?pwd=VVRudTh3a3hZc0pZMnArWnF3c1h0Zz09
Meeting ID: 841 8859 2548
Passcode: 569936
One tap mobile: +13126266799,,84188592548# US (Chicago)
Dial by your location: +1 312 626 6799 US (Chicago)
Find your local number: https://bloomington.zoom.us/u/kktMho5DN

Clicking on the link will take you to the meeting. You will automatically receive a dial-in number if you want to use your phone for audio and not your computer microphone.

I. Call to Order and Introductions

II. Approval of the Agenda*

III. Approval of the Minutes*
   a. August 12, 2022

IV. Communications from the Chair

V. Reports from Officers and/or Committees
   a. Technical Advisory Committee
   b. Citizens Advisory Committee

VI. Reports from the MPO Staff

VII. Old Business
   a. FY 2022 - 2026 TIP Amendments
      (1) Rural Transit
         (a) DES# TBD - Four (4) Cameras with DVR Systems for Ten (10) Rural Transit Vehicles
      (2) Monroe County
         (a) DES# 1702957 - Vernal Pike Connector Road - FY 2023 Construction Engineering
         (b) DES# 1802977 - Fullerton Pike, Phase III - FY 2023 Right-of-Way Acquisition
      (3) City of Bloomington
         (a) DES# 2200020 - High Street Intersection Modernizations and Multiuse Path

VIII. New Business

a. Bloomington Transit Alternative Fuels and Infrastructure Assessment Study
b. GO Bloomington Transportation Demand Management

IX. Public Comment on Matters Not Included on the Agenda *(non-voting items)*
Limited to five minutes per speaker. The Committee may reduce time limits if numerous people wish to speak.

X. Communications from Committee Members on Matters Not Included on the Agenda *(non- voting items)*

a. Communications
   (1) SR45 Corridor DES #1800199 and DES #1800086 Timeline
b. Topic Suggestions for Future Agendas

XI. Upcoming Meetings

a. Technical Advisory Committee - September 28, 2022 at 10:00 a.m. (Hybrid)
b. Citizens Advisory Committee - September 28, 2022 at 6:30 p.m. (Hybrid)
c. Policy Committee - September 9, 2022 at 1:30 p.m. (Hybrid)

XII. Adjournment

**Action Requested / Public comment prior to vote limited to five minutes per speaker. (The Committee may reduce time limits if numerous people wish to speak).*

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BLOOMINGTON • MONROE COUNTY **mpo**

POLICY COMMITTEE
Meeting Minutes
August 12, 2022
1:30 - 3:00 p.m.
Hybrid Meeting - City of Bloomington Council Chambers (#115)

Policy Committee Present: Jason Banach, Nate Nickel (proxy), Jillian Kinzie, Chris Wahlman, (proxy), Doug Horn, Andrew Cibor (proxy), Lisa Ridge, Julie Thomas, Margaret Clements, Sarah Ryterband, Pam Samples, Steve Volan, Kate Wiltz

Staff present: Pat Martin, Ryan Clemens

I. Call to Order by Steve Volan and Introductions.

II. Approval of the Agenda*
**** Steve Volan requested a voice vote for acceptance given all Policy Committee members were present. Motion carried by a unanimous voice vote 12:0 - Approved.**

III. Approval of the Minutes*
a. June 10, 2022.
Sarah Ryterband noted a correction of the minutes. ****Jillian Kinzie motioned to approve the meeting minutes as corrected. Lisa Ridge seconded. Motion carried by roll call vote 12:0 - Approved.**

IV. Communications from the Chair
a. Steve Volan welcomed the entire Committee.

Wiltz joined the meeting.

V. Reports from Officers and/or Committees
a. Technical Advisory Committee (TAC)
(1) Nate Nickel reported the TAC met on the morning of August 12th and recommended approval of FY 2022-2026 TIP Amendments for Rural Transit, Monroe County, and the City of Bloomington.
b. Citizens Advisory Committee (CAC)
(1) Sarah Ryterband reported the CAC met on August 10th and recommended fiscal constraint approval of the FY 2022-2026 TIP Amendments for Rural Transit, Monroe County, and the City of Bloomington. The CAC additionally recommended a text modification of the BMCMPO Public Participation Plan (PPP).

VI. Reports from the MPO Staff
a. FY 2023-2024 Unified Planning Work Program (UPWP)
(1) Staff reported on FHWA approval of the UPWP with stated federal planning emphasis areas, the programmed budget, and a special allocation of planning funds for a Bloomington Transit Strategic Plan. Work began on July 1, 2022.
b. FY 2022-2026 Transportation Improvement Program (TIP) - FY 2022 Fund Balance

(1) Staff referenced a meeting packet page showing the BMCMPO's 100% expenditure of all allocated funds within FY 2022 ending on June 30, 2022. INDOT additionally allocated $983,997 of Infrastructure Investment & Jobs Act (IIJA) funds at the end of the fiscal year that are available for programming until September 30, 2022. The staff subsequently issued an "IIJA Call for Projects". Today's meeting agenda seeks TIP Amendment approval of the IIJA applications received from Rural Transit, Monroe County, and the City of Bloomington. Discussion ensued.

c. SR 48 Speed Limit Improvement

(1) Ryan Clemens reported on the discovery of an unusual multiyear crash history on SR 48 west of the Monroe County, his analysis, reporting to INDOT, and an INDOT engineering investigation that will lead to a 10-mile per hour speed limit reduction along the corridor (55 MPH to 45 MPH) from SR 43 to S Cave Road. This action coupled with additional advisory signage will probably lead to safer motorist operation through the corridor. Discussion ensued.

d. INDOT FY 2023 Target Setting Draft V5 5.16

(1) Staff presented INDOT's Draft Crash Targets with the observation that fatalities and suspected serious injuries have increased with a statewide economic recovery. Discussion ensued.

e. CY 2021 INDOT Public Transit Annual Report

(1) Staff reported on the posting of the report by INDOT's Office of Transit and a modest recovery of annual ridership by Bloomington Transit.

f. INDOT Electric Vehicle Infrastructure Deployment Plan Available for Review and Public Comment

(1) Staff noted the official posting of INDOT's draft plan, the opportunity for public comment, and a finalization schedule calling for FHWA approval by September 30, 2022. Kate Wiltz noted the absence of Americans with Disabilities ADA (ADA) references within the plan. Staff encouraged the submission of this fact to INDOT. Discussion ensued.

VII. Old Business

a. FY 2020 - 2024 TIP Amendment / FY 2022 - 2026 TIP Amendment*

(1) Ryan Clemens presented DES# 2200146 - Eagleson Avenue Bridge over the Indiana Rail Road sponsored by Indiana University. Discussion ensued. ****Lisa Ridge motioned for approval. Julie Thomas seconded. Motion carried by a roll call vote 13:0 - Approved.**

VIII. New Business

(1) FY 2022 - 2026 TIP Amendments*

(a) Rural Transit DES#TBD - Four Cameras with DVR Systems for Ten Rural Transit Vehicles - FY2022 Additional IIJA funds programmed for use in FY2023 totaling **$7,600.00**.

(b) DES# 1702957 - Venal Pike Connector Road - Construction Engineering - FY2022 Additional IIJA funds programmed for use in FY2023 totaling **$277,232.00.**

(c) DES# 1802977 - Fullerton Pike Phase III - Right-of-Way Acquisition - FY2022 Additional IIJA funds programmed for use in FY2023 totaling **$210,967.00**.

(d) DES# 2200020 - High Street Intersection Modernization and Multiuse Path - FY2022 Additional IIJA funds programmed for use in FY2023 totaling **$488.198.00**.

Staff noted the availability of BMCMPO IIJA program funds totaling $983,997 that must achieve INDOT program, purchase order, and/or FTA-Flex approval by September 30, 2022. The BMCMPO *Call for IIJA Projects* issued on July 13, 2022 resulted in project amendment applications from Rural Transit, Monroe County, and the City of Bloomington. Due to all amendment applications received totaling over the amount of total IIJA program funds for the BMCMPO, discussion ensued as to how to best allocate the funds among the four project applications. Rural Transit submitted an IIJA program funding request totaling $7,600, which the Committee agreed that they will receive the total amount applied for. The Committee agreed that Monroe County and the City of Bloomington will split the remaining funds equally by Local Public Agency for this round of funding. The total funding for the three projects is as follows: Fullerton Pike Phase III (Des# 1802977) FY 2023 right-of-way acquisition - $210,967; Vernal Pike Connector Road (Des# 1702957) FY 2023 construction engineering - $277,232; and High Street Intersection Modernization and Multiuse Path (Des# 2200020) FY 2023 preliminary engineering - $488,198. All applications in a sum total of $983,997.00 meet a fiscal constraint requirement of available IIJA funds. ****Sarah Ryterband moved to approve the FY 2022-2026 TIP amendments with the understanding that the staff will receive applications for the agreed split of IIJA funds by August 15th. Jillian Kinzie seconded. Motion carried by a roll call vote 13:0 - Approved.**

IX. Public Comment on Matters Not Included on the Agenda (non-voting items)
   a. None

X. Communications from Committee Members and Topics for Future Agendas (non-agenda items)
   a. Communications
      (1) Sarah Ryterband noted a text modification approved by the Citizens Advisory Committee (CAC) of the BMCMPO within the Public Participation Plan (PPP) regarding Public Meetings and Workshops. The text presented was as follows: "The MPO will try to hold these meetings at various locations throughout the urbanized area *and to enable remote participation when members of the public cannot attend in person*. The purpose of these workshops will be to support development and public review of the Long Range Transportation Plan. The MPO will also conduct 1-2 rounds of interagency coordination workshops, timed to coincide with the preparation for annual development of the Transportation Improvement Program (TIP). This coordination will provide the technical support needed in the preparation of the TIP for public comment and review through the Committee Meeting process." The Technical Advisory Committee (TAC) and Policy Committee will consider this text modification for adoption at their upcoming meetings.
      (2) Chris Wahlman noted that Jeffersonville will host the 2022 Indiana MPO Conference from October 4th - 6th.

(3) Julie Thomas reported on correspondence with INDOT regarding a modification of the programmed SR 45 corridor project (SR 45/46 Bypass to Smith Road) schedule and draft design considerations. Discussion ensued. INDOT will seek public comment and schedule a project public hearing later this calendar year.

b. Topics for Future Agendas
   (1) INDOT report on SR 45 corridor

XI. Upcoming Meetings
   a. Policy Committee - September 9, 2022 at 1:30 p.m. (Hybrid)
   b. Technical Advisory Committee - September 28, 2022 at 10:00 a.m. (Hybrid)
   c. Citizens Advisory Committee - September 28, 2022 at 6:30 p.m. (Hybrid)

XII. Adjournment*
   a. **** Sarah Ryterband motioned to adjourn the meeting. The Committee seconded. Motion carried.**

**Action Requested / Public comment prior to vote (limited to five minutes per speaker).*

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Meeting Recording:
https://catstv.net/government.php?issearch=banner&webquery=Policy+Committee
https://catstv.net/m.php?q=11543

Project List FY 2022-2026

RURAL TRANSIT

Rural Transit Operation Assistance [BLO-22-010 (1802840), BLO-23-010 (1802841), BLO-24-010 (1802842), BLO-25-010 (1802843), BLO-26-010 (1802844)]						
Funding Source	**2022**	**2023**	**2024**	**2025**	**2026**	**Total***
5311	$875,524	$910,545	$946,967	$984,845	$1,024,239	$4,742,120
Local Match & PMTF	$312,096	$324,579	$337,563	$351,065	$365,108	$1,690,411
Local Fares & In-Kind	$563,428	$585,965	$609,403	$633,780	$659,131	$3,051,707
Totals	$1,751,048	$1,821,089	$1,893,933	$1,969,690	$2,048,478	$9,484,238
*Estimated Total Project Cost (23 CFR 450.218(i)(2); 23 CFR 450.326(g)(2))						

Four Cameras with DVR Systems for ten Rural Transit Vehicles [Des#: TBD]						
Funding Source	**2022**	**2023**	**2024**	**2025**	**2026**	**Total***
IIJA		$7,600				$7,600
Local Match		$1,900				$1,900
Totals	$0	$9,500	$0	$0	$0	$9,500
*Estimated Total Project Cost (23 CFR 450.218(i)(2); 23 CFR 450.326(g)(2))						

FY 2022-2026 Project List

MONROE COUNTY

Bicentennial Pathway Project, Phase 1 [0902215]					
Project Phase	**Fiscal Year**	**Federal Source**	**Federal Funding**	**Local Match**	**Total***
CE	2022	TAP (TE)	$231,200	$57,800	$289,000
CN	2022	TAP (TE)	$1,539,200	$384,800	$1,924,000
Totals			$1,770,400	$442,600	$2,213,000
*Estimated Total Project Cost (23 CFR 450.218(i)(2); 23 CFR 450.326(g)(2))					

Vernal Pike Connector Road [1702957]					
Project Phase	**Fiscal Year**	**Federal Source**	**Federal Funding**	**Local Match**	**Total***
RW	2022	Local		$2,000,000	$2,000,000
CE	2023	Group III Program	$814,350	$199,919	$1,291,501
		IIJA	$277,232		
CN	2023	Group III Program	$5,134,550	$2,230,320	$7,364,870
Totals			$6,226,132	$4,430,239	$10,656,371
*Estimated Total Project Cost (23 CFR 450.218(i)(2); 23 CFR 450.326(g)(2))					

Vernal Pike Connector Road Extension - Bridge [1900406]					
Project Phase	**Fiscal Year**	**Federal Source**	**Federal Funding**	**Local Match**	**Total***
PE	2022	Local		$10,000	$10,000
CE	2023	Group III Program	$73,650	$270,705	$344,355
CN	2023	Group III Program	$1,065,450	$1,480,250	$2,545,700
Totals			$1,139,100	$1,760,955	$2,900,055
*Estimated Total Project Cost (23 CFR 450.218(i)(2); 23 CFR 450.326(g)(2))					

Fullerton Pike/Gordon Pike/Rhorer Road, Phase III [1802977]					
Project Phase	Fiscal Year	Federal Source	Federal Funding	Local Match	Total*
PE	2022	Local		$377,000	$377,000
	2023	Local		$100,000	$100,000
	2024	Local		$10,000	$10,000
RW	2023	STP	$421,934	$286,266	$919,167
		IIJA	$210,967		
CE	2024	Local		$1,500,000	$1,500,000
CN	2024	STP	$2,750,133	$12,125,485	$14,875,618
Totals			$3,383,034	$14,398,751	$17,781,785
*Estimated Total Project Cost (23 CFR 450.218(i)(2); 23 CFR 450.326(g)(2))					

Fullerton Pike, Phase III Bridge [2001721] (Kinned with 1802977)					
Project Phase	Fiscal Year	Federal Source	Federal Funding	Local Match	Total
		BR			

Karst Farm Greenway - Connector Trail [1900405]					
Project Phase	Fiscal Year	Federal Source	Federal Funding	Local Match	Total*
PE	2022	Local		$213,400	$213,400
RW	2023	Local		$270,000	$270,000
CE	2024	Local		$114,000	$114,000
CN	2024	TAP	$155,801	$758,199	$914,000
Totals			$155,801	$1,355,599	$1,511,400
*Estimated Total Project Cost (23 CFR 450.218(i)(2); 23 CFR 450.326(g)(2))					

Pedestrian Trail Crossing Improvements [1900493]					
Project Phase	Fiscal Year	Federal Source	Federal Funding	Local Match	Total*
PE	2022	Local		$20,000	$20,000
CN	2024	HSIP	$88,184	$9,800	$97,984
Totals			$88,184	$29,800	$117,984
*Estimated Total Project Cost (23 CFR 450.218(i)(2); 23 CFR 450.326(g)(2))					

Crosswalk Safety Improvements Project (FY25) [2200014]					
Project Phase	Fiscal Year	Federal Source	Federal Funding	Local Match	Total*
PE	2023	Section 164	$70,571	$29,429	$100,000
CE	2025	HSIP	$66,255	$7,745	$74,000
CN	2025	HSIP	$364,540	$55,000	$419,540
CN	2025	Section 164	$110,460		$110,460
Totals			$611,826	$92,174	$704,000
*Estimated Total Project Cost (23 CFR 450.218(i)(2); 23 CFR 450.326(g)(2))					

Downtown Curb Ramps Phase 3 [1900403]					
Project Phase	Fiscal Year	Federal Source	Federal Funding	Local Match	Total*
CE	2023	HSIP	$61,393	$6,822	$68,215
CN	2023	HSIP	$369,402	$45,477	$414,879
		Section 164	$39,889		$39,889
Totals			$470,684	$52,299	$522,983
*Estimated Total Project Cost (23 CFR 450.218(i)(2); 23 CFR 450.326(g)(2))					

Downtown Curb Ramps Phase 4 [2200021]					
Project Phase	Fiscal Year	Federal Source	Federal Funding	Local Match	Total*
PE	2024	Section 164	$110,460	$4,540	$115,000
CE	2026	HSIP	$66,255	$7,745	$74,000
CN	2026	HSIP	$364,540	$55,000	$419,540
CN		Section 164	$110,460		$110,460
Totals			$651,715	$67,285	$719,000
*Estimated Total Project Cost (23 CFR 450.218(i)(2); 23 CFR 450.326(g)(2))					

High Street Intersection Modernizations and Multiuse Path [2200020]					
Project Phase	Fiscal Year	Federal Source	Federal Funding	Local Match	Total*
PE	2023	IIJA	$488,198	$311,802	$800,000
RW	2024	STP	$242,110	$857,890	$1,100,000
CE	2026	Local		$640,000	$640,000
CN	2026	STP	$2,992,243	$2,638,244	$5,800,000
CN	2026	TAP	$169,513		
Totals			$3,892,064	$4,447,936	$8,340,000
*Estimated Total Project Cost (23 CFR 450.218(i)(2); 23 CFR 450.326(g)(2))					

ALTERNATIVE FUELS AND INFRASTRUCTURE ASSESSMENT STUDY

Prepared by: WSP
Presented: June 22th, 2022

Agenda

INTRODUCTION

BACKGROUND

Objective

Building upon initial Feasibility analysis and comparison study of three alternative fuel bus technologies:

1. Compressed Natural Gas (Omitted from deep-dive analysis)
2. **Battery-Electric**
3. **Hydrogen Fuel Cell**

BPTC Fleet Summary

- 42 buses
- Peak vehicle requirement of 29 buses
- 30', 35', and 40' low floor buses (fixed route)
- Two battery-electric, 35’ BEBs and chargers
- Funding for 8 additional BEBs and charging stations
- Planning to expand up to 8 60’ buses
- Long-term plan to expand 10 additional 40’ BEBs

Facility Background

- Facility is **shared with University Campus** Bus service
- The University owns the land
- BPTC owns the facilities and structures
- Site is near capacity
- **Adjacent land available to be purchased**

Initial Analysis Results Summary

Metric	CNG	BEB	FCEB		
			Delivered Liquid	On-site Production	
				SMR	Electrolysis
Vehicle Range	✓				
Physical Space Requirements	✓	✓	✓		
Fueling/Charging Time			✓	✓	✓
Fuel Availability		✓		✓	✓
Energy Requirements	✓		✓		
Lifecycle GHG Emissions		✓			
Tailpipe Emissions		✓	✓	✓	✓
Community Acceptance		✓			
Vehicle Cost	✓				
Infrastructure Capital Costs***	✓	✓	✓		
O&M Costs	✓				
Financial Incentives		✓	✓	✓	✓
No Fatal Flaws	✓	✓	✓	✓	✓

TECHNOLOGY DEEPER DIVE

UPDATES TO THE PREVIOUS REPORT

Battery-Electric Bus

- Bus Size-Specific Efficiency (Based on Pilot Data)
- Typical and Conservative Scenarios
- Near, Mid, and Long-Term Energy Needs
- 100% ZE Fleet Strategies

Fuel Cell Electric Truck

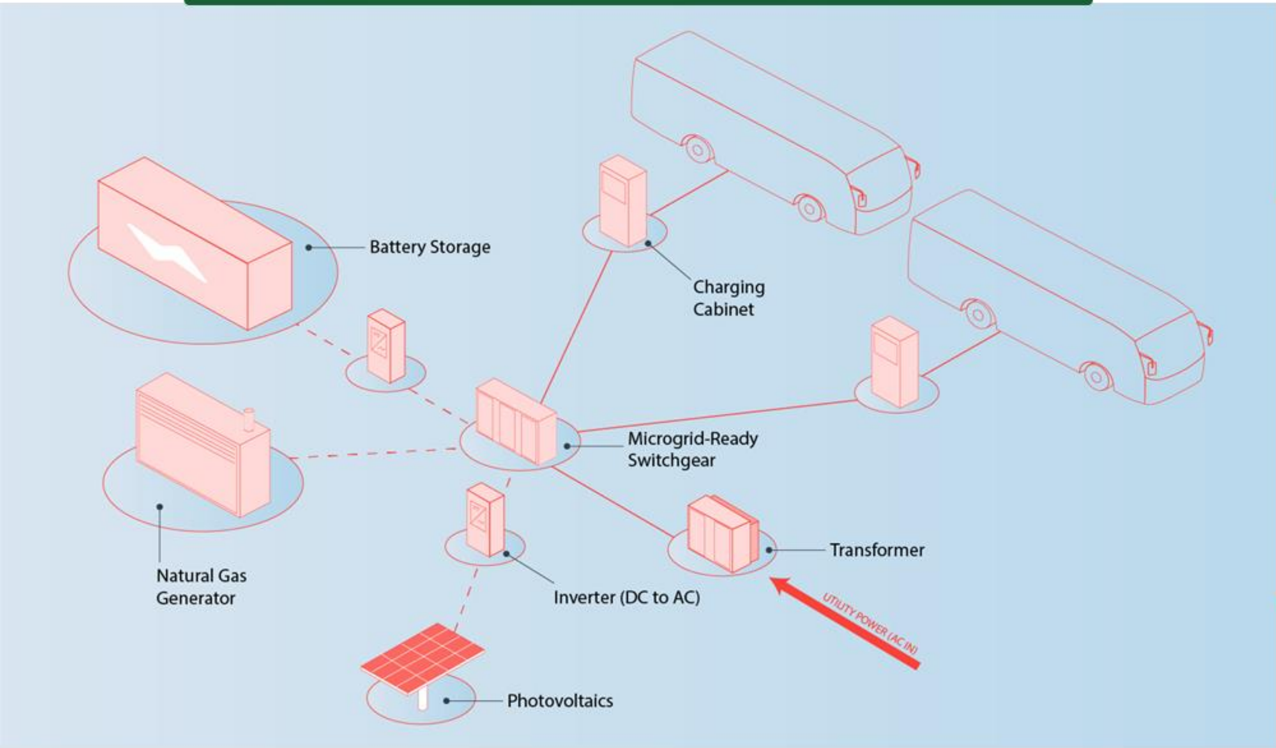
- Bus to Block Assignments
- Altoona based Central Business District (CBD), and Arterial (ART) efficiencies
- Updated Daily Fuel Requirements

Cost Analysis

- Refined Infrastructure Cost Estimates
- Refined Fuel Cost Estimates
- Lifecycle Cost Estimates

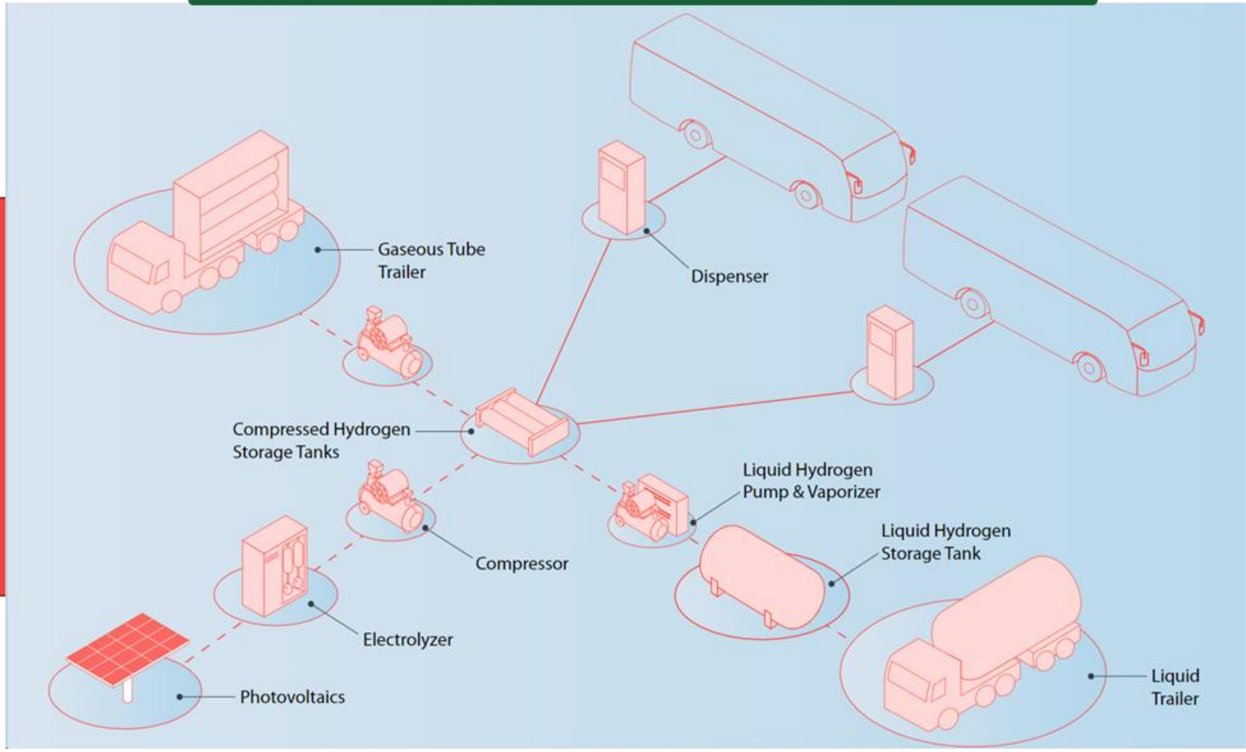
FUEL/TECHNOLOGIES

Battery-Electric Bus (BEB) System



- Electric Vehicle
- Zero Tailpipe Emissions
- Long Refuel Time
- Short Range
- More Efficient
- Less Well-to-Wheel Emissions

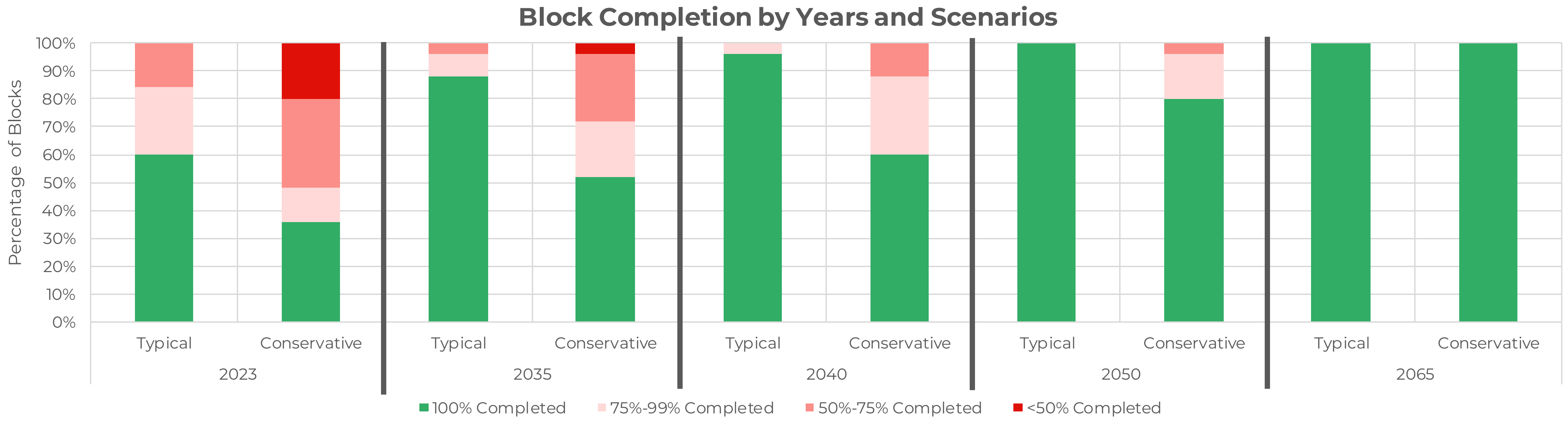
Fuel Cell Electric Bus (FCEB) System



- Electric Vehicle
- Zero Tailpipe Emissions
- Short Refuel Time
- Long Range
- Less Efficient
- More Well-to-Wheel Emissions

BATTERY-ELECTRIC BUSES

SERVICE COMPLETION



- In 2023, approximately 60% of the service blocks can be completed with BEBs in the typical scenario. The number goes down to 36% in extreme conditions (conservative scenario), such as during the coldest day of winter.
- In typical operating conditions, no blocks are less than 50% completed. These blocks might be able to be completed with strategic electrification phasing and service changes, without additional BEBs needed.
- The block completion rate will improve over the years, with 88%, 96%, and 100% of all service blocks being able to be completed by BEBs in typical condition in 2035, 2040, and 2050, respectively*.

Assumptions:
- 2.5% annual cumulative range growth (conservative assumption)
- **Typical scenario:** during average operating conditions
  - 35-foot bus: Annual average of pilot BEBs efficiency (2.17 kWh/mile)
  - 40-foot bus: Market Average (2.12 kWh/mile)
- **Conservative scenario:** during extreme weather condition
  - 35-foot bus: Average of the maximum efficiency of pilot BEBs (3.3 kWh/mile or 1.5x typical efficiency)
  - 40-foot bus: 1.5x typical efficiency (3.23 kWh/mile)

* Appendix A provides a detailed illustration on the block completion improvement over the years

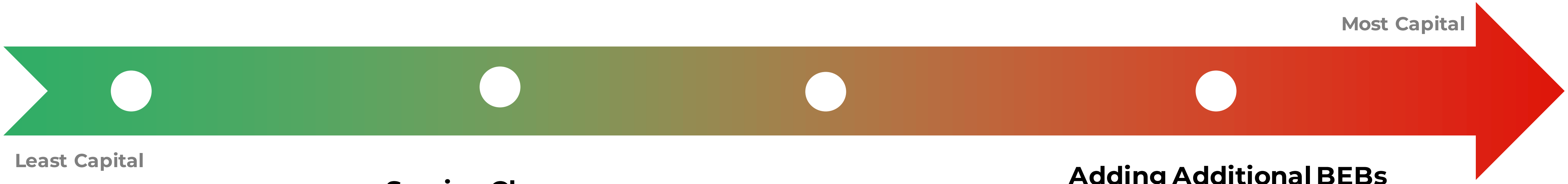
STRATEGIES FOR FAILING BLOCKS:

Strategic Phasing

Allowing for technology to mature

Utilizing Bus with Better Efficiency

(i.e., specific models, 40-foot buses)



Service Changes

(i.e., Block splitting to be completed by existing spare vehicles)

Adding Additional BEBs

Block Splitting to be completed by additional BEBs

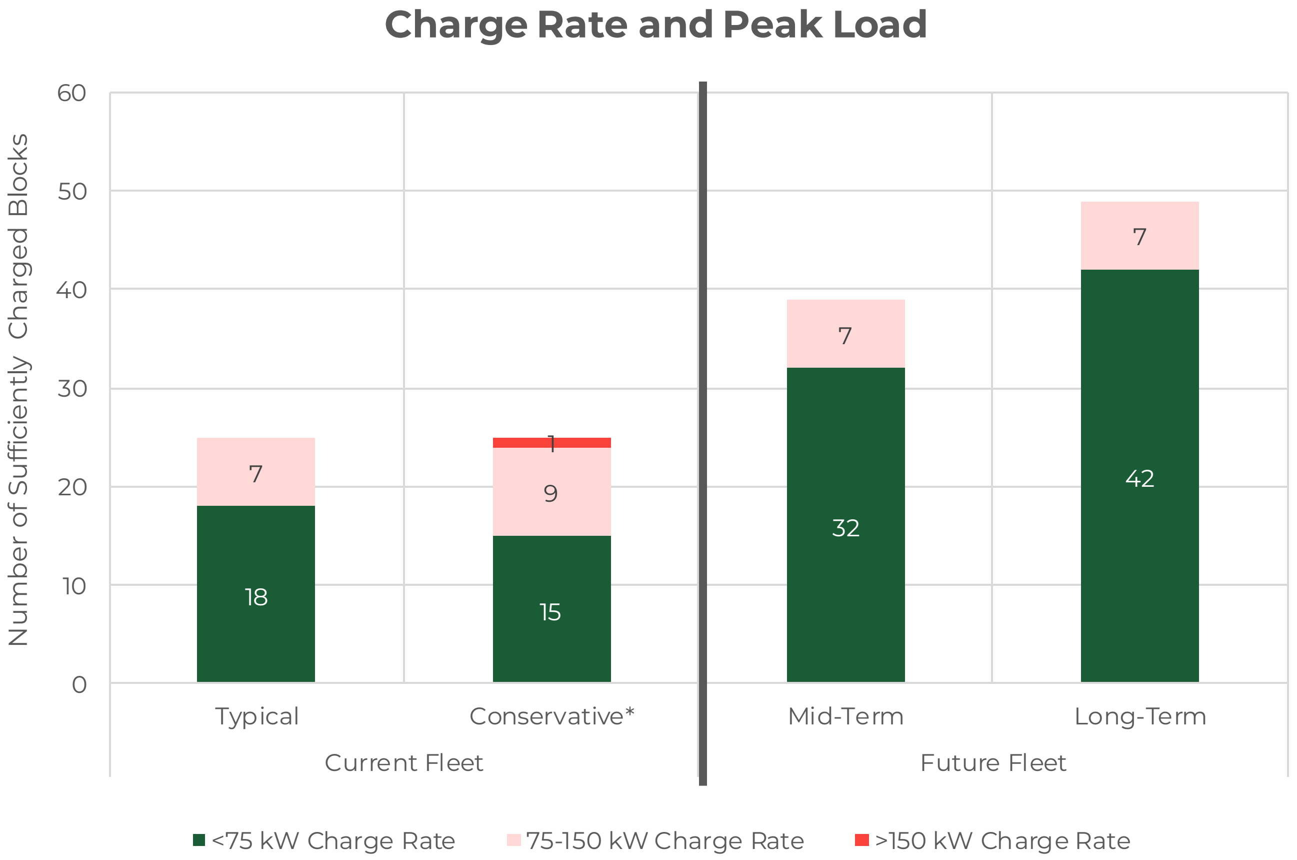
Fuel Cell Technology

Longer range, with additional fueling infrastructure needs

Opportunity Charging

Fast chargers at layover locations. Requires additional infrastructure and higher fuel cost

ENERGY REQUIREMENT



Assumptions:

- New vehicles will be assigned to blocks that can be sufficiently charged with 75 kW charge rate
- Vehicles would be able to receive the needed kWh to complete service

Charge Rate

- **18 blocks** can be sufficiently charged at **75 kW** charge rate
- **Seven blocks** can be sufficiently charged at **75-150 kW** charge rate
- In the conservative scenario, **one block** needs at least **156 kW** charge rate to be sufficiently charged. Strategic phasing may mitigate issue if efficiencies improve

Number of Chargers Needed & Peak Load

- BEBs typically require large utility upgrades to the site and higher daily power consumption for charging
- The use of a charge management system (CMS) is essential to reduce the peak demand and chargers needed

Charger Needs

	# 150 kW DC Charger**	# 300 kW DC Charger	Max. Peak Load
Current	13	1	2.25 MW
Mid-Term	20	1	3.30 MW
Long-Term	24	1	3.90 MW

*Conservative scenario is provided as a comparison. However, future fleet numbers are based on typical operation

**Assuming 1:2 charger to dispenser ratio. Actual number of charger will vary based on the chosen charger rate and configuration after taking into consideration site limitations

100% BEB FLEET GOAL OPTIONS

A

2035

88% blocks can be completed

To complete failing blocks:

- **Better efficiency** (i.e., other models or 40-foot buses)
- **Block splitting**

B

2040

95% blocks can be completed

To complete failing blocks:

Block splitting

C

2050

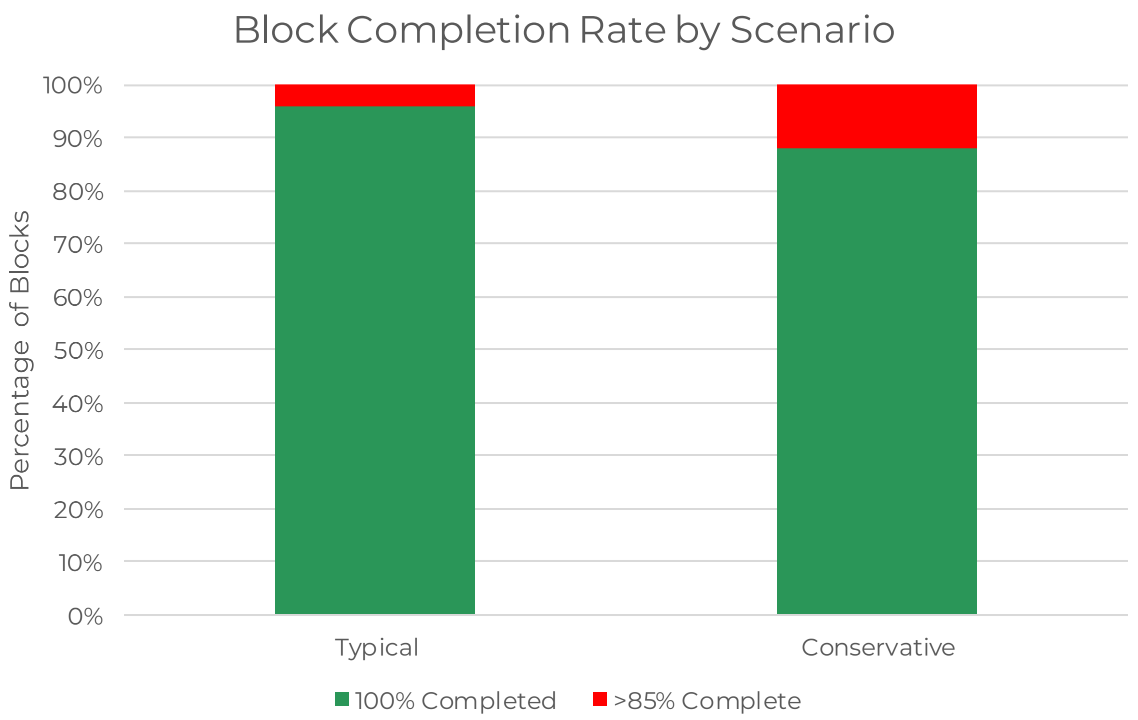
All blocks can be completed

FUEL CELL ELECTRIC BUSES

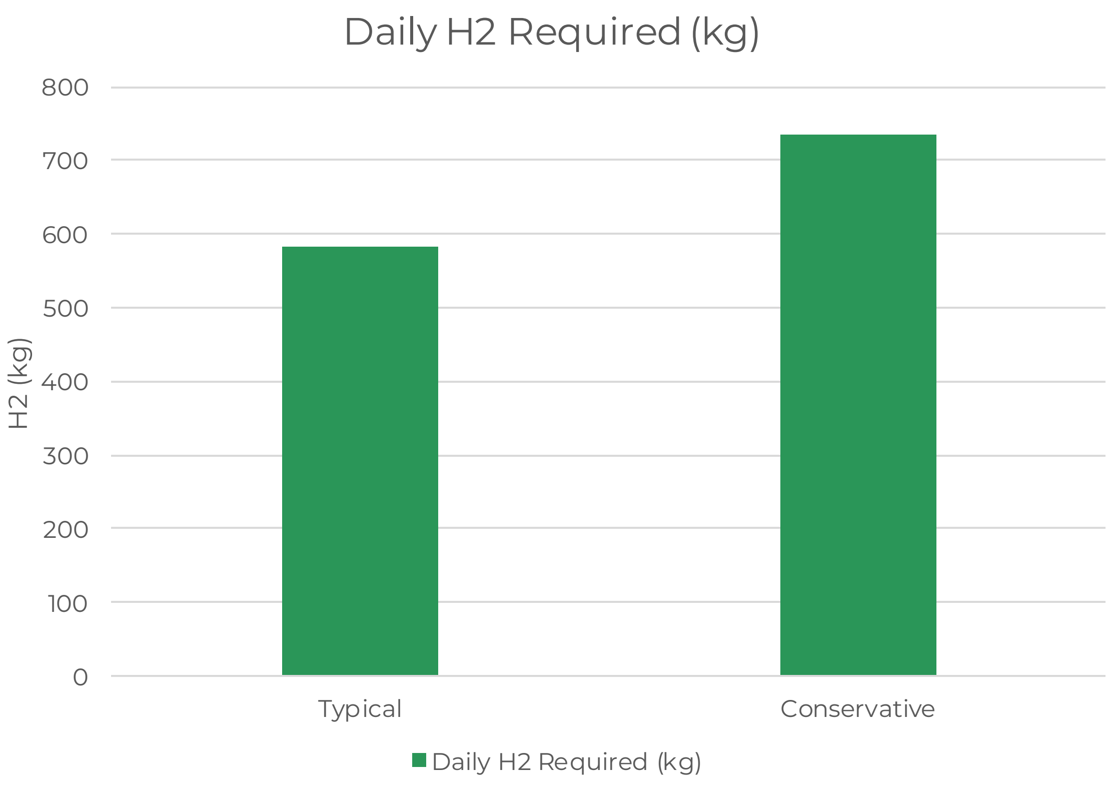
SERVICE COMPLETION

Assumptions:
- Only 3 models of FCEB are currently available on the market
- NF XE40 was used to model 40' FCEB vehicles.
- ENC Access-FC was used to model 35' vehicles. This vehicle is currently made in a 40' configuration, but the manufacturer offers a 35' vehicle.
- **Typical Scenario:** during average operating condition
  - 35-foot bus: Altoona CBD efficiency of 6.81 mi/kg, useable tank of 45 kg
  - 40-foot bus: Altoona CBD efficiency of 6.92 mi/kg, useable tank of 36 kg
- **Conservative scenario:** during extreme weather condition
  - 35-foot bus: Altoona ART efficiency of 5.58 mi/kg, useable tank of 45 kg
  - 40-foot bus: Altoona COM efficiency of 5.34 mi/kg, useable tank of 36 kg

- Under both typical and conservative scenarios, more than 85% of blocks can be completed with FCEB technology. A few of the longest routes cannot be completed by existing FCEB technology.
- Technology improvements are expected, and these few outstanding blocks may be able to be completed by this technology with 5-10 years of advancement.



ENERGY REQUIREMENT



Fueling Requirements:
- **Typical Scenario:** 582 kg/day
- **Conservative scenario:** 735 kg/day
- Hydrogen fuel is measured in kg of compressed gas
- FCEBs require 8 minutes to fuel to completion

Infrastructure Requirements:

- Hydrogen fueling infrastructure should be sized for a conservative scenario to provide for operational resiliency.
- Compressed liquid hydrogen storage is recommended, to increase the amount of fuel storage in a smaller footprint.
- Today's compressed liquid fuel storage tanks can store 4,500 kg of fuel, or approximately one week of fuel under conservative conditions

PHYSICAL SPACE REQUIREMENTS

- H2 will require ventilation upgrades to indoor maintenance bays
- Required space varies depending on several factors including existing facility layout, and fuel delivery vs on-site production, etc.
- On-site hydrogen production relatively requires most space for the production equipment and storage.
- The NFPA requires large setbacks from air intakes, property lines, diesel fuel storage, and other on-site buildings or equipment.

PHYSICAL SPACE REQUIREMENTS

Fuel Storage

Hydrogen fuel requires on-site storage regardless of production or delivery method

SMR

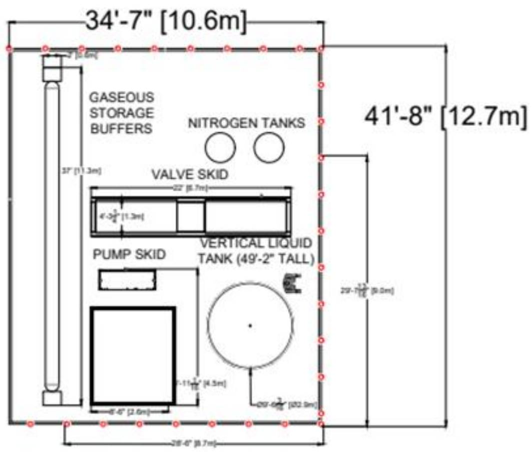
Steam Methane Reformation is the process of splitting hydrogen ions from natural gas (methane)

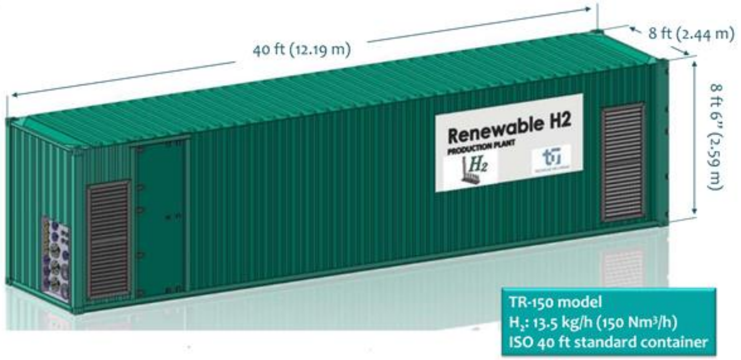
Small scale on-site SMR equipment is available for transit applications, but requires additional footprint and capital cost.

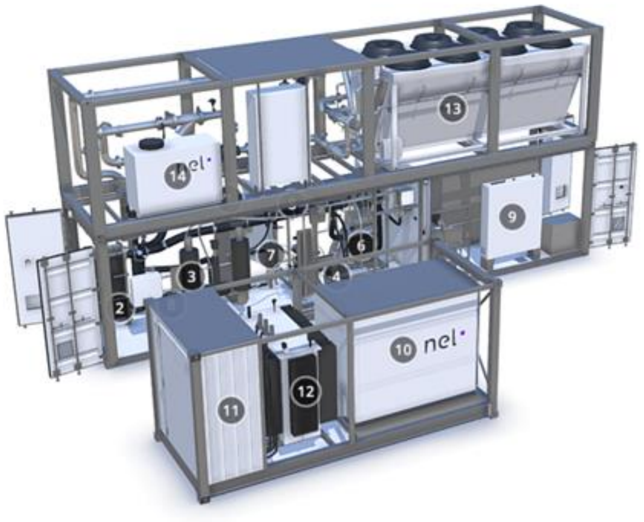
Electrolysis

Hydrogen atoms are split from water using electricity

On-site production equipment is available, but comes with a large footprint and capital cost







100% FCEB FLEET GOAL OPTIONS

2022

85% of blocks can be completed under conservative modeling scenarios

To complete failed blocks, midday re-fueling, which requires under 10 minutes, is recommended.

2035

It is expected that all blocks can be completed.

COST ANALYSIS

CAPITAL COSTS

Metric	BEB	FCEB		
		Delivered	On-site Production	
		Liquid	SMR	Electrolysis
Infrastructure Capital Costs	$2.0M	$8.3M	$10.7M	$12.1M
40' Bus Unit Cost	$1.1M	$1.4M	$1.4M	$1.4M
35' Bus Unit Cost	$1.1M	$1.2M	$1.2M	$1.2M
Total Vehicle Capital Costs	$46.2M	$54.3M	$54.3M	$54.3M
Total Capital Costs	$48.2M	$62.6M	$65.0M	$66.4M

- The infrastructure cost estimates do not include facility or utility upgrades since they vary greatly between transit agencies
- Twenty-five 150kW charging cabinets and one DC fast-charger were used in the BEB infrastructure cost estimate
- The FCEB infrastructure for both delivery and on-site production includes the cost of storage and dispensers
- The existing four 30-ft and 25-ft vehicles are assumed to be replaced with 35-ft BEBs and FCEBs

MAINTENANCE COSTS

Metric	BEB	FCEB		
		Delivered	On-site Production	
		Liquid	SMR	Electrolysis
Average Maintenance Cost	$1.70/mi	$1.03/mi	$1.36/mi	$1.05/mi
Annual Total	$1.19M	$0.74M	$0.96M	$0.75M
Lifetime Total*	$14.3M	$8.87M	$11.5M	$9.03M

- The estimated annual and lifetime maintenance costs only considers the weekday service vehicles
- The average maintenance cost is higher for both BEBs and FCEBs when compared to BPTC's existing cost of approximately $0.92/mi**

*Includes tire service cost

**In BPTC's 2021 Operating Expenses report, the vehicle operations and vehicle maintenance costs under the Materials and Supplies category were added and divided by the fleet's total annual vehicle miles to calculate the existing O&M cost per mile

FUEL COSTS

Metric	BEB	FCEB	
		Delivered	On-site Production
$/Unit of Fuel	$0.19/kWh	$8.00/kg	$5.00/kg
$/Mile	$0.48	$0.90	$0.56
Annual Total – Typical Scenario	$0.49M	$1.46M	$0.91M
Annual Total – Conservative Scenario	$0.74M	$1.84M	$1.48M
Lifetime Total – Typical Scenario	$5.9M	$17.5M	$10.9M
Lifetime Total – Conservative Scenario	$8.9M	$22.1M	$13.8M

- The estimated fuel costs only considers the weekday service vehicles
- Fuel costs vary depending on the typical and conservative scenarios for both BEB and FCEBs

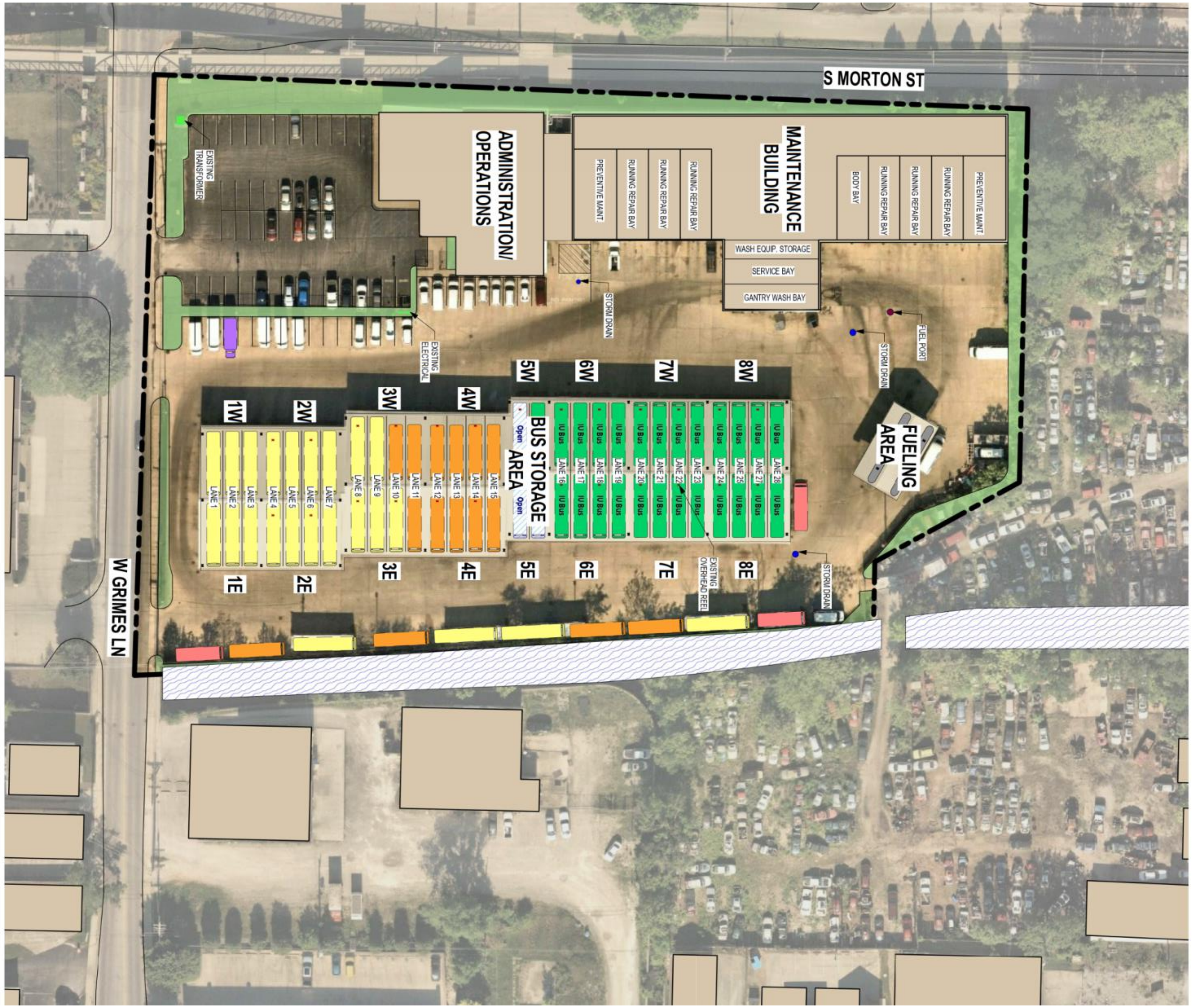
TOTAL ESTIMATED LIFECYCLE COSTS

Metric	BEB	FCEB		
		Delivered	On-site Production	
		Liquid	SMR	Electrolysis
Estimated Lifecycle Costs – Typical Scenario	$68.4M	$89.0M	$87.4M	$86.3M
Estimated Lifecycle Costs – Conservative Scenario	$71.4M	$93.6M	$90.3M	$89.2M

- The estimated lifecycle costs includes the capital, O&M, and fuel costs
- The cost estimates do not include the agency's planned expansion
- Although not all vehicles were able to meet the existing block requirements, additional vehicles were not added to the lifecycle cost estimates

FACILITIES

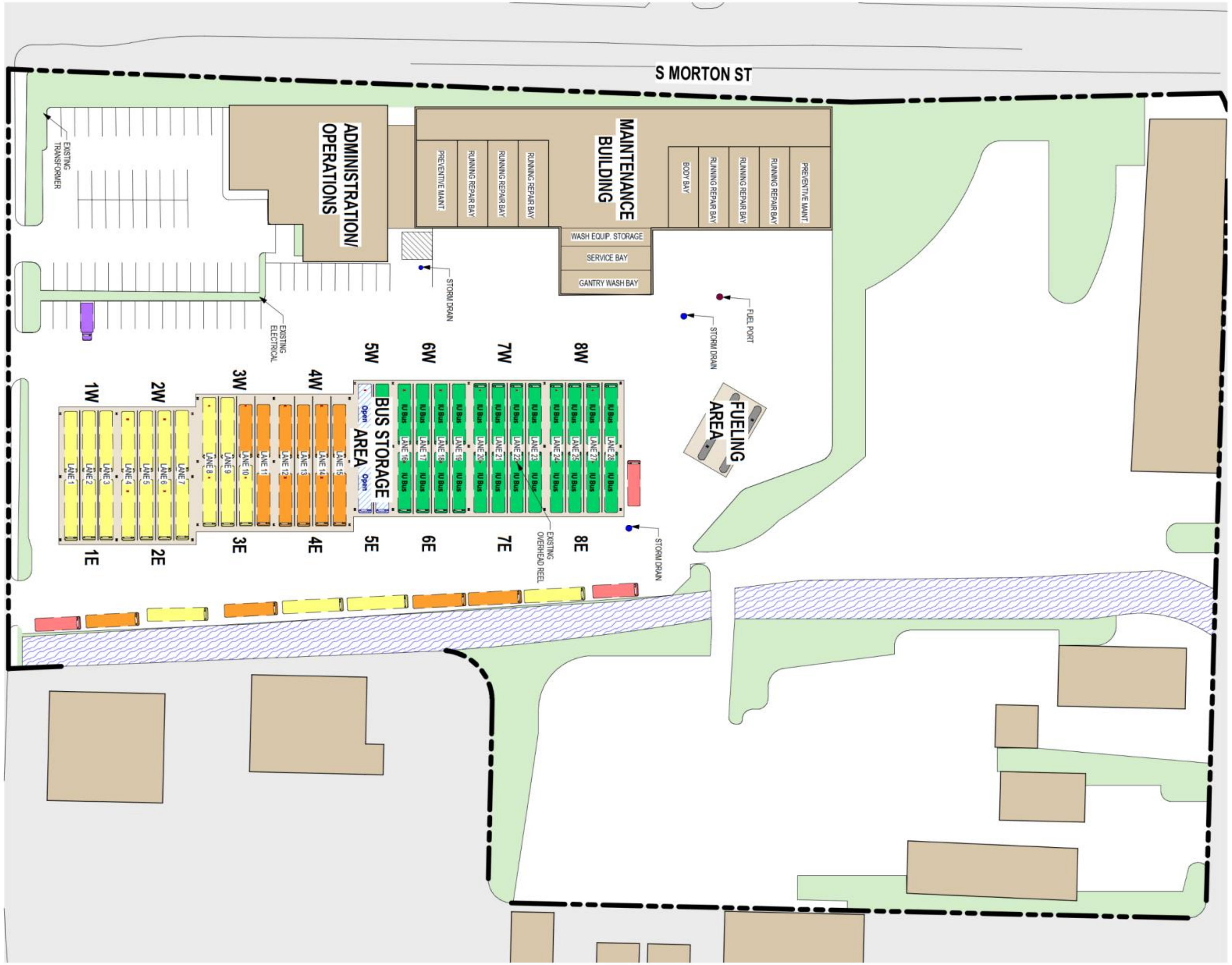
EXISTING SITE LAYOUT



EXISTING SITE LAYOUT

POTENTIAL SITE EXPANSION

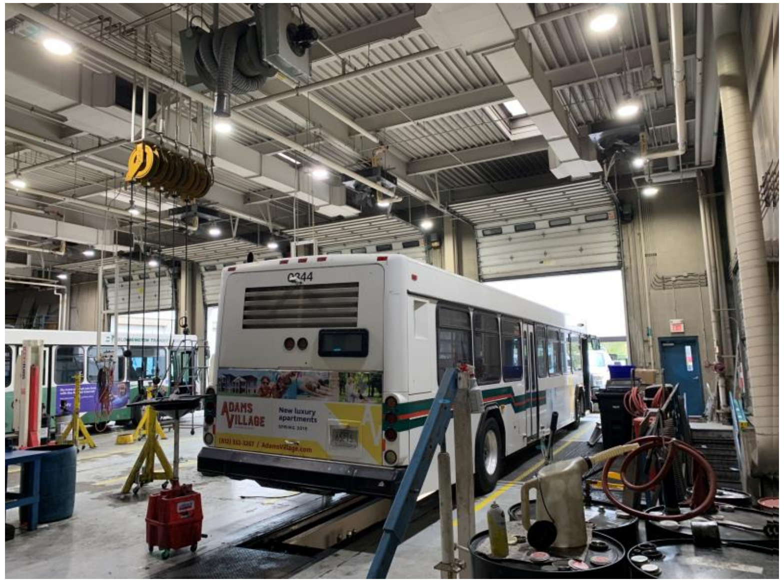
POTENTIAL SITE EXPANSION

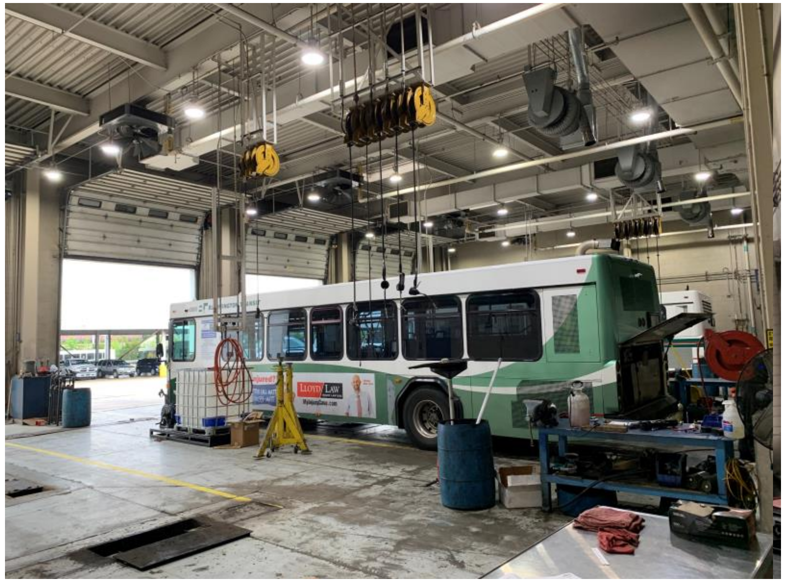


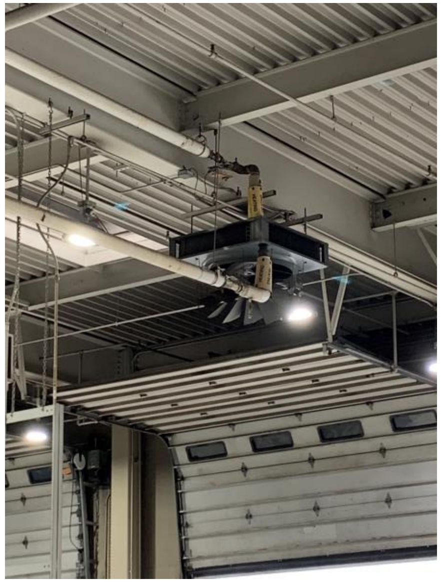
TRANSFER CENTER

TRANSFER CENTER

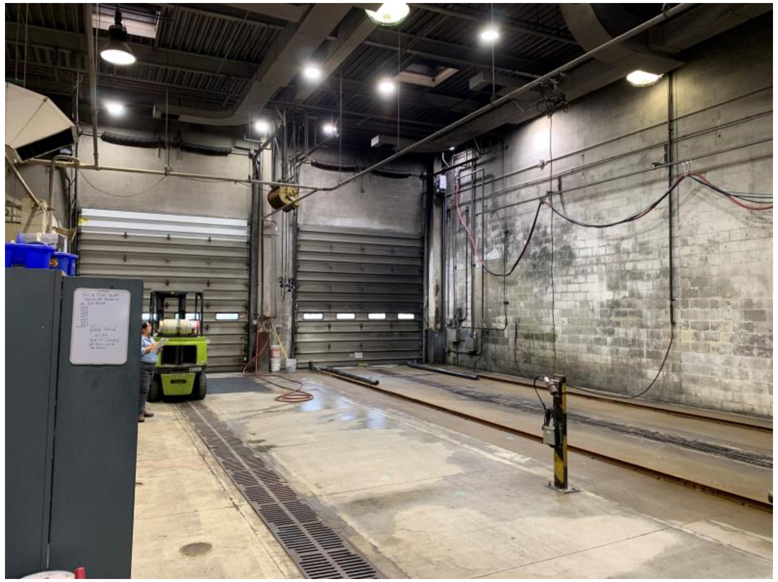
MAINTENANCE AREAS



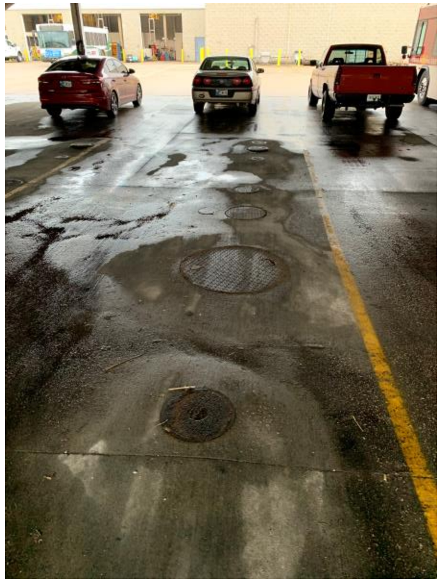




WASH BAYS



FUEL ISLAND



PARKING CANOPY

EXISTING AND PROJECTED FLEETS

EXISTING FLEET		PROJECTED FLEET	
40’ BUS	23	40’ BUS	42
35’ BUS	15	35’ BUS	15
30’ BUS	3	30’ BUS	3
>30’ Bus	1	60 BUS	6
TOTAL	42	TOTAL	66

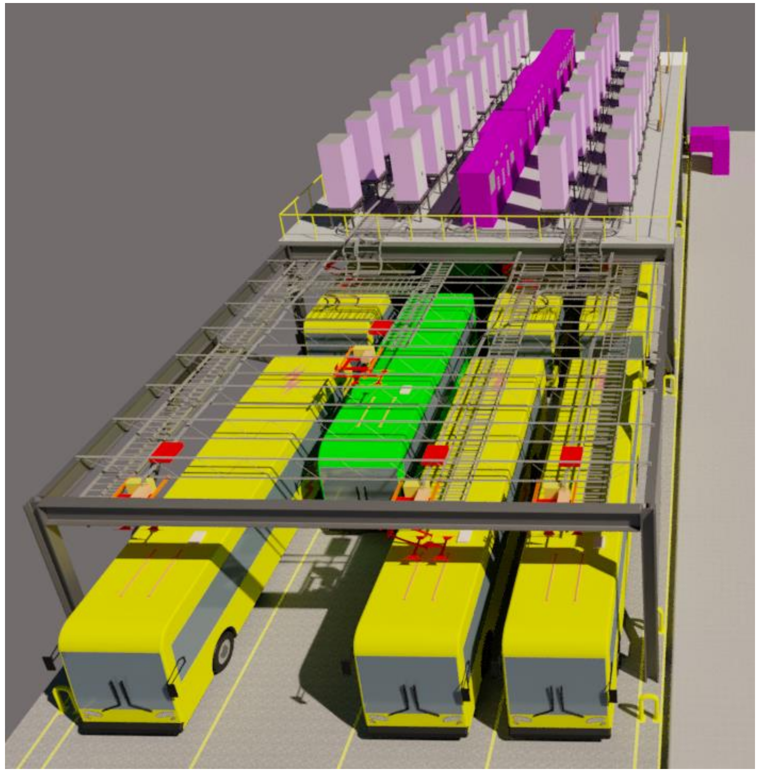
- 25 IU buses also share the site but are not part of this study

- Concepts were developed to accommodate 40’ buses and artics to allow for potential fleet makeup changes and provide maximum flexibility

BATTERY ELECTRIC BUSES

Battery-Electric Bus Assumptions

- Depot BEB Charging via 2:1 charger-to-dispenser ratio @ 150 kW
- Plug-in or Pantograph can be supported by the overhead design
- All future charger infrastructure will be mounted overhead on platforms
  - *Existing site is extremely constrained and cannot support ground mounted infrastructure*
  - *The site is adjacent to a stream which has had a recent flooding event*
  - *Elevated designs maximize resiliency and maximize site capacity*
- Potential transit center Charging via dedicated 450 kW overhead pantograph positions
  - *Plug in not recommended due to public access*
  - *Induction not recommended due to lack of standard*



BT wsp

BATTERY ELECTRIC BUSES

BEB Load Requirements

Battery Electric Bus (BEB) Power Requirements

Charge curve factor applied: 135

Assumed Charger Size (kW): 150 Plug-in or pantograph

	A	B	F	G	H	I	J	K	O	P
				(F x 25%)	(F - G)	(H / 150)	(A x H)	(B x H)	(A x 150)	(B x 150)
			Battery Size kWh	**Safety Factor 25% SOC**	**Max Charge Needed kWh**	**Hours to Charge**	**Max Power Needed (kWh)**		**Max kW**	
Fleet	**Exist**	**Max Fleet**					**Exist**	**Max Fleet**	**Exist**	**Max Fleet**
40-foot BEB	42	60	440	110	330	2.444	13,860	19,800	6,300	9,000
60-foot BEB	0	6	660	165	495	3.667	-	2,970	-	900
Subtotal	**42**	**66**					**13,860**	**22,770**	**6,300**	**9,900**

Less Spares:	0%	6,300	9,900
Less 50% for 2:1 chargers		3,150	4,950
TOTAL LOAD NEEDED		**3.15mW**	**4.95mW**

BATTERY ELECTRIC BUSES

EXISTING FLEET – NO EXPANSION

- Can meet existing fleet needs
- No room for fleet growth
- IU fleet cannot be electrified in place
- Difficult to phase due to lack of bus parking and construction laydown spacing

BATTERY ELECTRIC BUSES

PROJECTED FLEET – EXPANDED SITE

- Can meet full projected fleet needs
- Offers space if IU electrifies
- Simplifies transition phasing with added property

BATTERY ELECTRIC BUSES

PROJECTED FLEET – EXPANDED SITE (FULLY ISOLATED)

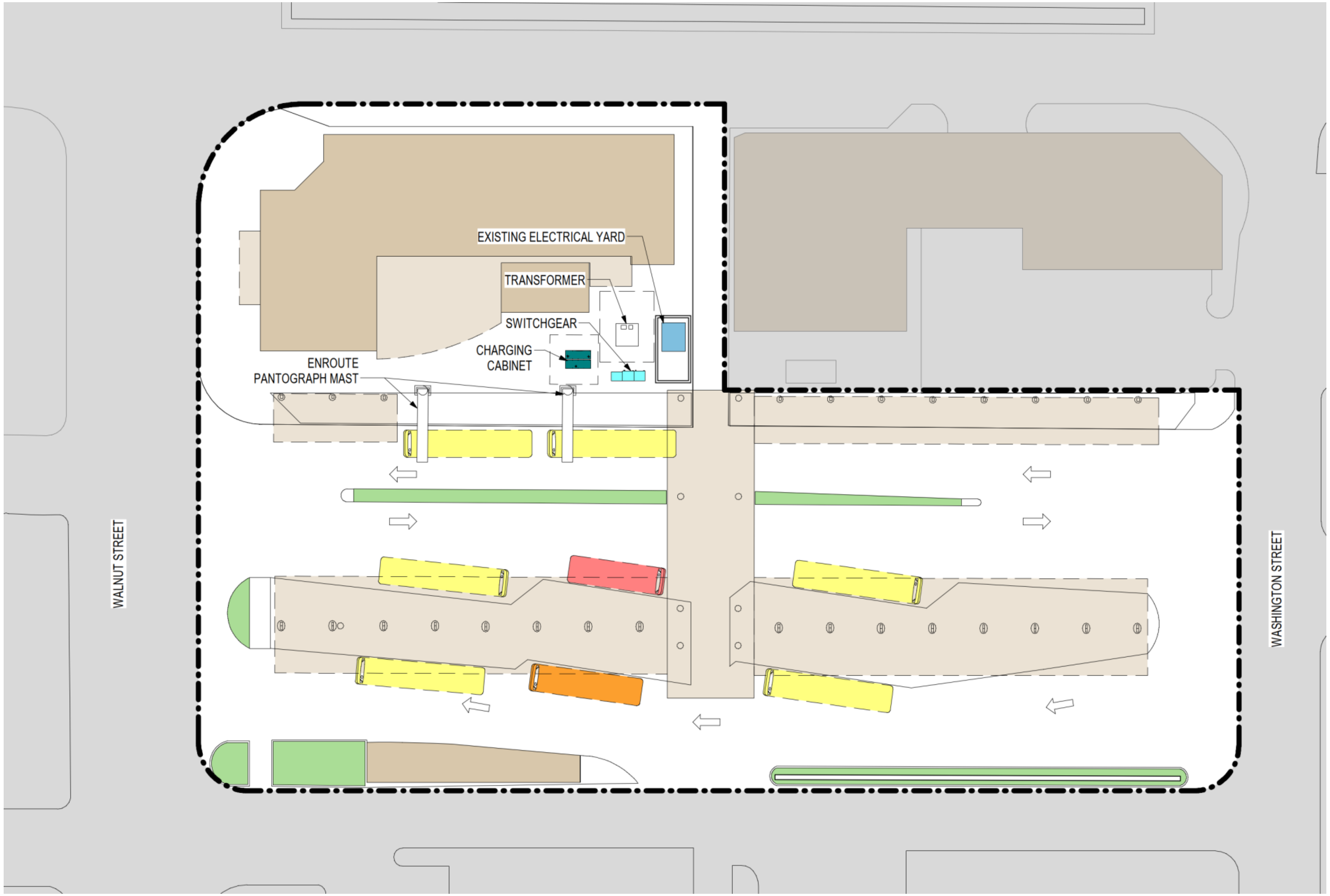
- Can meet full projected fleet needs
- Offers space if IU electrifies
- Simplest transition phasing as existing parking is never disturbed
- Increases design complexity and costs with distribution of power across the stream
- Stream crossing not designed for buses

BATTERY ELECTRIC BUSES

PROJECTED FLEET – EXPANDED SITE (FULLY ISOLATED)

- Can meet full projected fleet needs
- Offers space if IU electrifies
- Simplest transition phasing as existing parking is never disturbed
- Increases design complexity and costs with distribution of power across the stream
- Stream crossing not designed for buses

TRANSFER CENTER - BEB

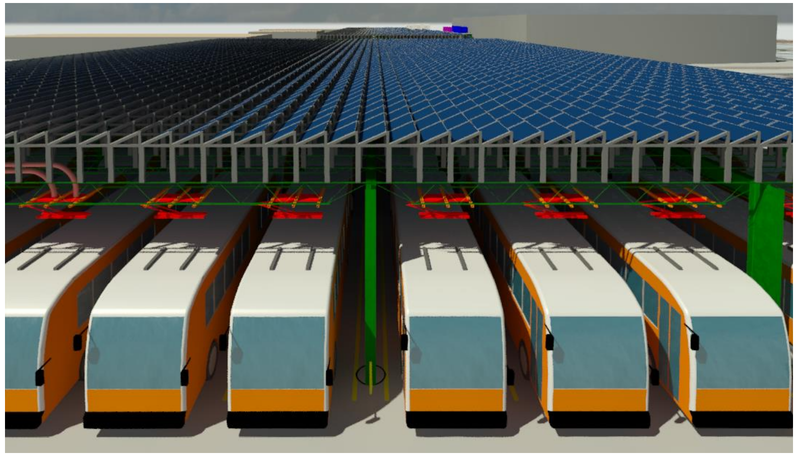


- Utilize overhead pantographs: limits public access and no driver interaction required
- Charge at 450 kW to achieve “fast” range extension
- Deploy adjacent to facility to avoid trenching
- Canopy likely must be shortened to allow for pantograph

BATTERY ELECTRIC BUSES

Findings & Recommendations

- Ground-mounted charging is not viable due to site constraints and lack of resilience
- Existing parking canopy does not support overhead charging equipment and should be removed
- Existing fleet can be charged within the existing site footprint
  - **Not inclusive of the IU Fleet*
- The projected fleet cannot be charged within the existing site
  - *Adjacent site required for fleet expansion*
- **BPTC should consider acquiring the adjacent site to allow for fleet growth and to ease the transition process**



HYDROGEN FUEL CELL ELECTRIC BUSES

HFCEB and Natural Gas Assumptions

- Hydrogen Supply Options
  - *Delivery of liquid hydrogen*
  - *On-site production of hydrogen via:*
    - Steam Methane Reformer (SMR)
    - Hydro-electrolysis
- Utilize existing fuel and service island if possible
  - *Maintains single circulation and service pattern*
- Minimize piping from storage
- Gases cannot be piped across the existing stream divide
- Existing canopies should accept lighter than air fuels with minimal modifications

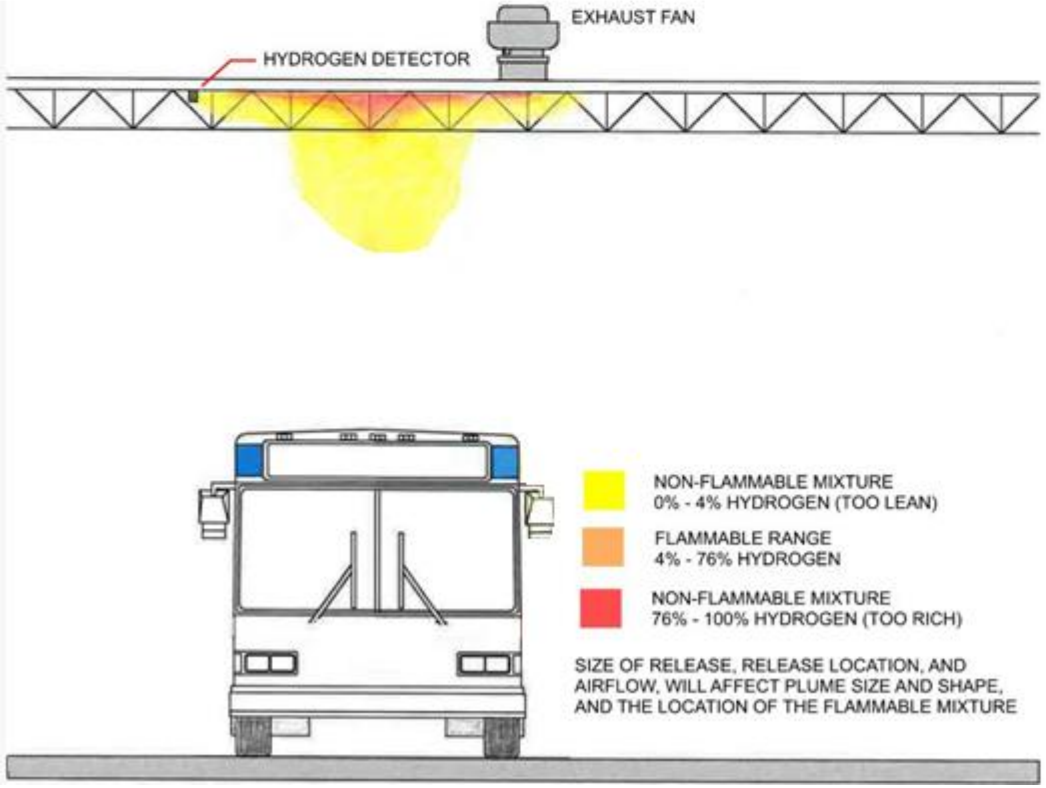
Note concepts for NG storage were not developed as they fit within the same or reduced footprint as liquid hydrogen requirements

HYDROGEN FUEL CELL ELECTRIC BUSES

HFCEB Impacts

Maintenance Facility Requirements:

- No open flame heating systems
- Noncombustible walls + ceilings
- Standby power for safety systems
- Defuel required to service Hydrogen system components
- Hydrogen / NG detection systems
- Mechanical exhaust ventilation
- Electrical designation of vehicle repair spaces
- Automatic fire suppression



HYDROGEN FUEL CELL ELECTRIC BUSES

EXISTING FLEET – NO SITE EXPANSION

- Inadequate space for hydrogen storage and dispensing equipment
- Does not meet hydrogen storage and setback requirements

HYDROGEN FUEL CELL ELECTRIC BUSES

PROJECTED FLEET – EXPANDED SITE

- Ample space for hydrogen storage and dispensing equipment
- Meets hydrogen storage and setback requirements
- Allows existing fuel lanes to be utilized for both fleets during transition

HYDROGEN FUEL CELL ELECTRIC BUSES

PROJECTED FLEET – EXPANDED SITE (FULLY ISOLATED)

- Ample space for hydrogen storage and dispensing equipment
- Meets hydrogen storage and setback requirements
- Allows existing fuel lanes to be utilized for both fleets during transition

HYDROGEN FUEL CELL ELECTRIC BUSES

PROJECTED FLEET – EXPANDED SITE w/ STEAM METHANE REFORM GENERATION

- Requires a second fueling island – piping hydrogen across the stream not ideal
- Dual fueling service needs during transition difficult
- Capital costs extremely high upfront

HYDROGEN FUEL CELL ELECTRIC BUSES

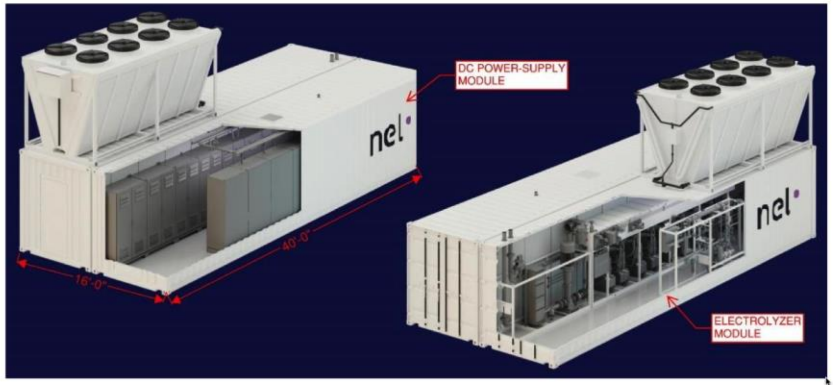
PROJECTED FLEET – EXPANDED SITE w/ HYDRO-ELECTROLYSIS GENERATION

- Ample space for hydrogen storage and dispensing equipment
- Meets hydrogen storage and setback requirements
- Allows existing fuel lanes to be utilized for both fleets during transition

HYDROGEN FUEL CELL ELECTRIC BUSES / NATURAL GAS

Findings & Recommendations

- Hydrogen fueling requires site expansion
- Liquid hydrogen delivery is the most feasible option to maintain efficient site circulation and operations
- On-site generated hydrogen cannot be efficiently piped to the existing fuel island
- Locating a new hydrogen fueling / service lanes in the expanded site across the stream introduces a chokepoint and requires multiple service patterns during transition
- Existing maintenance facility and wash bays needs extensive upgrades to ventilation, heating, lighting, and monitor / alarming systems to accept either lighter than air fuel –natural gas or hydrogen
- Difficult to retrofit the facility during continued operations
- **Hydrogen fueling is feasible but poses major operational challenges**



KEY FINDINGS

KEY FINDINGS

Battery Electric Bus

- Provide the least-cost option with the least lifecycle emissions, but will take the longest to transition
- Currently, 60% of the blocks can be completed in typical condition.
- Based on technology forecast, by 2050, all blocks can be completed by BEB
- Charge Management System will be key in reducing the number of chargers needed and peak load

Fuel Cell Electric Bus

- FCEBs are viable under multiple fueling scenarios, including on-site production. However large on-site electrolysis is extremely nascent and SMR produces GHG emissions on-site
- Currently, 95% of blocks can be completed in typical conditions.
- Based on technology forecast, by 2035 all blocks can be completed by FCEBs.
- Fueling infrastructure to support these vehicles requires a large on-site footprint and high upfront capital cost.

Cost Analysis

- On-site production of hydrogen has higher initial capital costs but a lower lifecycle cost when compared to hydrogen delivery
- Overall, BEBs have a lower lifecycle cost estimate when compared FCEBs

NEXT STEPS

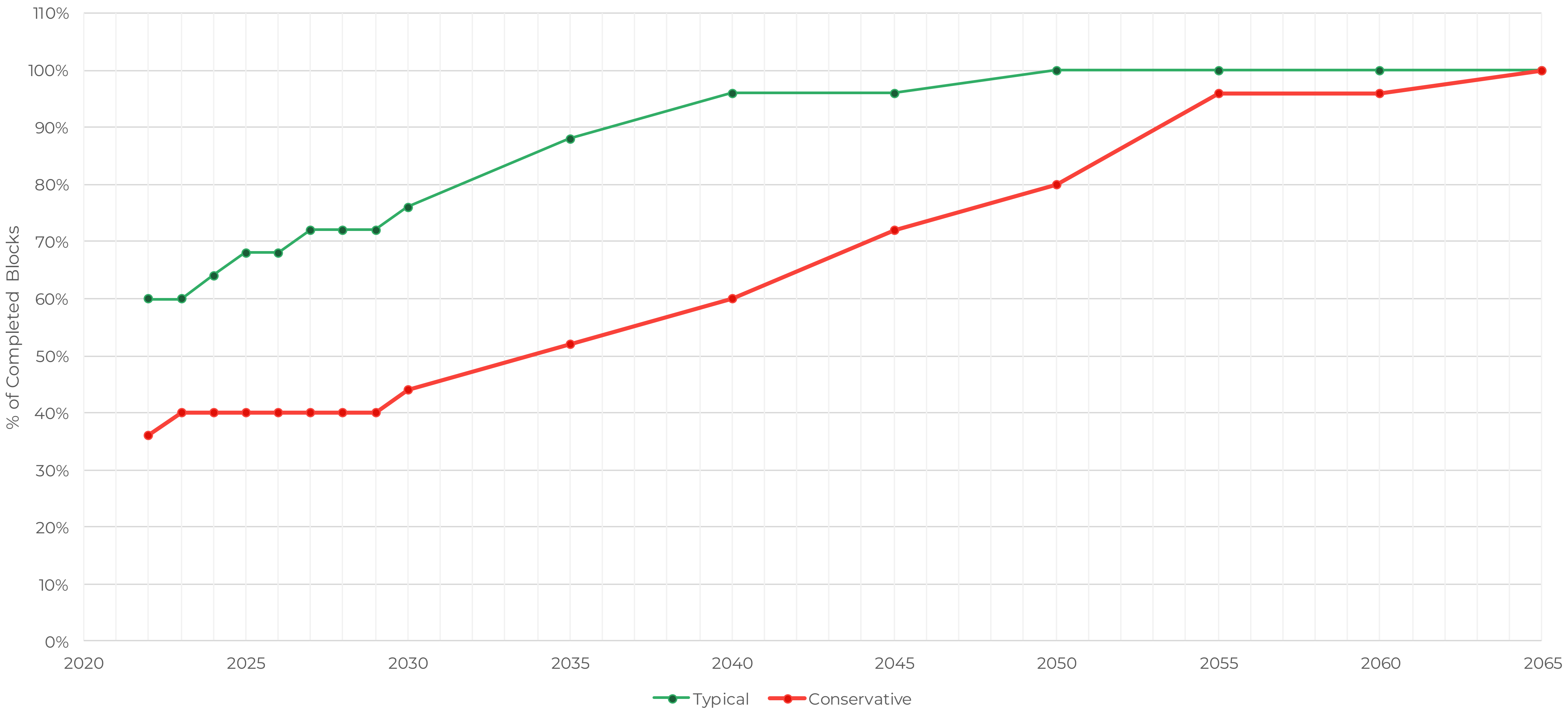
RECOMMENDATIONS & NEXT STEPS

1. BPTC should consider transition timeline goals when determining best-fit technology
2. **Recommend continuing to pursue a BEB technology, however, a small-scale FCEB pilot may uncover BPTC's preferences**
3. Once fuel-type is determined, begin detailed design and conversations with key stakeholders (OEMs, utility/fuel supplier, etc.)

Questions?

APPENDICES

APPENDIX A – BEB TECHNOLOGY FORECAST



APPENDIX B: ALTERNATIVE FUELS AND INFRASTRUCTURE ASSESSMENT STUDY

ALTERNATIVE FUELS AND INFRASTRUCTURE ASSESSMENT STUDY

Task 2.1: Summary-Level Comparison of Battery-Electric, CNG, and Hydrogen

Prepared by: WSP
Submitted: March 25th, 2022

OUTLINE

01 | **Introduction**
(Background, Evaluation Categories)

02 | **Fuel/Technology Findings**
(Compressed Natural Gas, Battery-Electric, Fuel-Cell Electric)

03 | **Metrics Evaluation**
(Operational Impact, Social/Environmental Impact, Financial Impact)

04 | **Key Findings & Feasibility Assessment**
(Comparison Summary, Key Findings, Feasibility, Items for Consideration)

INTRODUCTION

INTRODUCTION

Objective

Prepare a feasibility analysis and initial comparison study of three alternative fuel bus technologies, compressed natural gas, battery-electric, and hydrogen fuel cell. Identify any fatal flaws with each technology as it relates to Bloomington Public Transportation Corporation (BPTC) operations, facilities, and sustainability goals.

Study Background

The BPTC is the entity of local government responsible for the provision of public transit services in the Bloomington Urbanized area. The BPTC operates two services, Bloomington Transit fixed route bus service and BT Access specialized van service for persons with disabilities.

The BPTC is at a crossroads on which alternative fuels could be used for future fleet and facilities. The resulting report of this assessment will provide BPTC policymakers the information needed to make sound decisions and guide next steps. The report will also document the competing alternative fuel technologies and the benefits and challenges, making sure a record is available for future reference.

Purpose and Assumptions

This initial summary-level assessment is provided to guide BPTC in selecting their future bus technology, which will be further evaluated in future tasks. This allows for a more strategic use of the alternative fuels planning budget.

Source: Bloomington Transit

BACKGROUND

Transit Fleet Background

BPTC fixed route service consists of 42 transit buses and has a peak vehicle requirement of 29 buses. The fixed route vehicle fleet consists of a mix of 30, 35, and 40-foot low floor buses with model years ranging from 2003 to 2021. Two 35-foot battery-electric buses (BEBs) have recently been acquired along with overnight charging stations located at the Grimes Lane administrative and maintenance facility. BPTC has approved 5339 apportionments for eight more BEBs and charging stations including a recent FY 2021 Low-No apportionment.

Source: Bloomington Transit

Facility Background

The Grimes Lane administrative and maintenance facility is a shared facility with the Indiana University Campus Bus service. The University owns the lands upon which the facility is sited and BPTC owns the facilities and structures. The existing admin/maintenance facility site is at or near capacity in terms of bus storage and operations.

Source: Bloomington Transit

PRELIMINARY TECHNOLOGY EVALUATION

Evaluation Methodology

To determine the feasibility of the three bus technologies considered, each was evaluated across three categories which include, 1) Operational Impacts, 2) Social and Environmental Impacts, and 3) Estimated Lifecycle Costs. Qualitative and quantitative metrics were provided to support the BPTC in selecting their best-fit bus technology.

The focus of this assessment was to identify any fatal flaws which would preclude the technology from successful deployment within BPTC's service network. As an initial feasibility study, many of the inputs and assumptions represent national trends; however, several metrics drew upon data specific to the BPTC's service and region. Specifically, the BPTC's GTFS service feed was used to compare bus range to service needs as well as annual fuel consumption, and the service region was evaluated for fuel availability.

Each of the evaluation categories are described in the following section. To further support the BPTC in selecting which bus technology best aligns with their needs and goals. This report will be followed with a guided Multi-Objective Decision Making Analysis (MODA), in which each metric will be provided a weighted value by the BPTC.

Evaluation Categories

1. **Operational Impact**
2. **Social & Environmental Impact**
3. **Estimated Lifecycle Costs**

EVALUATION CATEGORIES

Operational Impact

- **Vehicle Range:** The range of the fuel/technology type
- **Physical Space Requirements:** The scale of the space required to accommodate new infrastructure
- **Fueling or Charging Time:** The time it takes to fully fuel or charge the vehicle
- **Daily Energy Requirements:** The energy requirements to accommodate the vehicle type
- **Fuel:** Accessibility to fuel

Social/Environmental Impact

- **Lifecycle Greenhouse Gas (GHG) Emissions:** A measure of the cradle-to-grave GHG emissions of a fuel type
- **Local Air Quality:** A measure of tailpipe emissions, categorized by six pollutants: CO, Nitrogen Oxides, PM10, PM2.5, VOCs, and Sulfur Oxides
- **Community Acceptance:** Communities' general perception and acceptance of the specified vehicle type

Estimated Lifecycle Costs

- **Vehicle Capital Costs:** The purchase price of a vehicle
- **Infrastructure Capital Costs:** The capital costs of infrastructure to support 40 vehicles of the fuel/technology at BPTC's Grimes Lance facility
- **Operating and Maintenance Costs:** The cost per mile to operate and maintain a vehicle, inclusive of "fuel costs" and preventative maintenance costs.
- **Financial Incentives:** The availability of competitive grants and other funding.

FUEL/TECHNOLOGY FINDINGS

FUEL/TECHNOLOGIES OVERVIEW

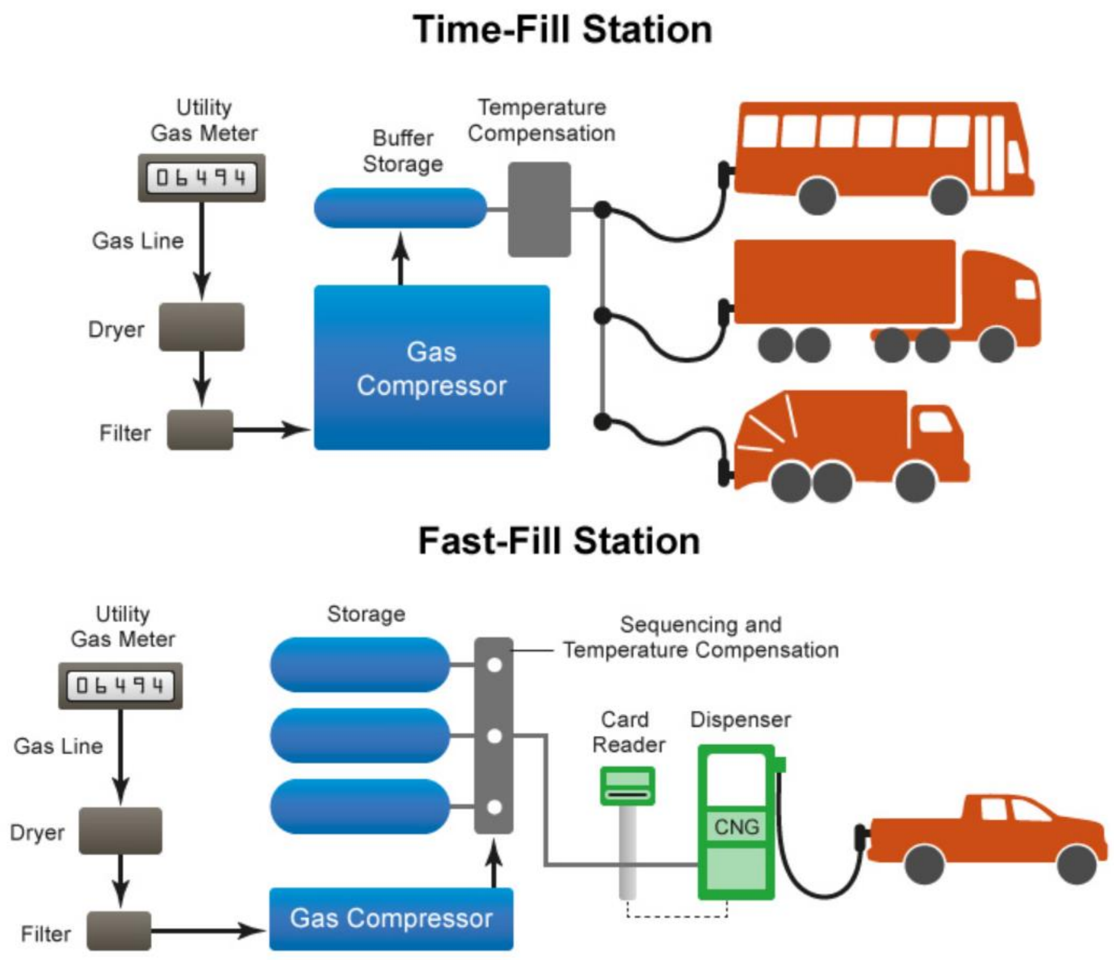
Compressed Natural Gas Buses

CNG is a cleaner burning fossil fuel alternative to diesel-powered vehicles with a more stable and less expensive price tag. These vehicles emit 90% less NOx and soot emissions, are easier and cleaner to maintain, as well as feature quieter operations and equal driving range, speed, and acceleration rates as compared to diesel buses.

CNG buses can be fueled by either fast-fill stations, time-fill stations or a combination of both. Fast-fill stations receive gas from a local gas utility and compress it to storage pressure (~4500-5000 PSI) to allow for rapid fueling similar to diesel. Time-fill stations also receive gas from the local gas utility, but utilize a much larger compressor and smaller storage for refueling during vehicle down time (~6-10) hours depending on service needs). Though fast-fill stations provide more rapid refueling, they also require more equipment and energy to operate, thus are the more expensive option. Some agencies opt for a hybrid approach which primarily uses time-fill stations, but maintain a small amount of extra storage for occasional fast-fill needs.

CNG is a *lighter-than-air gas* which may require upgrades to maintenance facilities that address ventilation and safety oversight.

CNG is readily available in just about every city or urban neighborhood almost anywhere in USA.



Source: U.S. Department of Energy

COMPRESSED NATURAL GAS BUS (CNG)

Operational Impact

- **Vehicle Range**
  - 345-400 for 40' buses
- **Physical Space Requirements**
  - ~ 60'x50'
- **Fueling Time**
  - Fast Fill: 4-5 minutes
  - Time Fill: ~6-10 hours
- **Daily Energy Requirements**
  - Low when compared to BEBs and on-site production of FCEBs
- **Fuel Availability**
  - There are 3 local CNG suppliers: Northville NG Fuels, KAKCO CNG Fuel, and Love's Trillium. Fast fuel public fueling stations available in Indianapolis and surrounding area but not in Bloomington (American Natural Gas; JEM Energy; CNG Source Fueling; Crown Clean Fuels).

Social Equity/Environmental Impact

- **Lifecycle GHG Emissions**
  - *506.3K kgCO2e*
- **Local Air Quality**
  - *VOC= 18 kg; CO= 677 kg; NOx= 18 kg; PM10 = 2 kg; PM2.5 = 2 kg; SOX = 4 kg*
- **Community Acceptance**
  - *Mayor pushing for landfill biogas conversion to CNG and transition bus fleet to CNG; on average CNG bus operates 10 decibels lower than diesel. However, communities tend to disapprove of CNG since it creates tailpipe emissions.*

* Used conversion factor 1DGE=1.136GGE and assumes 5.7mi/DGE

Costs

- **Vehicle Capital Costs**
  - 40' = ~$500k (includes estimated cost for vehicle add-ons)
- **Infrastructure Capital Costs**
  - ~$2.4M for fuel tanks, station and dispensers
- **Operating and Maintenance Costs**
  - O&M Cost: ~$0.44/mi
  - Fuel Cost: ~$2.21/GGE or $0.44/mi*
  - Total: ~$0.88/mi
- **Financial Incentives**
  - Alternative Fuel Vehicle Inspection & Maintenance Inspection
  - Compressed Natural Gas Tax Credit;
  - Idle Reduction and Natural Gas Vehicle Weight Exemption
  - Volkswagen Environmental Mitigation Trust - Medium & Heavy-Duty Grant Program
  - Special Fuel Tax Exemption - exempt from state gross retail tax

FUEL/TECHNOLOGIES

Battery-Electric Buses

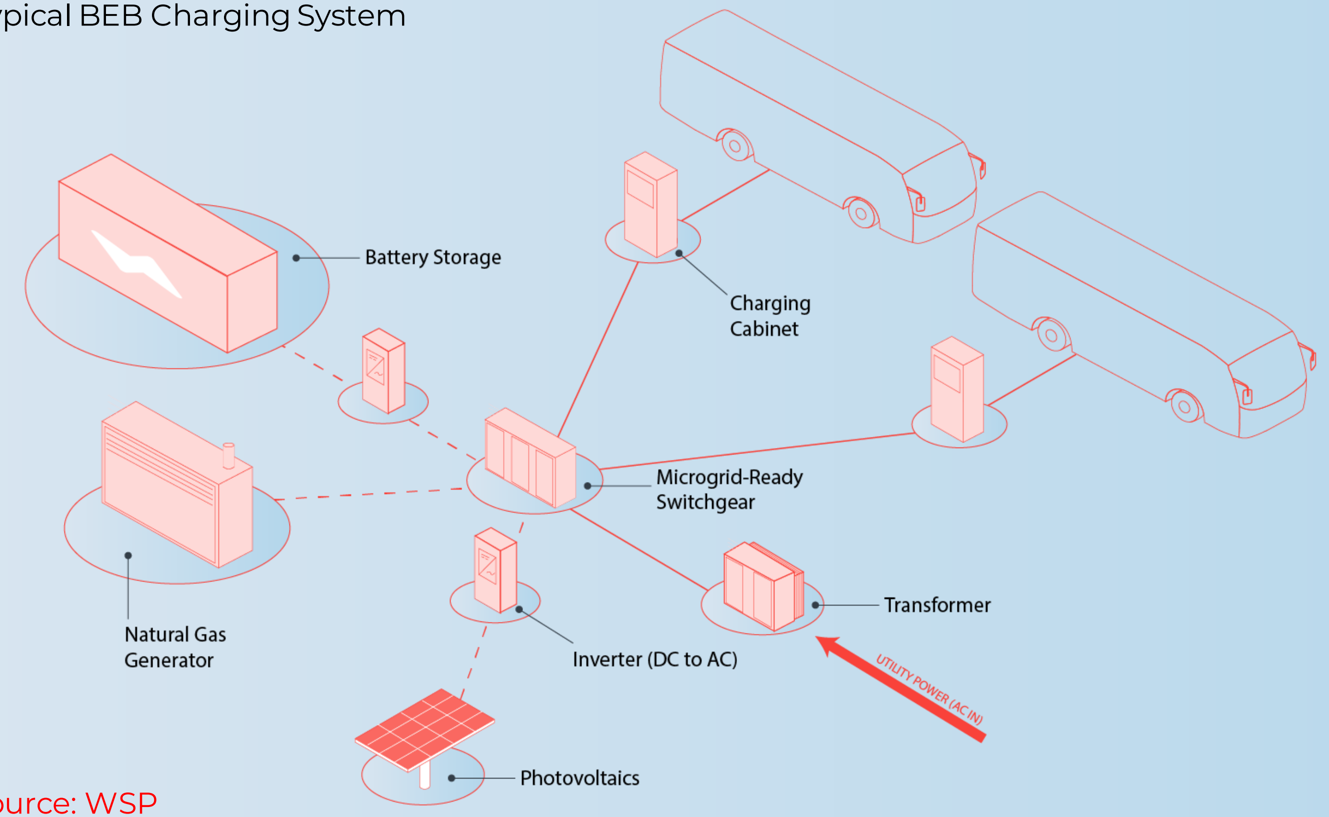
BEBs provide many environmental benefits to the community and region, as well as life-cycle cost savings to the operating agency. However, BEBs currently lack the range capabilities of other bus types.

The performance of a BEB is typically measured by the range and efficiency of the vehicle. A BEB's efficiency is expressed in kilowatt-hours per mile and can be highly variable depending on a myriad of factors, including regional climate and weather conditions, geographical topography, road sinuosity, ridership, battery health, operator driving style, and traveling speeds.

Electricity is stored in rechargeable battery packs that power an electric motor. Though larger batteries offer greater range, they also increase the weight of the BEB and reduce the efficiency. This fuel/technology would require additional infrastructure, including charging and electrical equipment.

Due to the nascency of the technology, the understanding of the staffing and training needs for both the vehicle and charging equipment is still developing. Vehicle OEMs and several charger OEMs provide training to help the transition from ICE to BEB technology.

Typical BEB Charging System



Source: WSP

BATTERY-ELECTRIC BUS (BEB)

Operational Impact

- **Average Vehicle Range (Advertised):**
  - 30’ : 165 miles
  - 35’ : 197 miles
  - 40’ : 212 miles
- **Physical Space Requirements:**
  - Will vary based on depot layout and chargers’ configuration
- **Fueling or Charging Time*:**
  - Varies based on each model acceptance rate and battery size
  - Ranging from 1.4 hours to 5 hours
  - Average of 2-3 hours
- **Daily Energy Requirements:**
  - Daily energy consumption = 11.675 MWh (assuming peak fleet daily mileage of 4670 miles)
  - Additional peak demand of 3 MW**
  - Increasing charger-to-dispenser ratio and using charge management software (CMS) can decrease the number of chargers and peak power demand
- **Fuel Availability**
  - Electricity is available as long as the site has the required equipment and enough capacity

Costs

- **Average Vehicle Capital Costs**
  - 30’ : $874 K
  - 35’ : $1.1 M
  - 40’ : $1.1 M
- **Infrastructure Capital Costs**
  - 20 Cabinets = $2.77 M
  - Excluding costs for site preparation, utility upgrades, and other structural construction costs if BPTC prefers overhead structure
- **Operating and Maintenance Costs**
  - O&M Cost = $1.77/mile
  - Fuel Cost = $0.31/mile***
  - *Total = $ 2.08/mile*
- **Financial Incentives:** Increasing grant and fundings for ZE vehicles and related infrastructures on the federal level

Social/Environmental Impact

- **Lifecycle GHG Emissions:** 506.3K kgCO2e
- **Local Air Quality:** Nothing from tailpipe (see Appendix B).
- **Community Acceptance:** Increasing acceptance for BEB

* Based on advertised maximum acceptance rate for plug-in chargers of the bus models. Assuming buses are charging from 0-100%
** Assuming 1:2 charger to dispensers ratio, 150 kW, 20 cabinets charging simultaneously
*** If the facility falls into High Load Factor rate structure, the fuel cost will double due to the 4x higher demand charge

FUEL/TECHNOLOGIES

Hydrogen Fuel Cell Electric Buses

Fuel cell electric buses (FCEBs) are electric vehicles that use compressed hydrogen as fuel to create electricity through a fuel cell. This electricity then powers an electric drivetrain in the vehicle. These vehicles share many of the same capabilities as BEBs such as zero harmful tailpipe emissions, near silent operations, and regenerative braking (a method of capturing kinetic energy when stopping to supply additional power to the battery).

Hydrogen fuel is currently produced either by steam methane reformation (SMR) or electrolysis. SMR produces hydrogen by using heat and water to separate hydrogen molecules from methane, which results in the release of greenhouse gases. Electrolysis, on the other hand, uses electricity to split water into hydrogen and oxygen.

Transit agencies can produce hydrogen on-site via these two methods or they can have it delivered. There are currently three hydrogen fuel suppliers within a 1000-mile radius of BPTC that can provide liquid hydrogen delivery.

Hydrogen Plant Locations Relative to BPTC

Source: Google Maps

FUEL-CELL ELECTRIC BUS (FCEB)

Operational Impact

- **Vehicle Range**
  - Up to 300 – 350 miles for 40' buses
- **Physical Space Requirements**
  - Off-site Production/on-site Liquid Hydrogen Storage
    - Full System: ~40'x60' (Includes compression, storage, dispensing, and safety buffer)
  - On-site Production
    - 50'x130'
- **Fueling or Charging Time**
  - <15 minutes
- **Daily Energy Requirements**
  - Liquid Storage: ~ 2.5 kWh per kilogram (kg)
  - On-site production: ~6 kWh/kg for SMR and ~50 kWh/kg for electrolysis
- **Fuel Availability**
  - Liquid Hydrogen Delivery: There are three hydrogen plants that can deliver to Indiana. AC Transit has not missed a single delivery in a year. However, some agencies have expressed concerns regarding uncertainty with hydrogen fuel costs.
  - On-site Production: Transit agencies that have on-site hydrogen production have experienced downtime in utility outages and require an on-site backup liquid hydrogen supply

Social Equity/Environmental Impact

- **Lifecycle GHG Emissions:**
  - On-Site Production (ton CO_2e):
    - Electrolysis: 1.35K
    - SMR: 0.81K
  - Hydrogen Delivery:
    - Electrolysis: 1.45K
    - SMR: 0.91K
- **Local Air Quality:** No tailpipe emissions
- **Community Acceptance:** Communities are generally more cautious with the installation of new hydrogen storage, and on-site production near their community due to the risk of hydrogen seepage and combustion.

Costs

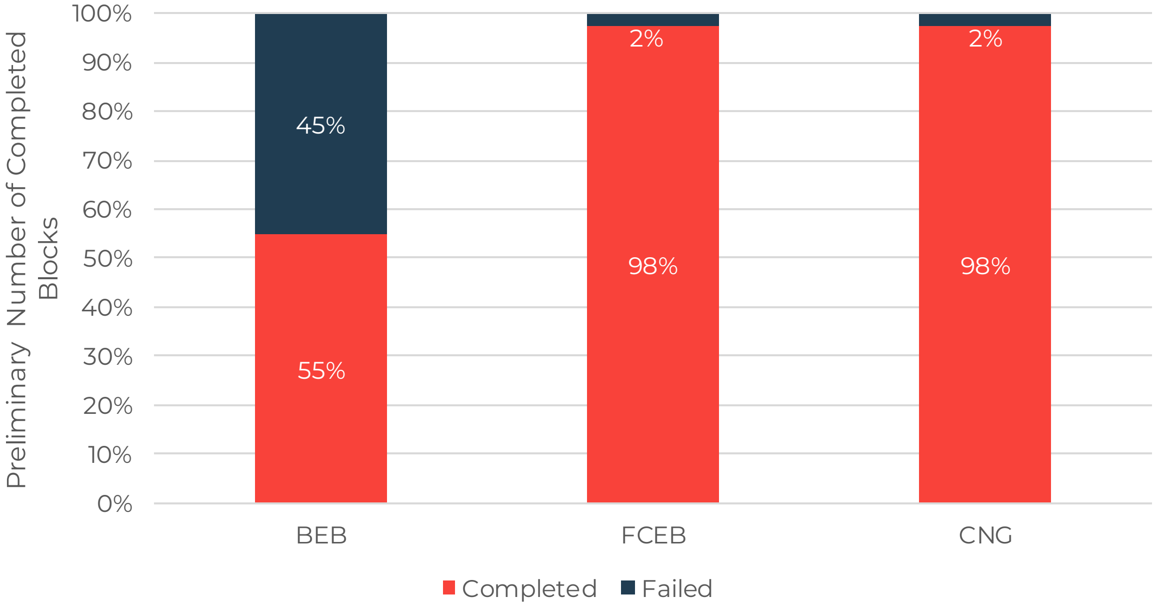
- **Vehicle Capital Costs**
  - 40': ~1.3M (includes estimated cost for vehicle add-ons)
- **Infrastructure Capital Costs****
  - Liquid Delivery
    - Full System: ~$3.8-$4.7M
    - Lighter than air facility upgrades: ~$2.0M
  - On-site Production (SMR)
    - $10M (does not include storage)
    - Lighter than air facility upgrades: ~$2.0M
  - On-site Production (Electrolysis)
    - Electrolysis (1000kg): $8.3M
    - Additional Liquid Storage: $3.8M
    - Lighter than air facility upgrades: ~$2.0M
- **Operating and Maintenance Costs*****
  - Off-site Production:
    - O&M Cost: ~$1.03/mi
    - Fuel Cost: ~$8.00/kg or ~$1.00/mile (assuming 8mi/kg)
    - Total: $2.03/mi
  - On-site Production
    - O&M Cost
      - Electrolysis: ~$1.05/mi
      - SMR: ~$1.36/mi
    - Fuel Cost: ~$5.00/kg or $0.63/mi
    - Total
      - Electrolysis: ~$1.68/mi
      - SMR: $1.99/mi
- **Financial Incentives**
  - Section 5339: Bus and Bus Facilities Formula Funds Grant
  - Section 5339(c): Low or No Emission Vehicle Program

* The lifecycle GHG emissions for gaseous hydrogen was used for this analysis
** Does not include cost of facility upgrades
***Includes fuel cost per mile. Uses an estimated $8/kg for off-site production of hydrogen fuel and $5/kg for on-site production

METRICS EVALUATION

OPERATIONAL IMPACT

Vehicle Range



- Based on the vehicle range* almost all blocks can be completed by either fuel cell or CNG technology without refueling
- Strategies can be explored to mitigate BEB failing blocks, such as on-route charging and strategic transition phasing

Metric	CNG	BEB	FCEB
40' bus range (miles)	345 – 400	133-212	300 – 350
Score	**High**	Low	Medium

Physical Space Requirements

- All fuels will need facility upgrades
- Required space varies depending on several factors including existing facility layout, charger configuration, and fuel delivery vs on-site production, etc.
- On-site hydrogen production relatively requires most space for the production equipment and storage

Metric	CNG	BEB	FCEB	
			Delivery	On-site
Physical Space Requirement	**Medium**	**Medium**	**Medium**	High

OPERATIONAL IMPACT

Fueling or Charging Time

- Varies on the type of fueling/charging configuration
- For CNG, fast-fill fueling can take a few minutes while time-fill can take several hours
- Based on BPTC's service requirements, BEBs will require between 1-5 hours to recharge. Actual charging time can vary depending on vehicle's acceptance rate, battery size, and state of charge.

Metric	CNG	BEB	FCEB
Fueling/Charge Time (hrs:min)	0:04 – 0:05 / Multiple Hours	2:00 – 3:00	<0:15
Score	Medium*	High	Low

*Average between time-fill and fast-fill was used

Energy Requirements

- BEBs typically require large utility upgrades to the site and higher daily power consumption for charging
- On-site production of hydrogen via electrolysis requires more energy than on-site production via SMR, liquid hydrogen delivery, and CNG

Metric	CNG	BEB	FCEB		
			Delivery	On-site Production	
			Liquid	SMR	Electrolysis
Energy Requirements	**Low**	High	**Low**	Medium	Medium

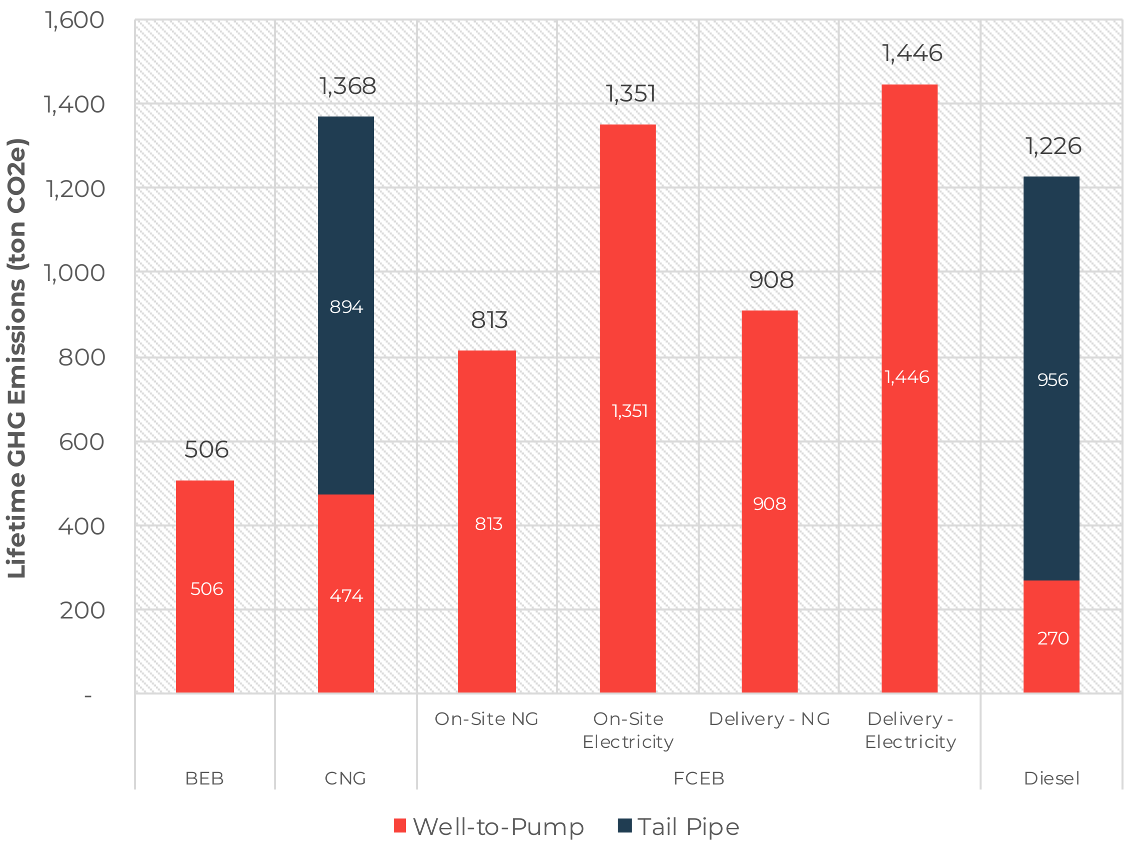
Fuel Availability

- BEBs will be charged with the site's utility power
- On-site hydrogen production will allow for hydrogen to be available at any time
- Odd-site production of hydrogen is dependent on fuel suppliers meeting their scheduled deliveries
- CNG is readily available and typically accessed via pipelines

Metric	CNG	BEB	FCEB	
			Delivery	on-site
Fuel Availability	Medium	**High**	Medium	**High**

SOCIAL/ENVIRONMENTAL IMPACT

Lifecycle GHG Emissions*



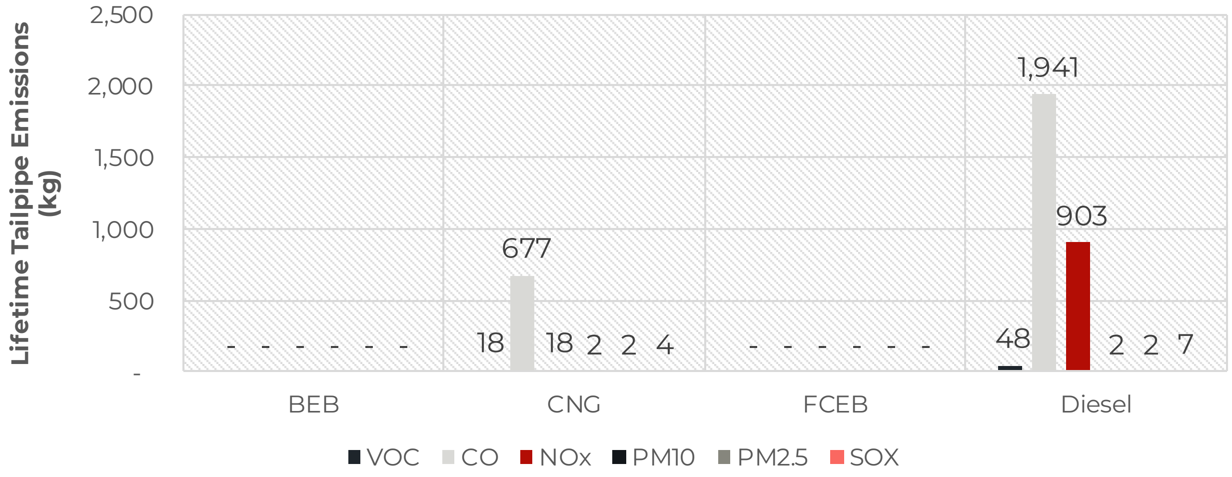
- **BEB** has the **least lifecycle GHG emissions in total**. Upstream emissions can be reduced if the grid mix becomes cleaner
- **CNG bus and hydrogen produced from electricity** have **higher total emissions** compared to diesel because the **higher upstream emissions**
- Despite not having any tailpipe emissions, **FCEB has substantial upstream emissions,** either from natural gas SMR or from electricity generation that mostly comes from fossil fuels

Metric	CNG	BEB	FCEB (Gaseous Hydrogen)			
			On-Site		Delivered	
			Natural Gas	Electricity	Natural Gas	Electricity
Lifecycle GHG (ton CO2e)	1.37	0.51	0.81	1.35	0.91	1.45
Score	High	**Low**	Medium	High	Medium	High

*Note: GHG emissions based on current regional grid fuel mix and does not consider future shifts to renewable energy which will significantly lower emissions.

SOCIAL/ENVIRONMENTAL IMPACT

Local Air Quality*



- **BEB** and **FCEB** have NO tailpipe emissions
  - However, fuel cell produced through electrolysis has the highest upstream NOx, PM10, PM2.5, and SOx emissions (see Appendix C)
- **CNG** bus has significantly lower emissions compared to diesel
  - However, CNG has the highest VOC and CO upstream emissions (see Appendix C)

Metric	CNG	BEB	FCEB (Gaseous Hydrogen)			
			On-Site		Delivered	
			Natural Gas	Electricity	Natural Gas	Electricity
Tailpipe Emissions (kg)	721	0	0	0	0	0
Score	High	Low	Low	Low	Low	Low

Community Acceptance

- BEBs are widely accepted by communities and supported in terms of sustainability initiatives
- Communities are generally more cautious around FCEBs due to the risk of hydrogen seepage and combustion
- CNG creates tailpipe emissions and therefore receives the lowest score

Metric	CNG	BEB	FCEB	
			Delivery	On-site
Community Acceptance	Low	**High**	Medium	Low

ESTIMATED LIFECYCLE COSTS*

Vehicle Capital Costs

- CNG vehicles have been on the market much longer than BEBs and FCEBs
- The cost of BEBs and FCEBs are expected to decrease as technology advances

Metric	CNG	BEB	FCEB
40' bus cost	$500K	$1.1M	$1.3M
Score	Low	High	High

Operating & Maintenance Costs

- CNG vehicles have the lowest O&M costs when compared o BEBs and FCEBs
- The cost of hydrogen and electricity are also expected to decrease in the upcoming years

Metric	CNG	BEB	FCEB		
			Delivered	On-site Production	
			Liquid	SMR	Electrolysis
O&M Costs**	$0.88/mi	$2.08/mi	$2.03/mi	$1.99/mi	$1.68/mi
Score	**Low**	High	High	High	Medium

**Includes fuel cost

Infrastructure Capital Costs

- The infrastructure capital costs for CNG, liquid hydrogen delivery, and BEBs range between approximately $2.5M - $5M
- On-site production of FCEBs have much higher capital costs at approximately $12M
- These estimates do not include facility or utility upgrades since they vary greatly between transit agencies

Metric	CNG	BEB	FCEB		
			Delivered	On-site Production	
			Liquid	SMR	Electrolysis
Infrastructure Capital Costs	$2.4M	$2.8M	$4.7M	$10M	$12.1M
Score	Medium	Medium	Medium	High	High

Financial Incentives

- There are several federal incentives for implementing BEBs and FCEBs since the country is moving towards net zero emissions
- In the state of Indiana, there are more CNG incentives than BEBs and FCEBs

Metric	CNG	BEB	FCEB
Financial Incentives	Medium	High	High

KEY FINDINGS & PRELIMINARY RECOMMENDATIONS

COMPARISON SUMMARY

Metric	CNG	BEB	FCEB		
			Delivered	On-site Production	
			Liquid	SMR	Electrolysis
Vehicle Range	**High**	Low	Medium	Medium	Medium
Physical Space Requirements	**Medium**	**Medium**	**Medium**	High	High
Fueling/Charging Time	Medium*	High	**Low**	**Low**	**Low**
Fuel Availability	Medium	**High**	Medium	**High**	**High**
Energy Requirements	**Low**	High	**Low**	Medium	Medium
Lifecycle GHG Emissions	High	**Low**	Medium/High**	Medium**	High**
Tailpipe Emissions	High	**Low**	**Low**	**Low**	**Low**
Community Acceptance	Low	**High**	Medium	Medium	Medium
Vehicle Cost	**Low**	High	High	High	High
Infrastructure Capital Costs* **	**Medium**	**Medium**	**Medium**	High	High
O&M Costs	**Low**	High	High	High	Medium
Financial Incentives	Medium	**High**	**High**	**High**	**High**

* Average between time-fill and fast-fill was used in this comparison analysis
** The lifecycle GHG emissions for gaseous hydrogen was used for this analysis
** Does not include cost of facility or utility upgrades

KEY FINDINGS*

Operational Impact

FCEB and CNG buses have an operational advantage due to the longer vehicle ranges. All three technologies have adequate time to refuel / recharge based on BPTC's service schedule. BEBs fall short of ~55% of the BPTC's block distances, but mitigations strategies such as strategic transition phasing and opportunity charging may supplement shortfalls.

Social/Environmental Impact

Battery-electric buses provide greater social and environmental benefits compared to other fuels due to lower lifetime GHG emissions, zero tailpipe emissions, and high community acceptance. FCEBs produce zero tailpipe emissions, however, most of the hydrogen produced in the U.S. is made via SMR which produces upstream emissions. CNG is a fossil fuel, thus has the lowest score in this category.

Financial Impact

CNG buses currently are the most affordable technology due to lower vehicle, infrastructure, and O&M costs, although, federal grants may preclude this technology in the near future. BEBs have the lowest costs in the zero-emission category, however FCEBs are expected to become more affordable as the technology matures. On-site production of hydrogen fuel may recover some of the FCEB operating costs, however, these technologies are relatively nascent, thus unpredictable and expensive.

*Based on scores applied to the metrics: 1 = Technology with the worst performance, 2 = Medium performance, 3 = Best performance

CONCLUSION & NEXT STEPS

1. No fatal flaws identified for any of the technologies. Successful implementation of FCEBs and CNG may require procurement of adjacent property, which is not considered in the financial calculations.

2. Zero-emissions goals and timelines should be considered in technology selection

3. Assessment of available space for infrastructure and Multi-Objective Decision Making Analysis (MODA) is recommended as a next step

4. Technology deep-deep dive including refined costs, site design recommendations, and service recommendations to follow selection of preferred technology

MODA INPUT

Evaluation Category	Evaluation Metric	Description	Rating (1-5)
Operational Impact	Vehicle Range	The range of the fuel/technology type.	
	Physical Space Requirements	The scale of the space required to accommodate new infrastructure	
	Fueling or Charging Time	The time it takes to fully fuel or charge the vehicle.	
	Energy Requirements	The energy required to accommodate the vehicle type	
	Disaster Resiliency	The possibility of operating the service during disasters	
Social Equity/ Environmental Impact	Life cycle GHG Emissions	A measure of GHG emissions.	
	Elimination of Fossil Fuel Vehicles by 2035	Whether or not the fuel/technology will result in an elimination of fossil fuel vehicles by 2035	
	Local Air Quality	A measure of tailpipe emissions, categorized by six pollutants: CO, Nitrogen Oxides, PM10, PM2.5, VOCs, and Sulfur Oxides	
	Community Acceptance	Communities' general perception and acceptance of the specified vehicle type	
Lifecycle Costs	Vehicle Capital Costs	The purchase price of a vehicle	
	Infrastructure Capital Costs	The capital costs of infrastructure to support 40 vehicles of the fuel/technology at BPTC's Grimes Lance facility	
	Lifetime Operating and Maintenance Costs	The annual costs to operate and maintain a vehicle, inclusive of "fuel costs", preventative maintenance, retirement, and overhaul costs.	
	Financial Incentives	The availability of competitive grants and other funding.	
Availability	Fuel	Accessibility to fuel	
	Technology	Technological availability such as available vehicle components	
	Training	Accessibility to operation and maintenance training	

APPENDIX

APPENDIX A - LIST OF ASSUMPTIONS FOR EMISSIONS CALCULATION

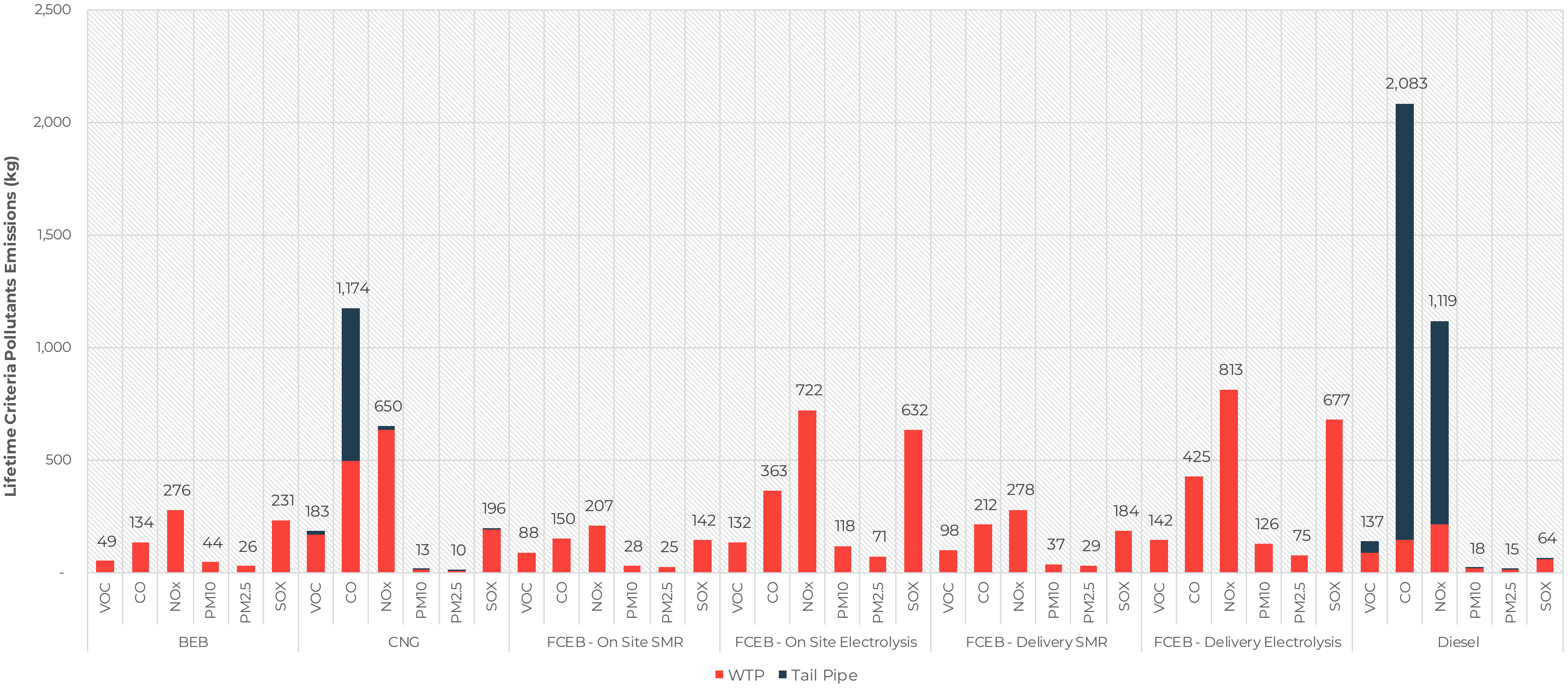
	Unit	CNG	BEB	FCEB	Notes
Vehicle Useful Life	Years	12			
Annual VMT	Miles	37,623			Based on average block distance assuming 261 days of service
Average Fuel Use	MPDGE	3.9	14.8	7.4	Number is sourced from peer agencies
Upstream Fuel Pathways		North America CNG Mix	Electricity: PJM Mix (Former RFC)	For Pathways that use Electricity: PJM Mix	Pathway as defined by GREET Model

APPENDIX B – GHG EMISSIONS AND CRITERIA POLLUTANTS

Emissions	BEB		CNG		FCEB								Diesel	
					On-Site Production				Delivery					
					Natural Gas		Electricity		Natural Gas		Electricity			
	WTP	Tail Pipe	WTP	Tail Pipe	WTP	Tail Pipe	WTP	Tail Pipe	WTP	Tail Pipe	WTP	Tail Pipe	WTP	Tail Pipe
GHG-20*	1.1214	0	1.0491	1.9802	1.8002	0	2.9915	0	2.0109	0	3.2022	0	0.5978	2.1179
VOC	1.10E-04	0	3.66E-04	3.98E-05	1.94E-04	0	2.92E-04	0	2.17E-04	0	3.15E-04	0	1.97E-04	1.06E-04
CO	2.97E-04	0	0.0011	0.0015	3.31E-04	0	8.05E-04	0	4.69E-04	0	9.42E-04	0	3.14E-04	0.0043
NOx	6.10E-04	0	0.0014	3.93E-05	4.58E-04	0	0.0016	0	6.17E-04	0	0.0018	0	4.78E-04	0.002
PM10	9.77E-05	0	2.38E-05	4.49E-06	6.30E-05	0	2.61E-04	0	8.16E-05	0	2.80E-04	0	3.49E-05	4.47E-06
PM2.5	5.86E-05	0	1.82E-05	3.97E-06	5.51E-05	0	1.56E-04	0	6.49E-05	0	1.66E-04	0	2.96E-05	4.11E-06
SOX	5.12E-04	0	4.26E-04	8.92E-06	3.15E-04	0	0.0014	0	4.07E-04	0	0.0015	0	1.27E-04	1.46E-05

* GHG-20 is in kgCO2e and inclusive of CO2, CH4, and N2O

APPENDIX C – LIFETIME CRITERIA POLLUTANT EMISSIONS



MPO Policy Committee

Presented by Jeff Jackson, Transportation Demand Manager, ESD - September 9, 2022

GO BLOOMINGTON

MOBILITY OPTIONS FOR A BETTER COMMUTE

CITY OF BLOOMINGTON

Transportation Demand Management

- The Transportation Demand Management (TDM) Plan was prepared in May 2020 – **The TDM Mission is reduce the number of single occupant vehicles (SOV)** operating within Bloomington.
- **Reducing SOV's will decrease carbon emissions, relieve traffic congestion, and increase parking capacity**
- The Transportation Demand Manager was hired on November 1, 2021
- Jeff Jackson's background
- Three competitive selection processes were completed to hire contractors to brand the TDM program, develop the website with a software matching platform.
- Budget funds were encumbered prior to the end of the 2021 calendar year

GO BLOOMINGTON
MOBILITY OPTIONS FOR A BETTER COMMUTE

CITY OF BLOOMINGTON

Branding – Q1

- The Affirm Agency recommended several logo names, designs and taglines.
- **Go Bloomington** was selected as the new TDM brand
- The selected tagline is **Mobility Options for a Better Commute**

Website Development – Q2

- The Affirm Agency was hired to design, develop, and implement the new website
- GoBloomington.org **is the new domain name**
- Ride Amigos has local DNA and was hired to integrate their software matching program into the website

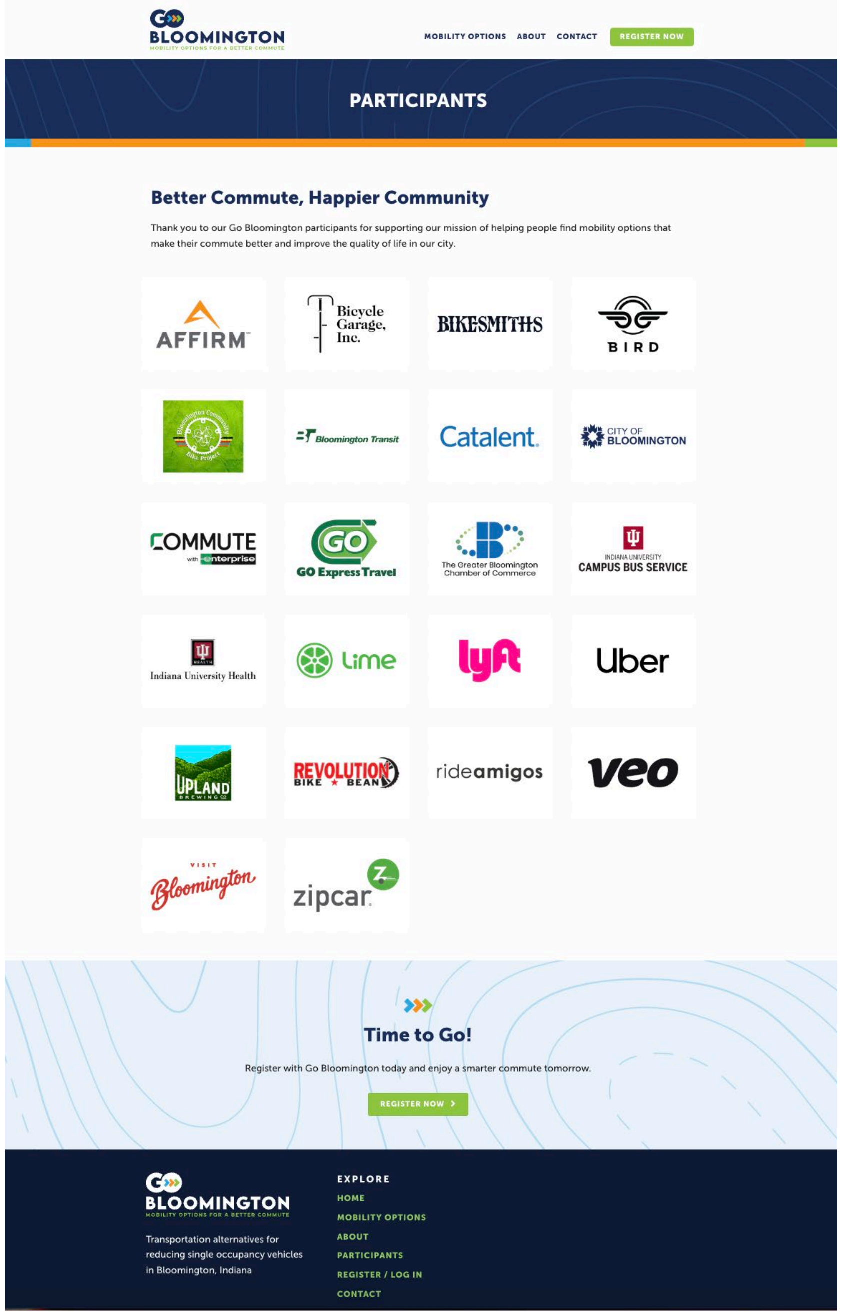
GO BLOOMINGTON
MOBILITY OPTIONS FOR A BETTER COMMUTE

CITY OF BLOOMINGTON

Marketing Plan – Q3 & Q4

- The Affirm Agency designed, developed and is implementing the marketing plan
- The marketing plan includes the following components; BT exterior bus ads, banners within the street right-of-way, banners within the B-Line right-of-way, utility bill leaflet, rack cards, posters, online advertising including pay-per-clicks ads, and social media
- Social media platforms to include Facebook, Instagram and LinkedIn
- **The formal launch occurred on September 6, 2022 at 2:00 p.m. in front of City Hall**

Employer, Business, and Community Participants



Federal Funding Opportunities

- Federal Transit Administration (FTA) – Bloomington Transit (BT) is this areas designated recipient of federal funding. Go Bloomington is required to submit all FTA grants through BT

- Federal Highway Administration (FHWA) – The new Infrastructure Bill includes **Carbon Reduction Formula Funding**. **TDM programs are specifically eligible for these funds.** The vast majority of TDM's are located in urbanized, non-attainment areas and therefor are funded by Congestion Mitigation Air Quality (CMAQ) grants. Go Bloomington is not eligible for CMAQ funding because Bloomington is not a non-attainment area. **This funding source is the only other federal funding opportunity designed specifically for TDM's such as Go Bloomington**.

Budget and Federal Funding Request

- **2023 - Proposed Budget** - as of August 25, 2022

General Fund	$68,871	(Local)
LIT	$160,000	(Local)
ARPA	$89,500	(Federal)
TOTAL	**$318,371**	

- **Carbon Reduction Formula Funding Request** **Amount**

20%	$45,774	(Local)
80%	**$183,097**	**(Federal)**
100%	$228,871	

Questions ?

Thank You !