Emission-free at the HOCHBAHN

Dr.-Ing. Markus Dietmannsberger, Head of Emission Free Drives & Sector Coupling

HOCHBAHN

Portrait bus traffic

Our mission

The way to zero emissions

Battery vs. hydrogen – our strategy

Challenges on the way to zero emissions

Costs – may it be a bit more?

CO_2 balance – may it be a bit less?

Thinking globally – social sustainability in the supply chain

HOCHBAHN

Portrait bus traffic

Our mission

The way to zero emissions

Battery vs. hydrogen – our strategy

Challenges on the way to zero emissions

Costs – may it be a bit more?

CO_2 balance – may it be a bit less?

Thinking globally – social sustainability in the supply chain

HOCHBAHN

9 depots with 20 hectare.

This roughly corresponds to the festival grounds of Hamburger Dom.

Around 1100 busses.

When strung together, this results in about 20 times the length of the Reeperbahn.

Around 600.000 passengers.

Every day.
This corresponds to twenty times the capacity of the Millerntor-Stadion.

Stakeholders Owned by the City of Hamburg

Portrait bus traffic

Our mission

The way to zero emissions

Battery vs. hydrogen – our strategy

Challenges on the way to zero emissions

Costs – may it be a bit more?

CO_2 balance – may it be a bit less?

Thinking globally – social sustainability in the supply chain

HOCHBAHN

„From 2020, only emission-free buses will be purchased in bus transport.

A continuous conversion of the bus fleet to emission-free drives will take place by 2030.“

Hamburger Klimaplan, p. 30

Portrait bus traffic

Our mission

The way to zero emissions

Battery vs. hydrogen – our strategy

Challenges on the way to zero emissions

Costs – may it be a bit more?

CO_2 balance – may it be a bit less?

Thinking globally – social sustainability in the supply chain

HOCHBAHN

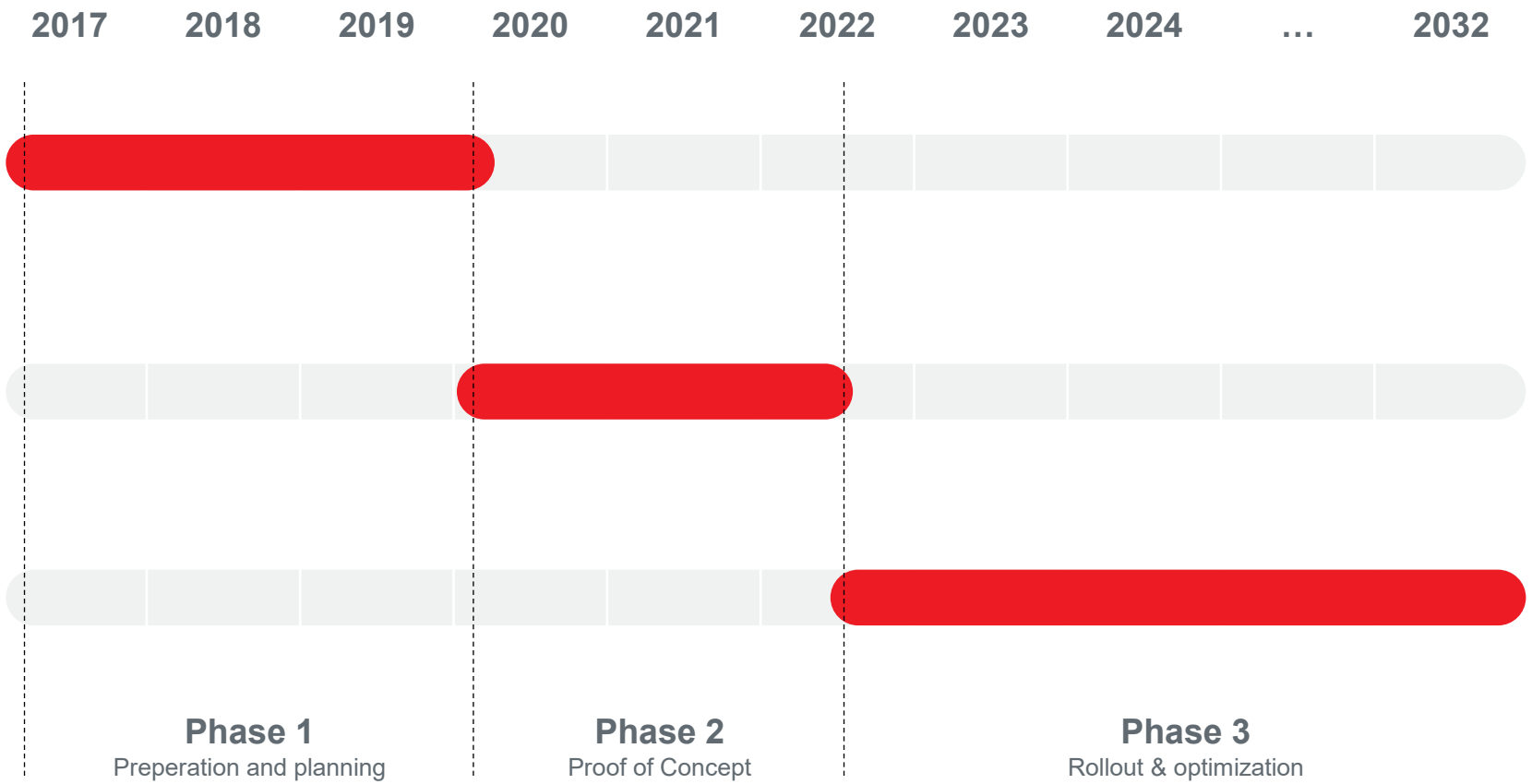
Our way to zero emissions.

The changeover in phases.

Preparation and planning
First buses, first charging, implementation of the basis systems

Proof of Concept
Up to 100 e-buses, 2 depots, extended functions of the system

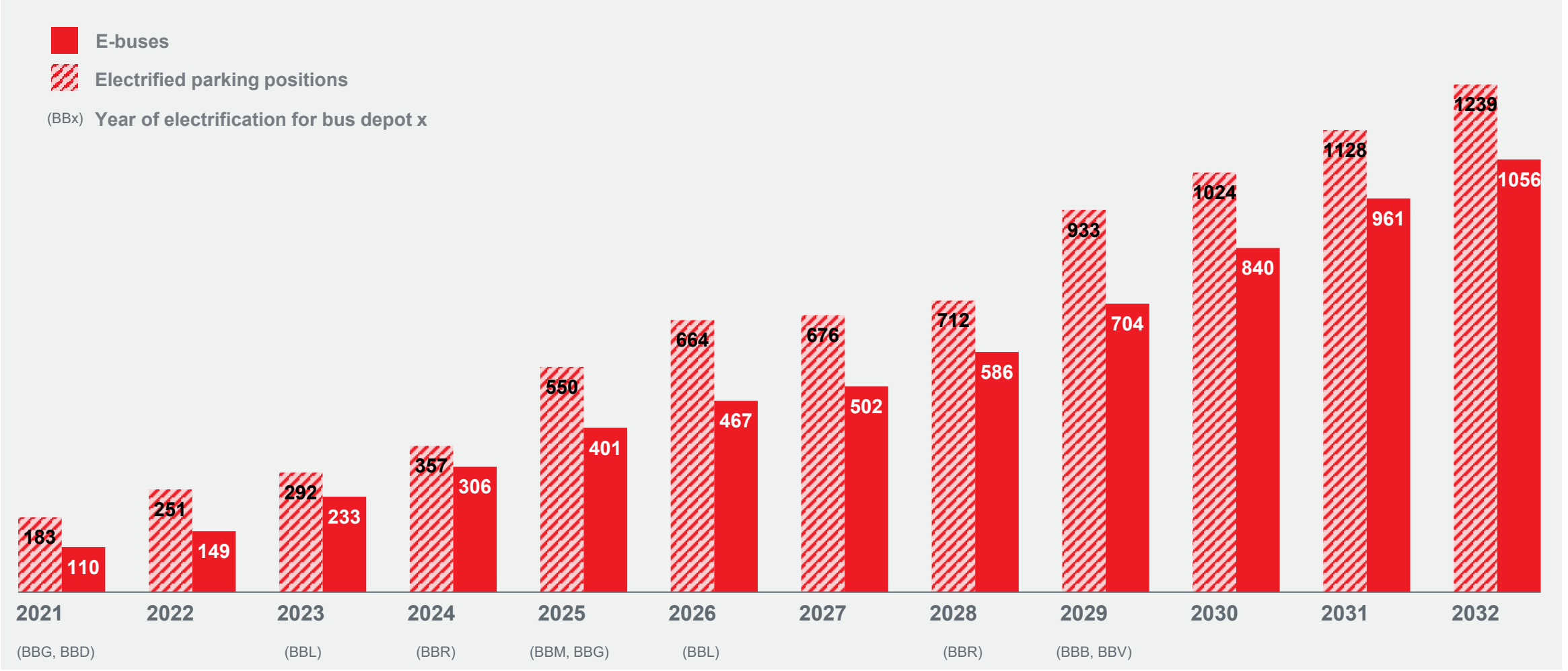
Rollout and optimization
successively all depots and 1100 buses



HOCHBAHN

Development of vehicles and charging infrastructure (incl. HH-Takt)

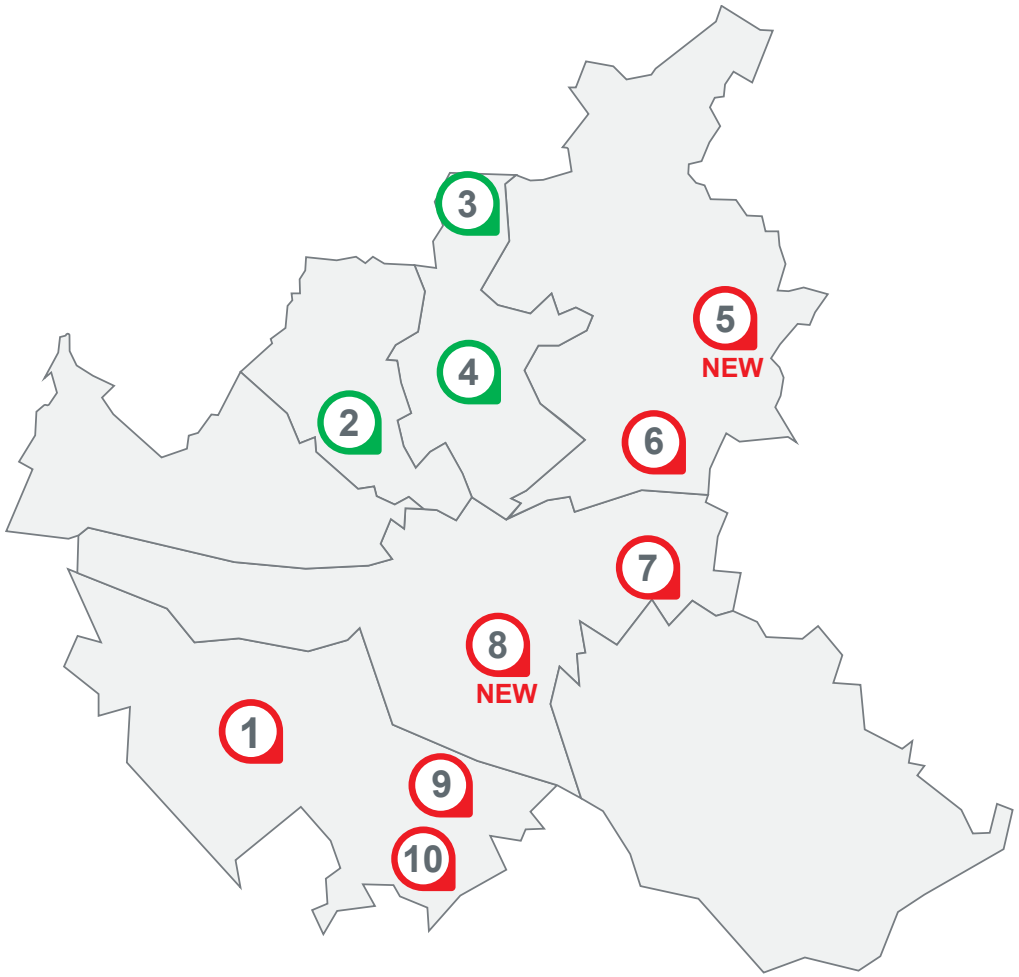
From the end of 2021 till the end of 2032



HOCHBAHN

Infrastructure of the HOCHBAHN

Electrifying.



1. **Süderelbe**
2. **Langenfelde**
   electrification started in 2021
3. **Hummelsbüttel**
   electrification started
4. **Alsterdorf**
   further expansion of electrification in progress
5. **Meiendorf NEW**
   new construction purely electric (2026)
6. **Wandsbek**
7. **Billbrook**
8. **Veddel NEW**
   new construction purely electric (in planning)
9. **Harburg II**
10. **Harburg**

HOCHBAHN

Portrait bus traffic

Our mission

The way to zero emissions

Battery vs. hydrogen – our strategy

Challenges on the way to zero emissions

Costs – may it be a bit more?

CO_2 balance – may it be a bit less?

Thinking globally – social sustainability in the supply chain

HOCHBAHN

The right path to zero emissions?

The strategy of the HOCHBAHN.

Strategic basis

Battery bus with depot charging

Strategic option

Opportunity Charging

Strategic option

Fuel cell hybrid /
range extender

HOCHBAHN

Why depot charging?

For us the technology of choice – for good reason.

- High market availability
- Production-ready technology
- Low operational complexity
- Maintaining high productivity
- Pre-conditioning
- Infrastructure in own depots

HOCHBAHN

Hydrogen – fuel of the future?

HOCHBAHN´s hydrogen strategy.

- Need rather for large vessels
- First:
  Procurement of a small number of pieces
- Infrastructural hydrogen is always taken into account.
- For a small fleet, refueling at an external gas station

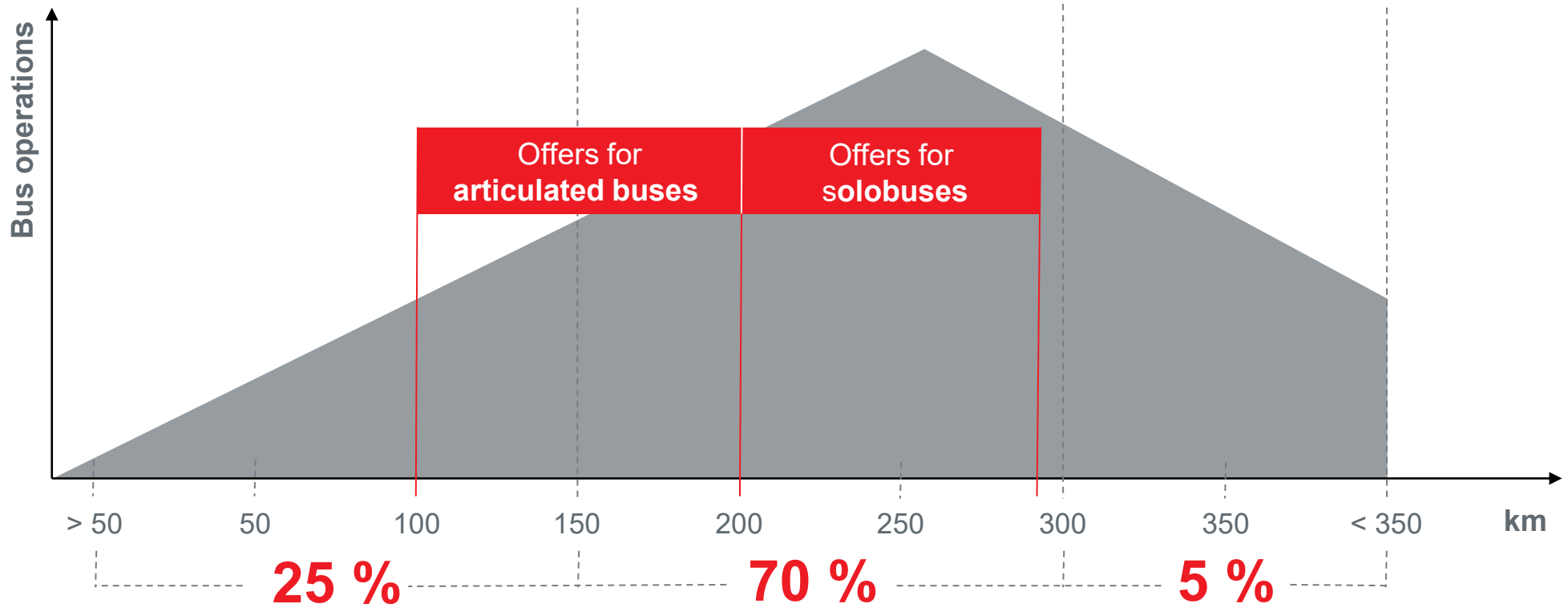
HOCHBAHN continues to see itself as an important partner in the North German Reallabor and recognizes the importance of hydrogen for the overall economy.

HOCHBAHN

Bus operations vs. Range.

The daily range requirements in Hamburg.

The majority of daily bus operations are betweend **150 and 300 km**.



HOCHBAHN

Complex task

Factors of the transition

- Vehicle ramp-up
- Range
- Electric heating
- parking space requirements
- charging infrastructure
- Interoperability
- Standards
- cost minimization
- CO_2-balance
- …

- A concert …

HOCHBAHN

Portrait bus traffic

Our mission

The way to zero emissions

Battery vs. hydrogen – our strategy

▶ Challenges on the way to zero emissions

Costs – may it be a bit more?

CO_2 balance – may it be a bit less?

Thinking globally – social sustainability in the supply chain

HOCHBAHN

System integration.

The whole is more than the sum of its parts.

Required functions

- Charge
- Pre-Conditioning
- Disposition
- Power limitations
- Battery Strategies
- Secure communication

Approaches

- ISO 15118, OCPP
- V2ICP / VDV 261
- Charging schedule
- Load management
- Public / Private Key Infrastructure

HOCHBAHN

Disposition of E-Buses.

The right bus in the right place at the right time.

- Circulation scheduling taking into account the current state of charge (SoC) and the time of departure.
- Parking space scheduling for optional parking and smooth entry and exit of the E-buses.

HOCHBAHN

Connection to the power grid.

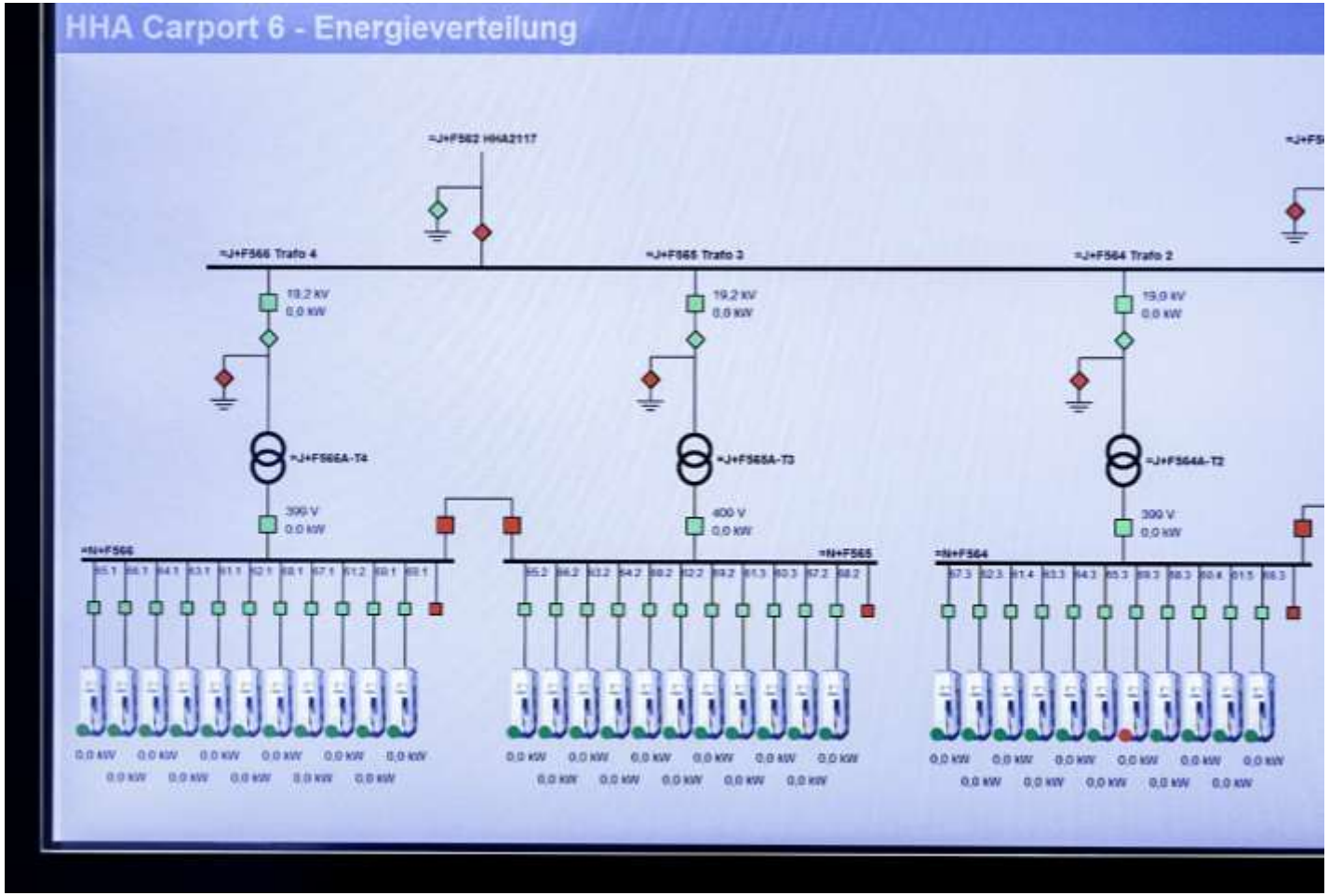
Power to the Buses.

- Upgrading of all network connections of the depots.
- High power requirements – some connections have to be made in the high-voltage grid.
- Long lead times up to 5 years.

HOCHBAHN

load and charge management.

When how much?



- Communication of relevant charging parameters
- Do all buses have to be charged at the same time?
- How can the load be distributed in an optimized way?

HOCHBAHN

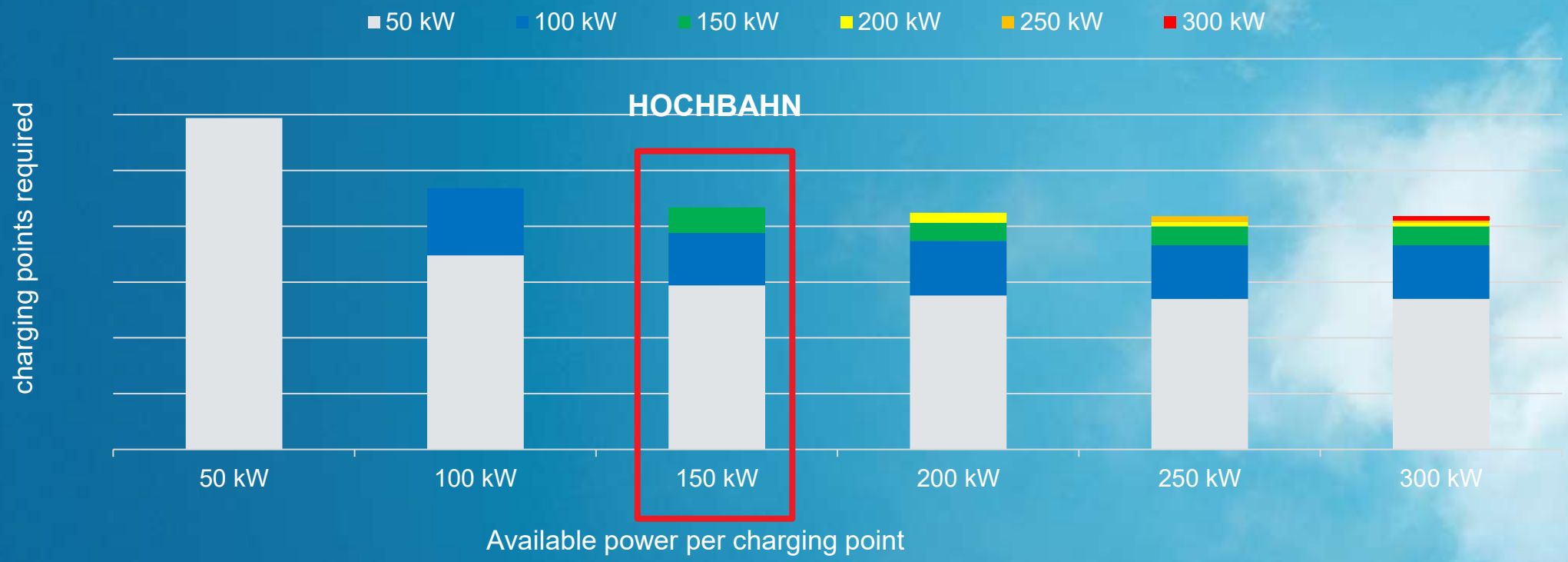
Transparent supply chains.

Sustainability for global solutions.

- Where do the raw materials for our batteries come from?
- What is the global impact of our actions?

HOCHBAHN

Dimensioning of Charging Infrastructure

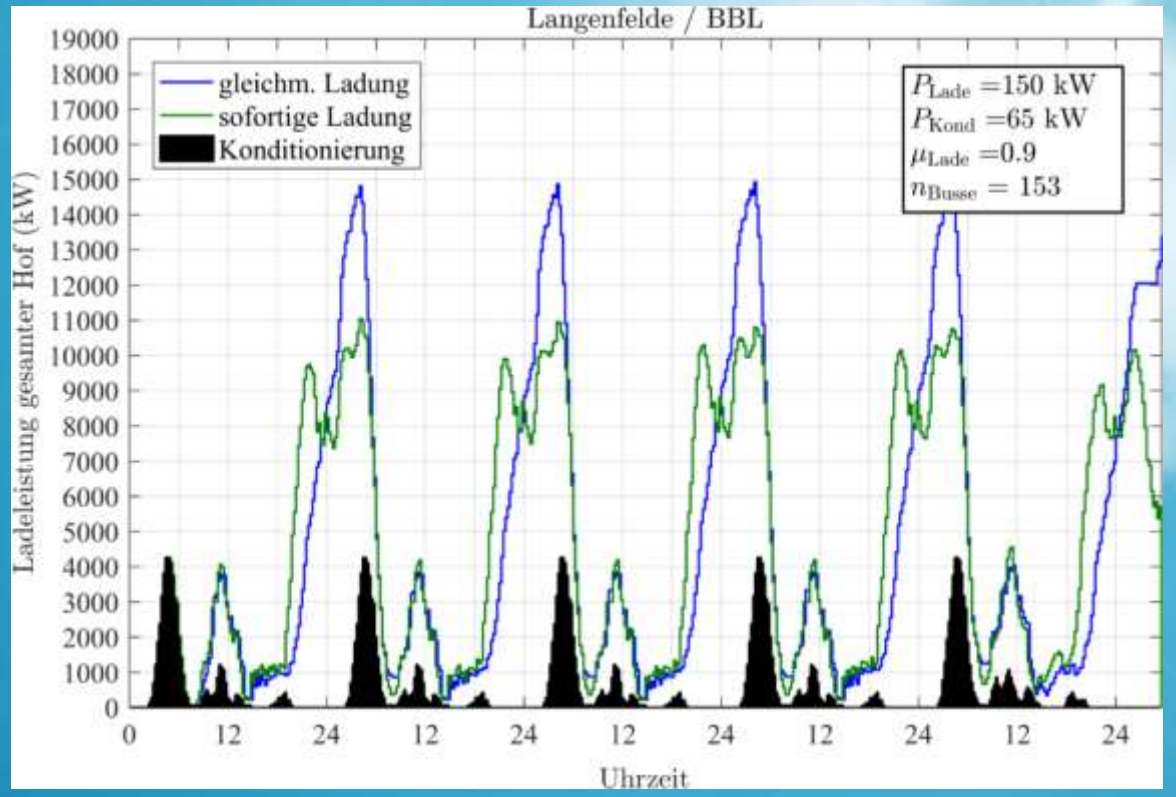


- A charging power of 150 kW is sufficient for charging buses on time and the required amount of flexibility.

Quelle: Carstens, 2019

Load Profile of a Bus Depot

- Slow charging not always better
- Potential for charging optimisation with respect to grid and market by using intelligent load management



Quelle: Schulz et al, 2016

Portrait bus traffic

Our mission

The way to zero emissions

Battery vs. hydrogen – our strategy

Challenges on the way to zero emissions

▶ **Costs – may it be a bit more?**

CO_2 balance – may it be a bit less?

Thinking globally – social sustainability in the supply chain

Relative total costs per year for solobus fleet

incl. emission costs** compared to diesel bus fleet

* HOCHBAHN service life 12 years; battery service life 6 years
** Emission costs: 215 € / t CO_2
***0,106 kgH2 / km

Legend

- Net personnel costs for bus operations
- Emissions
- Fuel oil consumption
- Consumption hydrogen***/electricity/diesel
- Personnel costs bus operation empty & I/O & Break
- Operation & maintenance charging infrastructure
- Manufacturing charging infrastructure
- Manufacturing hydrogen filling station
- Vehicle maintenance
- Vehicle procurement – FC system
- Vehicle procurement – Battery
- Vehicle procurement – vehicle body

Hinweis: Consumption and procurements that are not shown have the value 0.

HOCHBAHN

Portrait bus traffic

Our mission

The way to zero emissions

Battery vs. hydrogen – our strategy

Challenges on the way to zero emissions

Costs – may it be a bit more?

▶ **CO_2 balance – may it be a bit less?**

Thinking globally – social sustainability in the supply chain

HOCHBAHN

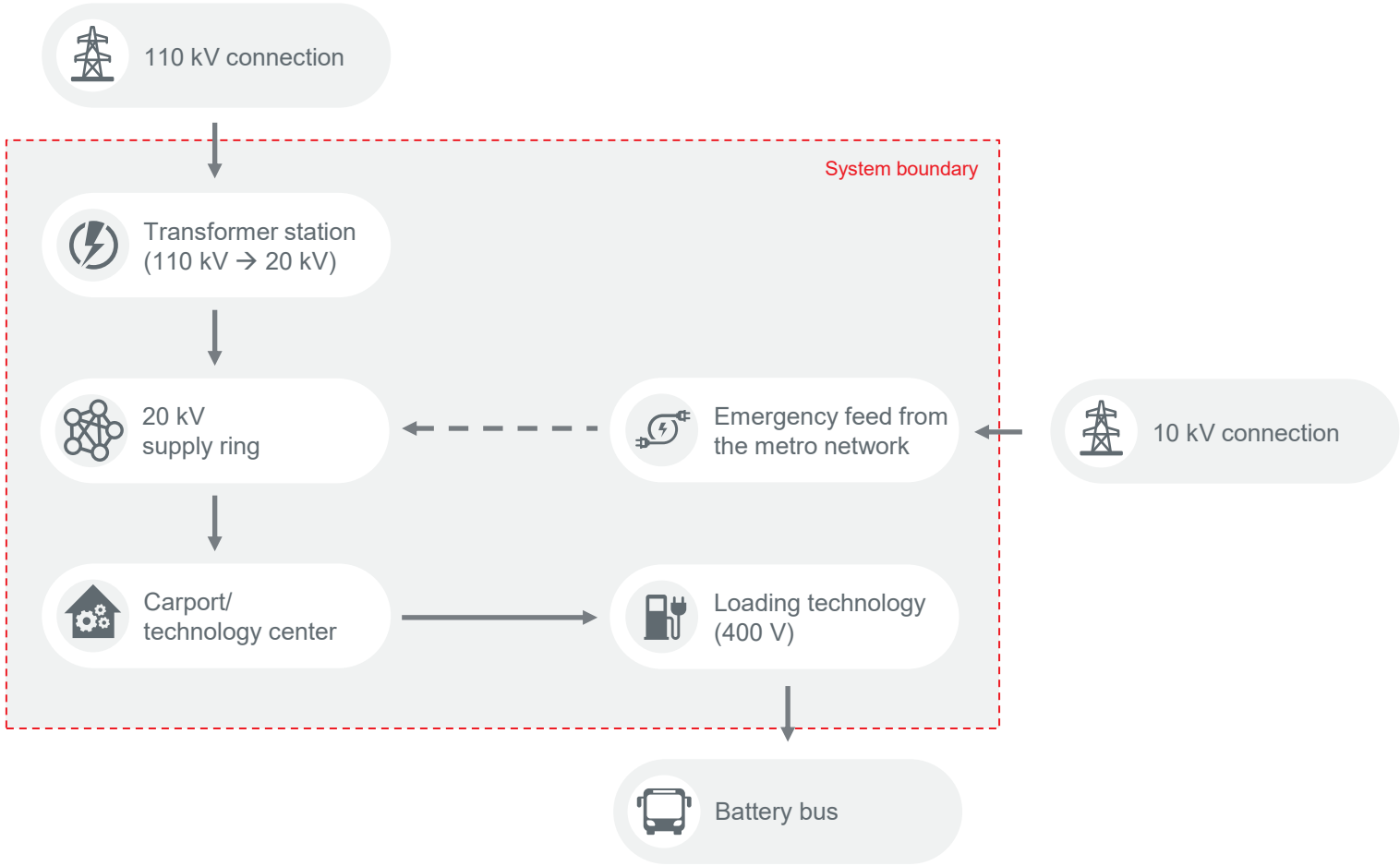
HOCHBAHN aims to be completely climate-neutral by 2030.

Climate neutrality 2030 - measures to achieve the target

- High quality certified green electricity
- Emission-free bus fleet and company vehicles
- Compensation of unavoidable emissions
- Qualitative reduction target for upstream and downstream emissions

Life cycle analysis for the charging infrastructure.

CO_2 emissions must also be accounted for in production and disposal.

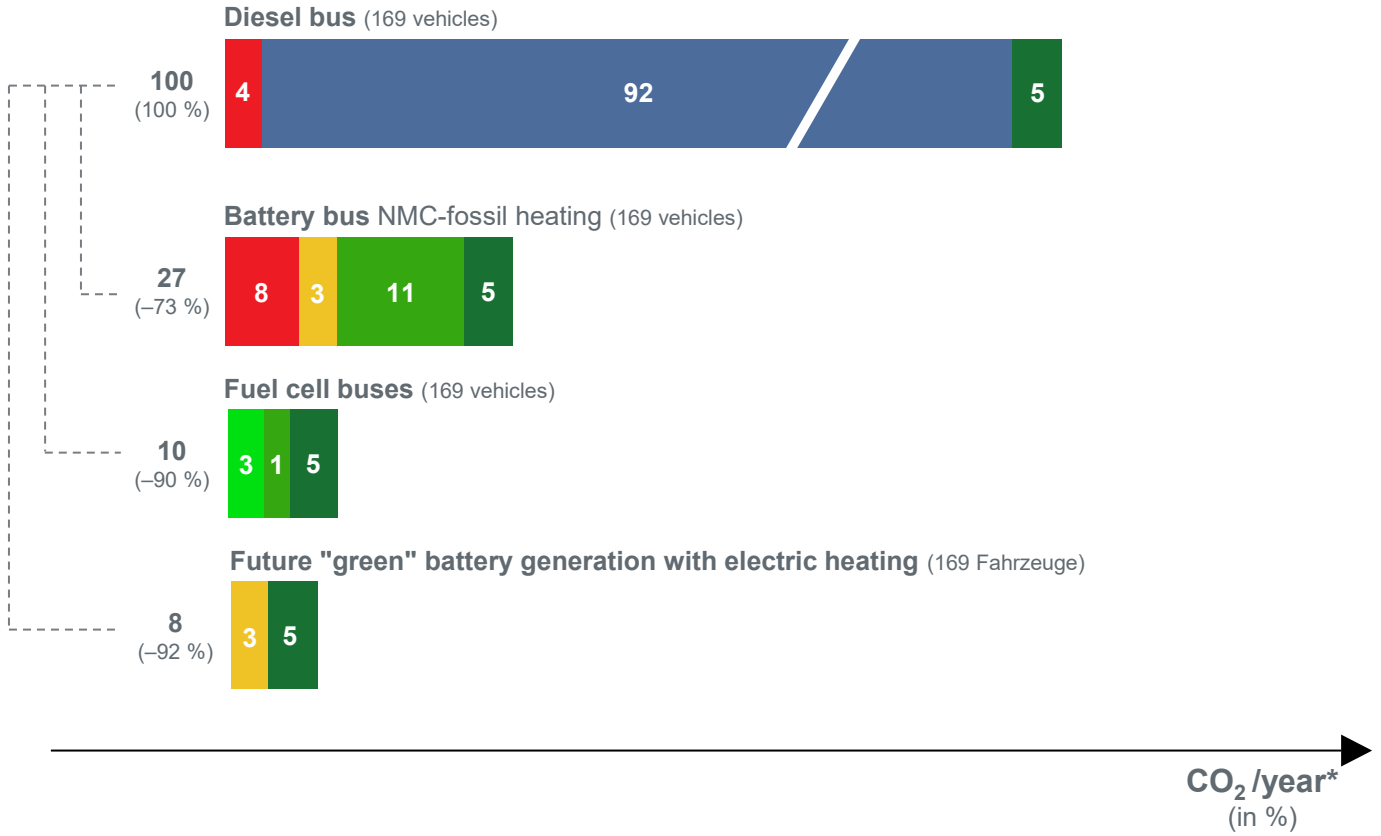


HOCHBAHN

Relative SB-fleet emissions per year*

compared to the Diesel bus fleet

* HOCHBAHN service life 12 years; battery service life 6 years



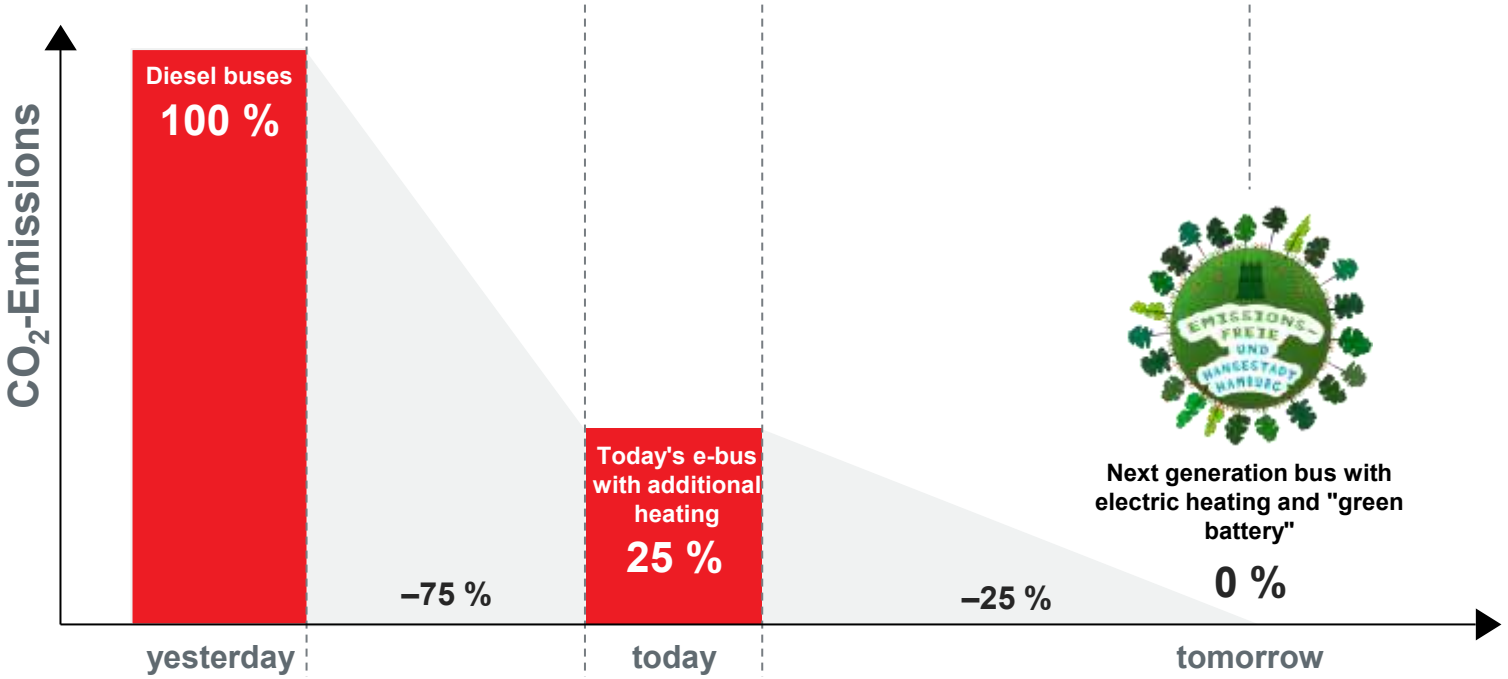
Legend

- Consumption heating oil
- Consumption Diesel
- Consumption hydrogen
- Manufacturing charging infrastructure
- Vehicle procurement – FC-System
- Vehicle procurement – Battery
- Vehicle procurement – vehicle body

Note: Consumption and procurements not shown have a value of 0.

HOCHBAHN

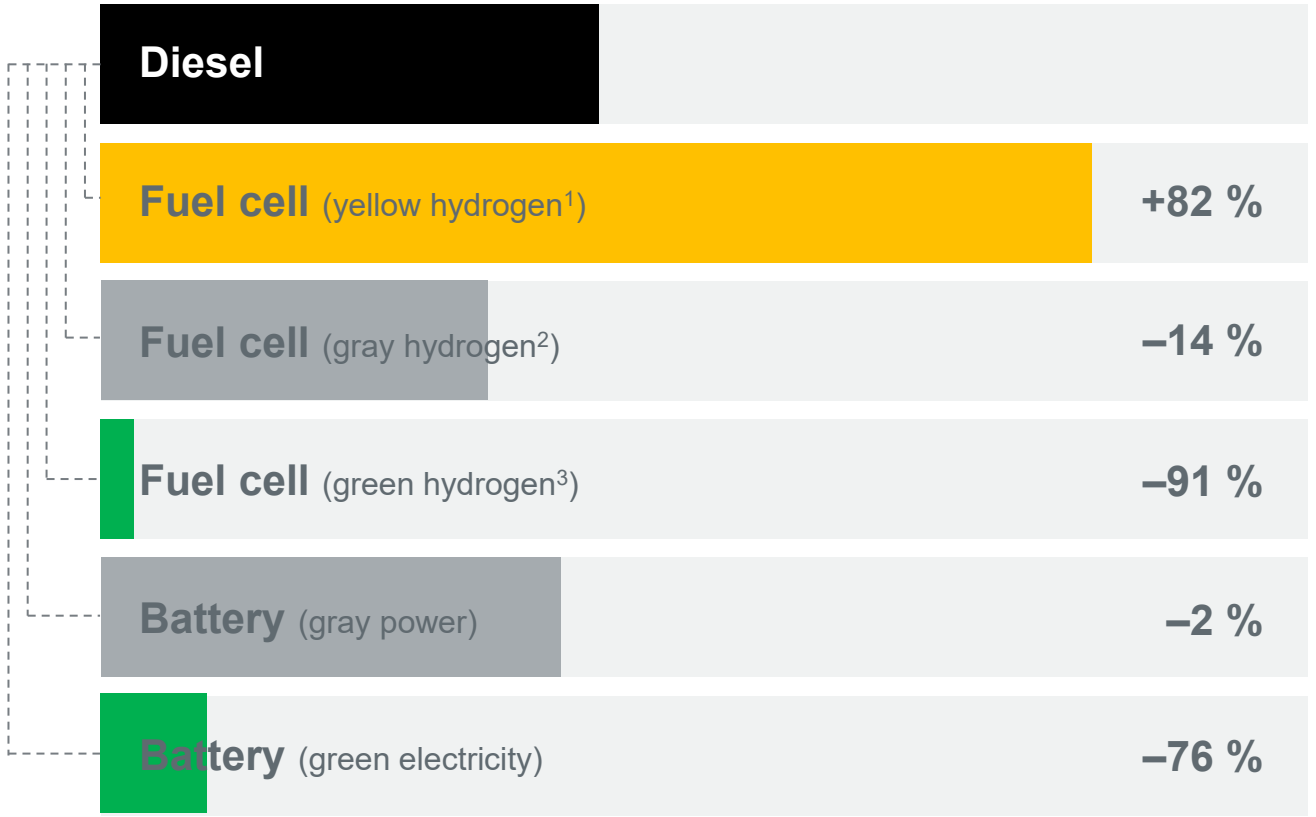
There will be even more in the future...



HOCHBAHN

CO_2-Emissions in comparison

Depending on the origin of the electricity or hydrogen



* Comparison for articulated buses, including consideration of an additional vehicle requirement for battery buses with limited ranges and a fossil heating system

1 Electrolysis with EU electricity mix, 225 g_{H2}/MJ, 27 kg_{CO2}/kg_{H2} Graustrom: 0,474 kg_{CO2}/kWh_e
2 Steam reforming, 100 g_{H2}/MJ, 12 kg_{CO2}/kg_{H2}
3 Electrolysis with green electricity, 13g_{H2}/MJ, 1,56 kg_{CO2}/kg_{H2}
Emissions in the infrastructure supply chain: 0,145 kg_{CO2}/kg_{H2}

HOCHBAHN

Portrait bus traffic

Our mission

The way to zero emissions

Battery vs. hydrogen – our strategy

Challenges on the way to zero emissions

Costs – may it be a bit more?

CO_2 balance – may it be a bit less?

▶ Thinking globally – social sustainability in the supply chain

HOCHBAHN

Sustainable procurement

We assume our responsibility.

Stage 1 Committing

Code of Conduct for suppliers and business partners

- All procurement processes of HOCHBAHN, except for non-critical small orders
- Standard components: Tenders and contracts

Setting an example and taking responsibility

Stufe 2 Evaluating

Detailed question on sustainability performance of the supplier

- For product-specific risks, initial focus: E-bus (battery)
- Sustainability criteria are part of the qualification system and the evaluation matrix

Meet NAP requirements, reduce image risks,increase credibility.

HOCHBAHN

Things are moving forward.

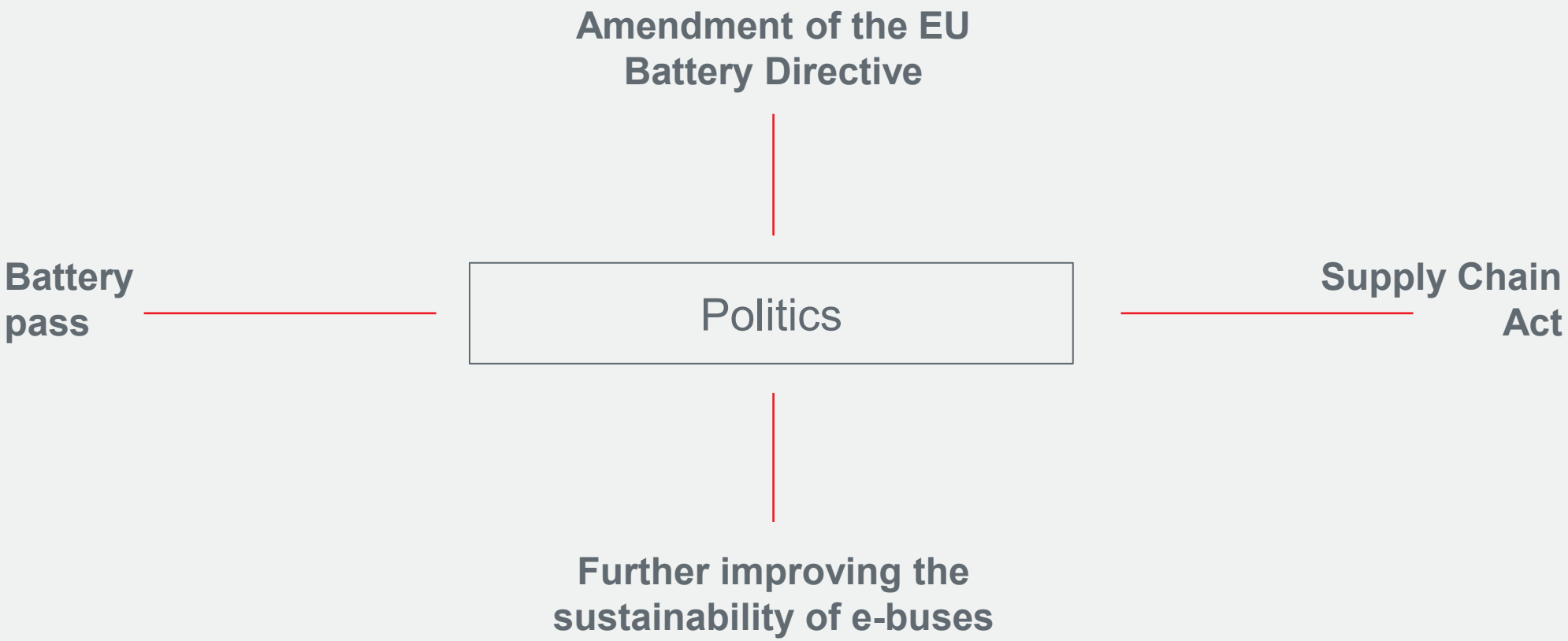
But we still have a long way to go.

- Sustainability criteria are relevant for awarding contracts for vehicles and charging infrastructure
- Promoting the topic in the industry in exchanges with other transport companies and at conferences
- Development of standards for the evaluation of sustainability in public transport
- Discussions with vehicle manufacturers with the aim of improving the sustainability of future e-buses

HOCHBAHN

Improve framework conditions.

It´s up to the politicians.

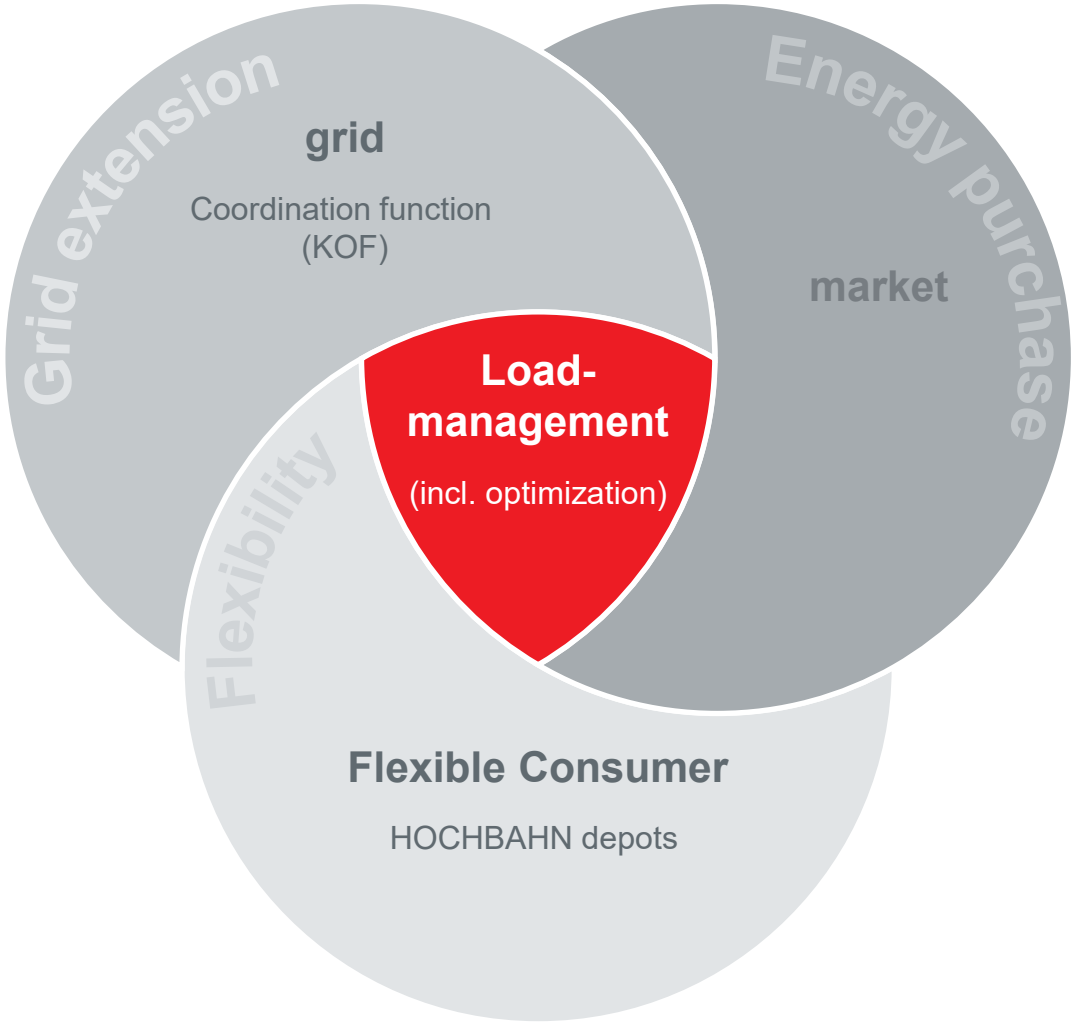


HOCHBAHN

Outlook

Smart Charging for Coupling of Sectors Mobilty and Electricity

KoLa – Coordination Platform and Load Management



HOCHBAHN


Our Mission.
Zero Emission.

References

Carstens, Leif (2019): *Strategic investigation on the charging power requirements of electric buses, taking various operational scenarios into account.* Masterarbeit, HafenCity Universität, Hamburg.

Schulz, Prof. Dr. Detlef; Dietmannsberger, Markus; Meyer, Marc; Schumann, Marc (2016): *Anforderungen an das Stromnetz durch Elektromobilität, insbesondere Elektrobusse, in Hamburg*. Metastudie Elektromobilität, Helmut-Schmidt-Universität, Hamburg.