
WELCOME TO ZERO

Scott Sauer

Chief Operating Officer

SEPTA

Dan Raudebaugh

Executive Director

CENTER FOR
TRANSPORTATION
AND THE ENVIRONMENT

About CTE

Who We Are

501(c)(3) non-profit engineering and planning firm

Our Mission

Improve the health of our climate and communities by bringing people together to develop and commercialize clean, efficient, and sustainable transportation technologies

Portfolio

$3.7B+

- Research, Demonstration, Deployment
- 100+ active projects totaling $365M+

Our Focus

Zero-Emission Transportation Technologies

National Presence

Atlanta, Berkeley, Denver, St. Paul

What We Do

Technology Development

Innovative pilots for pioneering tech

Smart Deployment

Technical solutions for early adopters

Transition Planning

Strategic plans for full-fleet electrification

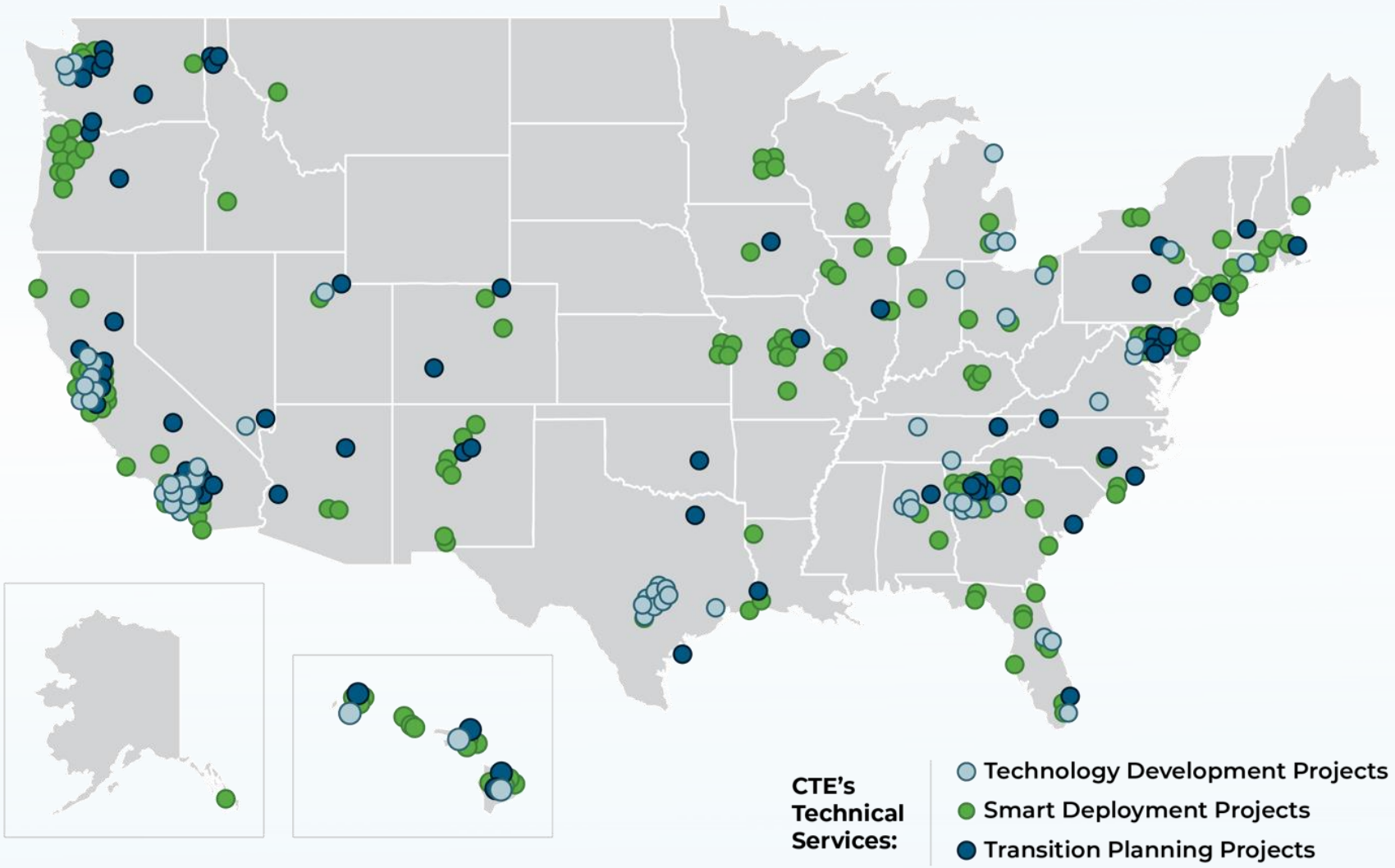
Advocacy

Unified advocacy for a zero-emission future

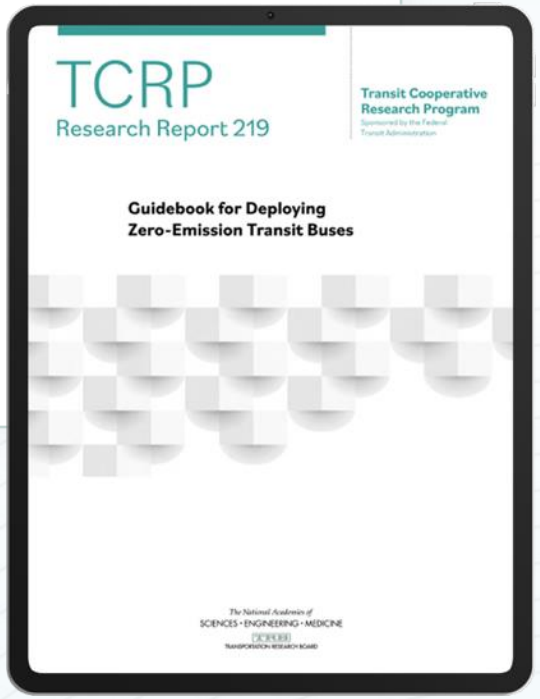
Grant Writing as a Service

Comprehensive support for team building and project planning

31 Years
130+ Active Projects

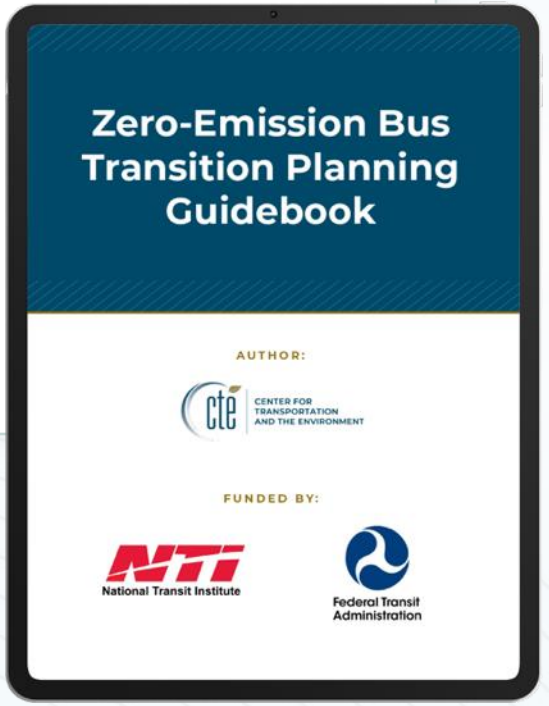


ZEB Deployment Guidebook



ZEB Transition Planning Guidebook

COMING SOON!



Major 40-Foot Bus OEMs

2020

Parallel Efforts

Solutions

Progress Payments

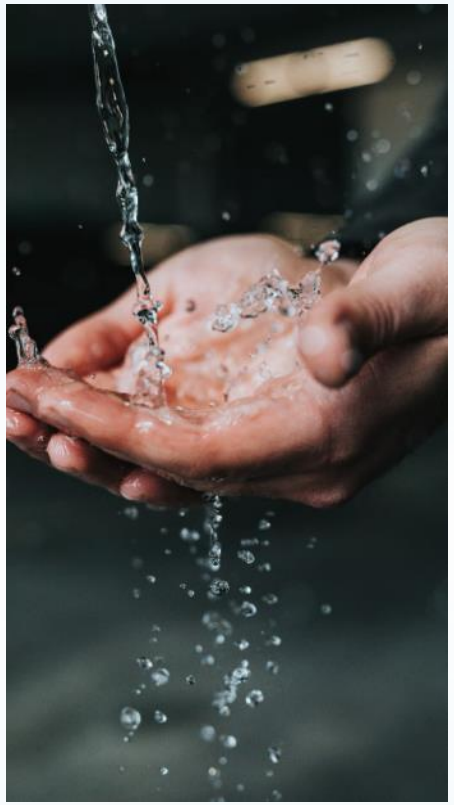
Payment Indexation

Reduced Customization

FEBRUARY 2024

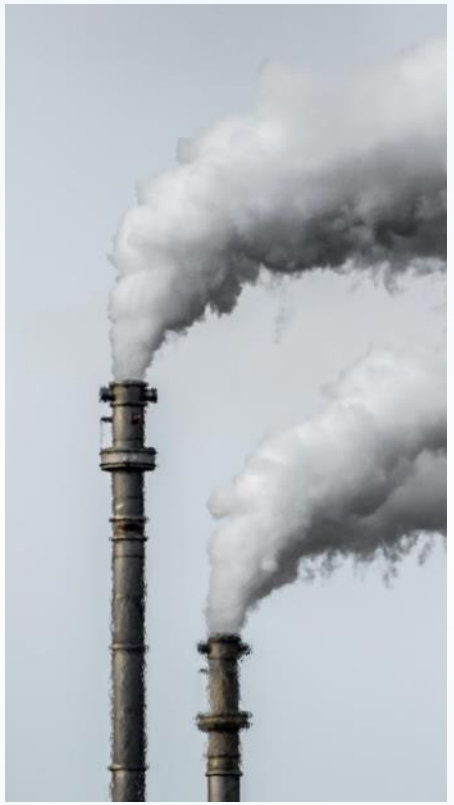
The White House Roundtable

Why don’t we just let agencies go back to diesel and invest in dedicated bus lanes?



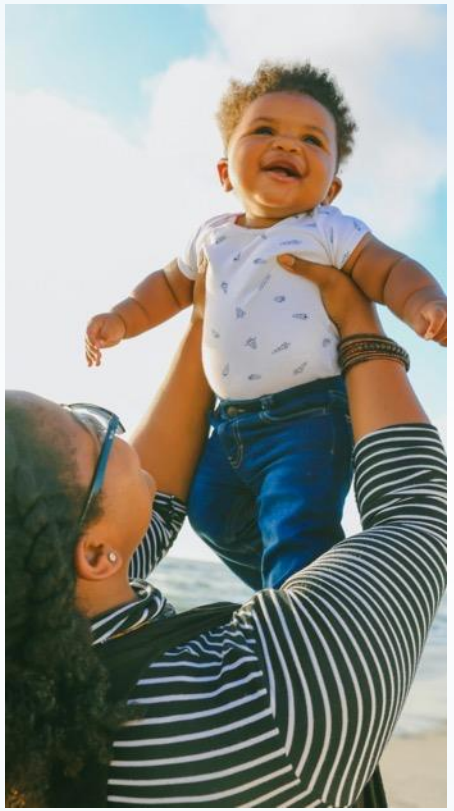
Public Health

Geopolitical Stability



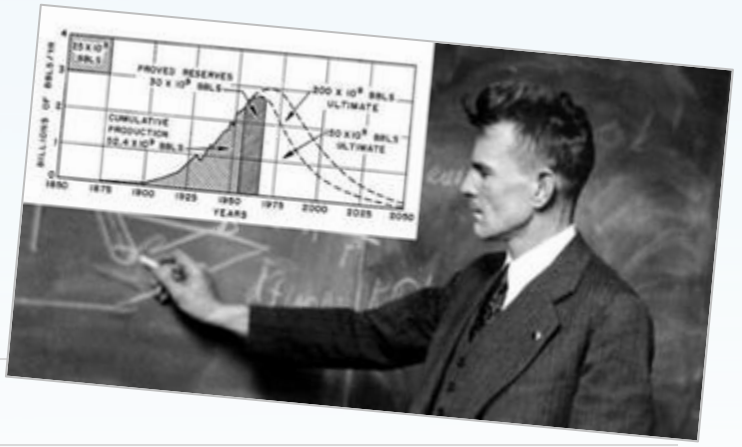
Climate Change

Sustainability

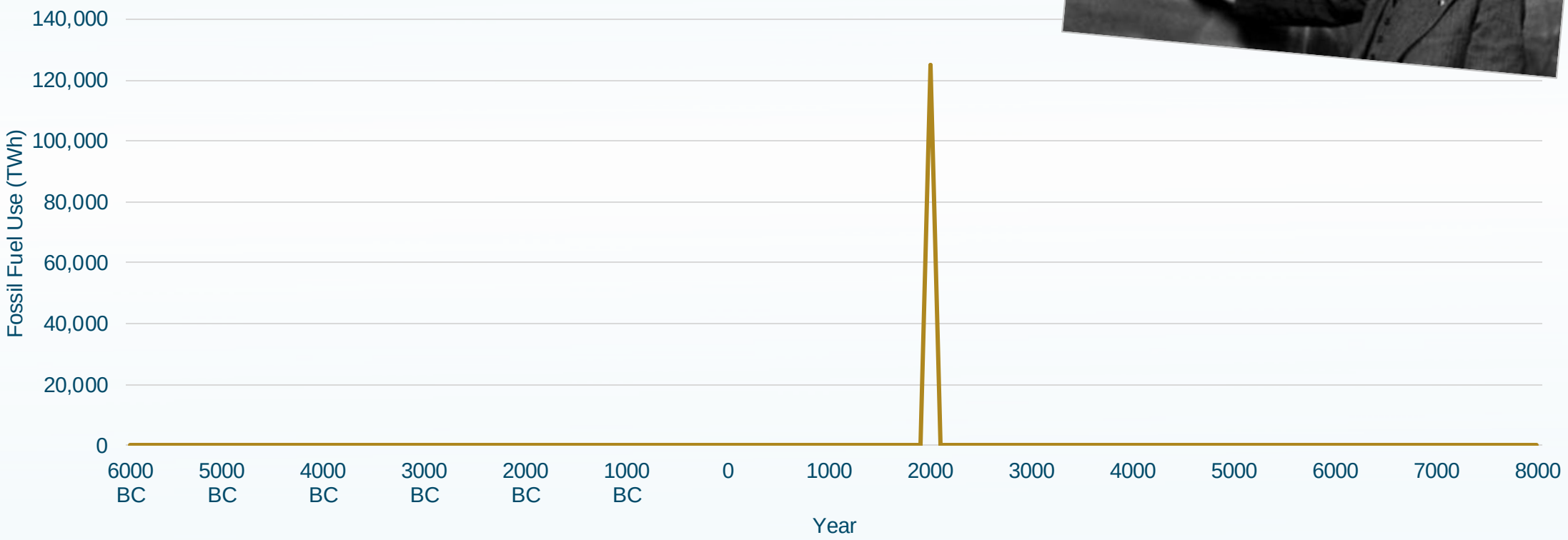


Legacy

Oil is a Finite Resource



Peak Oil



Life Without Oil

Medicine

Cosmetics

Plastics

Synthetic Rubber

Asphalt

Cleaning Products

Fuel

We Can Slow The Clock

67%

Transportation

33%

Other Industries

Industrial
Residential
Commercial
Electric Power

U.S. Energy Information Administration, Monthly Energy Review, July 2023, preliminary data

It is irresponsible to continue burning this valuable resource in applications where we have other technologies that work.

Let’s talk about a solution that we can address as industry leaders…

Who’s Driving the Bus?

Transit Agency CEOs

- Lead agency, set strategy
- Oversee capital projects and expansion
- Manage political relations and compliance
- Develop and implement transit plans
- Ensure service reliability and safety
- Build and maintain transit facilities
- Build community and government partnerships
- Advocate for transit funding and policy
- Manage public image and media relations
- Build and lead high-performance team
- Foster positive workplace culture
- Ensure financial and operational efficiency
- Environmental Stewardship
- Oversee project planning, execution, and funding
- Manage project timelines, budgets, and risks
- Drive technological and service innovation
- Promote environmental sustainability
- Foster a culture of continuous improvement
- Ensure healthy supply chains

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- **Environmental Stewardship**
- Oversee project planning, execution, and funding
- Manage project timelines, budgets, and risks
- Drive technological and service innovation
- Promote environmental sustainability
- Foster a culture of continuous improvement
- **Ensure healthy supply chains**

Who’s Driving the Bus?

Transit Agency Attorneys

- Ensure legal compliance
- Mitigate risk

“Managing risk is very different from managing strategy. Risk management focuses on the negative threats and failures rather than opportunities and successes.”

Robert S. Kaplan
Vice Chairman
Goldman Sachs

“He who is not courageous enough to take risks will accomplish nothing in life.”

Mohammad Ali

When Attorneys Drive the Bus…

…indemnitor agrees at its sole cost and expense to **hold harmless**…

…without reference to any applicability **of insurance**…

…against any damages, costs, expenses, **liabilities**, claims…

…fully **indemnify indemnitee** against any such negligence…

…regardless of any prior, concurrent, or **subsequent negligence** by indemnitee…

…indemnification to survive **termination** of the waiver…

A New Roadmap

Instead of Asking:

Can I do this?

Say:

I want to do this.

How do I do this?

How do I do this ethically?

How do I do this with the least amount of risk?

This goes way beyond bus procurements…

Three Tracks

Thank You to Our Gold Sponsors

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A Tribute to Excellence

Nuria Fernandez

Former FTA Administrator

Terry Garcia Crews

FTA Region 3 Regional Administrator

Mary Leary

FTA Associate Administrator for Research, Demonstration and Innovation

Thinking Systemically About ZEB Deployments

ZEB Con

AUG 27–29, 2024 • PHILADELPHIA

Thinking Systemically About ZEB Deployments

Carly Macias

Zero Emission Fleet Strategic Planning Manager

King County METRO

Jörn Schwarze

CTO

KVB

Richard Harrington

Engineering Director

GoAhead LONDON

Warren Berry

Director, Zero Emissions Systems Planning

NJ TRANSIT

King County Metro Zero Emission System Transition

Carly Macias,

Zero Emission Technical Advisory, Capital Division

Zero Emission Bus Conference (ZEB Con)

August 29, 2024

King County METRO

Moving forward together

ZERO EMISSIONS

Transit Agencies by Bus Fleet Size (2022)

#	Agency	Location	# Buses (2022)
1	NY MTA	New York, NY	5,830
2	NJ Transit	Newark, NJ	2,459
3	LA Metro	Los Angeles, CA	2,109
4	CTA	Chicago, IL	1,883
5	WMATA	Washington DC	1,591
6	SEPTA	Philadelphia, PA	1,449
7	**King County Metro**	**Seattle, WA**	**1,369**
8	MBTA	Boston, MA	1,236
9	Houston Metro	Houston, TX	1,184
10	MTA	Baltimore, MD	1,088

#	Agency	Location	# Buses (2022)
11	RTD	Denver, CO	1,035
12	SF MTA	San Francisco, CA	850
13	Miami-Dade	Miami, FL	841
14	PRT	Pittsburgh, PA	732
15	Pace	Arlington Heights, IL	693
16	Trimet	Portland, OR	653
17	CATS	Charlotte, NC	628
18	Metro Transit	Minneapolis, MN	572
19	DART	Dallas, TX	566
20	UTA	Salt Lake City, UT	554

Source: National Transit Database, 2022 Vehicle Dataset

Transit Agencies by Zero Emission Miles (2022)

#	Agency	Location	# Buses (2022)	Electric Miles (2022)
1	SFMTA	San Francisco, CA	850	4,262,047
2	**King County Metro**	**Seattle, WA**	1,369	3,229,470
3	AVTA	Lancaster, CA	86	2,634,881
4	LA Metro	Los Angeles, CA	2,109	1,442,768
5	ATN	Anaheim, CA	49	1,312,342
6	IndyGo	Indianapolis, IN	196	907,705
7	SEPTA	Philadelphia, PA	1,449	717,968
8	SunLine	Thousand Palms, CA	84	679,797
9	AC Transit	Oakland, CA	542	585,800
10	LA DOT	Los Angeles, CA	345	569,345

#	Agency	Location	# Buses (2022)	Electric Miles (2022)
11	Dayton RTA	Dayton, OH	154	521,072
12	Link Transit	Wenatchee, WA	28	483,986
13	St. Louis Metro	Saint Louis, MO	386	452,553
14	CARTA	Charleston, SC	89	430,238
15	GTA	Greensboro, NC	53	427,069
16	Laketran	Painesville, OH	37	426,620
17	RTC	Reno, NV	78	395,572
18	Star Metro	Tallahassee, FL	74	360,572
19	KAT	Knoxville, TN	71	353,389
20	Foothill Transit	West Covina, CA	359	343,569

King County METRO

Source: National Transit Database, 2022 Fuel and Energy Dataset

*Zero emission miles include miles traveled by battery electric buses, electric trolleybuses, and hydrogen fuel cell buses

Transit Agencies by Battery Electric Miles (2022)

#	Agency	Location	# Buses (2022)	BEB Miles (2022)
1	AVTA	Lancaster, CA	86	2,634,881
2	LA Metro	Los Angeles, CA	2,109	1,442,768
3	ATN	Anaheim, CA	49	1,312,342
4	IndyGo	Indianapolis, IN	196	907,705
5	LA DOT	Los Angeles, CA	345	569,345
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11	**King County Metro**	**Seattle, WA**	**1,369**	**411,760**
12	RTC	Reno, NV	78	395,572
13	Star Metro	Tallahassee, FL	74	360,572
14	KAT	Knoxville, TN	71	353,389
15	Foothill Transit	West Covina, CA	359	343,569
16	RTD	Denver, CO	1,035	310,502
17	CAT	Clemson, SC	31	308,707
18	Long Beach Transit	Long Beach, CA	224	275,471
19	LTD	Eugene, OR	99	243,060
20	DTS	Honolulu, HI	435	228,079

King County METRO

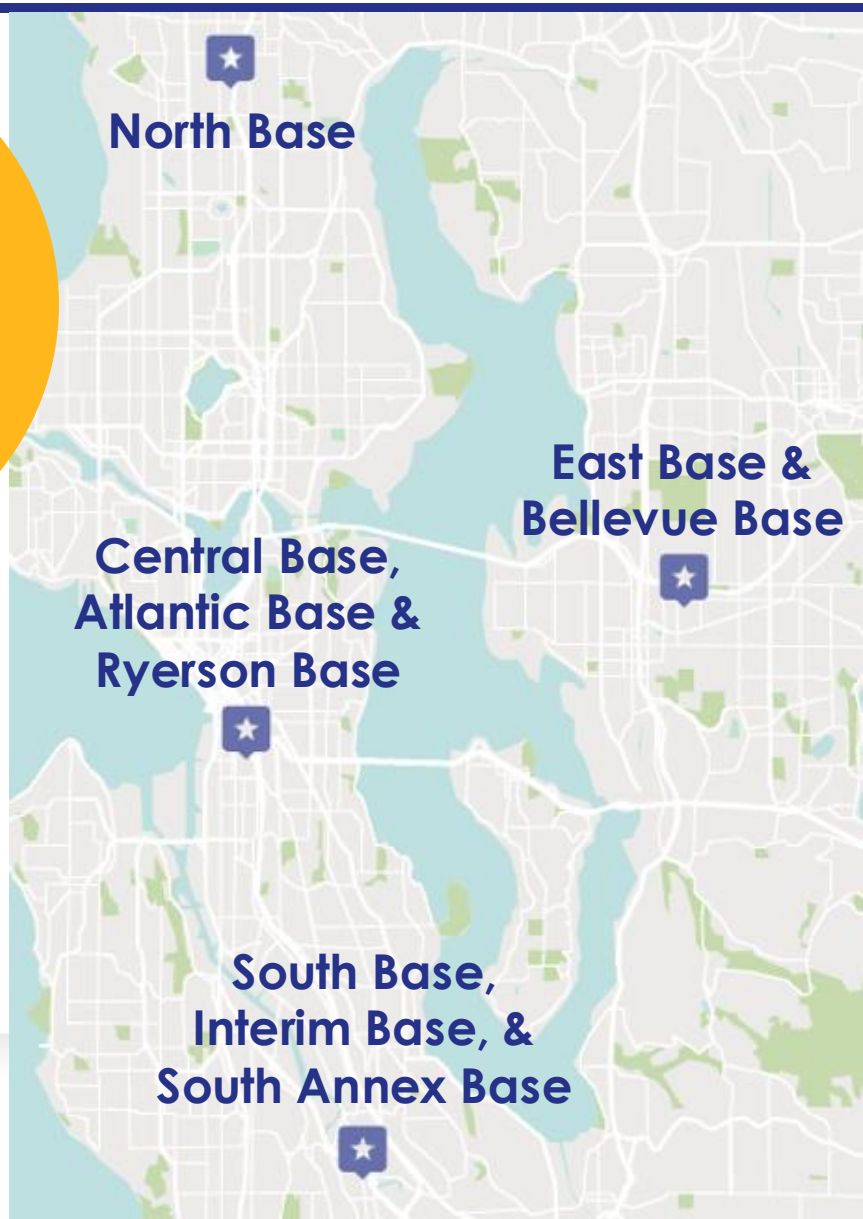
Source: National Transit Database, 2022 Fuel and Energy Dataset
*BEB miles only include miles traveled by battery electric buses

King County Metro Overview

- **1,470 Buses**
  - **655** Standard Buses (35/40 ft)
    - **31 40-ft Battery Electric Buses**
    - **110 40-ft Electric Trolleybuses**
  - **690** Articulated Buses (60 ft)
    - **20 60-ft Battery Electric Buses**
    - **64 60-ft Electric Trolleybuses**
  - **125** Sound Transit Buses
- **215 Bus Routes**
- **7 Bus Bases (9 by 2028)**
- **2,134 sq mi Service Area**

Commitment to Transition to 100% Zero Emission by 2035

Investing first in communities most affected by air and noise pollution from transportation



King County METRO

ZERO EMISSIONS

Moving to Zero Emission – Milestones

- **1940:** The electric trolleybus fleet & network began operation in Seattle
- **2004:** Metro is one of the first transit agencies to adopt diesel hybrids
- **2015:** Deployed 3 Proterra battery electric buses (BEBs) for pilot program
- **2018:** Deployed 8 more Proterra BEBs
- **2019:** Metro committed to transition the fleet to zero emission by 2035
- **2022:** Commissioned South Base Test Facility to test BEBs with charging solutions from two manufacturers (ABB & Heliox)
- **2022:** Deployed 20 40-ft and 20 60-ft New Flyer BEBs
- **2024:** Procured 89 40-ft Gillig BEBs (deliveries starting in 2025) with an option to purchase up to 306 more BEBs from Gillig

Near-Term Plans & Projects

- BEB Procurements & Testing
- Two New 100% BEB Bases (350 combined capacity)
- Opportunity Charging Projects
- Transit System Electrification Plan
- Evaluating State of Good Repair
- Software Implementation (CMS, Yard Management, BEB Planning Tools)
- Organization Change Management (business processes, team structure)

Challenges Planning for a Future that hasn't Arrived

- Competing priorities (service growth, state of good repair)
- Lack of Bus OEMs in U.S.
- Challenges with range/weight 60-ft BEBs
- Deciding when to pivot to new technologies
- Uncertainty around availability of hydrogen

Research & Pilot Testing

- South Base Test Facility
- Pilot BEBs & chargers from multiple manufacturers
- Visits to Transit Agencies in U.S. & Abroad
- Partnerships with University
- Involvement in ZEBRA, APTA, IBBG, TCRP

Other KCM Presentations at ZEB Con

- **Christina Arthur** discussing KCM ZE Capital Projects during "Facilities Build Out: Complexities from the Field"
- **Brandon Reno** discussing KCM Opportunity Charging during "Charging Strategies for Optimized Operations"
- **Elie Kourdahi** discussing KCM ZE Vehicle Maintenance during "Building Your ZEB Workforce"

Thank you!

Questions, Comments, & Discussion

King County METRO

ZERO EMISSIONS

Lessons Learned from Shifting to a Zero Emission Bus Fleet

Kölner Verkehrs-Betriebe AG

Jörn Schwarze
CTO

Zero Emission Bus Conference 2024

KVB Overview

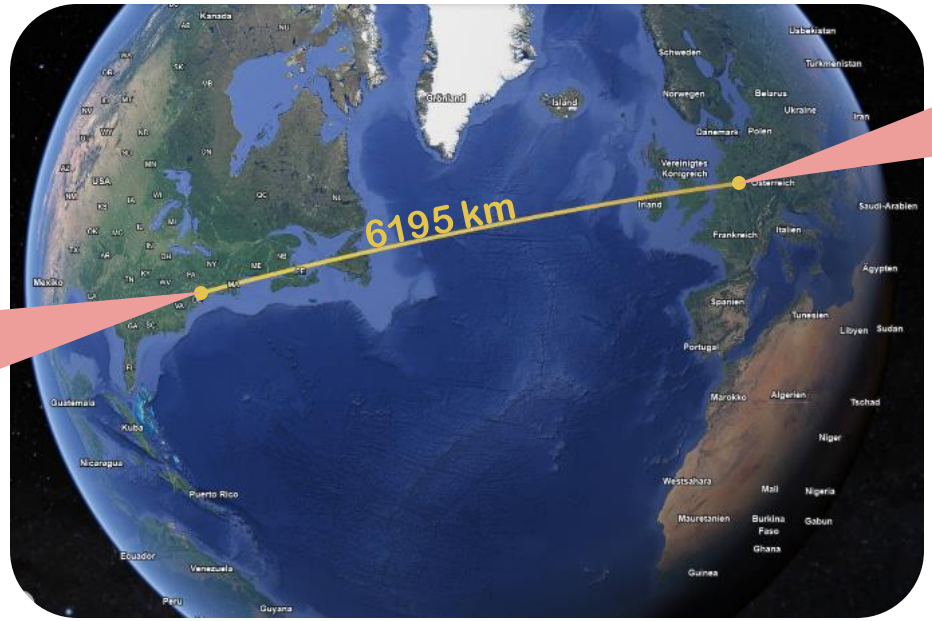
- 4th biggest communal public transport operator in Germany
- 235,8 Mio. passengers/year
- 330 Buses on 67 buslines
- Bus network length of 735 km
- 388 Light-Rail-Vehicles on 12 lines
- 4.159 employees
- 259,7 Million Euro sales revenue
- - 131, Million Euro company earnings

Annual Report 2023

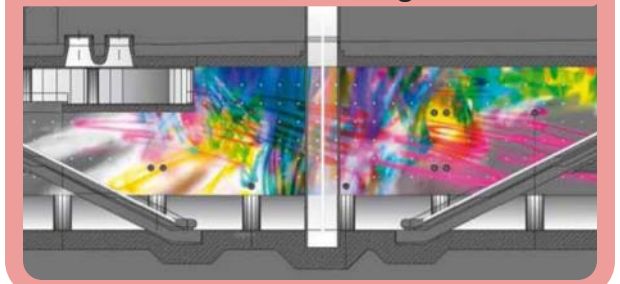
Connecting Art

Philadelphia´s and Cologne´s public transport is sharing the same artwork by Katharina Grosse

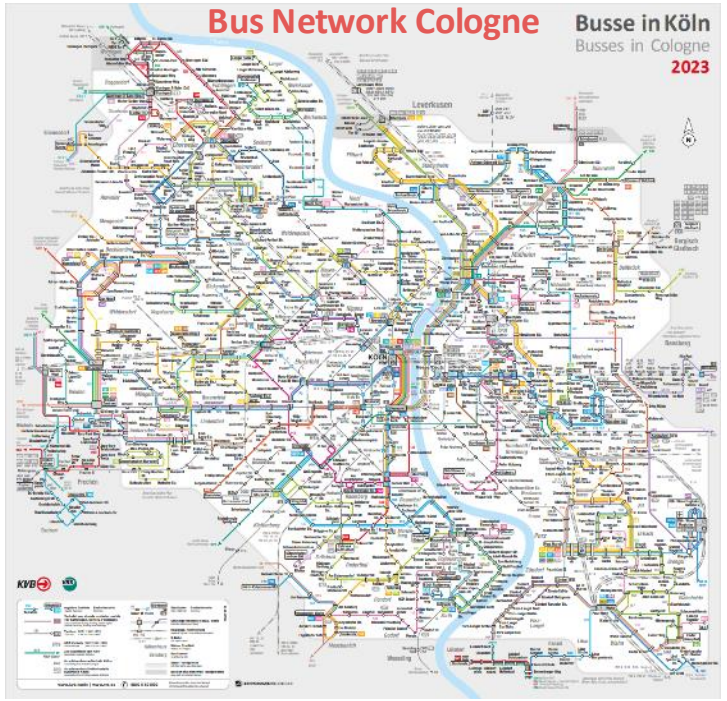
Railway Line Philadelphia



Tram Station Cologne



KVB – First Address for Public Transport in Cologne / Germany

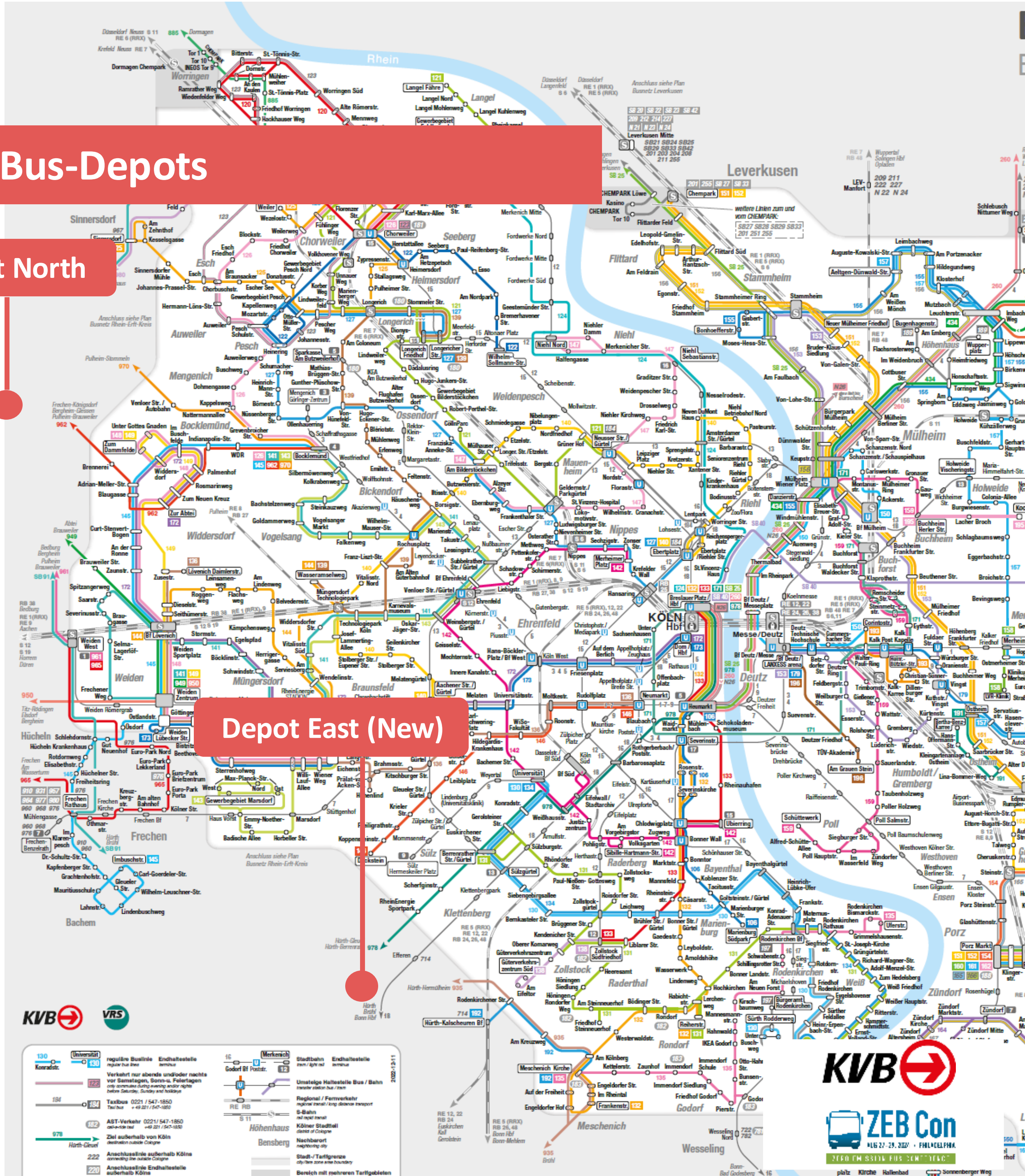


KVB has three Bus-Depots

Depot North

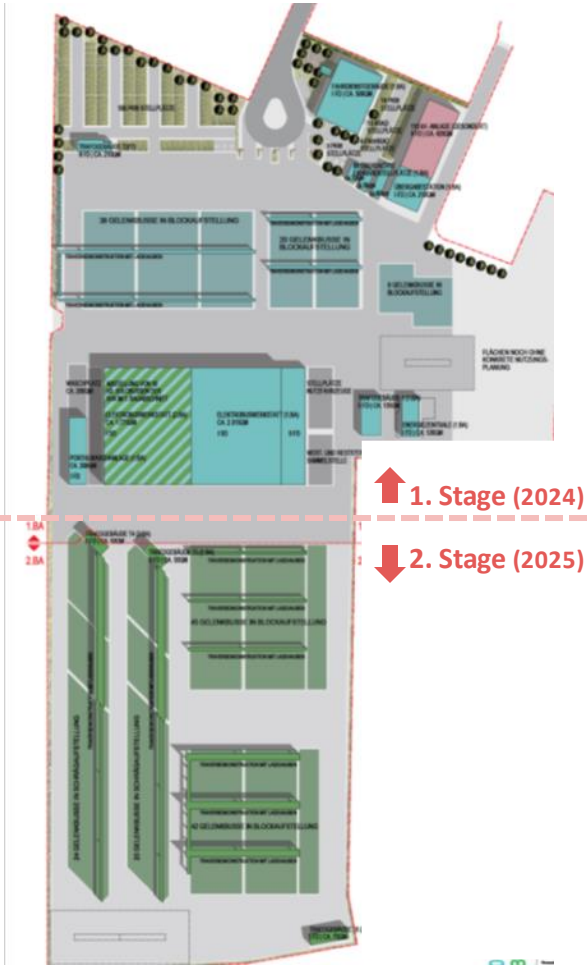
Depot West

Depot East (New)



Our New Bus Depot East

1st and 2nd Stage



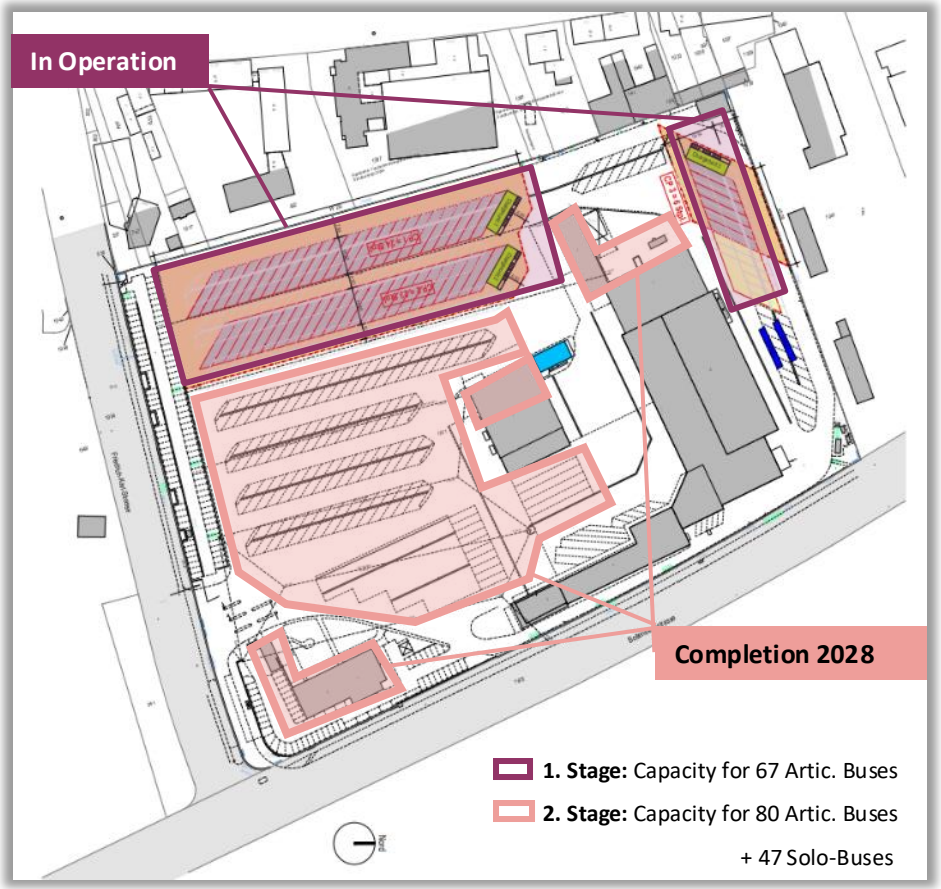
Source: Schüßler-Planungenieurgesellschaft mbH

Our New Bus Depot East

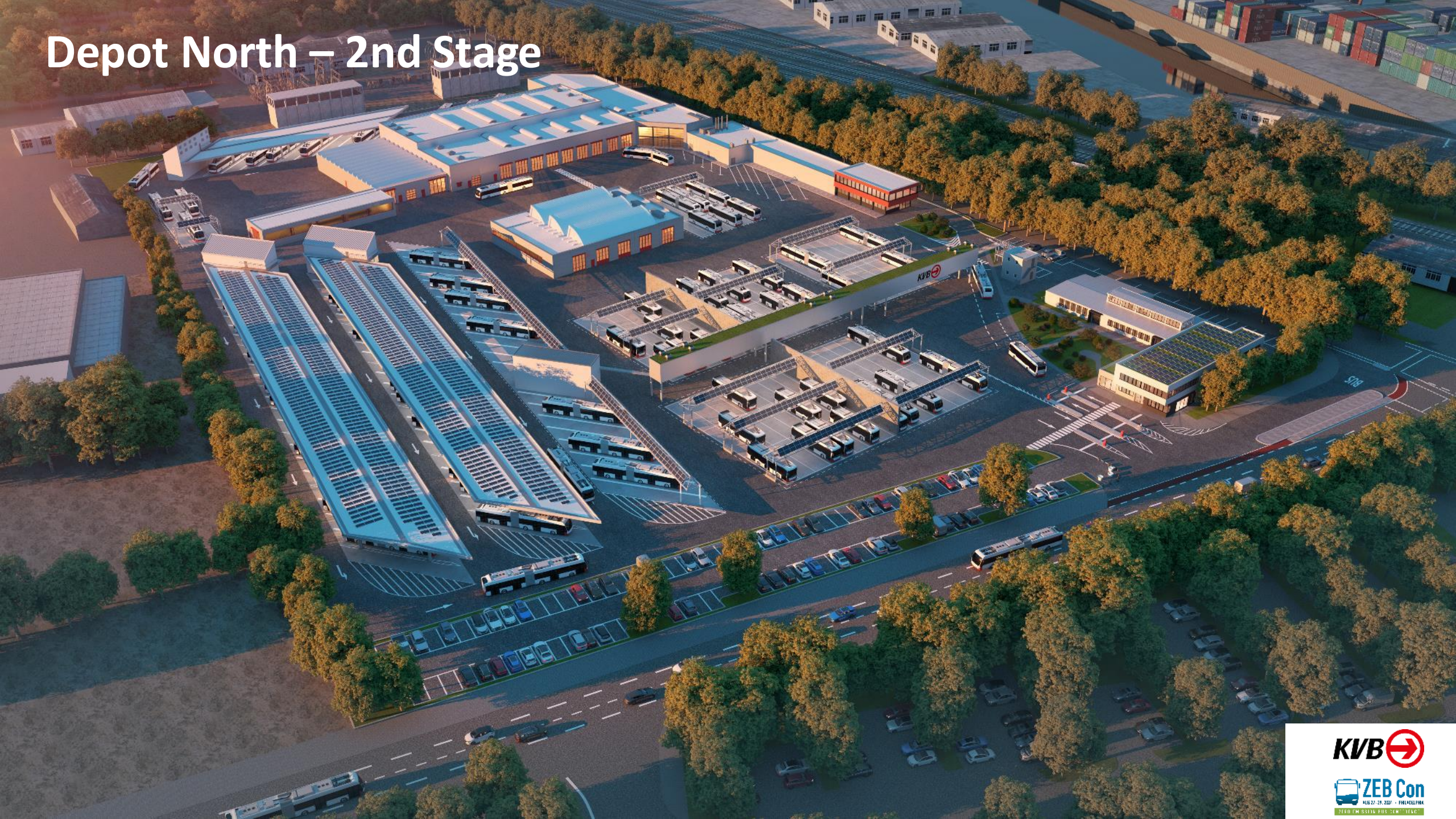
2nd stage

Retrofit of Depot North

Overview 1st and 2nd Stage

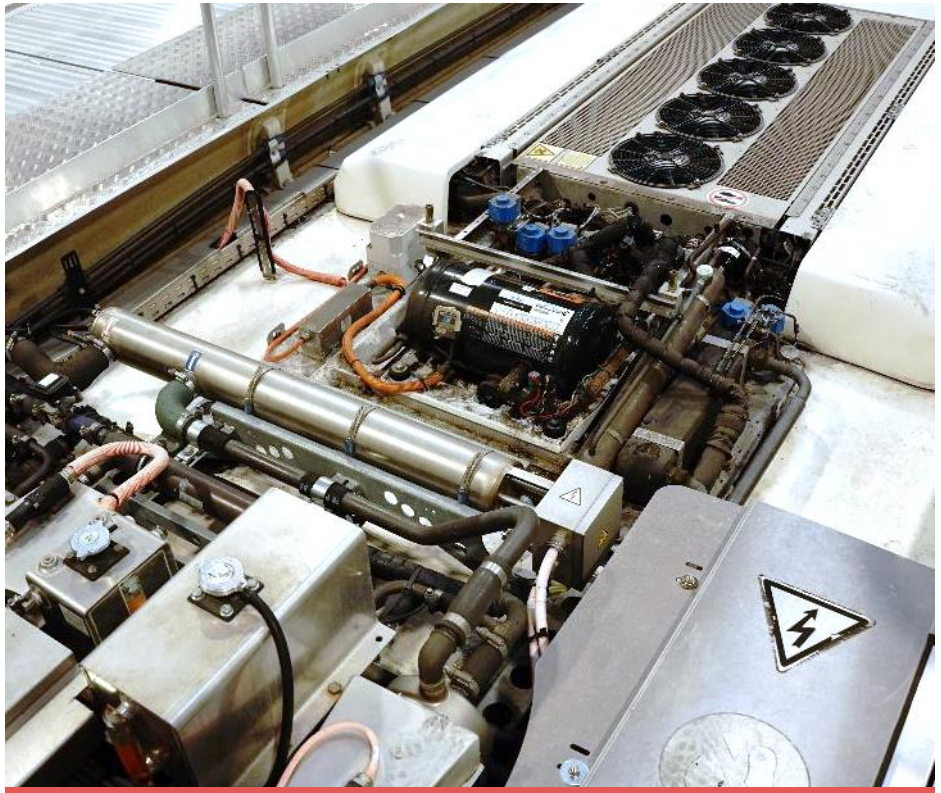


Depot North – 2nd Stage

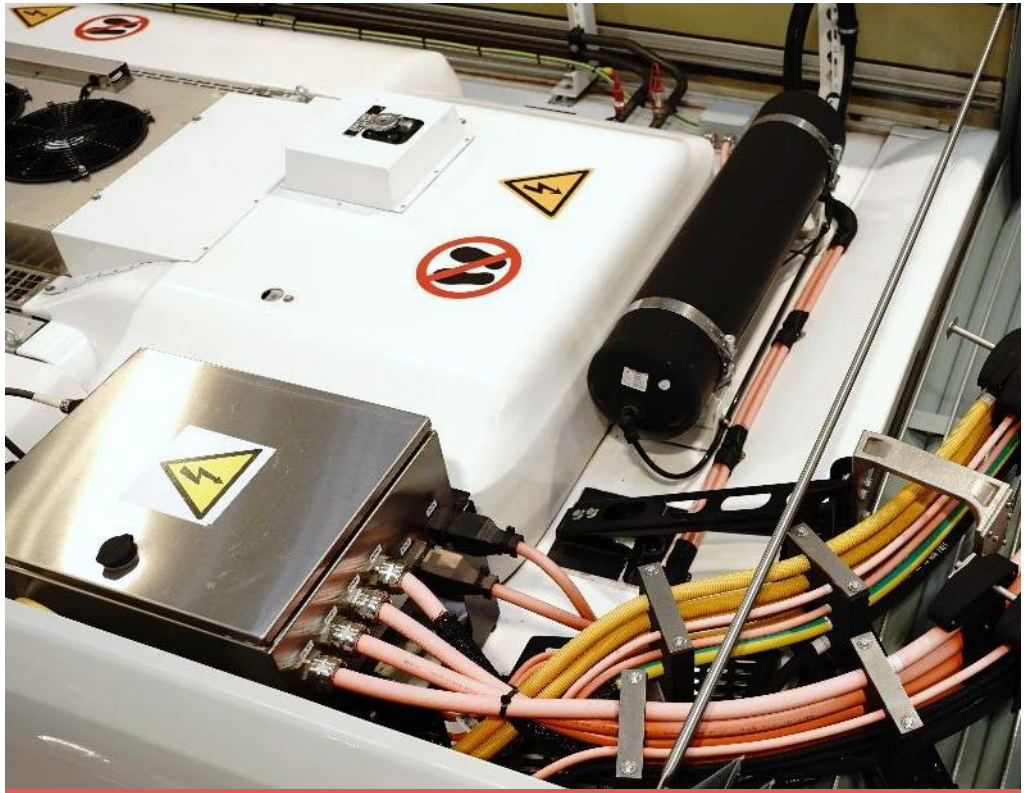


Improvements of Build Quality

Comparison 1st Generation vs. 3rd Generation



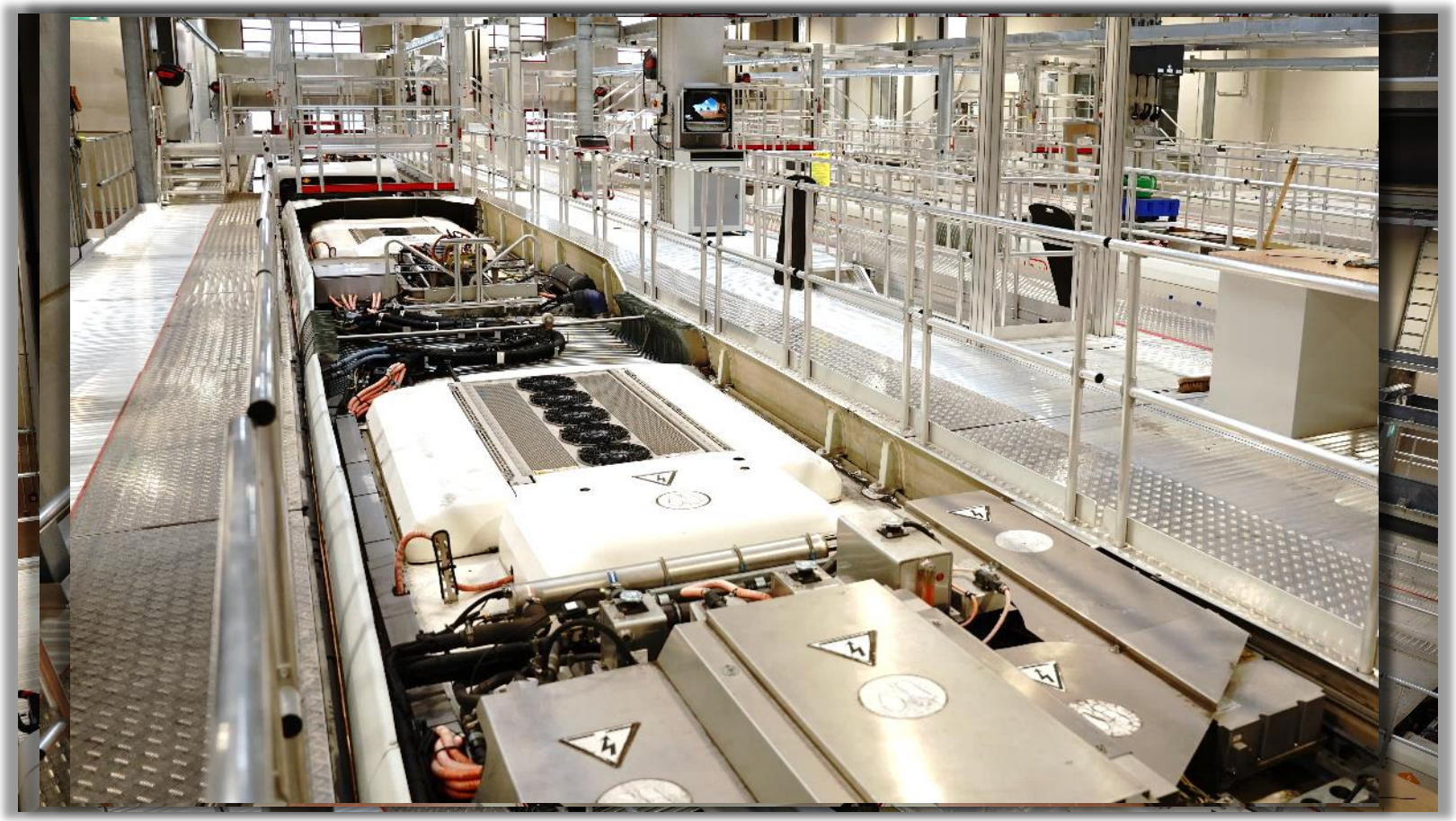
1st Generation, 2016



3rd Generation, 2023

Workshop Requirements Are Changing

The new e-bus workshop is highly suitable for maintenance work at the roof



Battery Packs Are Getting Heavier

2nd Generation

E-Bus Purchase 2020

- 53 E-Buses from VDL
- Switching 7 Lines to electric operation
- 18m length (articulated E-Buses)
- 19.980 kg curb weight
- 29.000 kg permissible total mass
- 420 kWh LFP Battery, 2700 kg
- 450-470 kW max. charging power
- 100 km minimum range (worst case)

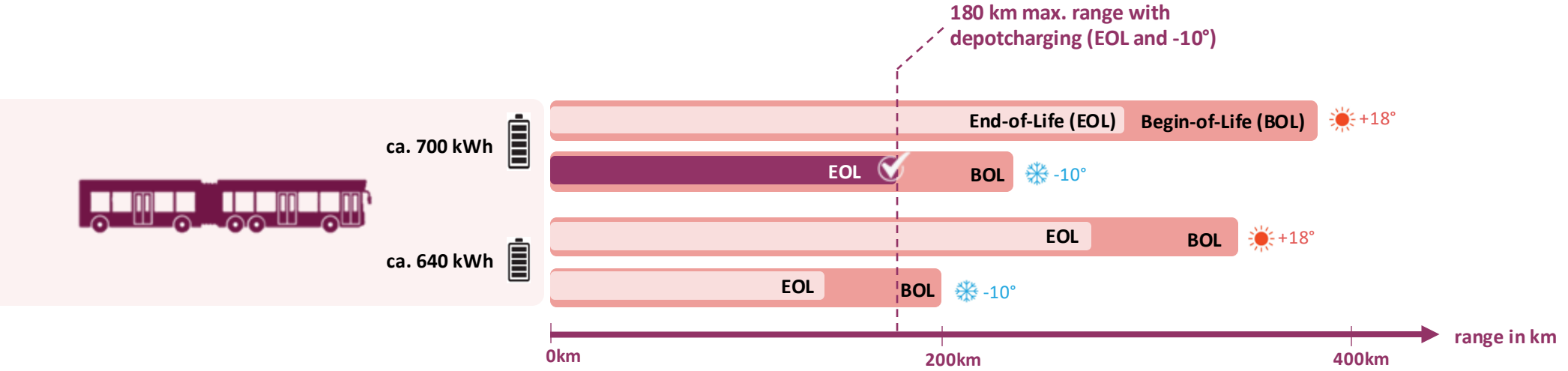
3rd Generation

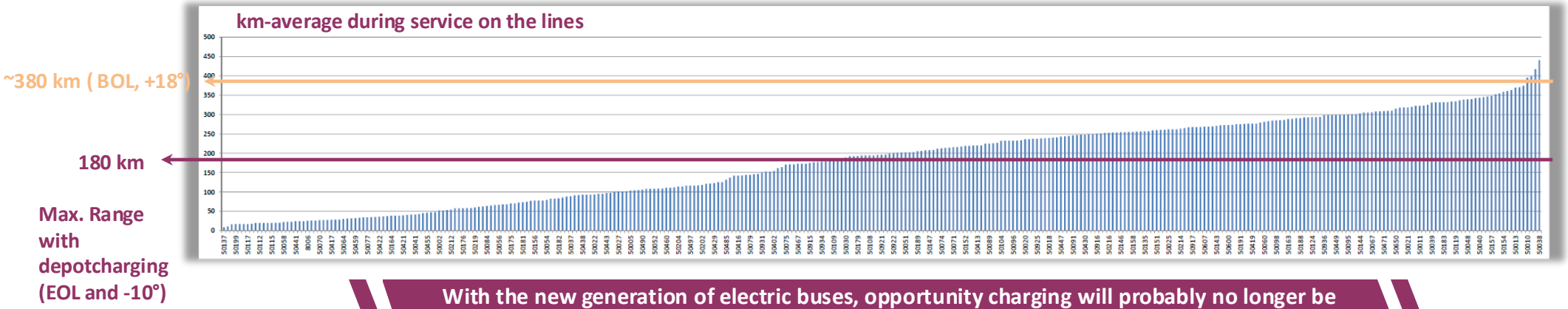
E-Bus Purchase 2023

- 51 E-Buses from VDL
- Switching 6 Lines to electric operation
- 18m length (articulated E-Buses)
- 20.730 kg curb weight
- 29.000 kg permissible total mass
- 525 kWh LFP Battery, 3350 kg
- 450-470 kW max. charging power
- 130 km minimum range (worst case)

E-Buses of the next generation

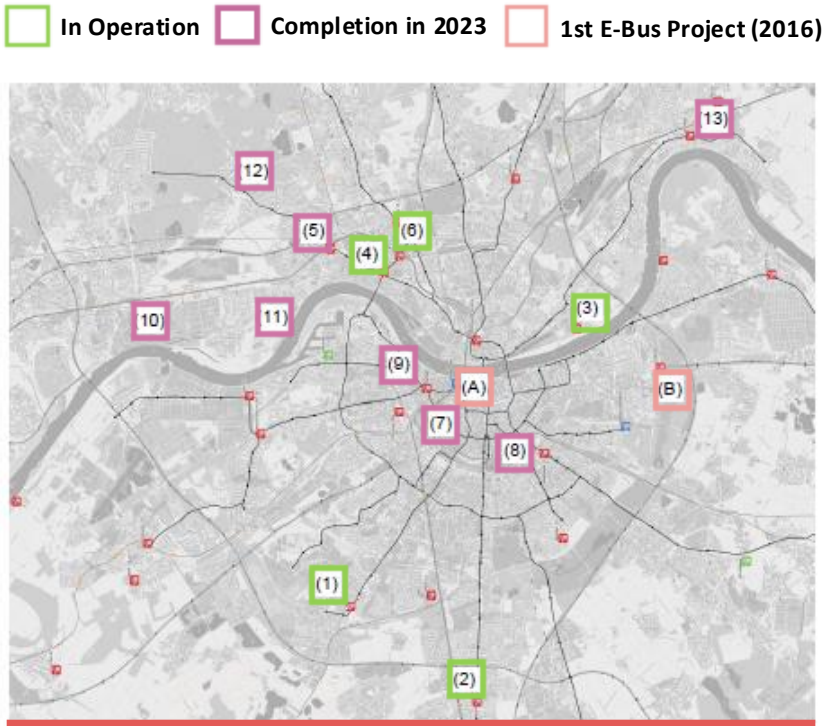
Scenario analysis





With the new generation of electric buses, opportunity charging will probably no longer be necessary. For medium line lengths, we expect that the required range will be available even in the worst case (EOL, -10°).

Status Quo: Charging Infrastructure



13 termini in the city network with 27 charging points with 500kW

Previous Planning:

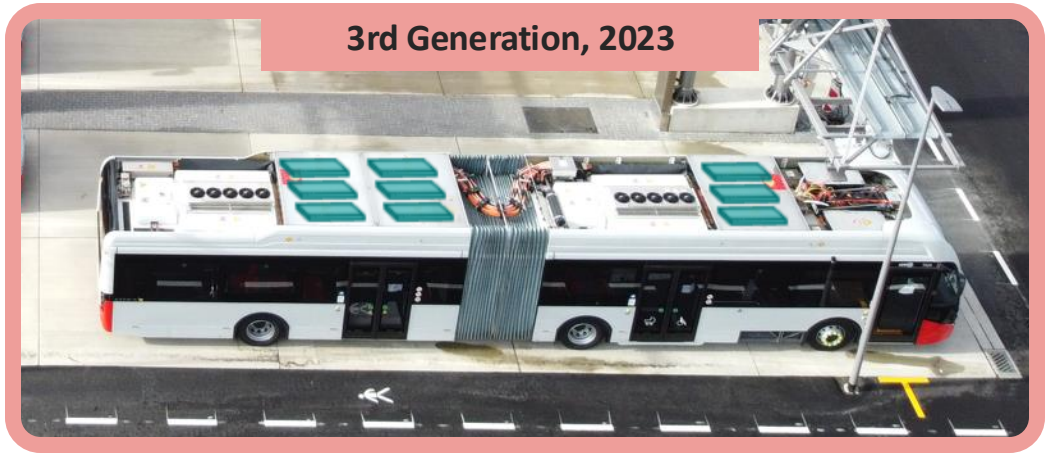
- Initial Approach:
  Depot charging complemented by opportunity charging at terminus of each line
- Transition of 13 lines by 2023
- For the E-bus purchases of 2020/2023 we will have 27 charging points in our network
- For the next E-bus generation in 2025 we propably don´t need any further charging points in the city
  → Change of initial planning

The Position of Battery Packs Will Change

From the roof

to the bottom

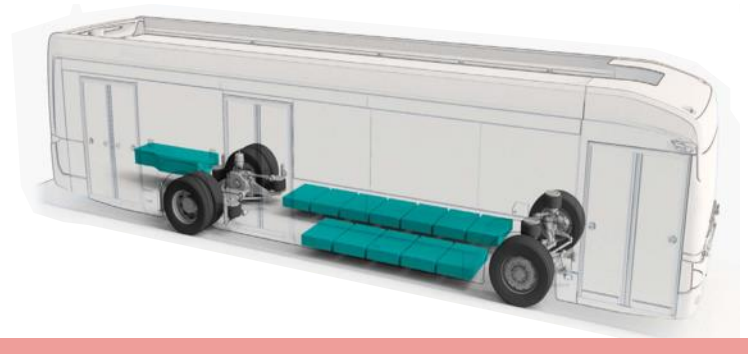
3rd Generation, 2023



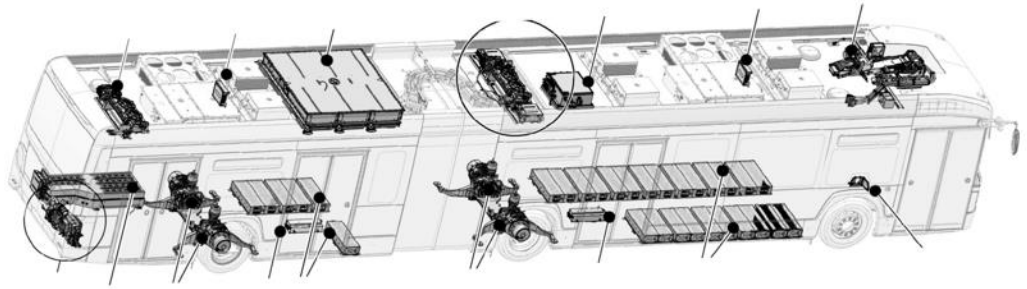
From the roof

to the bottom

Next Generation ~ 2025

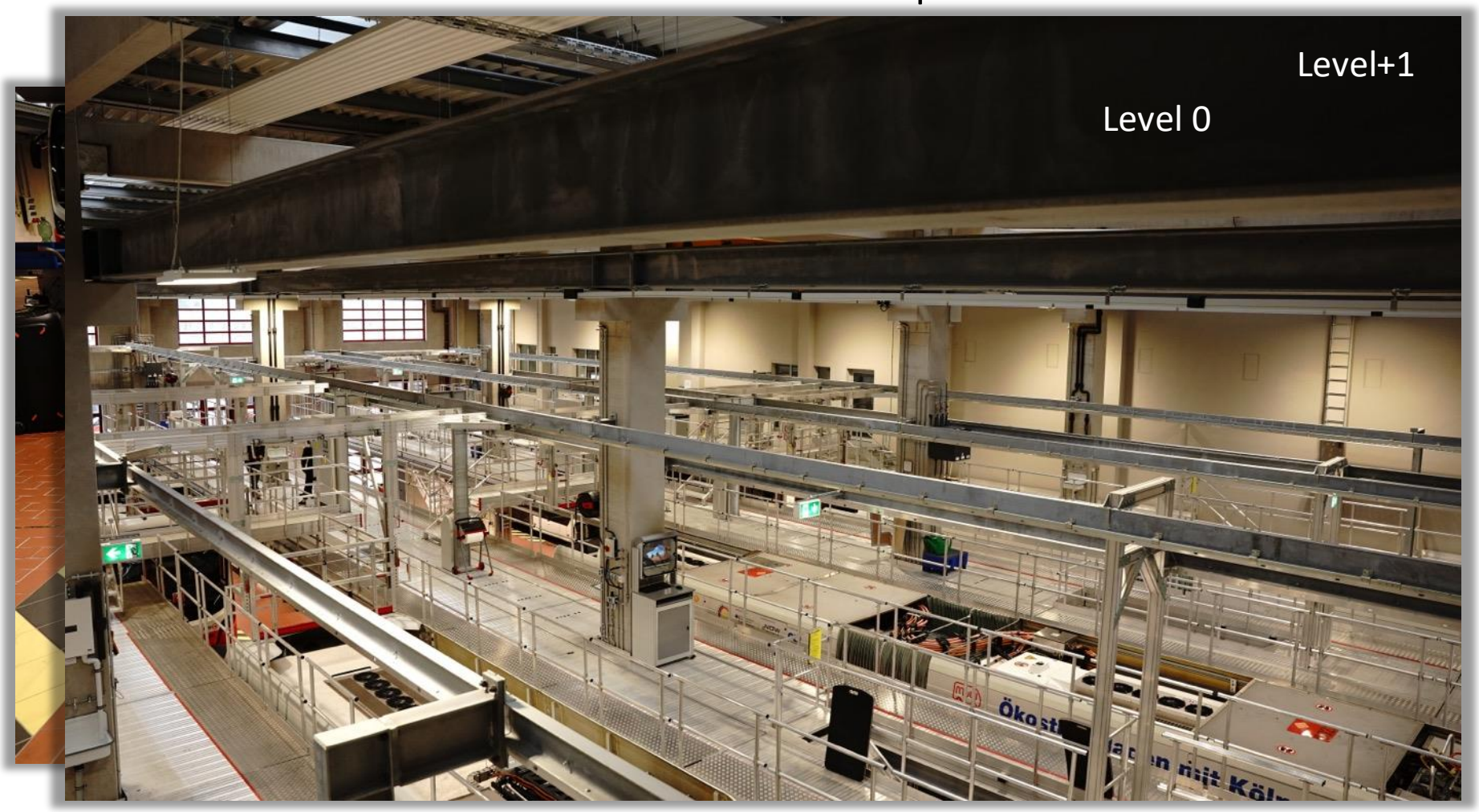


Next Generation ~ 2025



Workshop Requirements Are Changing

Also work stations on level 0 and level -1 are still important



Roundup

Thank You

Kölner Verkehrs-Betriebe AG

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CTO

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KVB

ZEB Con
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ZERO EMISSION BUS CONFERENCE

Richard Harrington

Go Ahead Group

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Our Journey

GoAhead

State of Play in GAL

Ev's in Service

624 EV's in service across 46 routes and 13 garages

Miles operated

Over 370,000 EV miles are operated every week within GAL

CO_2 reduction

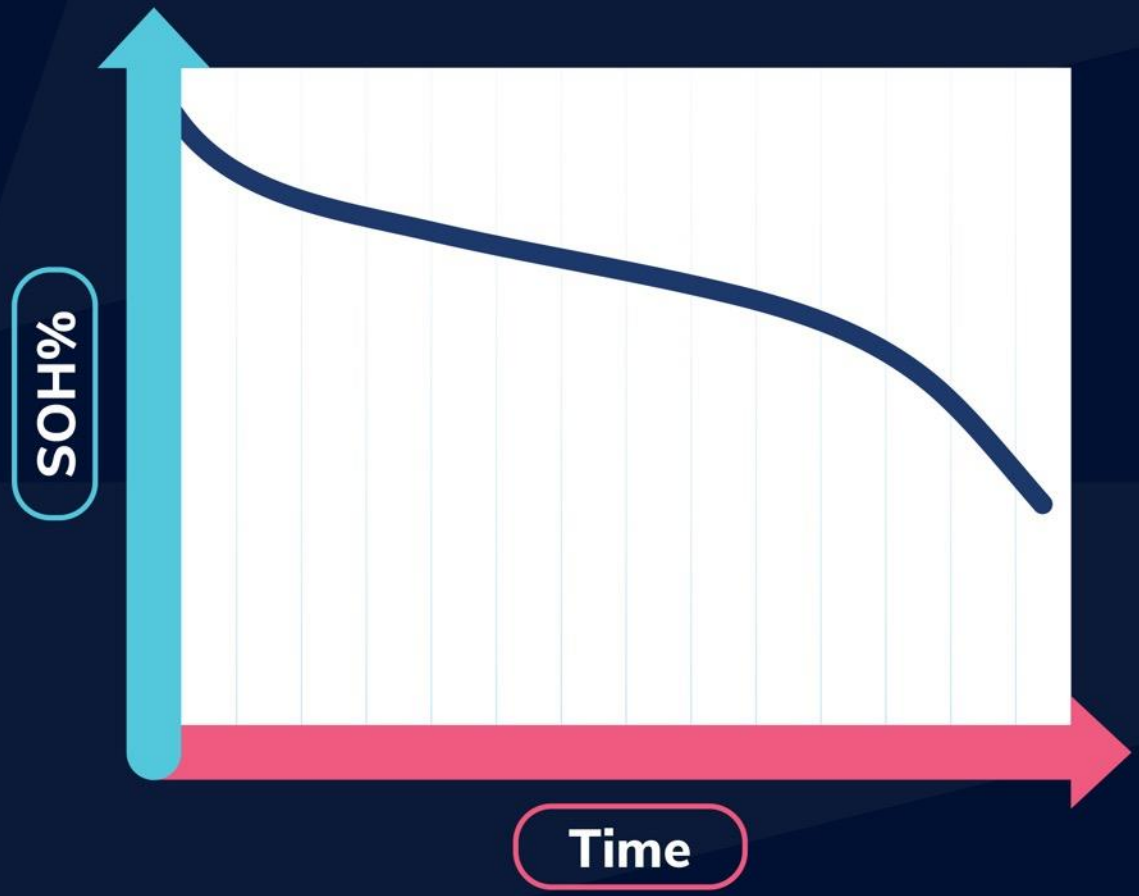
That equates to 380 tons of CO_2 (compared to a Euro 6 ICE) not being emitted onto the streets of London each week

In Build/storage

A further 466 EV's being readied for service

GoAhead

Planning routes



GoAhead

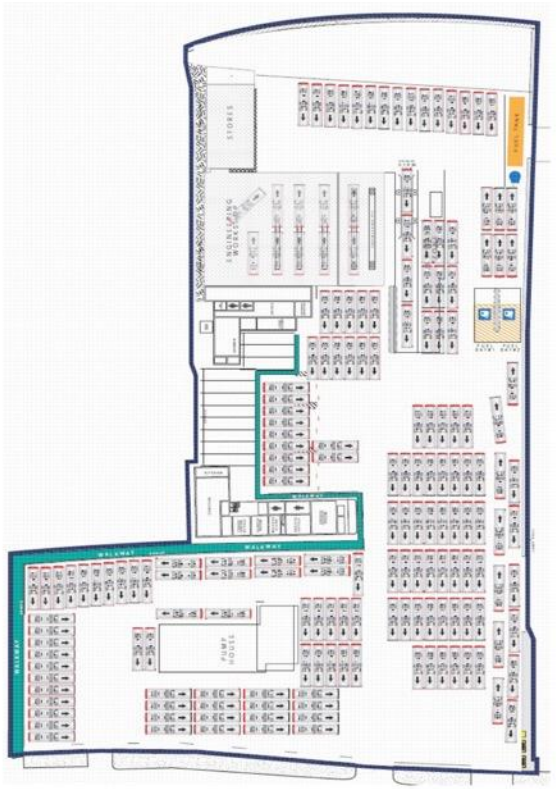
What is required in a garage?

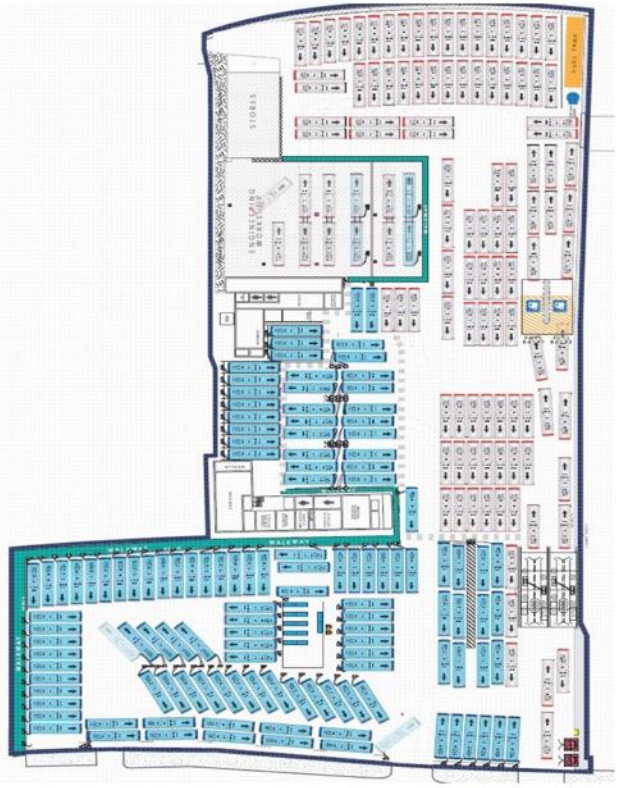
New charging options

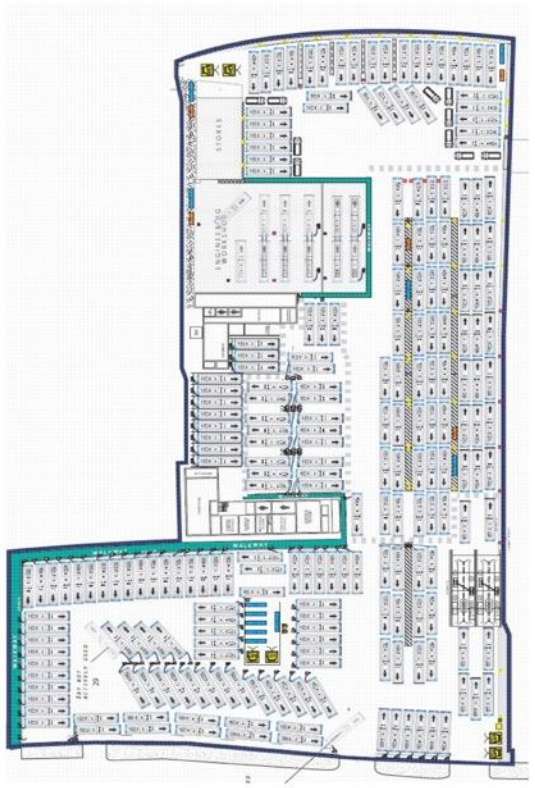
What if there are power restrictions?

GoAhead

Plan ahead, plan BIG

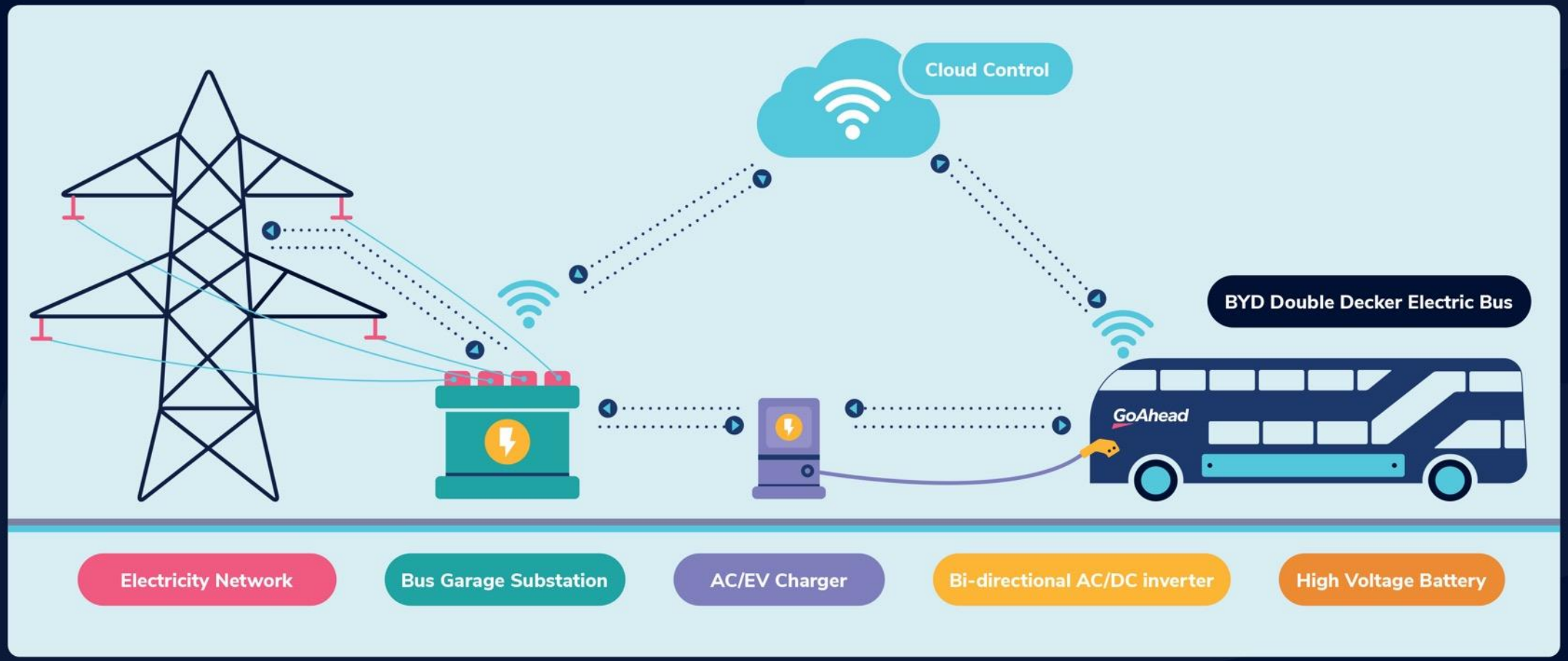






GoAhead

Bus to grid



GoAhead


GoNorthEast
GoAhead LONDON
Flexbuss
GoNorthWest
GoEastAnglia
Go-Ahead Singapore
GoSouthCoast
GoAhead
GoAhead IRELAND
BRIGHTON & HOVE buses.co.uk
GoAhead AUSTRALIA
GoSouthWest
GoAhead NORDIC
EastYorkshire
oxford bus company
GTR
GoAhead

GoAhead

AGENDA

- Timeline
- Facilities
- Procurement
- Project Management

NJ Transit Statewide Bus Garages

Newton Garage

Hilton Garage

Bus Garage Modernization

Bus Garage Moderization
Newton and Hilton Zero Emission Bus Deployments

Replaced Bus Garage

New Garage

Newton Garage Early Deployment

- Bus Deployment (Summer 2022)

Zero Emissions Bus System Design and Investment Planning

- Notice to Proceed
- Data Gathering and Existing Conditions Assessment
- System Design
- Investment Planning
- Final Zero Emissions Bus Investment & Transition Plan (2026)

Funded

Partially Funded

Unfunded

Garage Modernization

Phase 1

- Ironbound Expansion (Summer 2027)
- Meadowlands Outdoor Charging Facility (Late 2027)
- Hilton Garage Reconstruction (2030)

Phase 2

- 2026 – 2036

Phase 3

- 2034 – 2045

New Garage Facilities

- Union City Bus Garage (2030)
- Northern Bus Garage (TBD)

Zero-Emission Bus Purchase Milestones

10% (2024)

↓

50% (2026)

↓

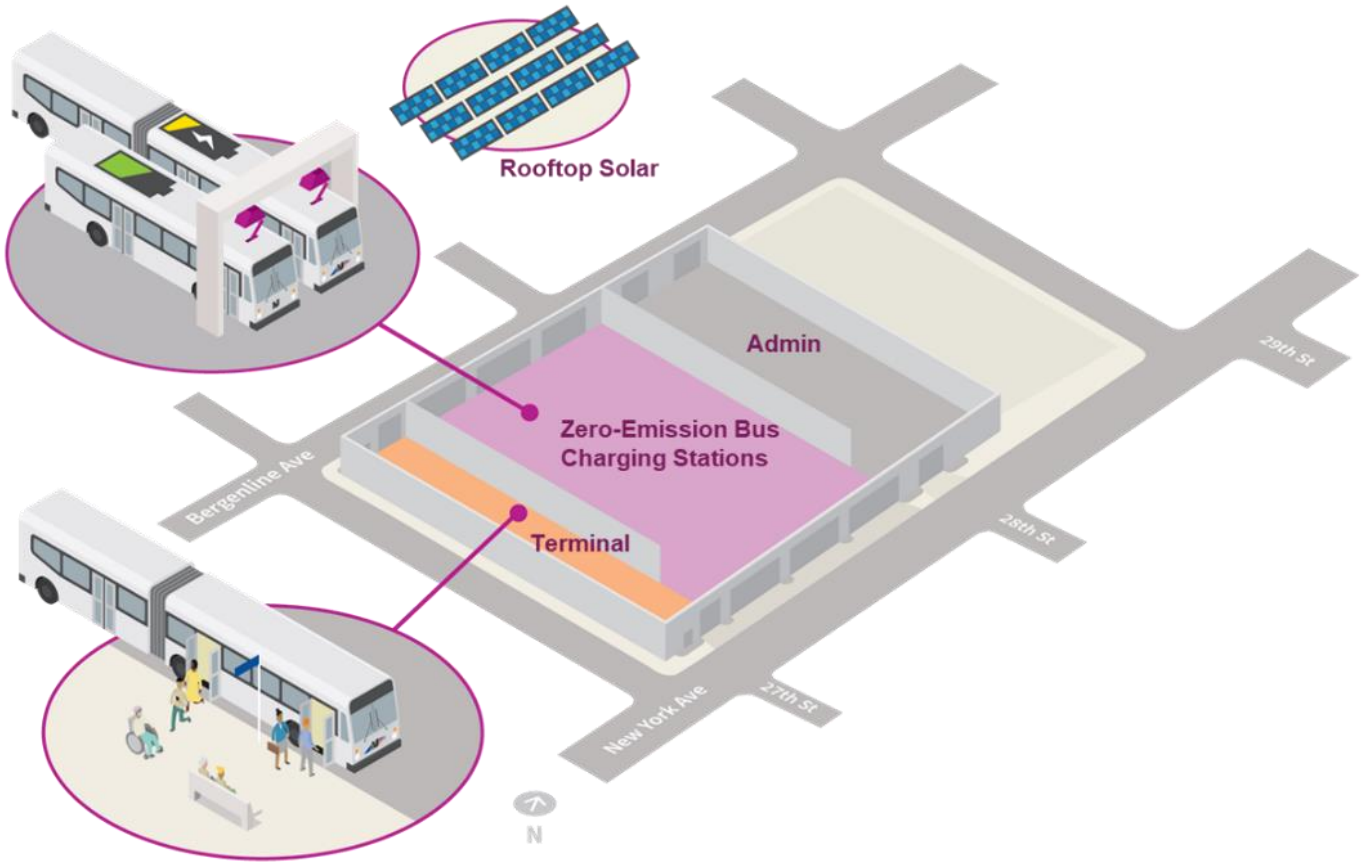
100% (2032)

NJ Transit Phase One Facility Projects

Facility	Context	Estimated Total Cost (2024)	Current Funding
Hilton Garage Reconstruction	Charging for approximately 75 60’ and 25 40’ BEBs.	$356M	$165M
Northern Bus Garage	Currently on hold to determine scope/size for next facility – property acquired	TBD	$50M
Union City Bus Garage	44 60' articulated BEBs and a public bus terminal in Union City.	$92M	$92M
Meadowlands Outdoor Charging Facility	Charging for approximately 70 40’ BEBs and 50 60’ BEBs.	$212M	$212M
Ironbound Expansion (Kearny Point)	Expanding a current garage in Newark NJ to place fleet during reconstruction of Hilton and future garages.	$50M	$50M

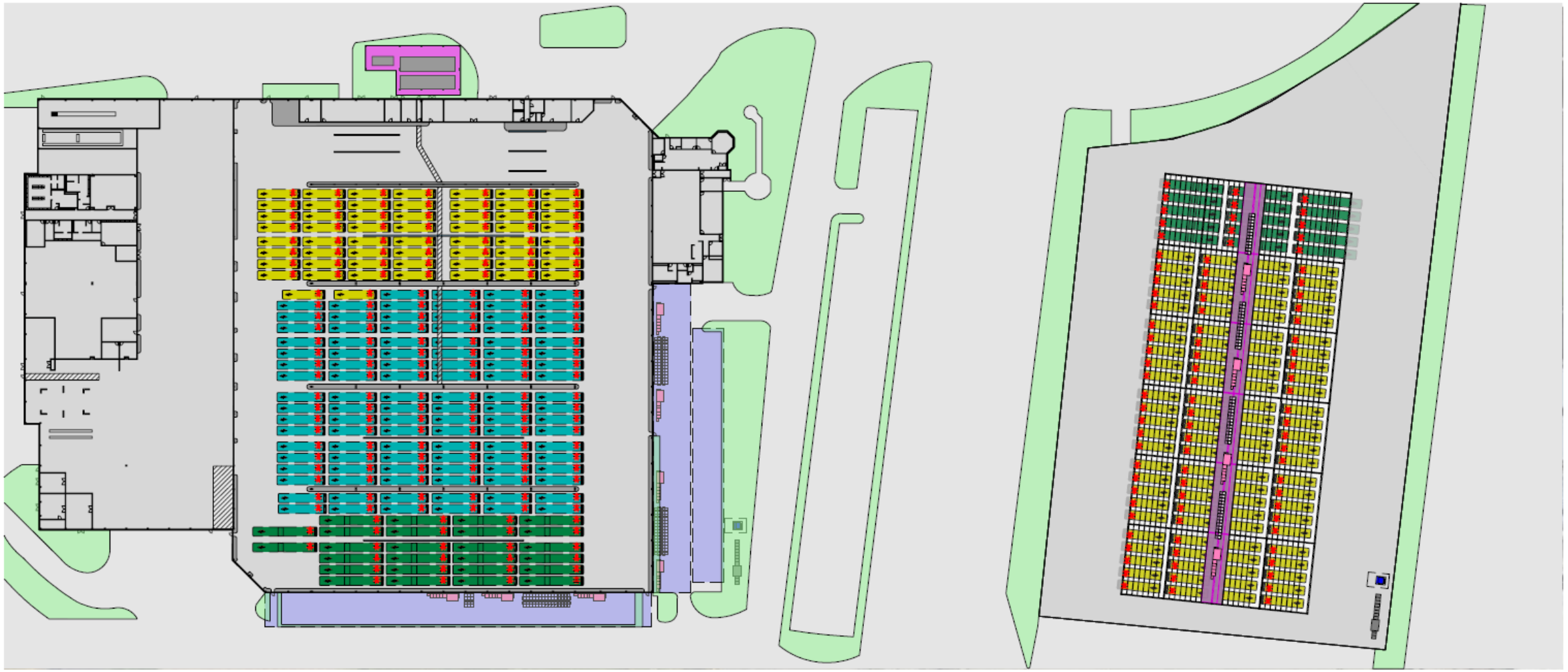
Union City Bus Garage & Terminal

- $92.3m funded
  - $44.67 m FTA Bus & Bus Facilities Grant
- Goal is to house approximately 45 BEBs
- Design contract awarded in summer 2024



*Improvements are generalized, final design still to be determined.

Meadowlands Outdoor Charging facility



BEB Procurement

- 67 40’ BEBs to be delivered by late 2027 (New Flyer XE40s).
- 175 articulated BEBs to be delivered starting in 2028 (new procurement)
- Need to consider garages than can accommodate shorter range cruisers for next phase.

Zero Emission Bus Investment and Planning Study

Research & Baseline

Task 2
Review NJT Bus Garage Infrastructure

Task 3
Review NJT Bus Operations

Task 4
Review Regulatory & Stakeholder Environment

Task 5
Establish & Monitor Recommended Standards & Practices

Alternatives Analysis

Task 6
Design Criteria for Bus Infrastructure

Task 7
500 Bus Deployment & Management Plan

Task 8
Full Transition Plan for Fleet, Infrastructure & Operations

Finalize & Document

Task 9
Phasing Options, Timeline & Business Case

Task 10
Final Report, Presentations & Recommendations

Electrification Challenges

- Currently, facility limitations drive fleet strategy
- In the future, fleet retirements drive facility strategy
- New bus garages are essential for capacity and swing space during renovations
- Costly, slow upgrades to older facilities for electrification delays vehicle procurement
- Continued federal and state funding a major concern
- Bus Industry in USA
- Later fleet replacements may be Hydrogen Fuel Cell technology due to range limitations

Thank you!

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