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BRUSSELS, BELGIUM 6-9 OCT 2025
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European Commission

EUROPEAN
ZERO EMISSION BUS
CONFERENCE 7th - 9th Oct 2025
@ Busworld Europe Brussels

Organised by

ERM

BUSWORLD foundation
the global bus alliance

Session #4

09:00 – 10:30

Shaping the Future: Zero Emission Bus Market Trends and Policy Support

PLENARY SESSION

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EU Policy Pathways for Bus Fleet Decarbonisation

Baiba Miltoviča

Transport, Energy and Infrastructure Section President,

European Economic and Social Committee

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European Zero-Emission Bus Conference 2025

Shaping the Future: Zero-Emission Bus Market Trends and Policy Support

Decarbonising Public Transport:
The Role of Zero-Emission Buses in Sustainable Urban Mobility Planning

Baiba Miltoviča

Transport Energy Infrastructure and Information Society (TEN)

Former TEN Section President

Brussels Expo, 8 October

European Economic and Social Committee

1. Sustainable Urban Mobility Plans (SUMPs): a foundation for public transport decarbonization
2. Support and capacity building: enabling bus decarbonization
3. Transport poverty
4. Stakeholders at the heart of mobility transitions
5. Framing zero-emission buses as central climate and environmental tools
6. Call to action

The One-Stop-Shop for the Transition to Hydrogen Fleets

Tim Evison

Managing Director, SympH2ony

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Sounds good. Performs even better.

Q. Battery or fuel-cell (FC)?
A. We will clearly need *both*!

Zur Web-Ansicht - 1. Oktober 2025

ener|gate messenger

energate exklusiv

Megawattladen

Netzanschlüsse werden zum "Bottleneck" beim E-Lkw-Laden

Karin Rådström • 2nd
CEO of Daimler Truck AG
19h • Edited • 30.9.2025

+ Follow

For some reason - posts about hydrogen always stir up emotions. I think hydrogen (not “instead of” but “in parallel to” electric) plays a role in the decarbonization of heavy duty transport in Europe for three reasons:

1. If we would go “electric only” we need to get the electric grid to a level where we can build enough charging stations for the 6 million trucks in Europe. It will take many years and be incredibly expensive. A hydrogen infrastructure in parallel will be less expensive and you don’t need a grid connection to build it, putting 2000 H2 stations in Europe is relatively easy.

……

Let’s build the infrastructure, the momentum, and the partnerships to make zero-emission transport a reality. 🚛 and let’s try to avoid some of the mistakes that we see now while scaling up electric. And let’s stop the debate about “either or”. We need both.

Q. Battery or fuel-cell (FC)?
A. We may well need both in *one* fleet!

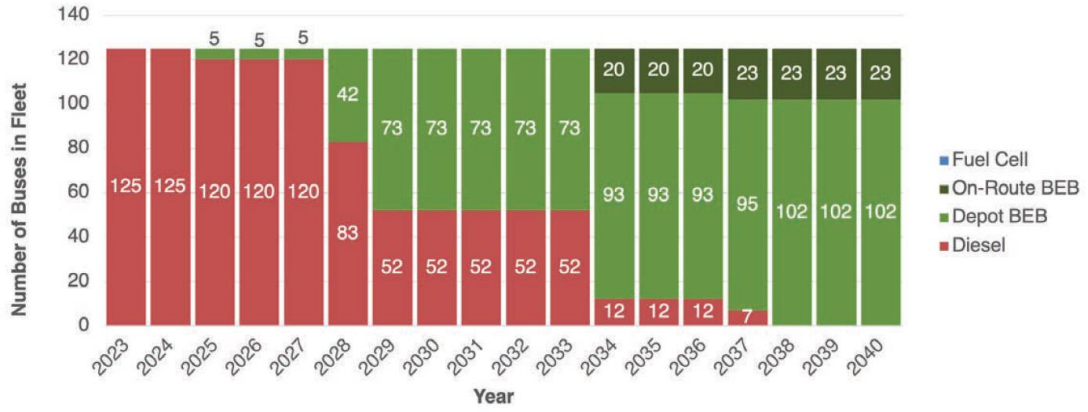


Figure 26 – Example Agency Opportunity Charging Fleet Composition Graph

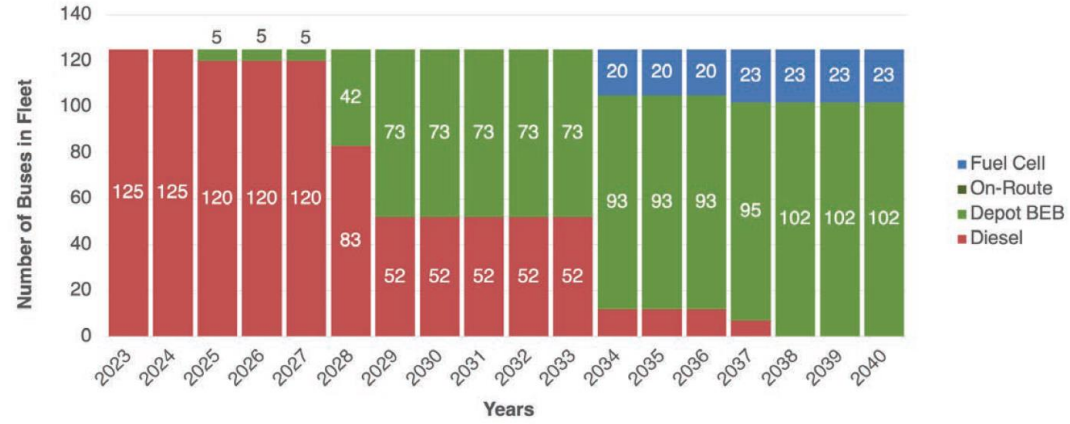


Figure 29 – Example Agency Mixed Fleet Composition Graph

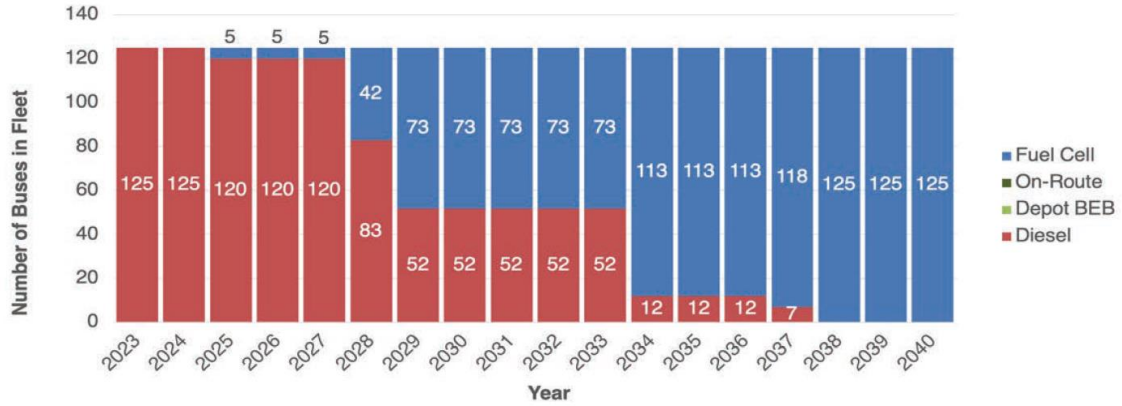


Figure 33 – Example Agency FCEB-Only Composition Graph

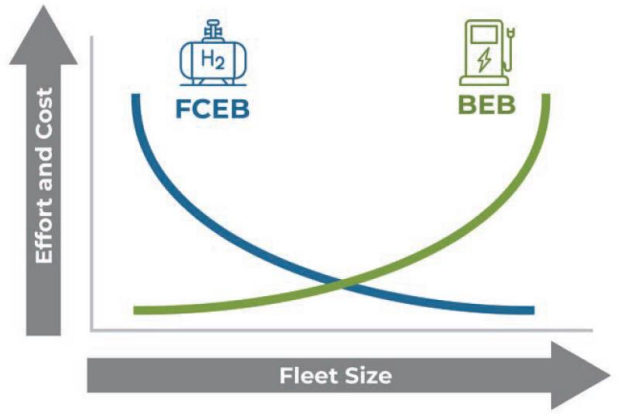


Figure 30 – FCEB vs BEB Effort and Cost as Fleet Size Increases

CTE: *„be aware that in all cases, the cost per bus of hydrogen infrastructure is more cost effective as fleets get bigger.”*

Source: CTE - Zero-Emission Bus Transition Planning Guidebook

SympH$_2$ony exists to help FC fleet operators transition to zero-emission operations: ZE made *easy!*

MESSER Gases for Life

Company
Messer is the world's largest privately owned specialist in industrial, medical and specialty gases and a highly professional and sustainable global player.

Products
Messer produces and supplies oxygen, nitrogen, argon, carbon dioxide, hydrogen, helium, shielding gases for welding, specialty gases, medical gases, food gases and many different gas mixtures.

Customers
Our gases are used in industry, environmental protection, medicine, the food industry, welding and cutting technology, 3D printing, construction, research and science.

TOYOTA TSUSHO EUROPE

Company
As the Toyota Group's sole general trading company, Toyota Tsusho develops and invests in new business from a global perspective. As automotive professionals with unique capabilities and know-how, we strive to lead the Toyota Group in the challenge to develop the evolution of next-generation mobility.

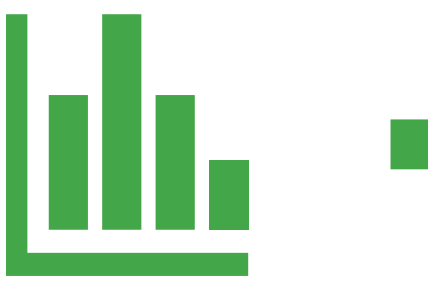
Products
Our services and solutions are focused on sustainability and value for society supplied by 8 business units with dedicated solution focus.

Customers
Our services are used in the automotive, chemical, steel industry and in African markets.

SympH$_2$ony

We work with you to plan an optimal transition

Then we stay by your side to help make it happen



Analyse

Support operator's evaluation of a complete, cost-optimised fleet transition

Design

Establish a programme of steps to achieve the fleet transition whilst minimising the risk for the operator

Implement

Take the first steps together, perhaps starting with a trial and then employing the 'one stop shop'

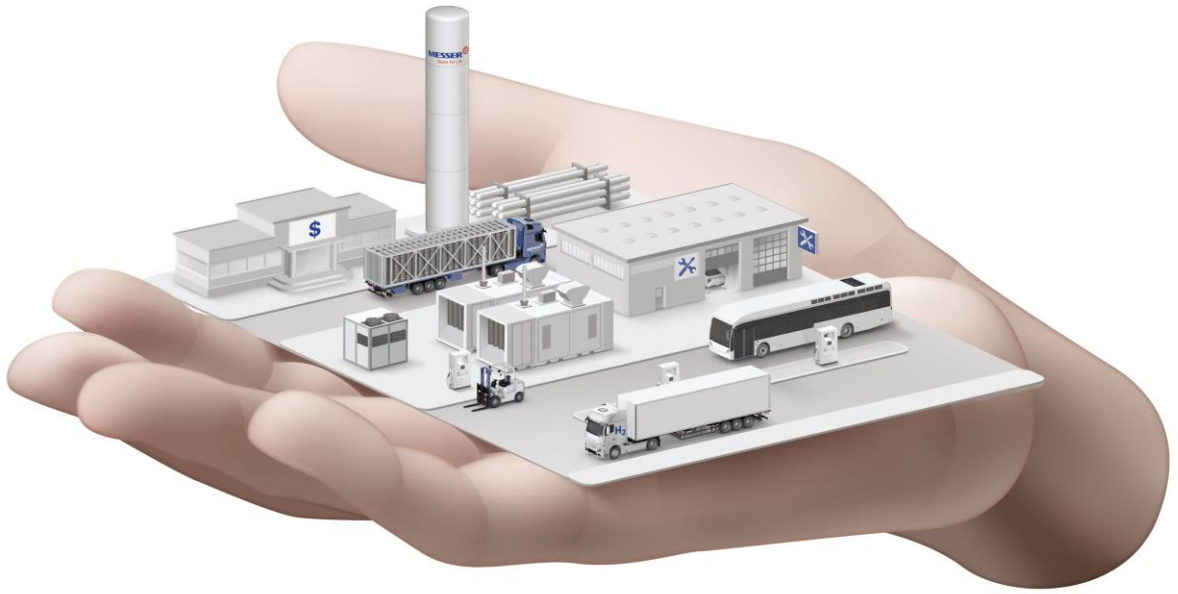
Support

Be a reliable partner at the fleet operator's side for the long-term, providing expertise, solutions and options

‘One Stop Shop’

Pay-per-km for a service package comprising:

- H_2 powered FC vehicles
- H_2 production and refuelling infrastructure
- H_2 back-up supply
- Maintenance for vehicles and H_2 infrastructure
- Operation services and power management
- Full compliance services (e.g. RFNBO ‘quota’)
- Flexible project related financing options
- Funding (if available)



ZE made EZ!

Zero emission made easy

With REVG we are already taking the first steps towards delivering the ‚one-stop-shop' as part of a full-fleet transition in Kerpen/DE:

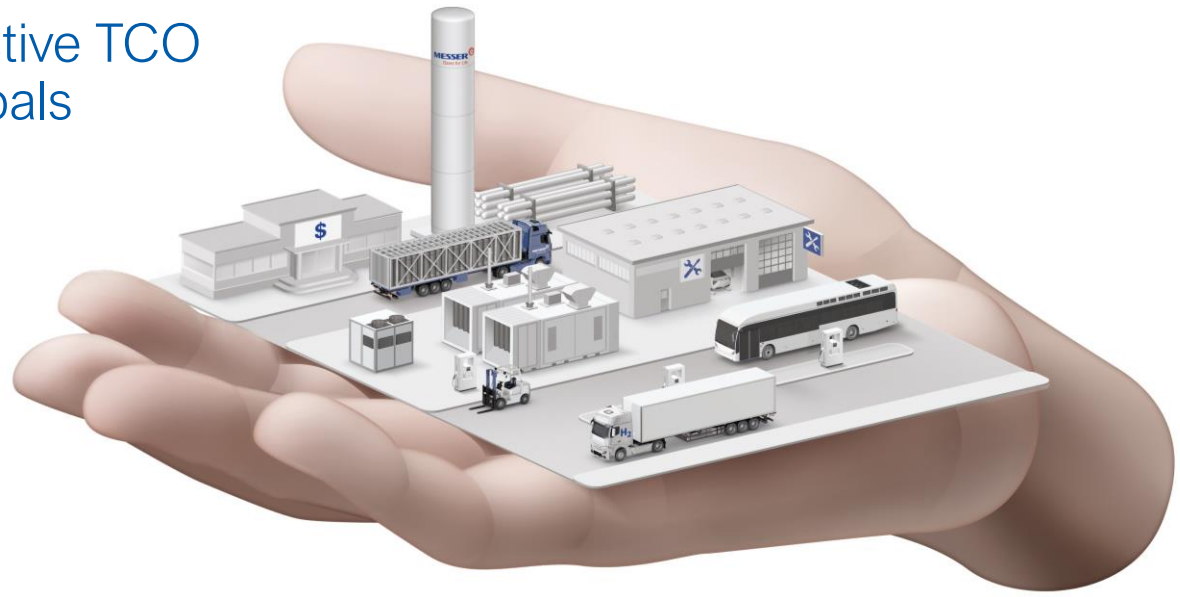
1. hydrogen service for 26 FCEB in operation today

2. trial of ‚pay-per-use' model for expansion of FCEB fleet, including tailored service development

3. support for REVG's long-term plans for ZE transition, optimising cost with on-site hydrogen production

Advantages of the “One Stop Shop”..

- **High reliability**
  More reliable and better coordinated service from a single provider.
- **Seamless transition**
  Experienced partners helping to deliver the implementation of fuel-cell & hydrogen technologies
- **Lower risk for the fleet operator**
  More responsibility lies with us - you only pay for the kilometers driven
- **Faster, more cost-effective rollout**
  Pay-per-use model (€/km) for predictable, attractive TCO based on taking larger steps towards your ZE goals
- **Tailored service**
  Package designed for your specific needs
- **Long-term partnership**
  Trusted partners sharing the journey with you



.. and it is not limited to FCEB!

Fuel-cell vehicle availability

1,5 - 5t	3,5 t	16-24t	19-27 t	40 t
				
• 1,5t – 5t lifting capacity • Commercially available	• Up to 700km range • Commercially available	• Up to 450 km range • Commerically available	• Up to 400 km range • Commercially available	• Up to 600 km range • Small series production
TOYOTA MATERIAL HANDLING	STELLANTIS	Paul	HYUNDAI	MAN IVECO SCANIA

How may we help *you*?

Get in contact with one of our experts!

Jason Dennis
H2 Business Developer
Toyota Tsusho Europe SA
jason.dennis@toyota-tsusho-europe.com

Andreas Noky
H2 Business Developer
Messer SE & Co. KgAA
Andreas.Noky@messergroup.com

Tim Evison
President
SympH2ony
tim.evison@messergroup.com

Kenji Yamanaka
Vice-President
SympH2ony
kenji.yamanaka@toyota-tsusho-europe.com

info@symph2ony.eu

The State of Play of ZEBs in the European Market

Eamonn Mulholland

Researcher, International Council on Clean Transportation

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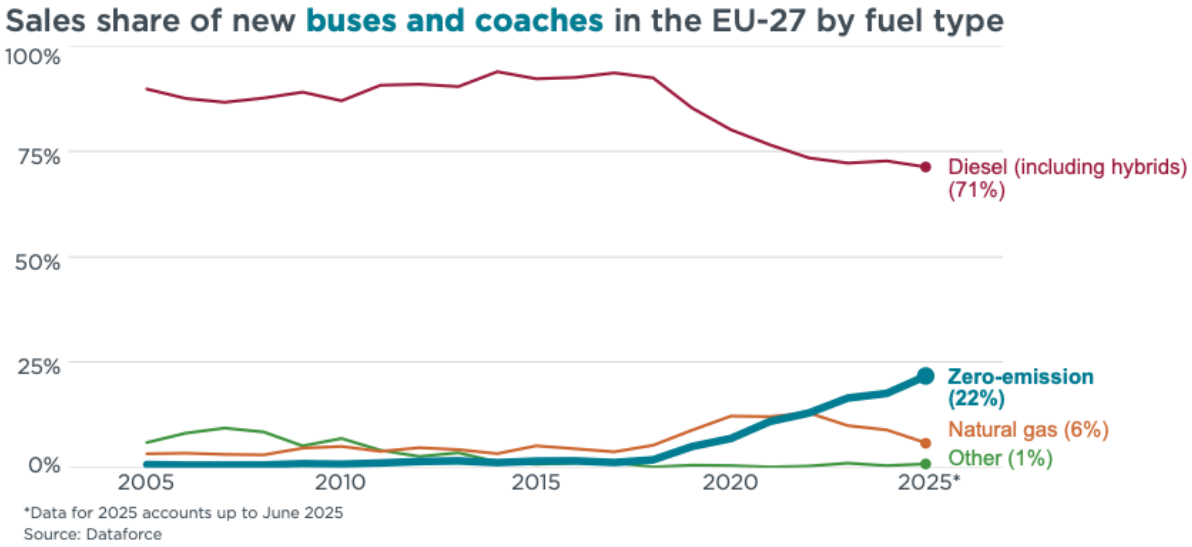
The rise and rise of the European electric bus

Eamonn Mulholland

8th October 2025

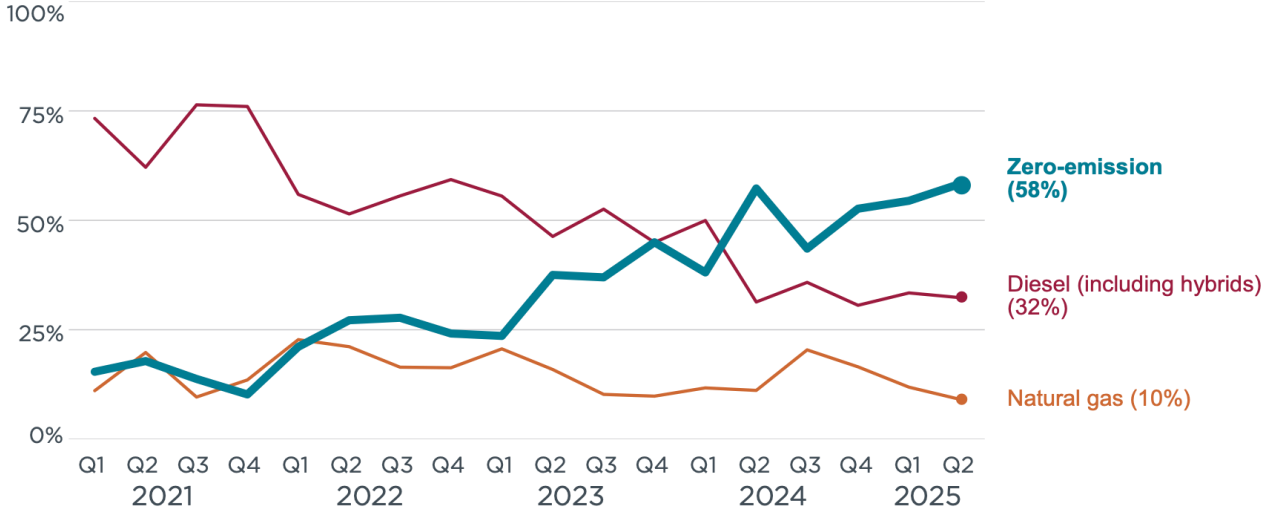
icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Zero-emission bus sales continue to climb



New zero-emission city buses are now more popular than combustion engines

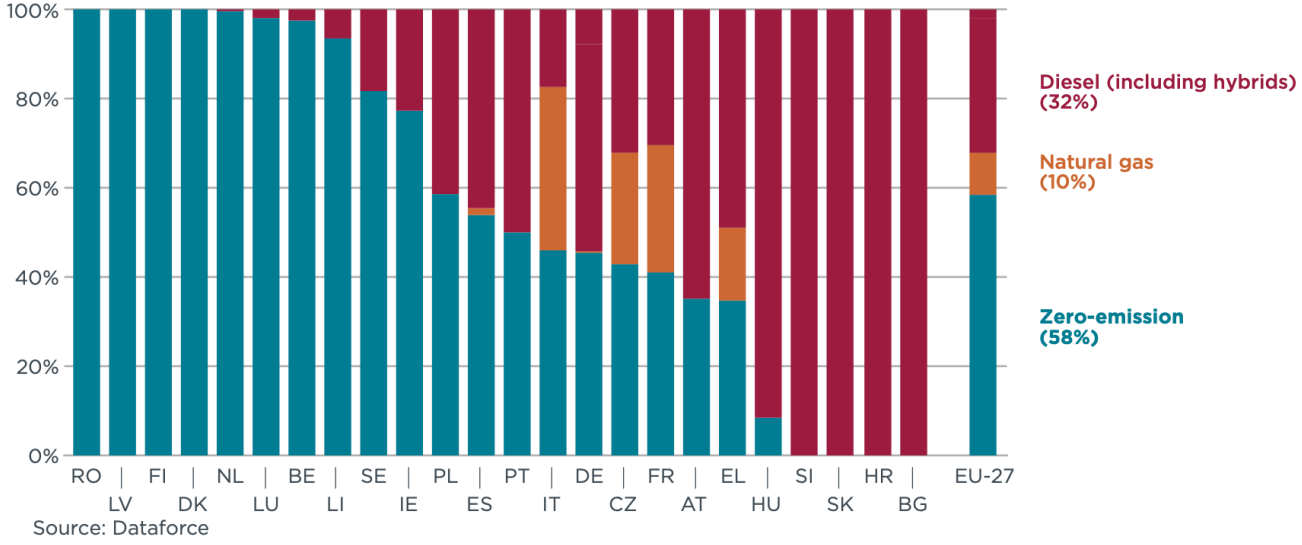
Sales share of new **city buses** in the EU-27 by fuel type



Source: Dataforce

Many Member States, in both the east and west, are only buying zero-emission city buses

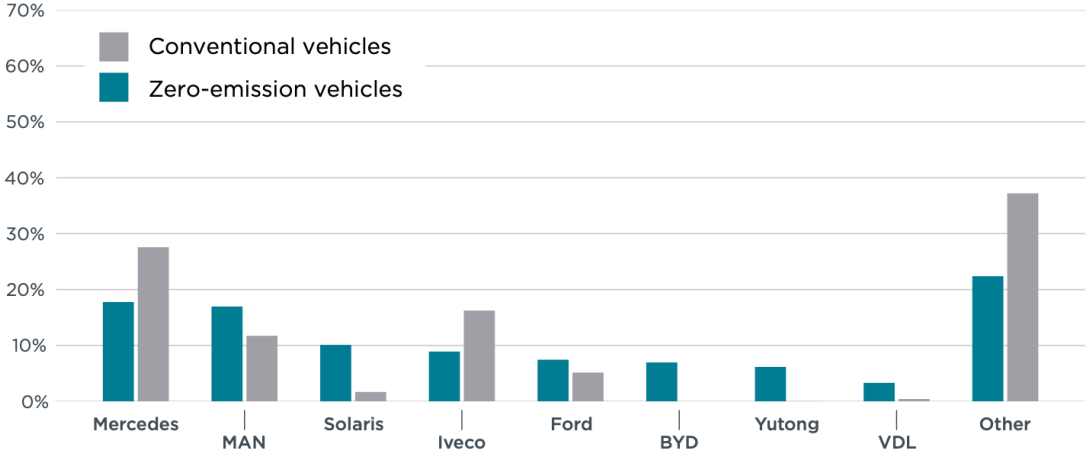
Sales share of new city buses by Member State in 2025



Source: Dataforce

Europe's legacy manufacturers are keeping pace with electrification

Sales share of new **buses and coaches** in 2025 in the EU-27 by manufacturer and powertrain

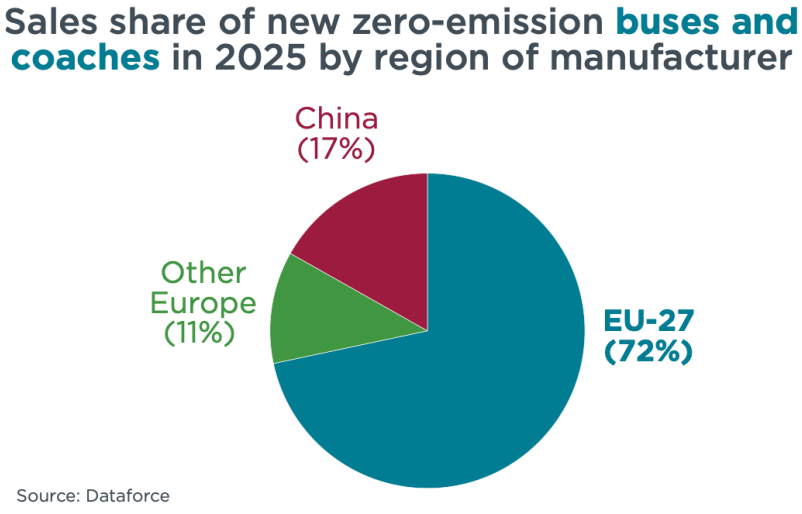


Source: Dataforce

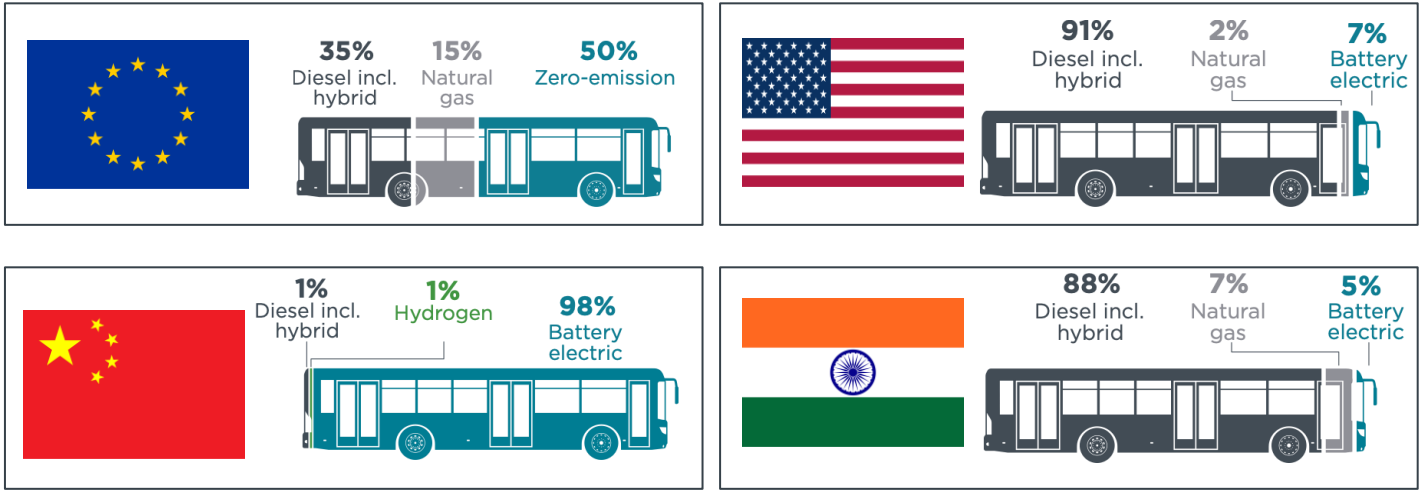
Most zero-emission buses sold in the EU are manufactured in Europe

- Manufacturers headquartered in **China** remain the greatest competitor to European manufacturers in the ZE market, particularly **Yutong**, **BYD**, and **King Long**

- **Ford Otosan**, based in Turkey, is the main supplier of zero-emission mini-buses



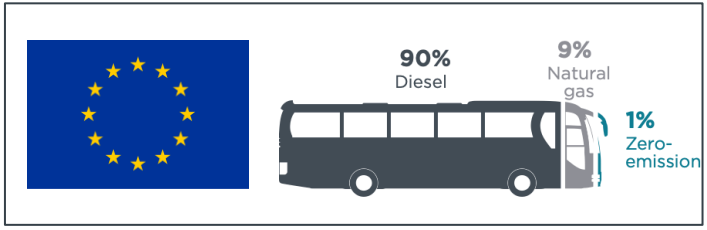
Global comparison of city bus sales by powertrain in 2024

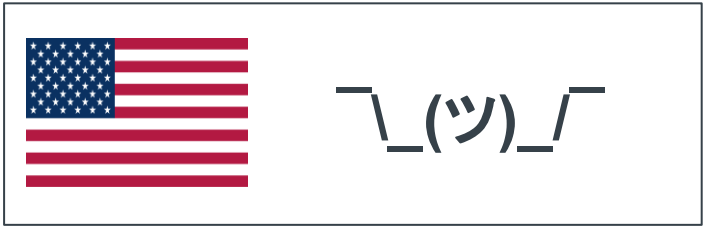


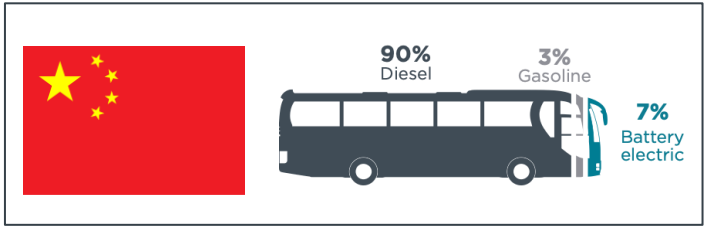
Note: Zero-emission in the EU includes both electric and H2 fuel cell. Data for the US includes both city buses and coaches.

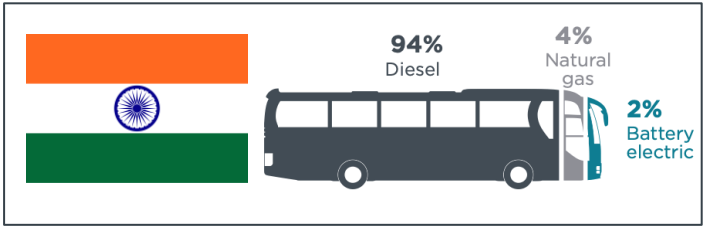
Sources: Dataforce (EU), Gasgoo Auto (China), Vahan dashboard (India), IHS Markit (US)

Global comparison of coach sales by powertrain in 2024





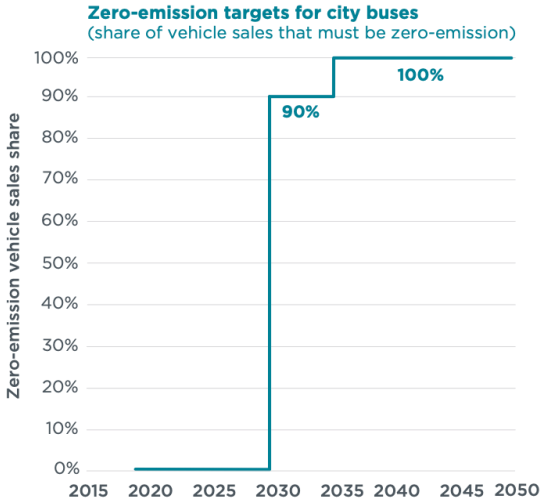


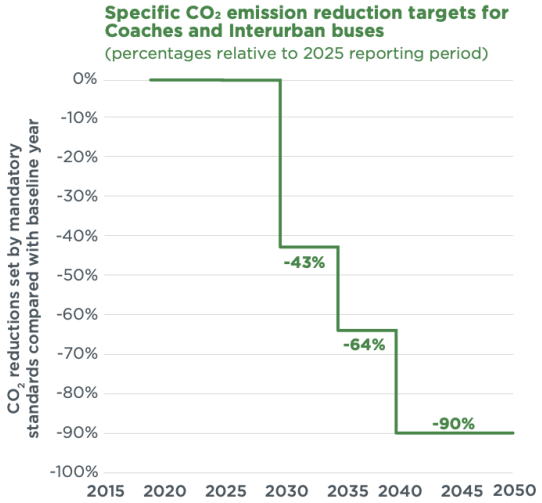


Note: Zero-emission in the EU includes both electric and H2 fuel cell. Data for China includes 3.5-7.5 tonnes.

Sources: Dataforce (EU), Gasgoo Auto (China), Vahan dashboard (India)

Buses and coaches face tough, but achievable, targets from 2030

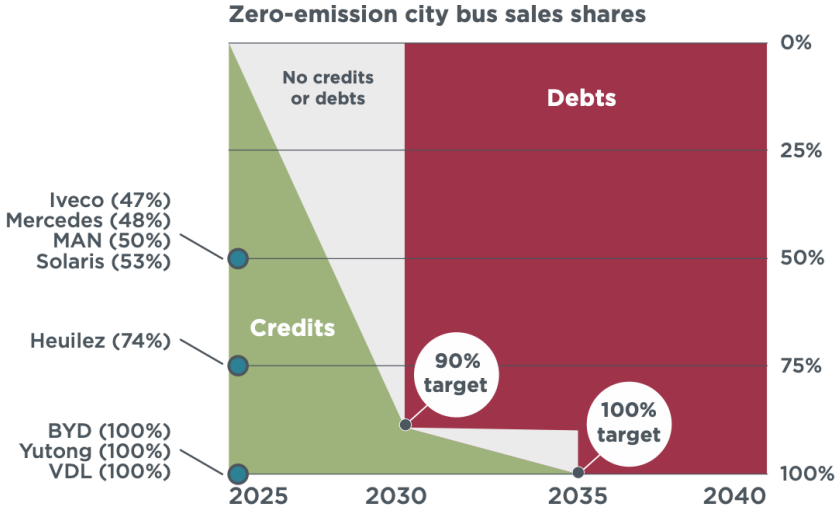




Source: (EU) 2024/1610 amending Regulation (EU) 2019/1242 as regards strengthening the CO2 emission performance standards for new heavy-duty vehicles

Most manufacturers are on track to earn credits in the bus standards

- Manufacturers can earn credits for **over-compliance** with the CO_2 standards
- Credits can be used for **under-compliance** in 2030 and beyond
- Many manufacturers are on track to earn significant credits in 2025, thanks to high zero-emission shares



Questions?

e.mulholland@theicct.org

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THE INTERNATIONAL COUNCIL
ON CLEAN TRANSPORTATION

Market Ramp-Up of ZEBs in Germany: Policy and Market Perspectives

Oliver Braune

Programme Coordination Electric Mobility,
German Federal Ministry of Transport

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ZERO EMISSION BUS
CONFERENCE 7th - 9th Oct 2025
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Market ramp-up of ZE-Buses in Germany: a policy and market perspective

ZEB Conference: Shaping the Future – Zero Emission Bus Market Trends and Policy Support

Oliver Braune
G 23 Electric Mobility and Charging Infrastructure
Federal Ministry of Transport

Vision: Zero Emission

Political and regulatory framework, objectives and background

Germany’s cornerstones of climate policy (2019 to 2025)

Climate Protection Programme 2030 (2019)

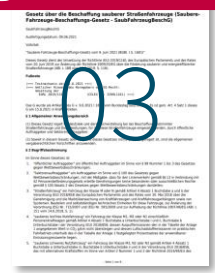
Clear goals for the transport sector, especially for public transport, are outlined. By 2030, 50% of city buses in Germany are to be electric.

Climate Protection Act (2019)

Intended to ensure the fulfilment of national climate protection targets and compliance with European targets.

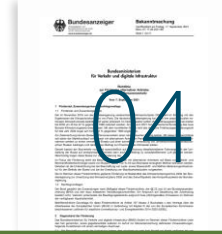
Vehicle Procurement Act (2021)

The minimum targets for low- and zero-emission buses in public transport are 45% for the first reference period until the end of 2025 and 65% for the second period until the end of 2030.



E-Bus Funding Guideline (2021)

Since 2021, the Bus Funding Guideline (FMT)/BMV) has been supporting the procurement of battery and fuel cell buses, battery trolleybuses, and biomethane-powered buses and their respective infrastructure.



Current activities (2024-2025)

The working report of the Expert Forum on Climate-Friendly Mobility and Infrastructure serves as the basis for additional measures to comply with the Climate Protection Act (2025).

Second amendment to the German Climate Protection Act 2024.

Regulatory framework at EU- and national level

(an overview, selected measures)

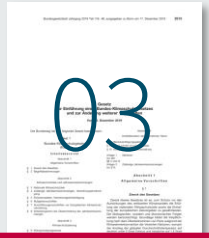
City buses:

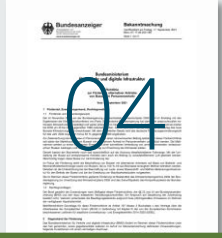
Should be 90% emission-free by 2030, and 100% emission-free by 2035.

Coach and intercity buses:

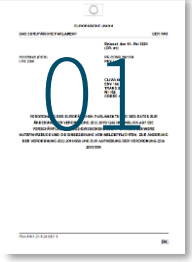
Emissions to be reduced by 45% by 2030, by 65% by 2035, and by 90% by 2040.

As part of the amendment to the Air Quality Directive and the new EURO VII emissions standard, the limit values for particulate matter and nitrogen dioxide currently in force in Europe are being revised.

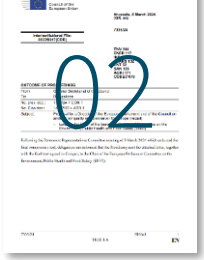




CO2 emission standards for heavy commercial vehicles



EURO VII and Air Quality Directive



Clean Vehicles Directive/ SaubfahrzeugBeschG

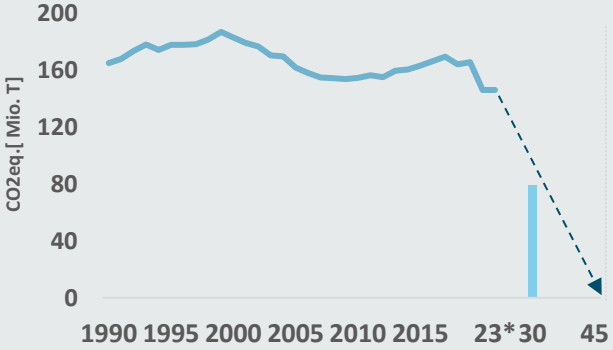
The minimum targets for low- and zero-emission buses in public transport are 45% for the first reference period until the end of 2025 and 65% for the second period until the end of 2030.

Energy Tax Directive/ GHG quota

The Energy Tax Directive and GHG quota trading are measures designed to make the use of zero-emission vehicles more economically attractive.

Climate policy challenges in transport

Greenhouse Gas Emissions (2023, 2024)



59% **Passenger cars**
591 bn passenger kilometers (cars) traveled in 2023
Vehicle fleet: 49.1 mio. units (1/1/2024)

0,8% **National Air Traffic**
4.9 bn passenger kilometers traveled in 2023

35% **National truck Traffic**
96 bn passenger or goods kilometers traveled in 2023 (N1 – N3)
Vehicle fleet: 3.97 mio. Units (1/1/2024)

2,5% **Buses**
4.29 bn passenger kilometers traveled in 2023
Vehicle fleet: 84.628 buses (1/1/2024)

0,5% **Rail transport**
56.7 bn (local rail transport) & 47.6 bn (long-distance rail transport) passenger kilometers traveled in 2023

1% **National Shipping Traffic**
4.32 bn passenger kilometers traveled in 2023

Sources: Umweltbundesamt, BMV, Kraftfahrt-Bundesamt

2024: 143 million tons of CO2e. | 2030: max. 79 million tons of CO2e. | 2045: Climate neutrality.

By 2030, emissions must be reduced by 65% , or 64 million tons of CO2e. To achieve this, almost half of the city buses are to be electric by 2030.

Target vision: Electrification of city buses in Germany

Support measures and challenges

VEHICLE FLEET
2019, 2021, 2024
E-Buses at January 1st

2030 TARGET OF THE FEDERAL GOVERNMENT
Half of all city buses in Germany are electric.

E-Bus Funding Guideline (2021-2025)
At least 3,500 buses approved in the BMV subsidy program, as of September 2025

Quelle: KBA, PtJ, NOW, BMDV

BMV Funding programme: Buses with alternative drives (E-Bus Funding Guideline)

Content, status, results, technologies

Funding programme*: Buses with alternative drives

Results and technologies

1.2 billion
euros subsidies

Support of 230 companies

3,500 buses funded

85,6 %

13,8 %

0,6 %

15,7% infrastructure funding

79,1 %

4,2 %

16,5 %

120 feasibility studies

+ 1,500 busses
(4th call)

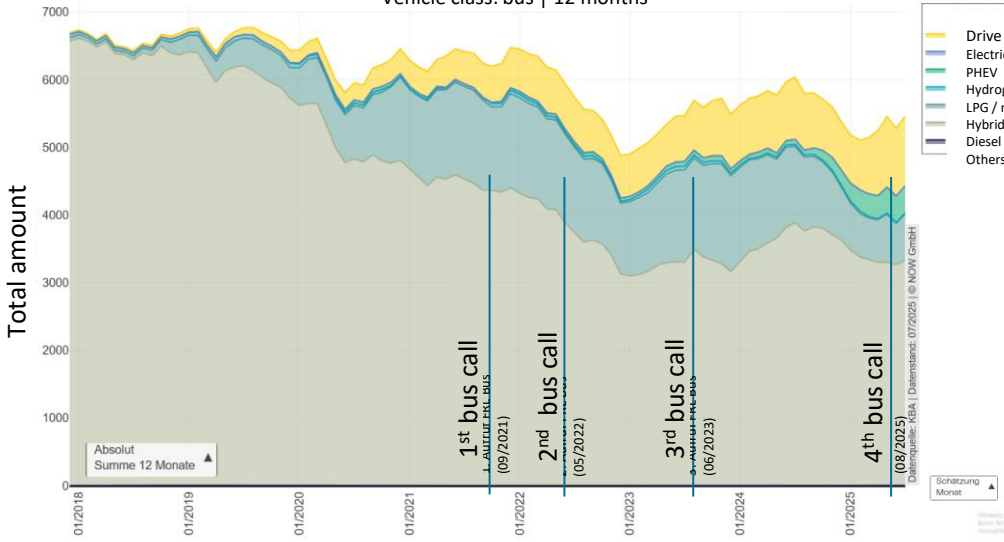
*Funding Guideline for the promotion of alternative drives for buses in passenger transport, BMV (Federal Ministry of Transport)

Market development

Electric bus fleet and new registrations in Germany

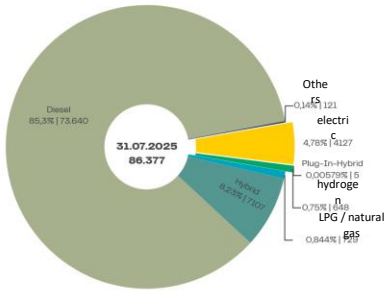
Development of monthly new registrations

Vehicle class: bus | 12 months

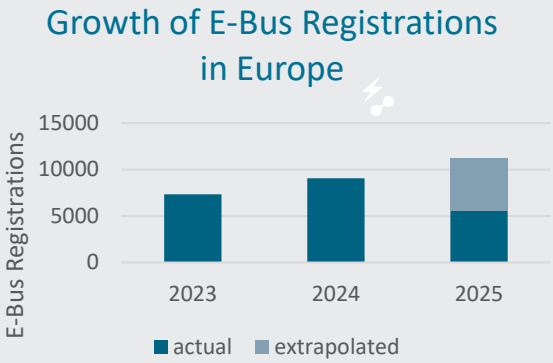


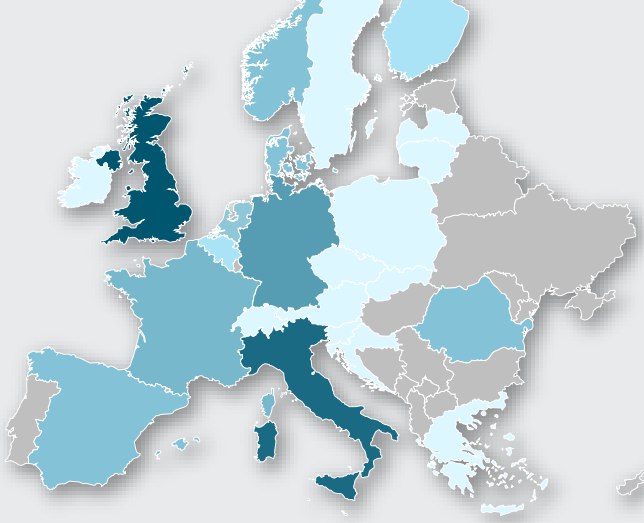
Current vehicle inventory

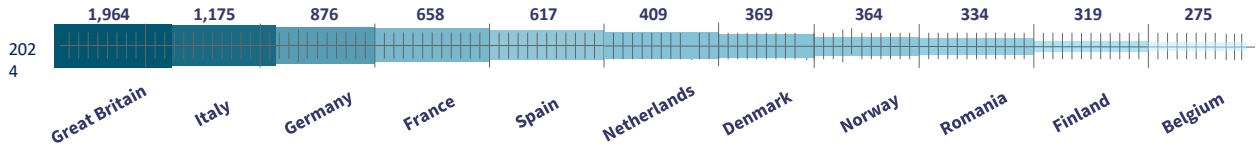
Vehicle class: bus



New Registrations of E-Buses







Source: https://www.acea.auto/files/Press_release_commercial_vehicle_registrations_2024.pdf

Programme Insights: Projects and Perspective

Flag ship projects

Representing the wide scope of the funding program

Pantograph charging at Kieler Verkehrsgesellschaft (KVG) | source: kvg-kiel.de

E-bus depot at Munich Airport | source: Munich Airport

Converted double-decker sightseeing bus from Willms Touristik in Cologne | source: Allison Transmission

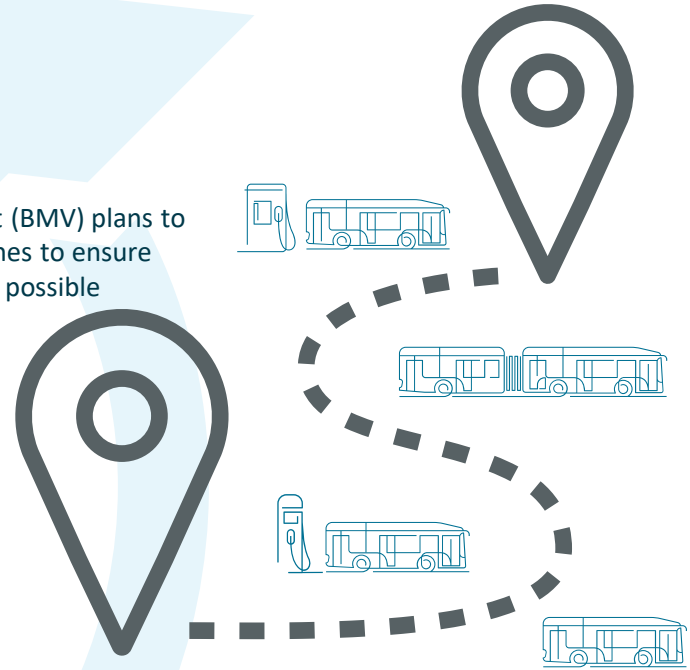
Articulated bus operated by DB Regio Bus Nord| source: DB Regio Bus Nord

E-Coach at Scharf Reisen| source: Scharf Reisen

Perspectives

Federal Ministry of Transport (BMV) plans to continue the funding guidelines to ensure the most seamless transition possible

Midterm goal reached:
Fundings led to market ramp-up



Contact details

Federal Ministry of Transport
Division G 23 Electric Mobility and Charging Infrastructure
Invalidenstraße 44
10115 Berlin

Contact Person

Oliver Braune,
Programme Coordination E-Mobility and Buses
Oliver.Braune@bmv.bund.de
www.bmv.de

Federal Ministry of Transport

Austria's ZEB Transition – the eMove Programme

Katharina Seper

Policy Advisor, Austrian Ministry of Innovation, Mobility & Infrastructure

EUROPEAN ZERO EMISSION BUS CONFERENCE 7th - 9th Oct 2025 @ Busworld Europe Brussels

ERM

BUSWORLD foundation
the global bus alliance

eMove Austria & EBIN

Zero Emission Bus Conference

Katharina Seper
BMIMI Dep. II/1 Mobility transition
08th October 2025

eMove Austria

Total Austrian BEVs in operation (August 2025)

Here you can find the latest numbers https://www.austriatech.at/en/zahlen-daten-fakten-archiv

239.980
BEV passenger cars in operation

500
BEV heavy duty vehicles in operation*

4,55 %
BEV passenger car share in total passenger cars

16.017
BEV light commercial vehicles in operation *

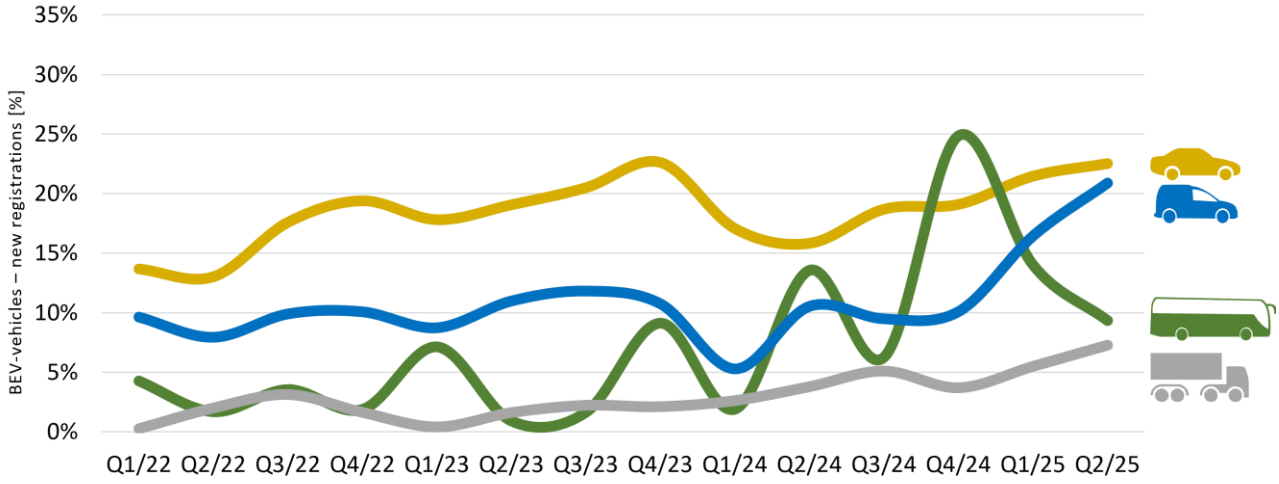
423
BEV-Busses in operation *

32.589
publicly accessible charging points

Source: Statistik Austria; E-Control / Visualisation: AustriaTech; Link: https://www.austriatech.at/de/zahlen-daten-fakten-archiv/

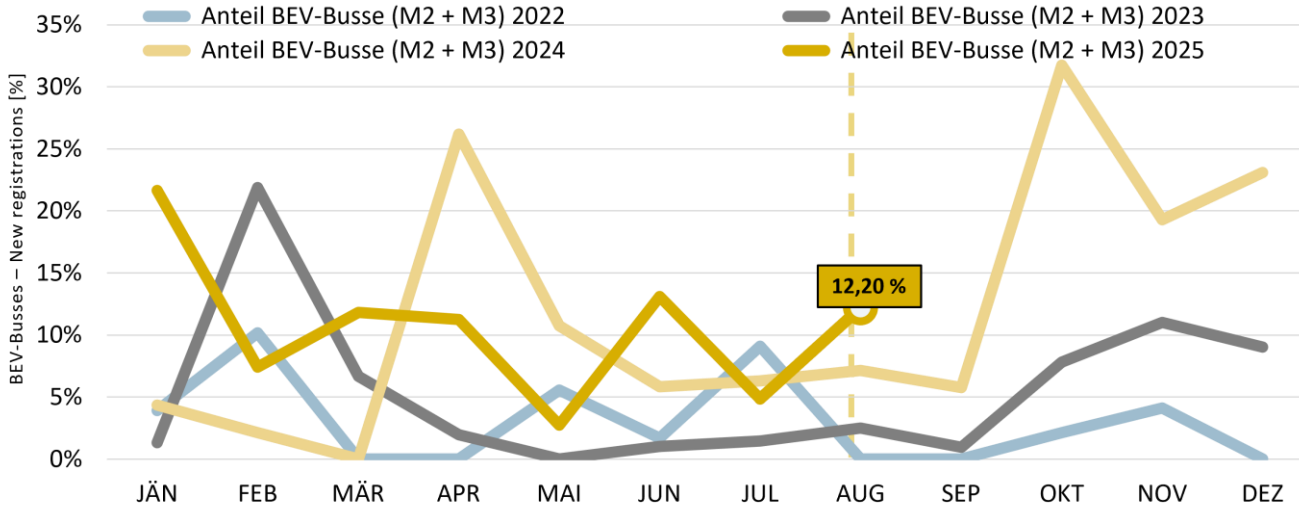
* extrapolated

New registrations:
Annual development of cars, buses, trucks



Source: Statistik Austria / Visualisation: AustriaTech

New registrations:
Annual Developements BEV-Busses



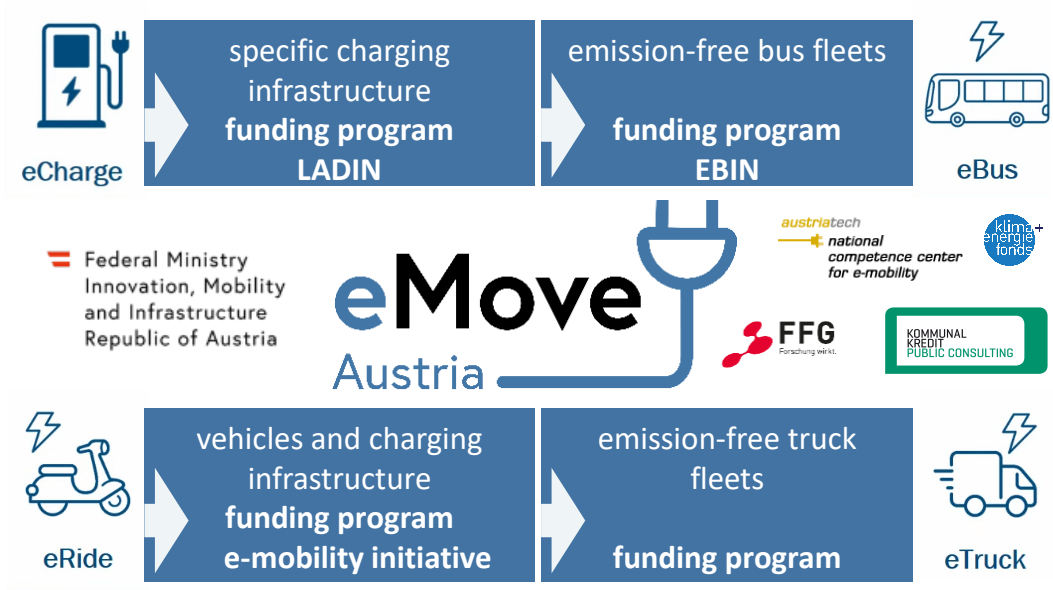
Source: Statistik Austria / Visualisation: OLÉ – Österreichs Leitstelle für Elektromobilität @AustriaTech

eMove Austria

Austrians federal programme to promote e-mobility

- **Holistic approach to the mobility transition:** consolidates all funding and measures (including regulatory policies) in the field of e-mobility
- **Goal by 2030:** 95% of the population should be within 10 km of a fast charging station
- **Investments 2025 & 2026:** approx. €480 million
- Scientific monitoring and annual performance report
- Online platform with consolidated information (in development)
- 4 areas: eCharge, eBus, eTruck, eRide

Austrian funding opportunities regarding e-mobility



eCharge

specific charging infrastructure

funding program LADIN

emission-free bus fleets

funding program EBIN

eBus

Federal Ministry
Innovation, Mobility
and Infrastructure
Republic of Austria

2026:

€ 30 million

for different charging use-cases

eMove Austria

eRide

vehicles and charging infrastructure

funding program e-mobility initiative

emission-free truck fleets

funding program ENIN

eTruck

eCharge

specific charging infrastructure

funding program LADIN

emission-free bus fleets

funding program EBIN

eBus

Federal Ministry
Innovation, Mobility
and Infrastructure
Republic of Austria

2025:

€ 83 million

2026:

€ 54,5 million

eMove Austria

eRide

vehicles and charging infrastructure

funding program e-mobility initiative

emission-free truck fleets

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eRide

vehicles and charging infrastructure

funding program e-mobility initiative

emission-free truck fleets

funding program ENIN

eTruck

eBus: EBIN Quick Check

2022-2024: **emission-free busses (BEV, FCEV, overhead line)** for use in **Austria** on **bus routes or in public service**
2025: extension to **more by types** (e.g. minibus)

Funding of **charging/refueling infrastructure** in addition to **bus procurement**

Funding is available to those who bear the costs.
e.g.: **bus companies, transport operators, energy suppliers**, …

recognition of costs upon submission

funding:
2022-2024: **80%** of the additional costs for buses
40% of the investment costs for infrastructure
2025**:** **60%** of the additional costs for buses
60% of the investment costs for infrastructure

EBIN 2022-2024

EBIN

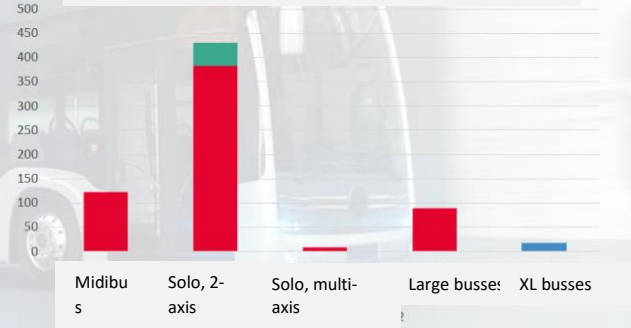
7 calls for proposals

50 projects

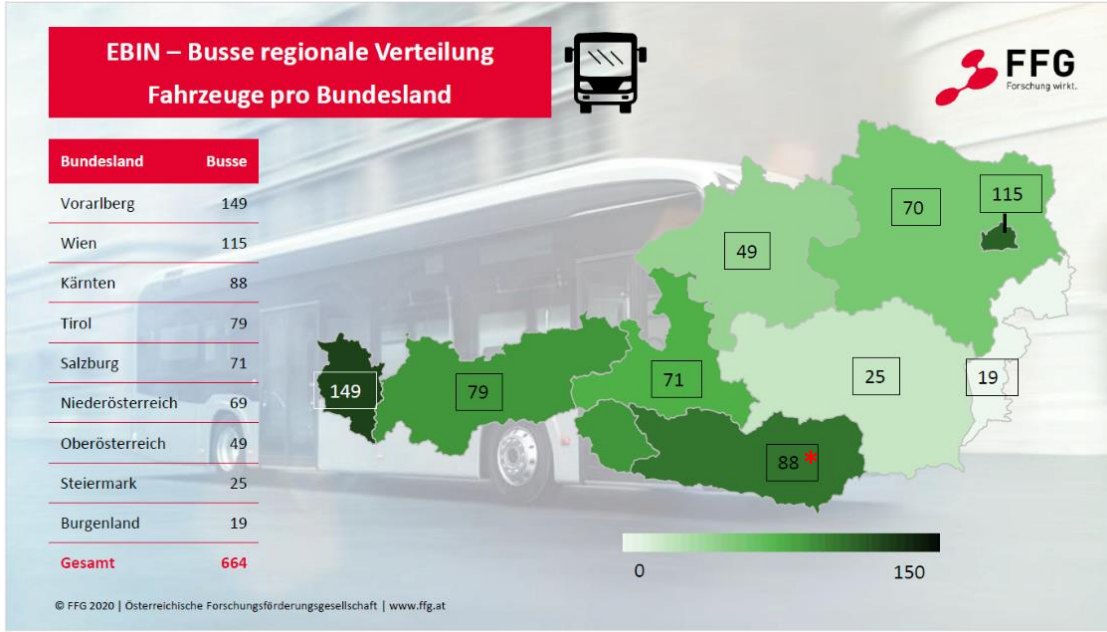
247 mio € funding secured

664 buses registered

Number of subsidized vehicles per size and type



EBIN 2022-2024: regional destribution per state



*still incl. KEBIP

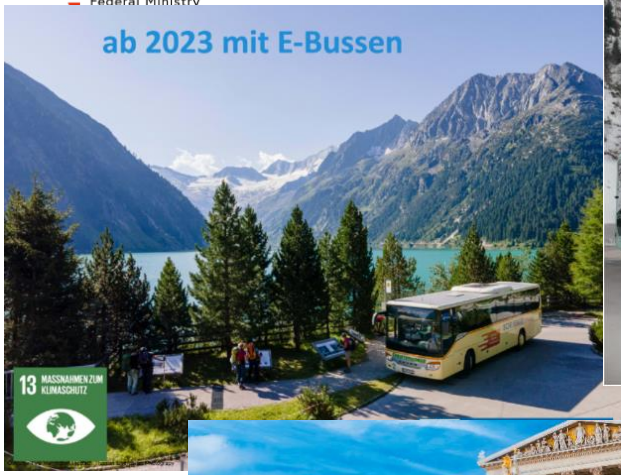
STELE: a platform to connect the energy and the mobility sector

www.stele.at

- Goal: developing a platform for the mobility as well as the energy sector, including for example:
  - Interactive map
  - Webtool for matching needs and offers
  - Webtool to support the fleet electrification
  - Checklist for fleet operators in order to support the decarbonization
- Regional matchmaking events take place - starting tomorrow
  - In order to connect stakeholders in every region of Austria

Listing of successful EBIN projects

https://www.ffg.at/ebin-erfolgsprojekte


ab 2023 mit E-Bussen
13 MASSNAHMEN ZUM KLIMASCHUTZ


100% GREEN ENERGY
TUXER SPORTBUS


BIGBUS VIENNA
100% ELECTRIC

© Wiener Linien / Manfred Helmer

Thank you!

Katharina Seper
Austrian Federal Ministry for Innovation, Mobility and Infrastructure
Department II/1, Mobility transformation
katharina.seper@bmimi.gv.at

Decarbonising the Hard-to-Electrify European Bus Routes

Tim Howgego

Independent Consultant

EUROPEAN ZERO EMISSION BUS CONFERENCE 7th - 9th Oct 2025 @ Busworld Europe Brussels

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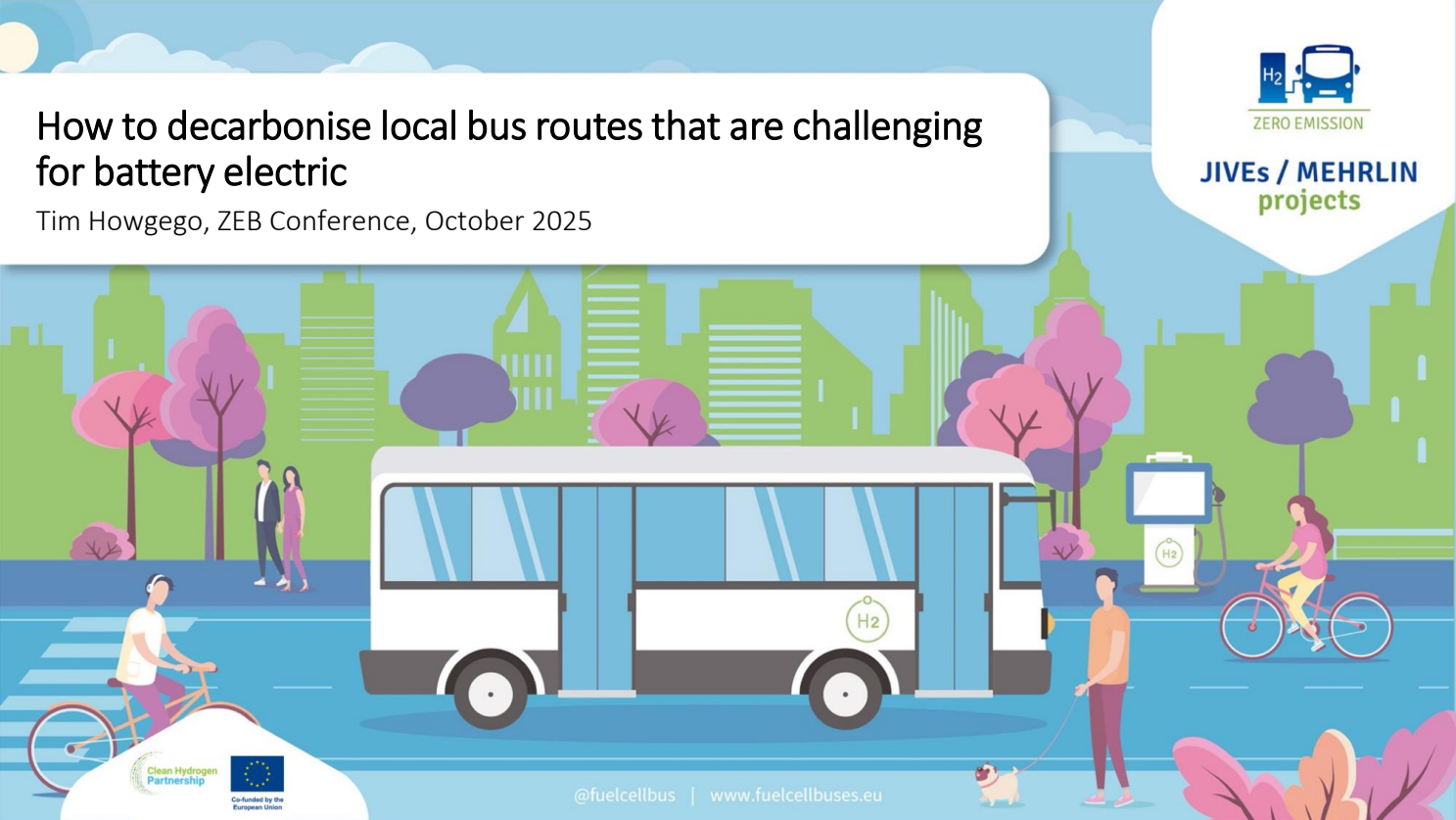
BUSWORLD foundation
the global bus alliance

ZERO EMISSION BUS CONFERENCE 2025

How to decarbonise local bus routes that are challenging for battery electric

Tim Howgego, ZEB Conference, October 2025



1

Problem: The longer-term route challenge for the battery electric bus

This presentation quantifies the longer-term bus route challenges, not depot fuel supply – but depot issues may force suboptimal solutions

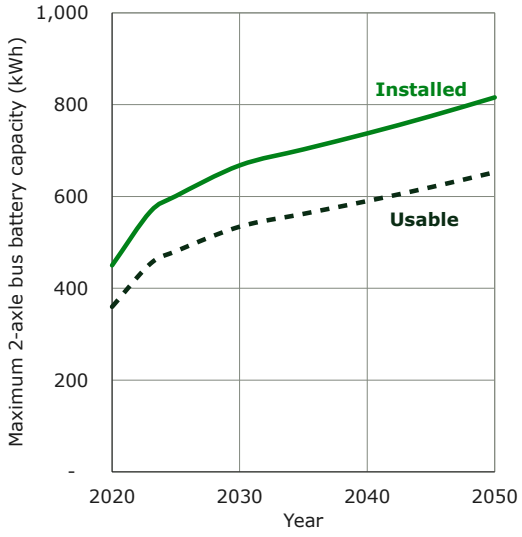
In practice, the biggest technical transition blocker is often depot fuel supply – be that grid connections or hydrogen at scale.

Long-term Battery Electric Bus (BEB) route compatibility and Total Cost of Ownership (TCO) analysis may reasonably ignore this as a *transitional* issue.

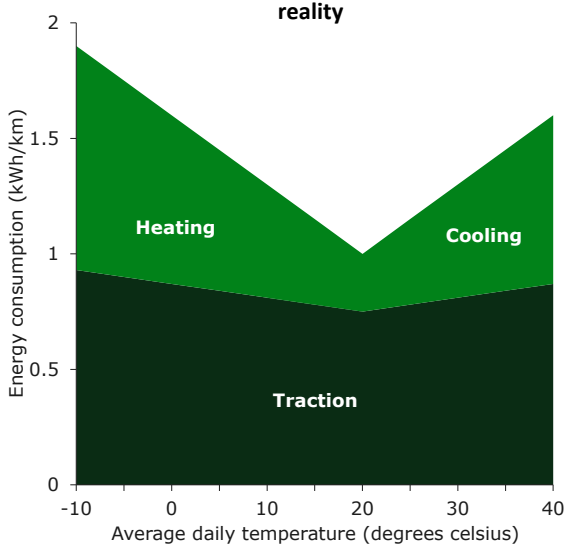
However, bus depots are not easily moved, and as decarbonisation targets draw closer, suboptimal solutions may be pursued – potentially suboptimal both on cost and risk.

The main constraints on Battery Electric Bus (BEB) compatibility are weight, primarily battery energy density, and local climatic extremes

BEB energy/range is weight-limited – we expect the rate of improvements (primarily in battery energy density) to slow in coming years – some other commentators are more optimistic



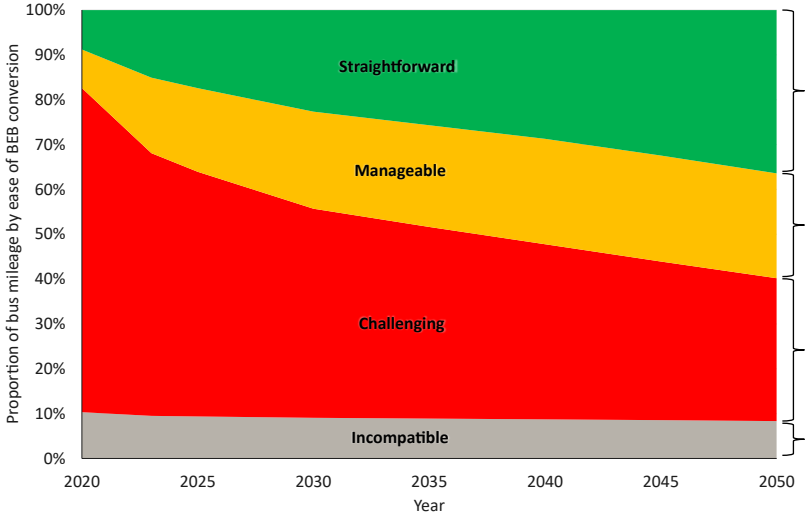
BEBs must be specified for the most extreme climatic temperature, which can double energy consumption – we assume battery-powered heating/cooling, which is not always reality



Indicative patterns only. Other factors can be important, including gradients, axles, doors, pre-heating and driving style.

BEBs lack the range to operate many routes on a single daily charge, with “challenging” routes requiring additional resources

Open data for scheduled public bus, for ¾ of Europe, was used to model energy and theoretical operations at route level. Routes were assigned compatibility with BEBs to 2050, assuming all energy from the battery:



BEBs can operate the route with a simple overnight at-depot charge.

There is sufficient slack in the existing route Peak Vehicle Requirement to allow BEB operation, but only if BEBs can return to depot during slack periods to charge.

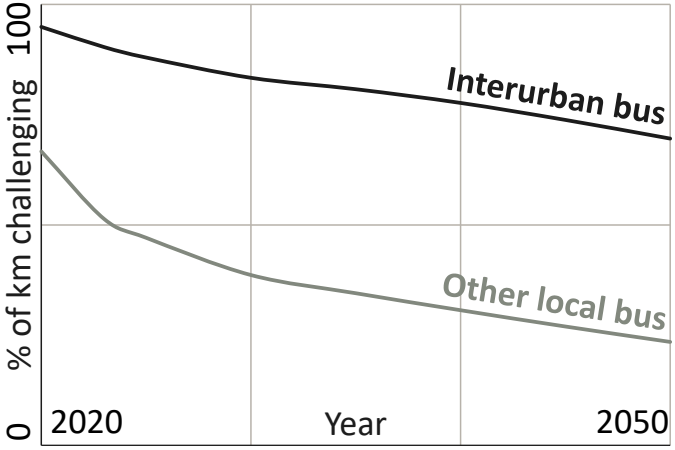
Insufficient slack in the existing vehicle allocation for BEB operation, so BEBs are likely to require one of the solutions outlined later in this presentation - **our assessments are made against these routes**.

Long distance intercity coach routes where one out-and-back BEB trip could not return to home depot.

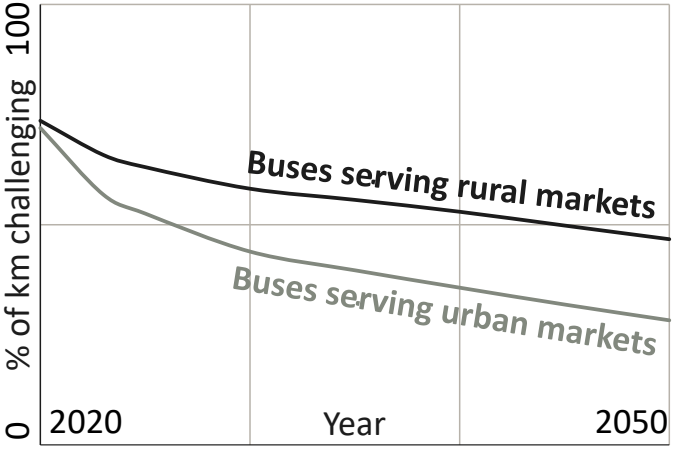
Full method and analysis: https://www.fuelcellbuses.eu/public-transport-hydrogen/d336-potential-hydrogen-buses-europe-results-bulk-analysis-passenger

Many interurban routes will remain challenging into the future – a broader policy concern as these form the backbone of rural networks

Interurbans are the local routes most challenging to decarbonise

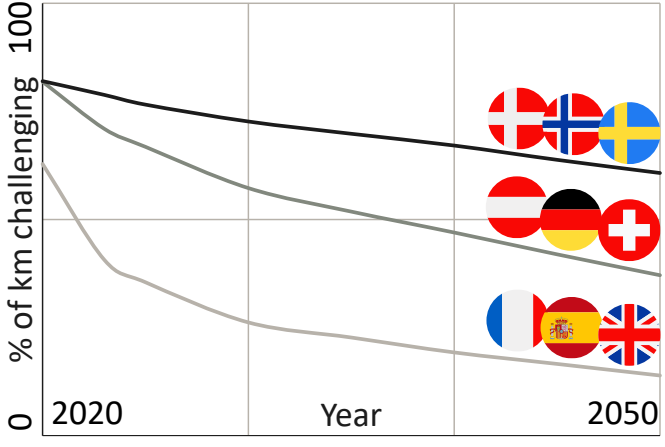


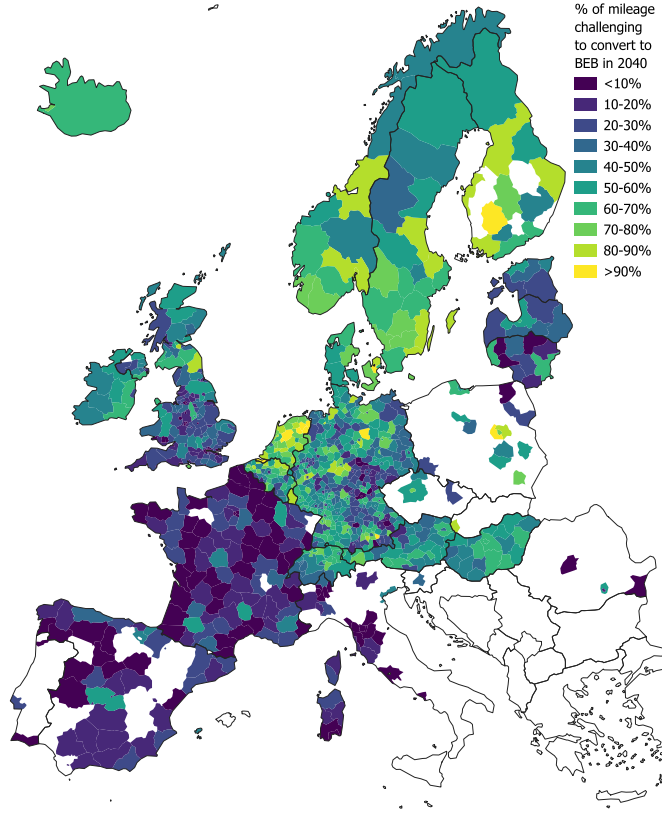
These tend to form the backbone of services to rural markets



Nations and regions differ in their proportions of challenging mileage

European nations differ, both in the proportion of current and future local bus mileage challenging to decarbonise





Regional differences can also be found within nations (NUTS3 mapped)

2

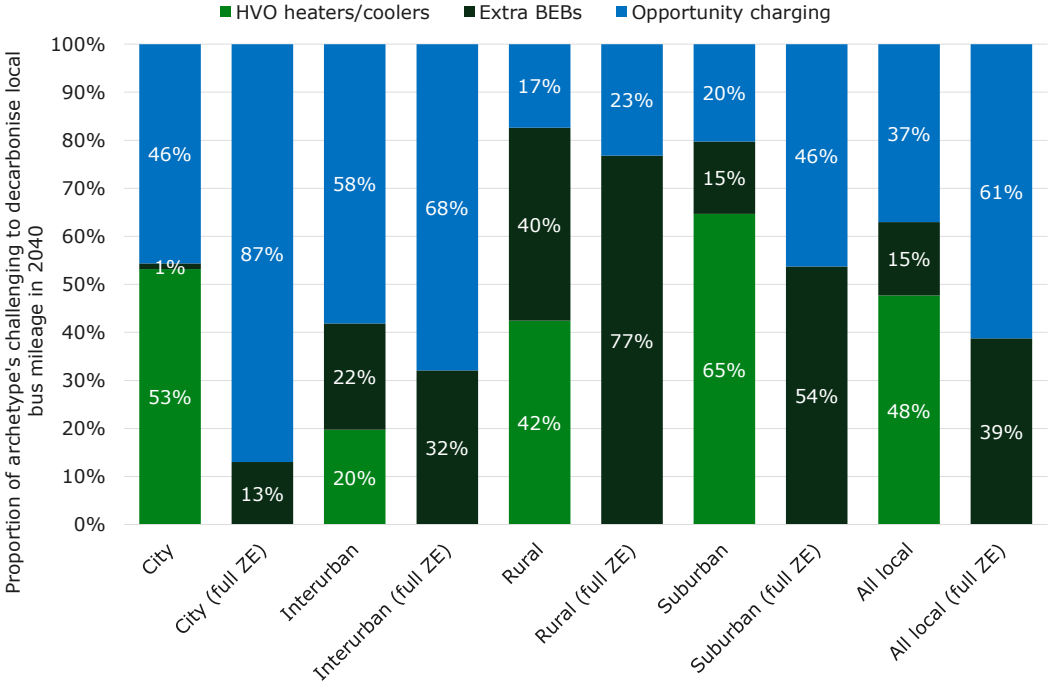
Theory: The TCO-optimal solution for challenging local bus routes

3 main BEB-based options selected for detailed Total Cost of Ownership analysis –excluding immature solutions such as induction

Option	HVO heaters/coolers	Opportunity charging	Extra BEBs
How it works	Passenger cabin energy can up to double energy use in extreme weather – fuelling this from HVO allows battery to be specified for traction only	Remote charging during natural breaks in service, typically using dedicated fixed pantograph chargers – BEB recharged throughout the day	Vehicles added to route peak requirement create sufficient slack to return buses to depot for daytime charging
Method caveats	Used current HVO prices – but supply is constrained	Assumed large battery topped up across the day – but small LTO battery with full recharge per trip theoretically cheaper	Assumed typical distance from termini to depot – not operator-specific
Pros	No major operational changes	Potentially minimal change to route operations	Resilient day-to-day and long term
Cons	Not fully Zero Emission – approximately 90% reduction	Remote fixed infrastructure adds risk and complexity	Requires operational and organisational flexibility
Proxy concept	Hydrogen range extenders	Remote plug charging	Inter-working peak-only routes into daytime network

Full method and evidence: https://fuelcellbuses.eu/public-transport-hydrogen/potential-hydrogen-buses-europe-analysis-alternatives-technical-report

The cheapest solution for challenging routes tends to be opportunity charging – unless HVO heater/coolers are considered ZE

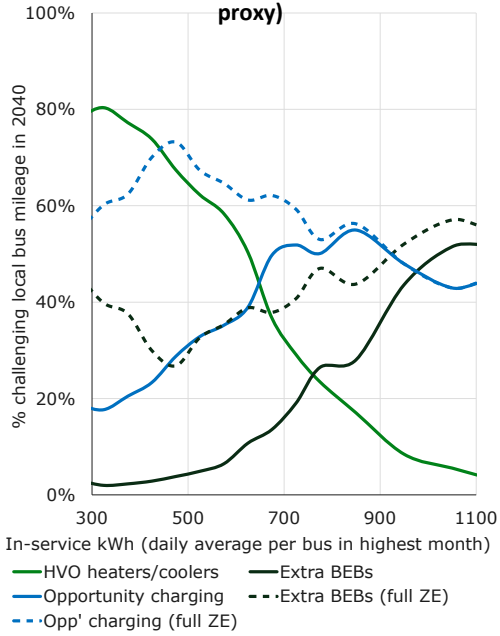


At current prices, HVO heaters/coolers would dominate challenging rural and suburban routes, and have a significant role in all routes – but is this sufficiently ZE?

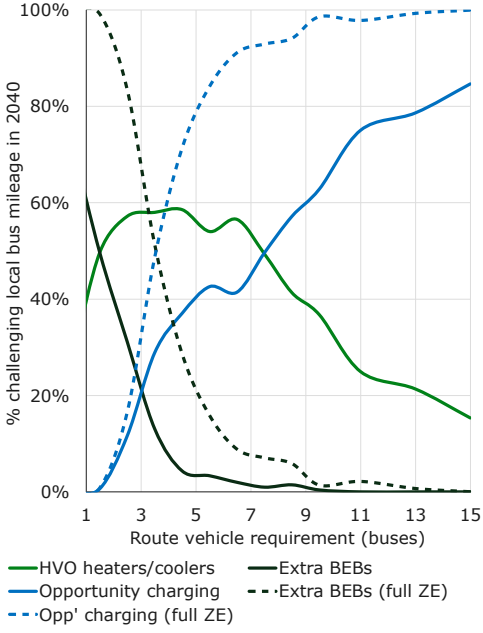
Without secondary heaters/cooler, opportunity charging is the main solution for challenging interurban and city routes, hence the main solution overall.

Daily bus energy and Peak Vehicle Requirement are the best two guides to cheapest option choice at route level

1. Daily bus energy (or duty mileage as proxy)



2. Peak Vehicle Requirement (PVR) of route

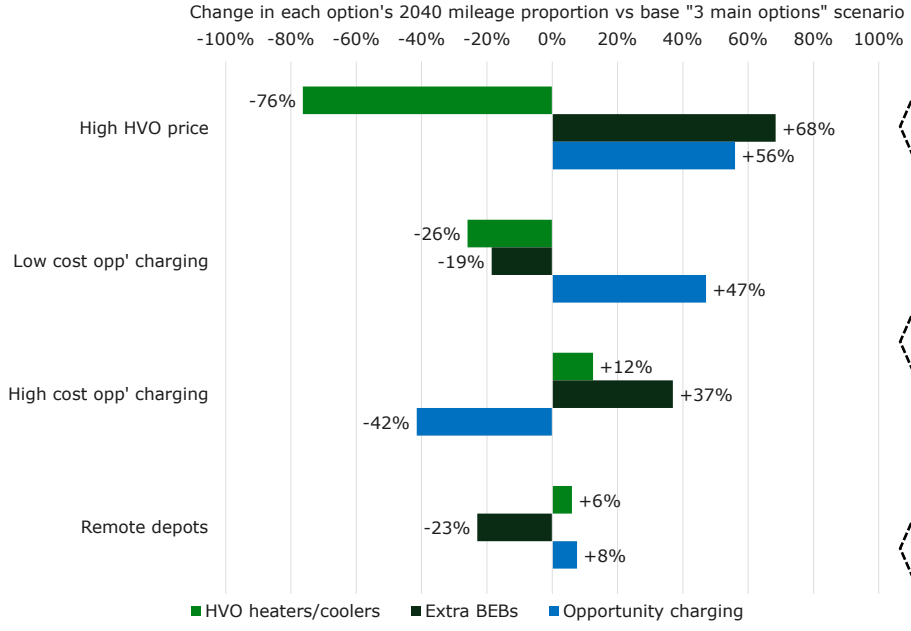


HVO heaters/coolers are good range-extenders, especially at lower PVRs where opportunity chargers would be poorly utilised.

Extra BEBs suit low-PVR routes where opportunity chargers would be infrequently used, and routes where energy requirements might exceed that of a single BEB in summer.

Opportunity charging is primarily dictated by PVR – the only solution for routes with more than 10 buses if secondary heaters/coolers are disallowed.

Pricing-in risks will tend to favour Extra BEB solutions, except where depots are remote, while option choice is very sensitive to HVO price

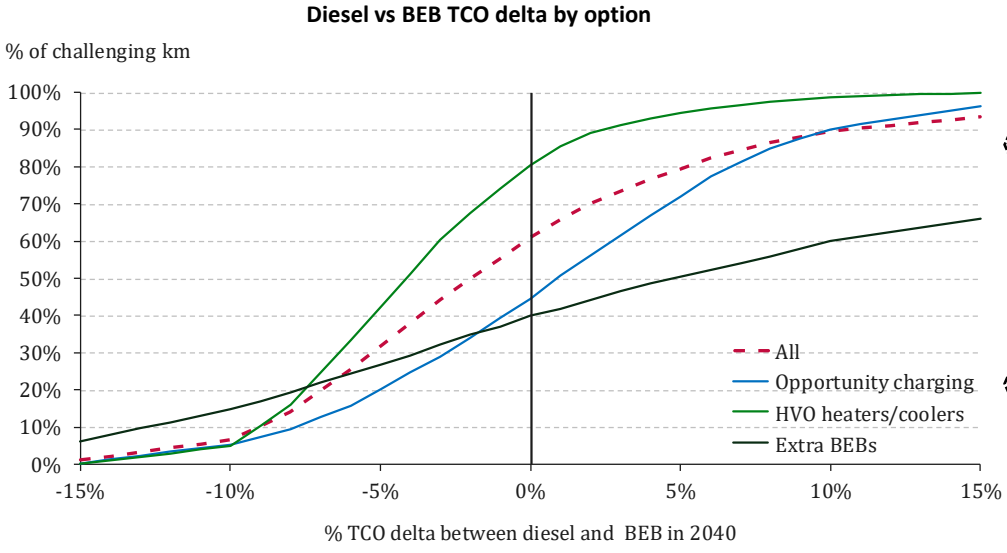


Double HVO price (plausible given constrained supply) reduces secondary heaters/coolers by 4/5 and promotes relatively low-risk Extra BEBs

Double or halving of opportunity charger costs is indicative of implementation risks – this helps explain their rarity

Only remote depots (3 times further) disfavour Extra BEBs – most likely in rural and SME operations where Extra BEBs can be best suited

Cost of BEB-based transition for challenging routes vs diesel – HVO could make the transition cheaper (assuming current prices)



With HVO heaters/coolers options only 40% of mileage is more expensive – without them, 2/3 is more expensive

Extra BEB solutions have the greatest spread of cost changes and tend to be the most expensive – but better manage risks

3

Practice: Operational flexibility, risk, and a potential market for hydrogen

Pre-TCO questions for challenging local bus route decarbonisations: Operational flexibility and ability to manage risk

ZERO EMISSION

How much operational and scheduling flexibility is there?

- Complete freedom to optimise services for BEBs
  - "Ember" approach – but established markets reluctant to change
- Freedom to optimise internal operations, but not passenger schedules
  - Common in "agile" GB bus – long-term modelling assumption
- No ability to change vehicle operations to better suit BEBs
  - 1:1 diesel-to-ZEB – often when constrained by labour or depot practices

How much risk can your operation or agency manage?

- Implementation & operation risk
  - Depot transition adds risk via new partners & processes – and any extra remote infrastructure multiplies these risks
- External policy & cost risk
  - In EU, unclear future policy & price for secondary HVO heaters/coolers – while in UK, uncertainty on ZEB service requirements
- Financial & asset risk
  - ZEBs double CAPEX, raising absolute risk – but battery life & residual risks are over-emphasised vs maximising utilisation

LFP changes presumptions: Reappraise battery life risk expectations to emphasise in-service utilisation, not residual battery life

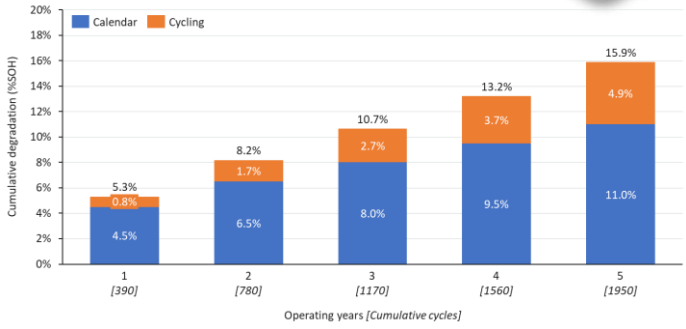
Adding extra cycles to a fixed calendar degradation (more cycles per year) will tend to give a **better lifetime payback** on investment than using the battery more sparingly over a potentially longer life…

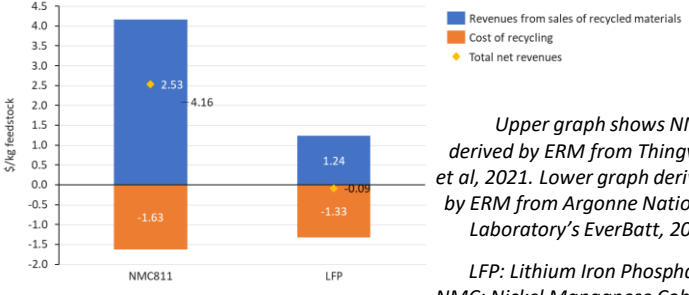
If those extra cycles are converted into in-service, revenue-earning, bus operation.

LFP batteries may pragmatically be assumed to have **no net residual value** at end of life.

LFP tends to **degrade less per cycle** than NMC, so tends to be better suited to multiple charges per day.

LFP has slightly **lower energy density** than NMC, so LFP-operated routes more likely to be "challenging".



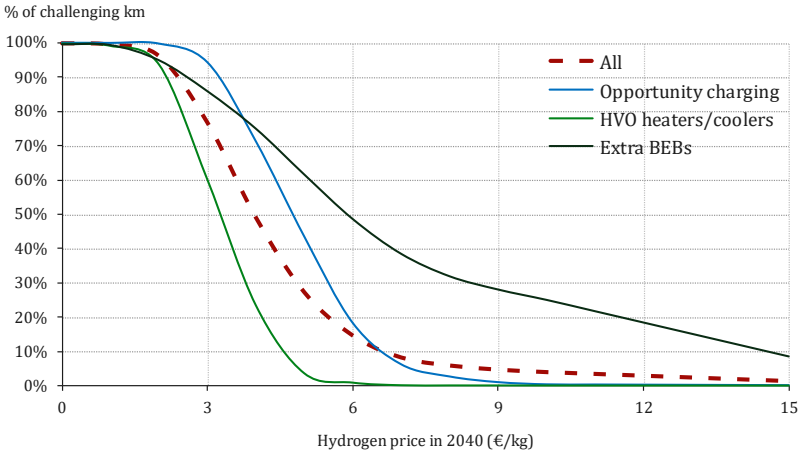


Upper graph shows NMC, derived by ERM from Thingvad et al, 2021. Lower graph derived by ERM from Argonne National Laboratory's EverBatt, 2023.

LFP: Lithium Iron Phosphate, NMC: Nickel Manganese Cobalt.

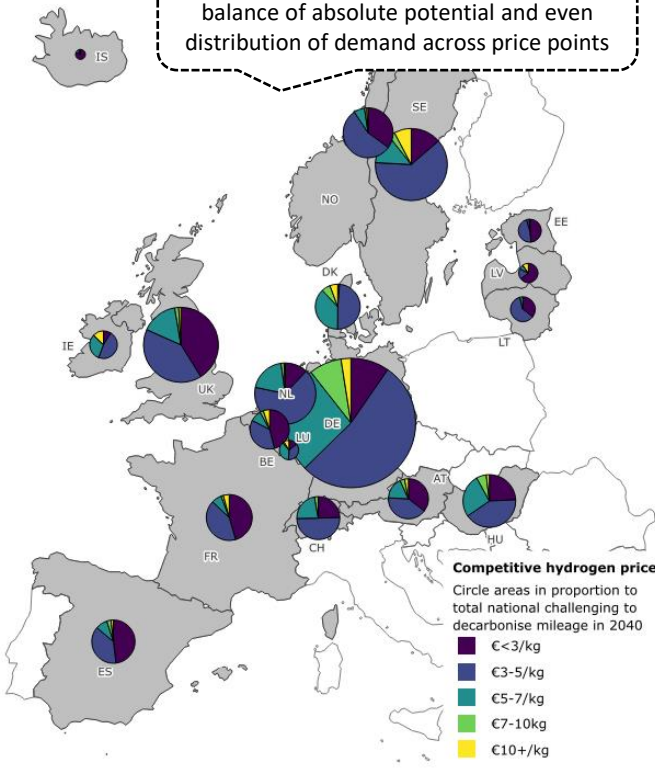
Green hydrogen's strength is not on cost, but its potential to counter inflexibilities and risks

Competitive hydrogen price vs cheapest battery-based option

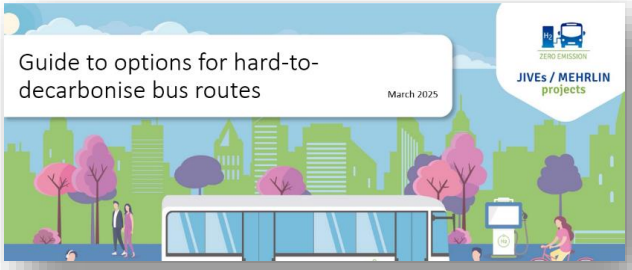


Hydrogen is most competitive where risks are being priced-in – and even more so where operators lack flexibility

Germany & Sweden show the best balance of absolute potential and even distribution of demand across price points



Publications: How-to strategy guide aimed at operators/agencies, plus technical reports containing detailed evidence & analysis



How-to guide

- Introduction to the challenge
- Overview & application of each main BEB-based option
- Niche options & hydrogen fuel cell alternative
- Strategic decision tree

Technical reports

- Analysis of hard-to-decarbonise scheduled bus routes covering ¾ of Europe
- Common and secondary technologies, with extra evidence around batteries
- TCO-based evaluation of main options, including competitiveness of hydrogen

https://fuelcellbuses.eu/publications

Thank you for your attention

Project coordination:

ERM

Project dissemination:

Hydrogen Europe

The **JIVE and JIVE2 projects** have received funding from the Clean Hydrogen Partnership under Grant Agreement No 735582 and 779563.

This Joint Undertaking receives support from the **European Union's Horizon 2020** research and innovation programme, Hydrogen Europe and Hydrogen Europe Research.

The **MEHRLIN project** is co-financed by the **European Union's Connecting Europe Facility.**

@fuelcellbus
www.fuelcellbuses.eu

For further details about this study, please contact:
Tim Howgego or **Eva Baker**

Clean Hydrogen Partnership

Co-funded by the European Union

Coffee Break

Next breakout sessions start at 11:00 – go to:

Room 1122 for

“Optimising Zero Emission Bus Operations: Leveraging Data & AI”

Room 1123 for

“Evolution of CAPEX and OPEX for Zero Emission Buses: Outlook and Strategies”

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