Implementing recharging inductive technology on heavy duty pavement bringing unlimited autonomy to electrical vehicles

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BOMBARDIER
the evolution of mobility
primove
true e-mobility

IFSTTAR

Roads of the Future

RELEVANT AXES

TECHNICAL SOLUTIONS

- Energy Exchange Infra./Vehicle/Network Mgnt
- Environmentally friendly / recyclable mat.
- Automated / self-diagnosed / self repair
- Communication
- Environmentally adaptable

PUBLIC TRANSPORT DEVELOPMENT

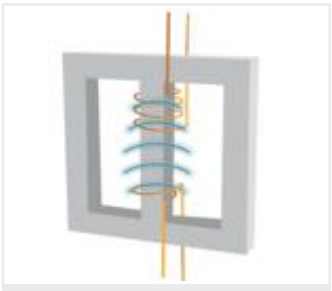
- e-mobility new standard
- Sustainable and Economically feasible
- Concepts adapted to urban env.

Technical Solution

PAVEMENT RECHARGING VEHICLES ENERGY

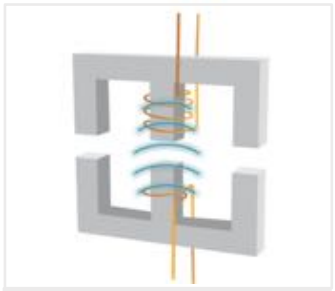
1. Inductive system: Initial Concept and challenges
2. Solution developed for Inductive charging at bus stops
3. Testing prototypes with the Full Scale Test at IFSTTAR
4. Improvements based on the full scale test

Concept and Challenges



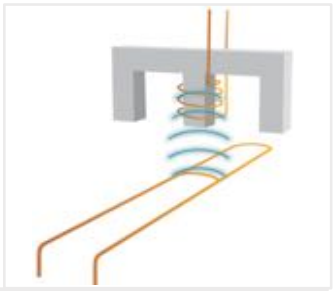
Schematic principle of a transformer

- **Iron core**
- **Primary and secondary windings**



Iron core can be split

- **Air gap between primary and secondary winding possible**

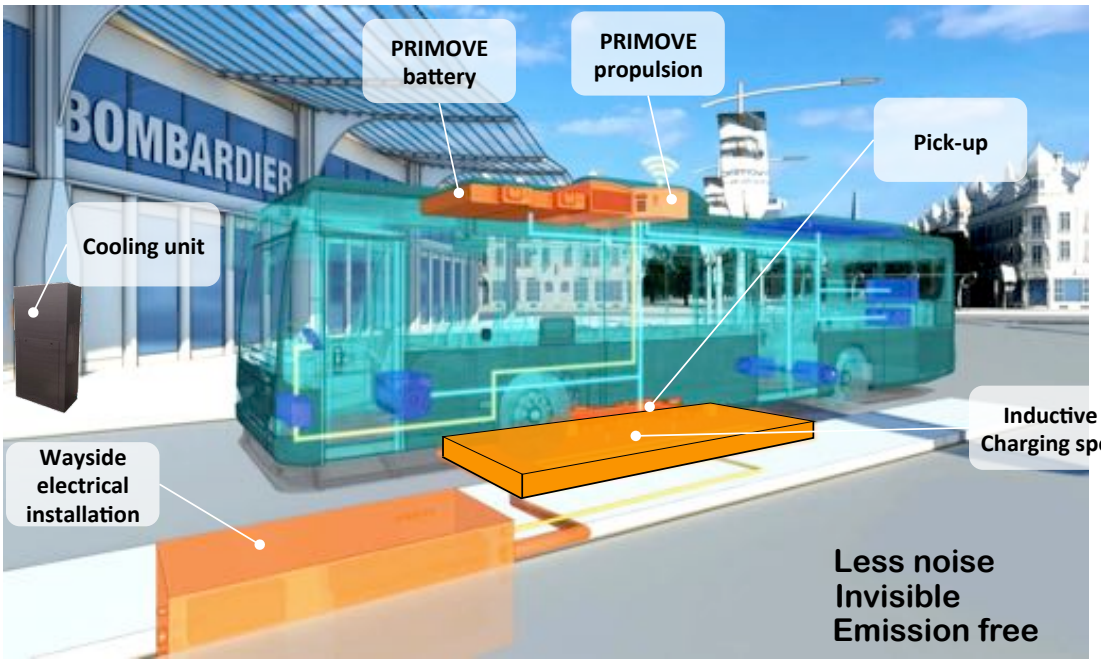


Primary side can be modified

- **Primary winding around iron core can be replaced by several cables**

How to implement the primary coil in the pavement?

Concept: Inductive recharge at bus stops



Pavement and Infrastructure Integration Challenges

Requirements

- Very Restrictive Tolerances
- Complex cable geometry
- Large amount of components
- Metallic objects forbidden
- Pavement function and adaptable to variable geometries

Engineering developed solutions

→ Production in factory environment / Prefabricated element

→ Optimized cables support design (material, process, minimal vol.)

→ Concrete mixture adapted

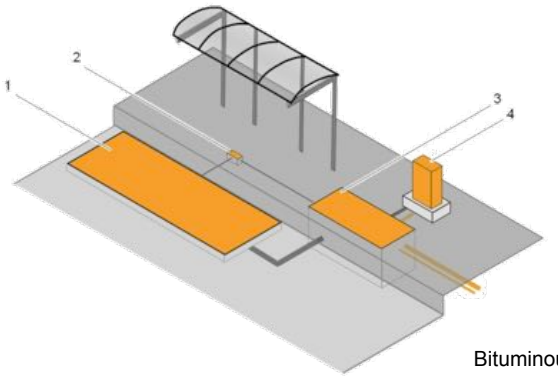
→ Optimized reinforcement position

→ Optimized holders

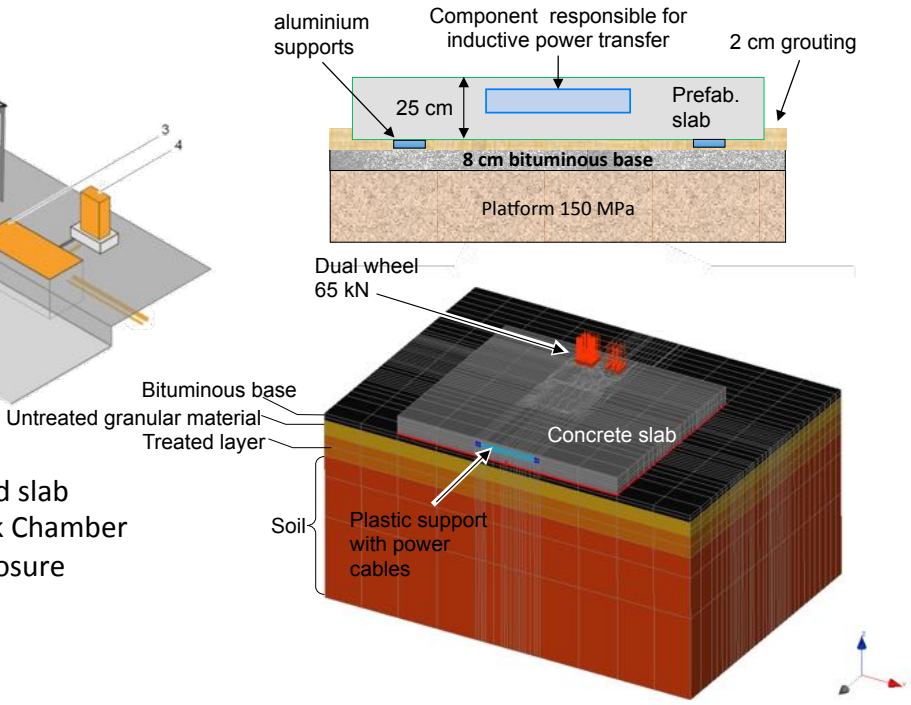
→ GFRP bars and dowels, plastic used when possible

BOMBARDIER PATENT FOR PREFAB SLAB WITH PRIMARY WINDING

Infrastructure integration



1. Prefabricated Road slab
2. Matching Network Chamber
3. Wayside Civil Enclosure
4. Cooling Unit



Full-scale test of first prototypes

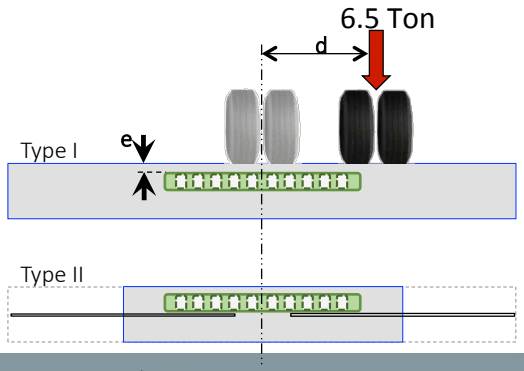
APT Facility at IFSTTAR – Nantes, France

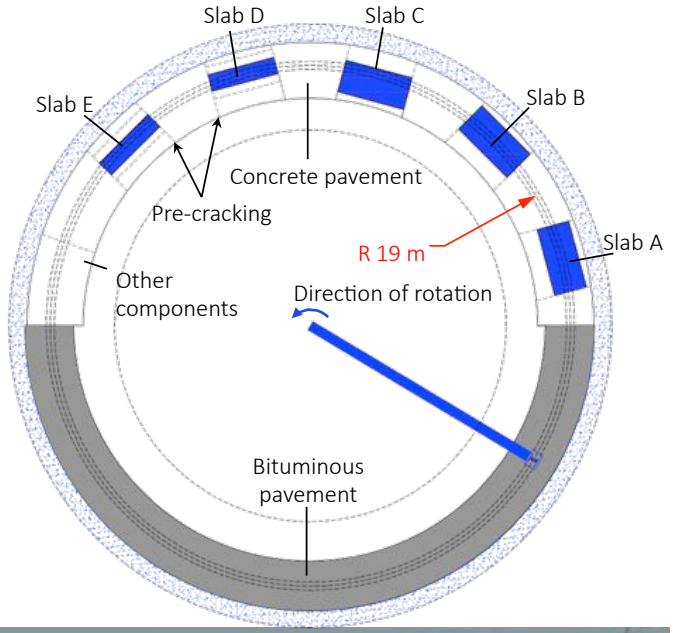
- Moving load in fatigue configuration: dual-wheel 65 kN
- Speed: up to 100 km/h (15 rounds/min.)
- Loading rate: up to 50 000 cycles/day

Testing configurations

First test on prototypes / 500.000 cycles 6.5 Tons on the wheel

Slab	Dimensions [m]	Loading position	Thickness of concrete cover **e** [cm]
A	5 x **2.4** x 0.25	middle	5.0
B	5 x **2.4** x 0.25	border	5.0
C	5 x **2.4** x 0.25	middle	4.0
D	5 x **1.25** x 0.25	middle	3.5
E	5 x **1.25** x 0.25	border	4.0



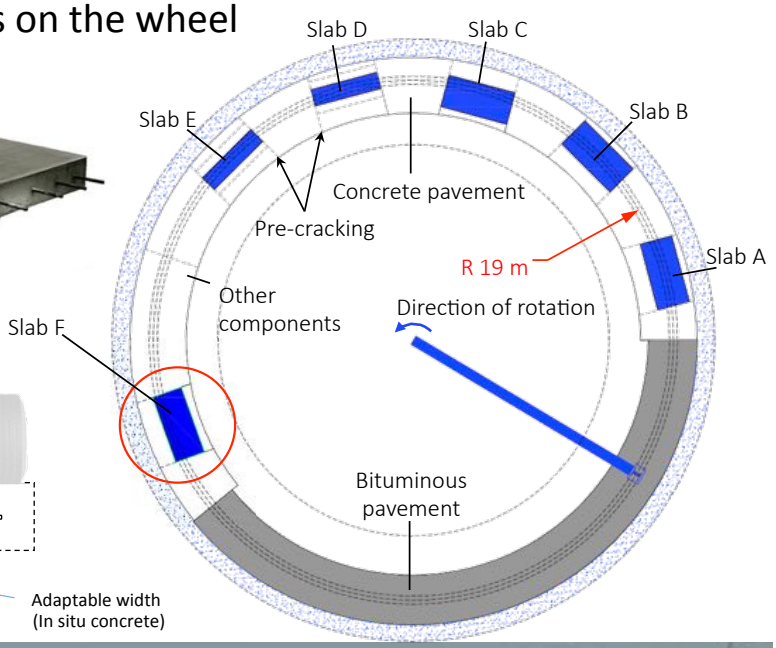


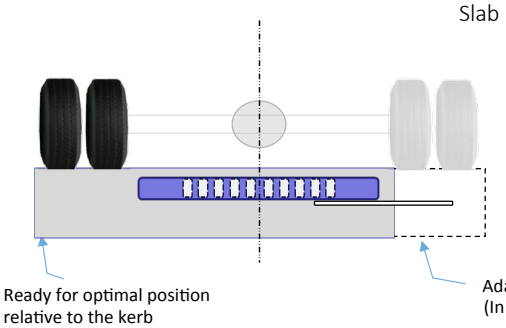
Construction of the test track

Testing configurations

Second test on final **PRIMOVE** Prefabricated Slab

1.000.000 cycles 6.5 Tons on the wheel





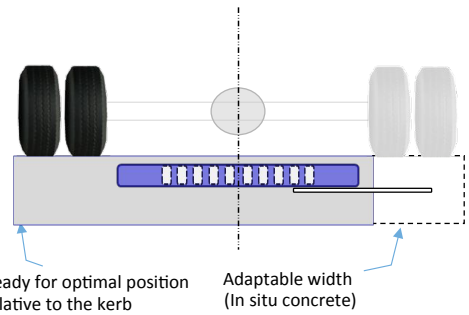
Improvements and Validation

First test

- Adjustment / calibration of the construction method for **semi-prefabricated concrete pavement**
- Achievement of integration of inductive system in the pavement
- Good results for durability test after 500.000 cycles
- FEM and test used to develop final generation

Second test

- Good results for durability test after 1.000.000 cycles
- Concrete mixture optimized → D_{max} optimized
- Self-leveling concrete controlled for road environment
- Curing procedure improved
- Additional transversal bars in top cover
- Additional longitudinal bars in top cover
- Geometry adapted for standard product
- Special procedure for producing surface texture



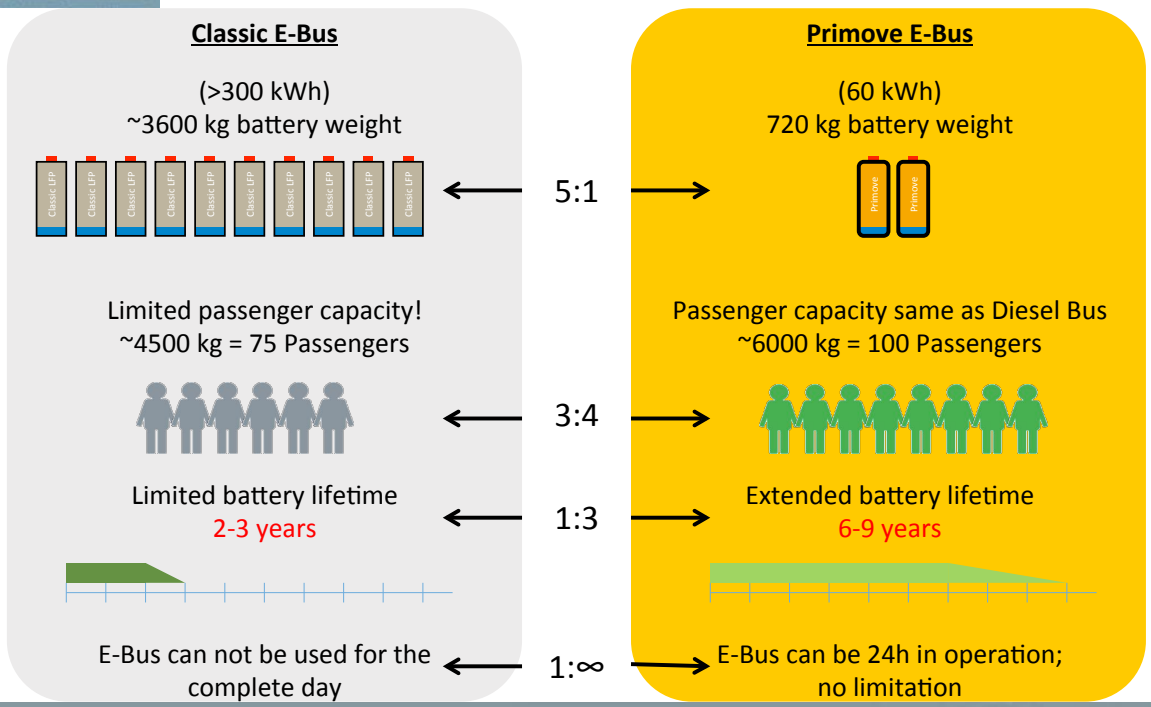
Public Transport Development

Opportunity Charging for Bus Transportation

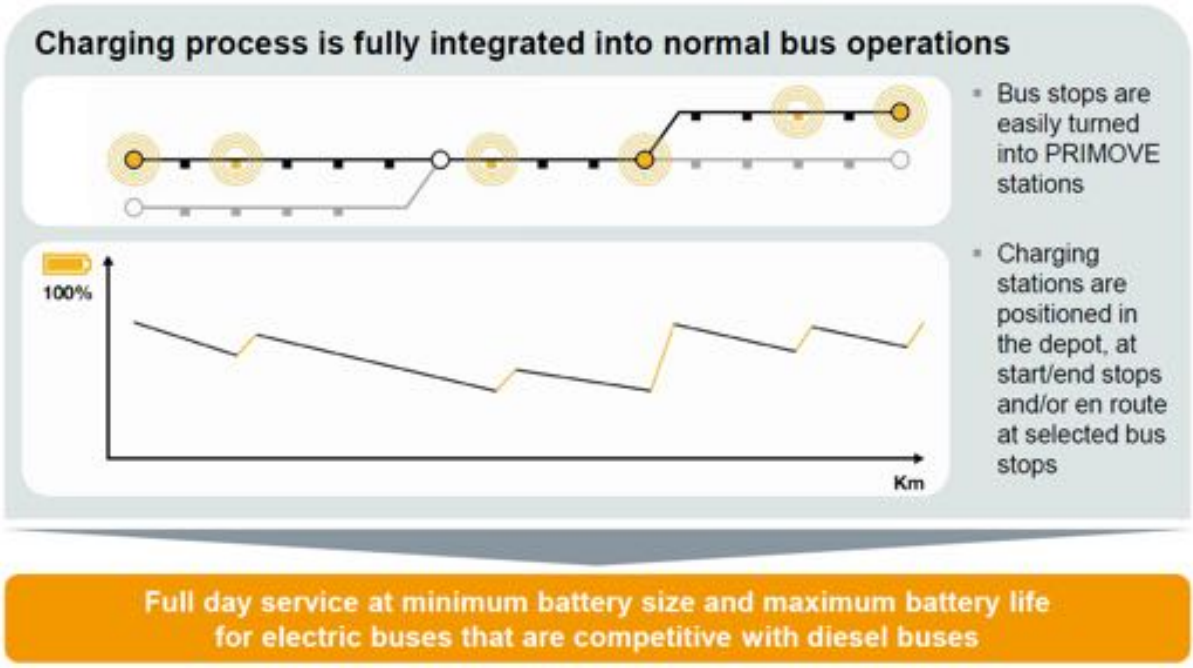
1. Electric buses limitations and opportunity charging
2. Three cities having **Primove** installed
3. A system communicating permanently
4. Dynamic charging: tests **looking forward for the future**

Primove New Energy Bus

Optimized opportunity charging versus classic E-bus



Opportunity charging



Complete PRIMOVE portfolio for true e-mobility

primove
true e-mobility

Applications	PRIMOVE charging	PRIMOVE battery	PRIMOVE propulsion and controls
Tram	PRIMOVE charging 200	PRIMOVE battery 50	MITRAC 500
Bus	PRIMOVE charging 200	PRIMOVE battery 60 / 90	PRIMOVE propulsion 140 / 210
Truck	PRIMOVE charging 200		
Commercial fleet	PRIMOVE charging 22		
Car	PRIMOVE charging 3.6 / 7.2		

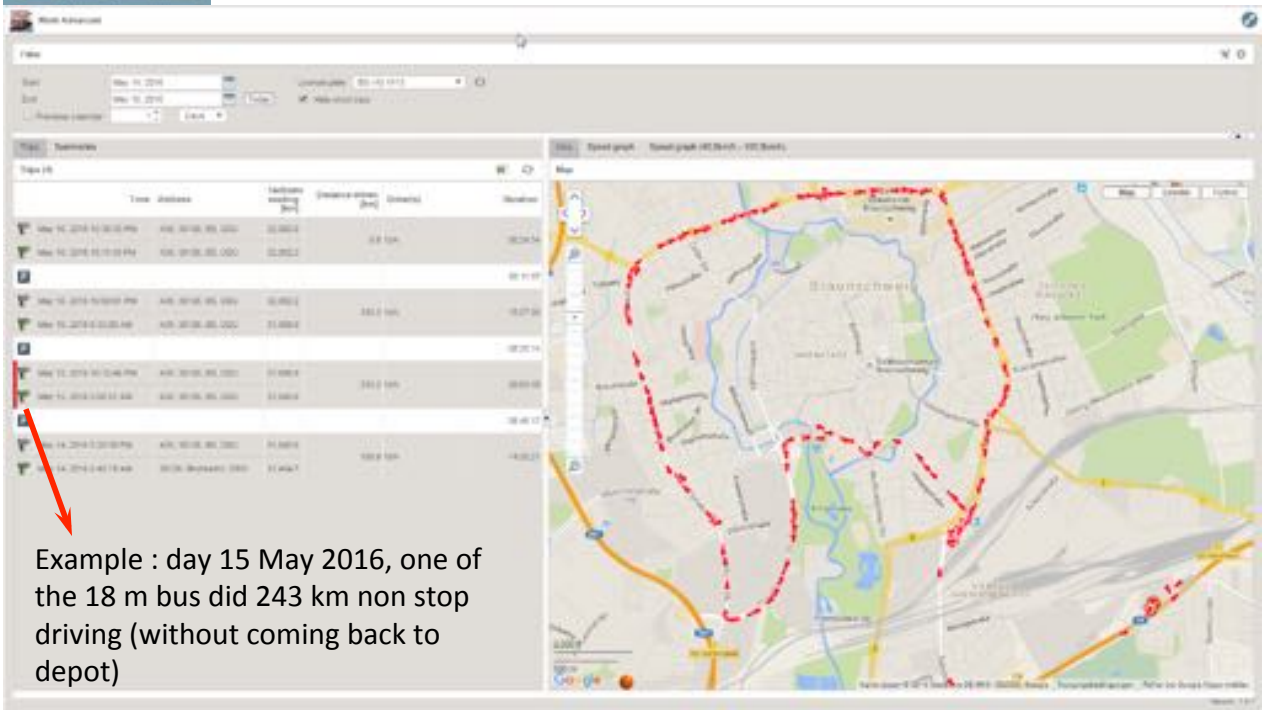
MANNHEIM

BERLIN

BRAUNSCHWEIG

Communicating permanently

Diagnostic tool always available



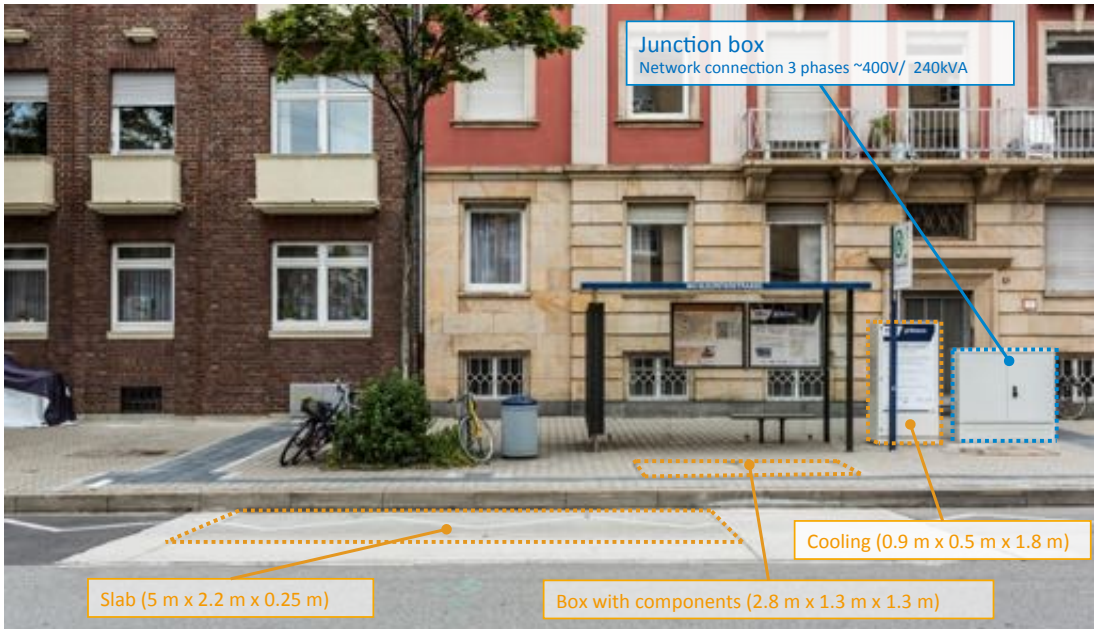
Example : day 15 May 2016, one of the 18 m bus did 243 km non stop driving (without coming back to depot)

Communicating permanently

Status of all the buses and Wayside charger components is always available via an Internet communication. Some of the info available are:

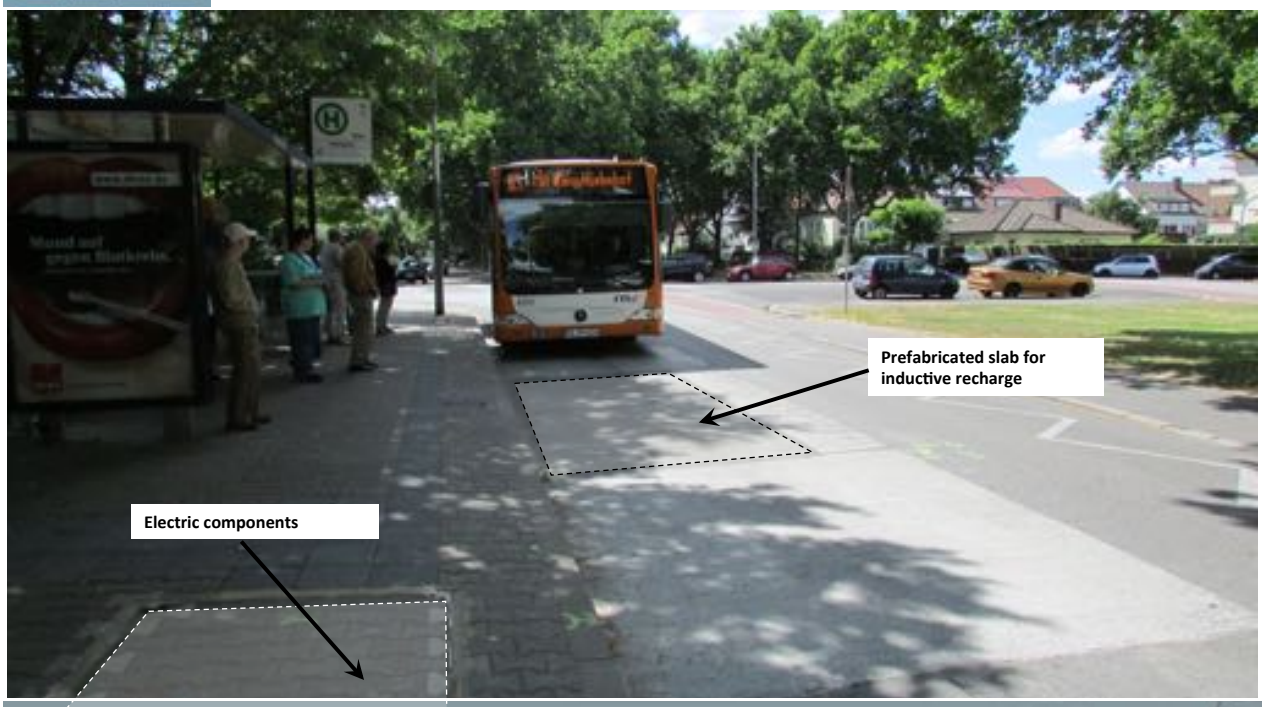
- Battery charge status
- Position of each bus
- Failures on any of the buses
- Wayside availability
- Wayside components failure

Static Charge
General integration



Public area needed for recharging system: 45m²

Static Charge
Example on service



Static Charge
Bus stops appearance in Berlin, Mannheim and Braunschweig




Invisible integration into the urban environment

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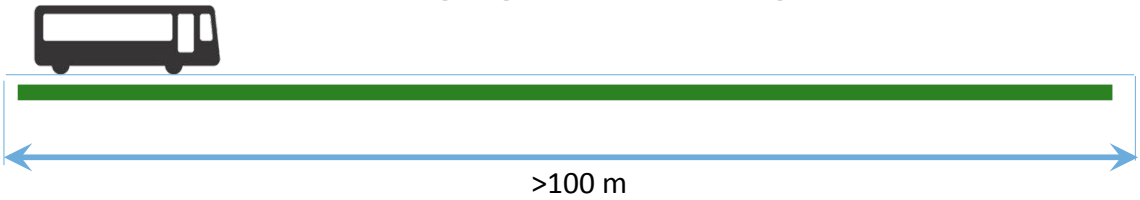
Dynamic Charge – Example (Belgium)

Charging while driving



Dynamic Charge – Example (Germany)

On the road to commercial operation… PRIMOVE

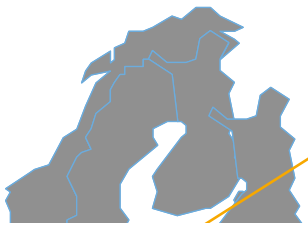
Commercial projects

Braunschweig
- Circular bus line
- 1+3 e-buses

Bruges
- City centre line
- 3 e-buses

Mannheim
- City centre line
- 2 e-buses

Berlin
- City centre line
- 4 e-buses



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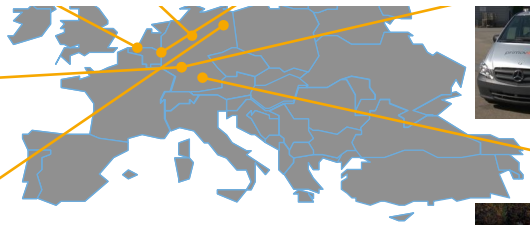

Bombardier Transport
www.primove.com

Development projects

Lommel
- Inductive charging tests
- 1 e-bus + 1 car

Mannheim
- Dynamic charging tests
- 1 e-bus

Augsburg
- Static & dynamic charging tests
- Tram, e-bus & van