International Hydrogen Symposium: Fuel Cell Buses

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23 Oct 2019

"Mobility's second great inflection point."

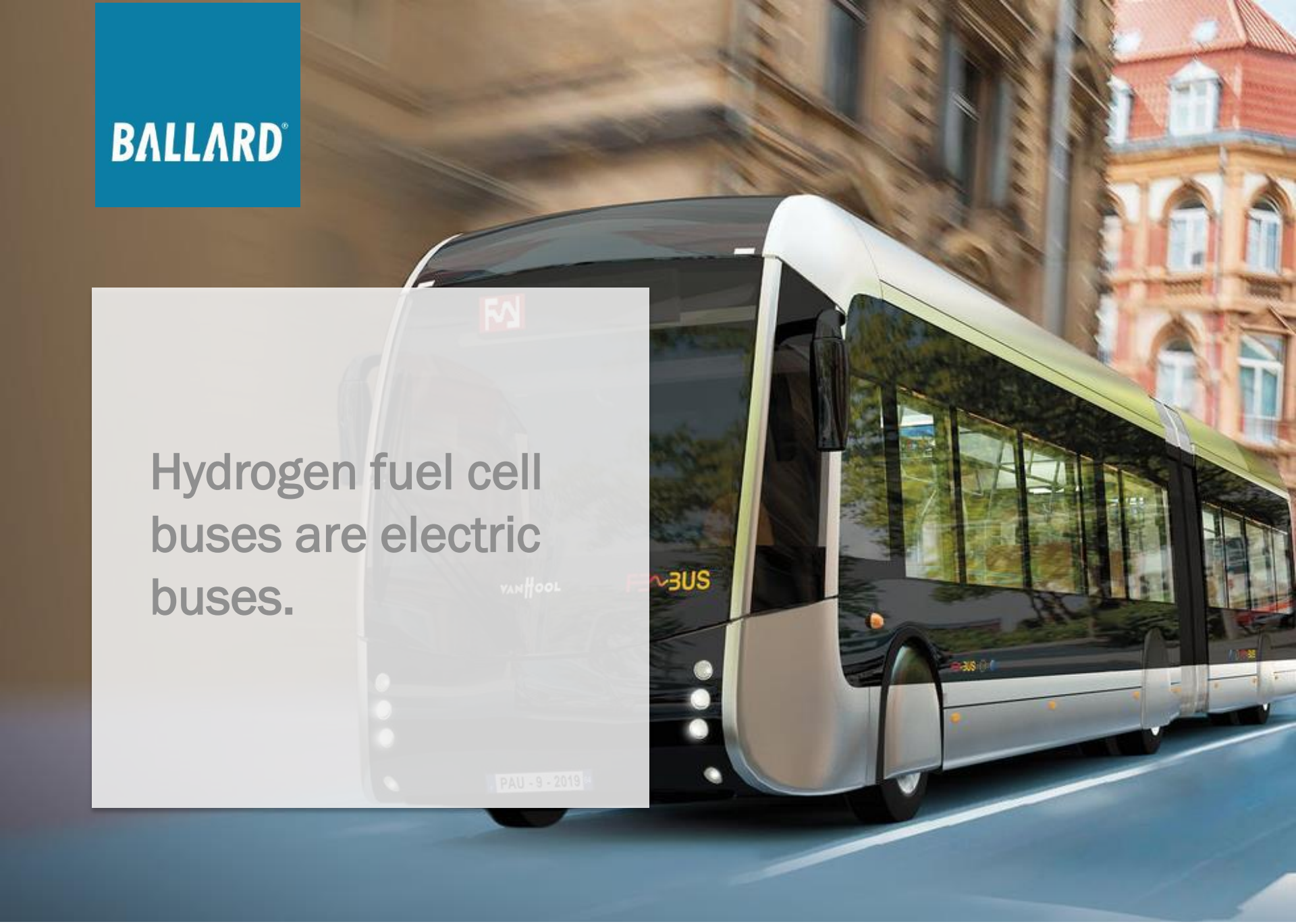
(McKinsey)

Why FC HDM?

- strongest value proposition
- lowest barrier to refueling infrastructure
- significant contribution to emissions reduction


BALLARD
In Feb 2019, EU set emission reductions for Class 8 trucks, requiring reductions of 30% by 2030; expect extended to buses in 2022.
MAN
DAF

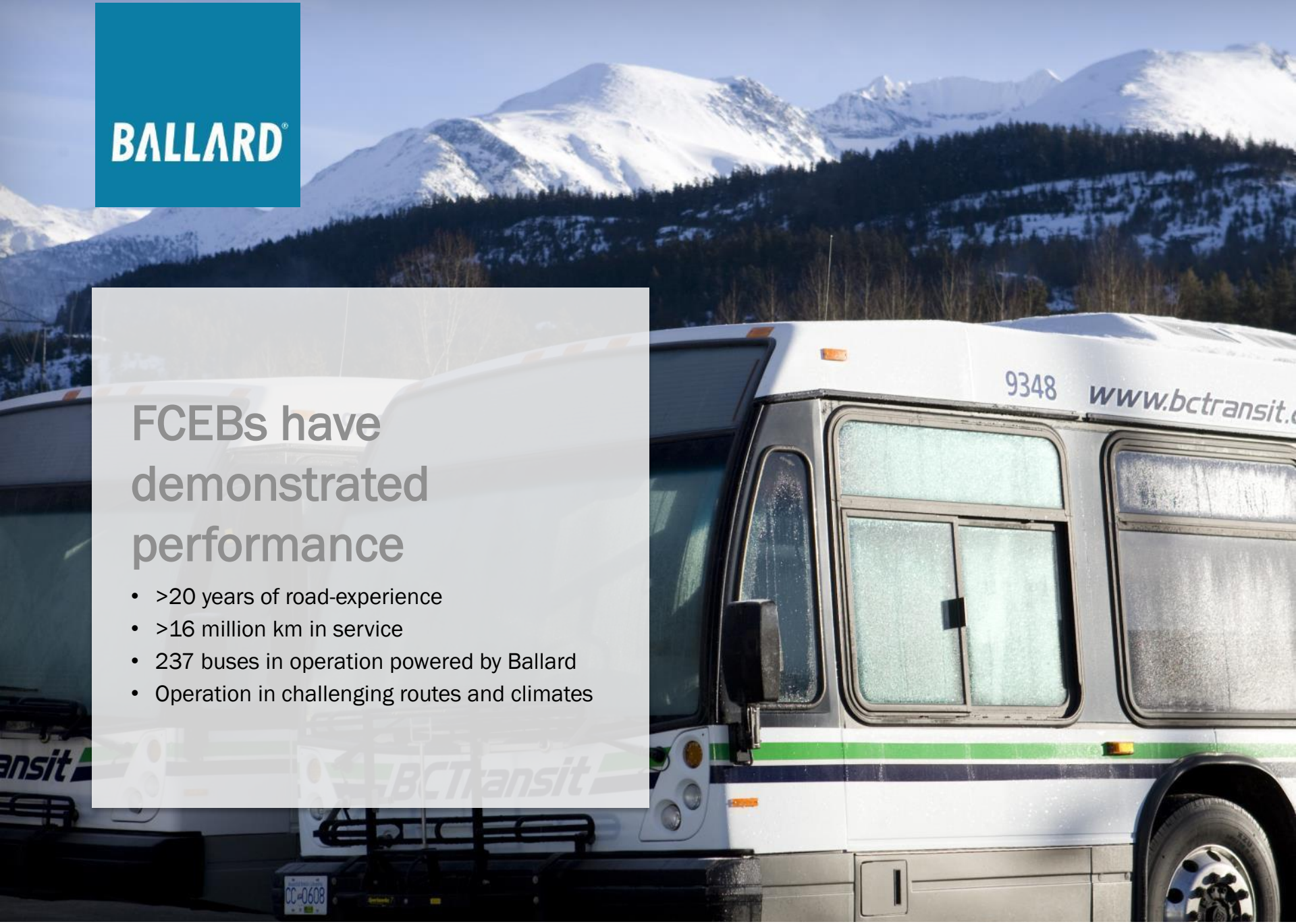
BALLARD®



Hydrogen fuel cell buses are electric buses.


BALLARD
Fuel cells enhance the performance of electric buses.
400-550km
Proven range
Significant reduction in vehicle weight
(carry more passengers)
Rapid refueling speeds
(6 to 10 minutes)
1:1 replacement of conventional vehicles
Urbino 12 hydrogen
HYDROGEN

There will be more than 2,000 FCEB on the road by 2020.



FCEBs have demonstrated performance

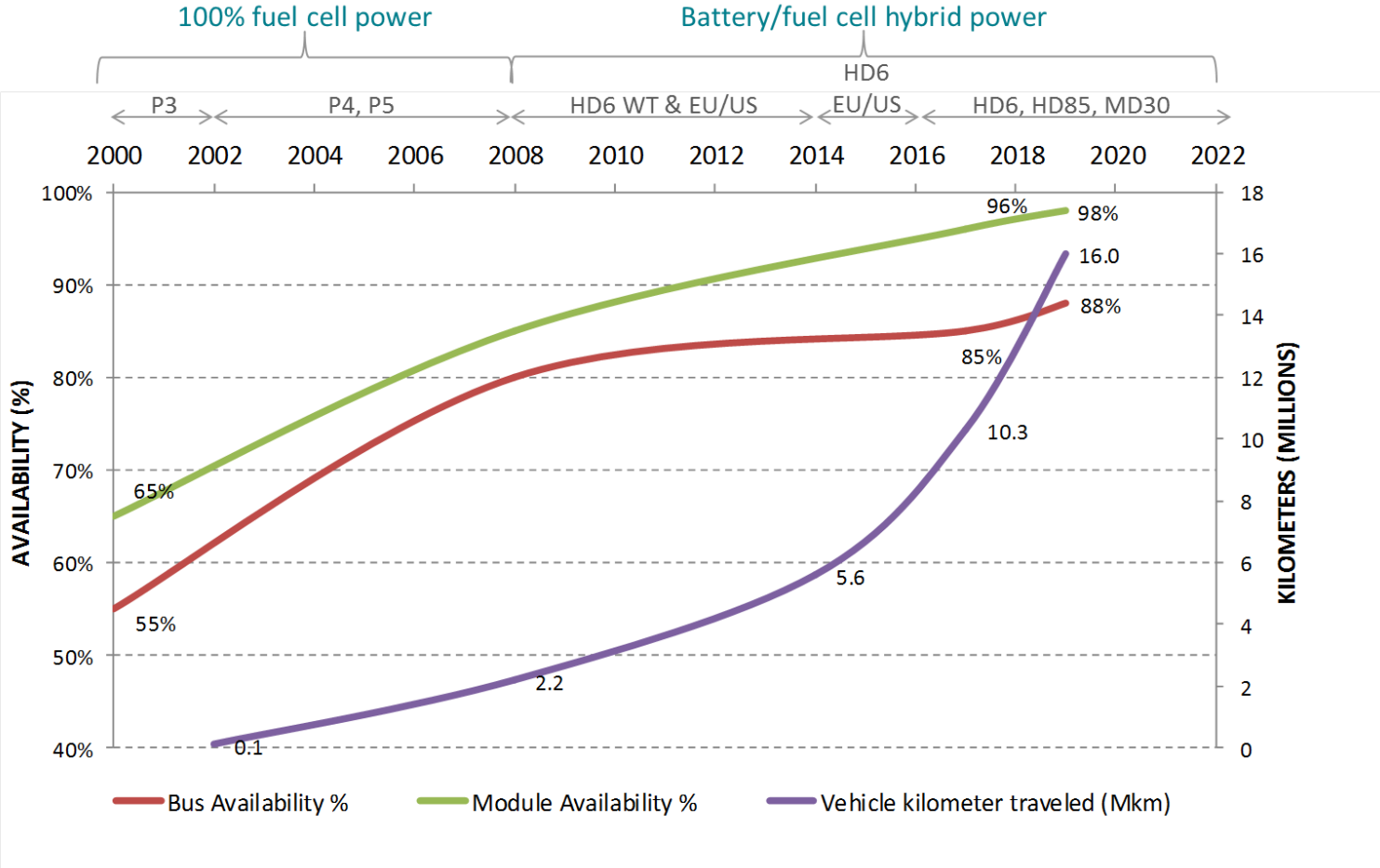
- >20 years of road-experience
- >16 million km in service
- 237 buses in operation powered by Ballard
- Operation in challenging routes and climates

Performance of FCEBs

Based on bus fleet monitored by Ballard in 2018 and 2019

- ✓ Range: **up to 500 km** (depending on H2 storage)
- ✓ Fuel consumption: less than **8kg/100**
- ✓ Fuel cell stack durability: **> 30,000 hrs** (proven in service)
- ✓ FCEB current maintenance cost: **€0.30/km**
- ✓ Environmental conditions:
  - Fuel cell power systems operates from **-40°C to +50°C** ambient temperature
  - Next generation module will include freeze start from **-25°c**

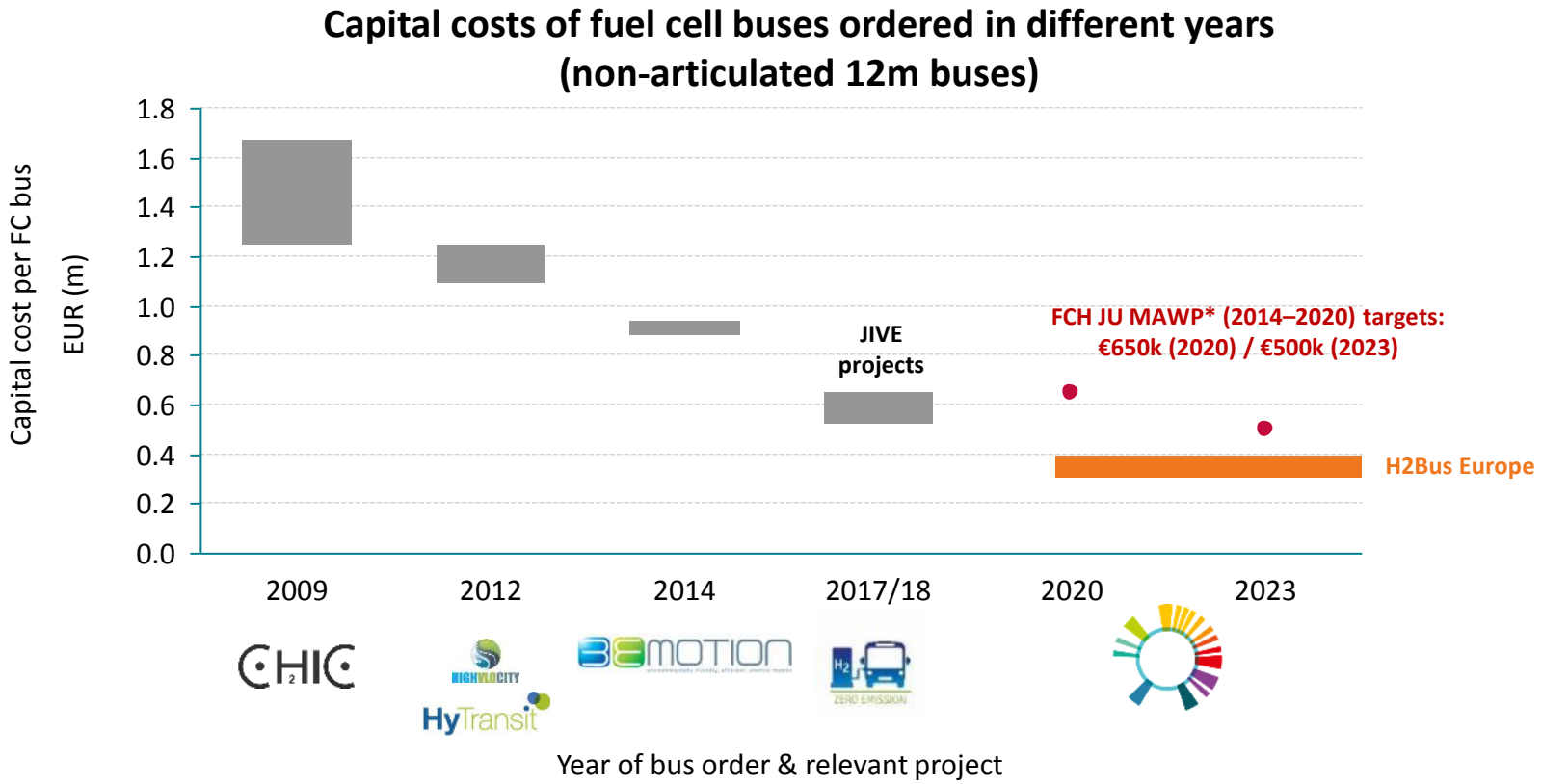
Performance of FCEBs



Average bus fleet availability: 88%

Average fuel cell module availability: 97%

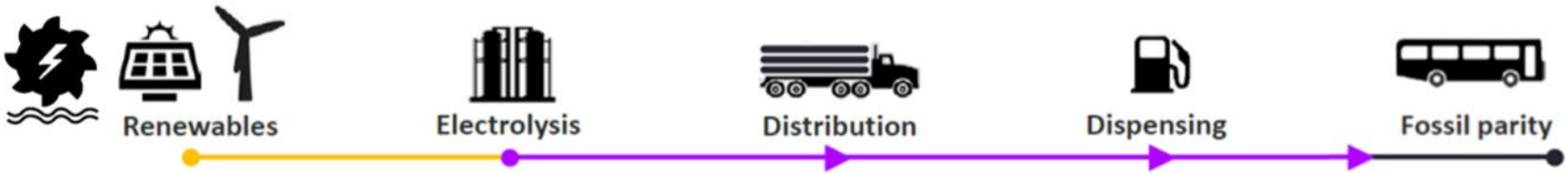
FCEB Capital Cost Reduction



* ***FCH JU MAWP*** is the Fuel Cells and Hydrogen Joint Undertaking's Multi-Annual Work Plan, the document that sets out the work plan and strategic targets for the second phase of the FCH JU's programme of research and innovation.

Source: Strategies for joint procurement of fuel cell buses - A study for the Fuel Cells and Hydrogen Joint Undertaking - 2018

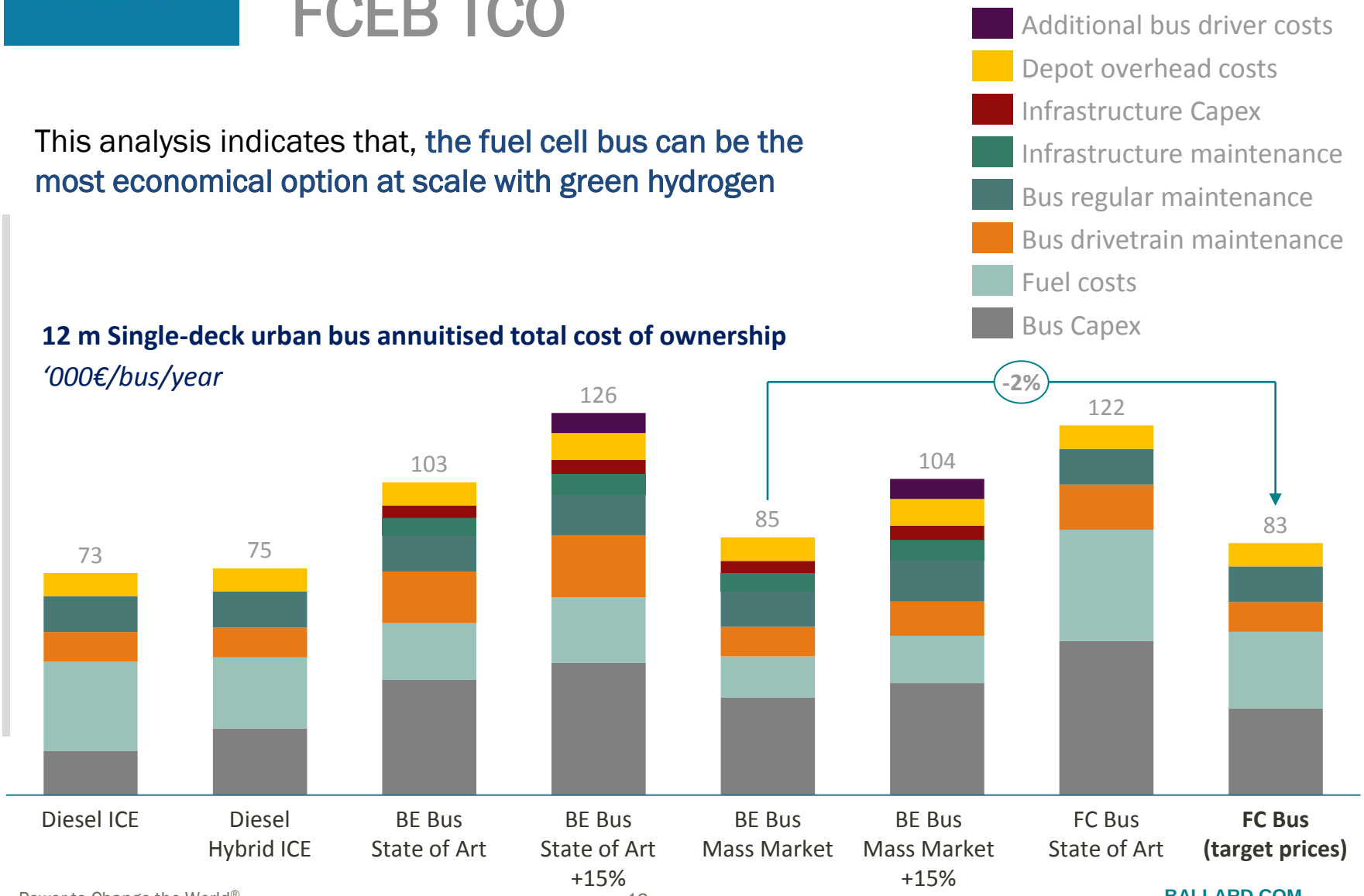
Hydrogen Cost Parity

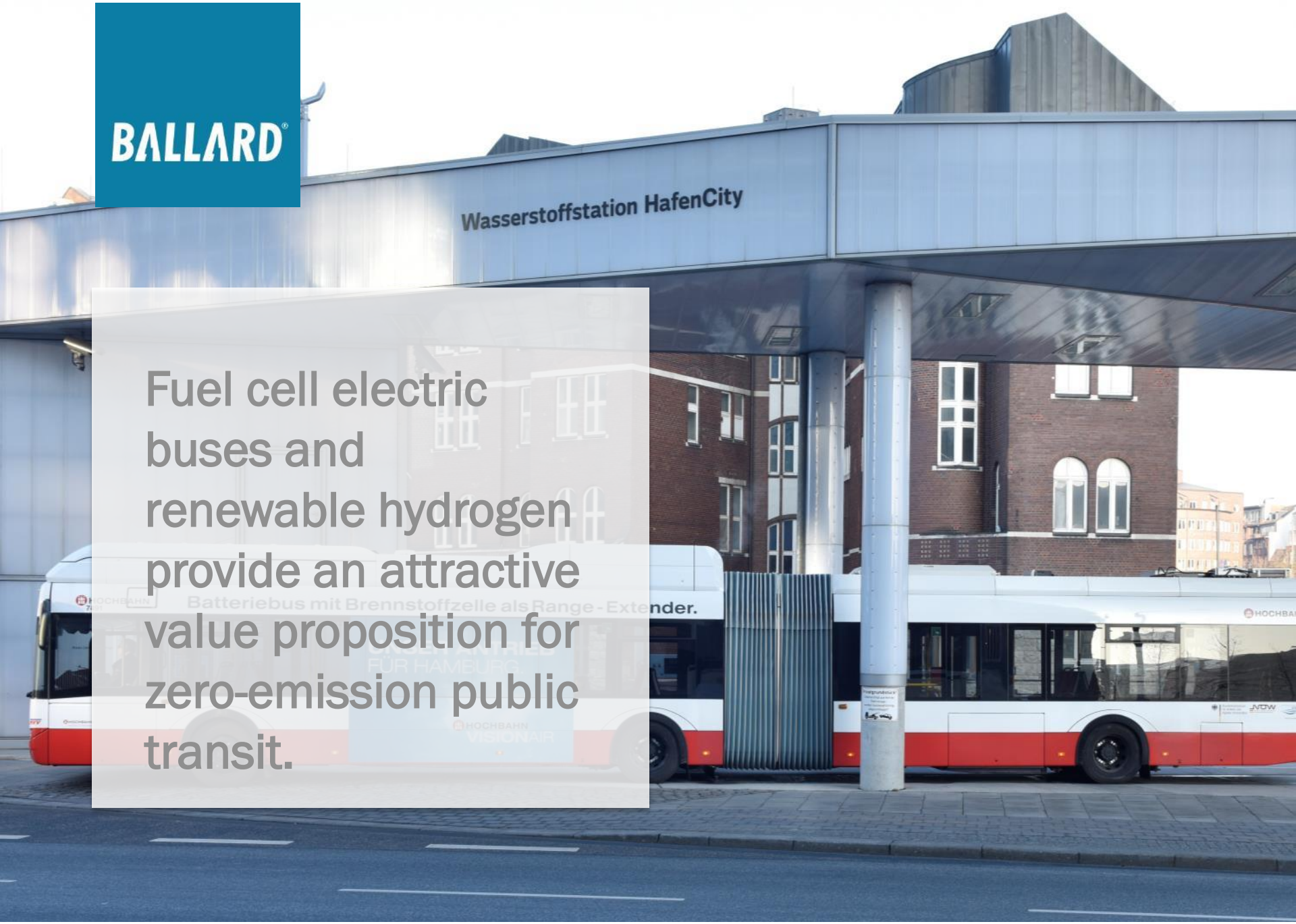


- Centralized hydrogen production facility with **100% renewable and low cost electricity**.
- The electrolytic hydrogen can be transported to several depots via **tube trailers** in a region (150 km radius)
- Hydrogen prices will be in the range €5-7/kg (depending on local electricity prices and volume of demand)
- **Hydrogen will reach parity with diesel** on a per kilometre basis with volume fleet (>100 vehicles)

FCEB TCO

This analysis indicates that, **the fuel cell bus can be the most economical option at scale with green hydrogen**





Fuel cell electric buses and renewable hydrogen provide an attractive value proposition for zero-emission public transit.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fuel cell power
for a sustainable
planet
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