Siemens eBus Charging Infrastructure
Innovative Charging Solutions for eBuses

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Siemens eBus charging infrastructure
Innovative technologies and solutions for (e-)buses

Introduction
Siemens eBus Portfolio, offerings & references
High Power Charging (HPC) – Off-board top-down pantograph
Fast charging via catenary – On-board bottom-up pantograph
Plug-in solutions with connector
Summary
Siemens eBus charging infrastructure
Different charging principles and possible drive concepts

- Intercity Coaches
  - Touristic Traffic (~10,000 buses)
  - Regional Traffic (~12,000 buses)
  - City Traffic (~20,000 buses)
- Non-scheduled Traffic

- Combustion engine
  - Gas (also hybrid)
  - Diesel (also hybrid)
- Electric drive
  - Opportunity charging
  - Overnight charging
- Fuel Cell

- Diesel (also as hybrid)

Distance:
- 50km
- 100km
- 150km
- 200km
- 250km
- 300km
- 350km
- 400km
- 500km
Siemens eBus charging infrastructure
Opportunity & Overnight charging: Both seen as viable options for charging of electric buses

Charging for electric buses
According to VDV 1)

Market / customers
Opportunity / overnight charging approach

- **No clear market tendency** towards ‘opportunity’ or ‘overnight / depot’ charging
- Customers expect to implement both charging approaches depending on specific ‘route’ and service requirements
- Challenges for both system will ‘materialize’ once electric bus systems are rolled out on a large scale (e.g. energy supply for bus depots; infrastructure in city centers)
- **Siemens offer solution for both**, opportunity & overnight charging for electric buses

Pro’s & Con’s opportunity vs. overnight charging

**Opportunity charging**
- Small battery size
- Unlimited range
- **Infrastructure in cities**
- **Operational flexibility**

**Overnight / depot charging**
- Operational flexibility
- Easy to operate
- Large battery size
- Insufficient range

Trolley bus applications out of scope for MO UT
Siemens eBus charging infrastructure
Driving standardization and ensuring system ‘interoperability’ for our customers

Visit us on: www.ebuscs.net
Siemens eBus charging infrastructure

World premiere: Siemens to prove interoperability of the charging system in Hamburg with Volvo & Solaris

World premiere in Hamburg

Interoperable Siemens infrastructure

- **Fully interoperable Siemens charging system** to deliver electric charge to Solaris and Volvo buses
- Siemens proves to customers that Siemens infrastructure can be easily integrated with different bus OEMs
- Siemens delivers strong evidence to its commitment to an open standard for electric bus charging
## Siemens eBus charging infrastructure

### High Power Charging systems in operation

<table>
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<th>High Power off-board charging</th>
<th>Passenger operation</th>
<th>Factory / test charger</th>
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<td>Volvo: Arendal / Hällered</td>
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<td></td>
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<td>Oslo (in execution)</td>
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<th>CCS depot chargers &amp; eCobus</th>
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<td>Stuttgart</td>
<td>Wright Bus</td>
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<td>Geneva</td>
<td>Volvo / Renault trucks</td>
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</tbody>
</table>

1) Siemens scope ‘eCobus’: ELFA drive, battery pack, depot charger
Siemens eBus charging infrastructure

eBus portfolio covers off- and on-board high power charging, vehicle control unit and depot chargers

<table>
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<th>High Power Charger (off-board)</th>
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<td>▪ High Power Charger</td>
<td>▪ High Power Charger</td>
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<td>▪ Mast, transformer, housing</td>
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<td>▪ Installation &amp; civil works</td>
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<tr>
<th>Vehicle Control &amp; Communication Unit</th>
<th>Depot chargers &amp; eCobus</th>
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<td><strong>Scope of supply</strong></td>
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<tr>
<td>▪ comBox and antenna</td>
<td>▪ High Power Charger</td>
</tr>
<tr>
<td>▪ Roof rails and DC switch</td>
<td>(cable plug-in)</td>
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<tr>
<td>▪ Vehicle integration</td>
<td>▪ ELFA drive train</td>
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<td>▪ Battery pack</td>
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### Siemens eBus charging infrastructure
Portfolio – eBus Charging Solutions

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<td>Off-Board Plug-In</td>
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<td>Power levels 30-120kW</td>
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<td>Grid Connection AC 400V</td>
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</table>

**Top-Down Pantograph**
- Power levels 150, 300 and 450kW
- Grid connection AC 400V to 20kV

**Charging @ catenary**
- Power levels 60 and 120kW
- DC 750V via catenary
- Connection via Plug-in to AC 400V 63A

**Plug-in Systems Off-board**
- Off-Board Plug-In
- Power levels 30-120kW
- Grid Connection AC 400V

**Plug-in systems On-Board**
- On-Board charging devices with 7 or 14kW
- Grid Connection 230/400V AC
Siemens eBus charging infrastructure
“We accompany our customers and partners from the idea to the realization!”

- System design & layout
- On-board components & integration
- Charging infrastructure
- Project execution, installation & service
Siemens eBus charging infrastructure
Portfolio – eBus Charging Solutions

Top-Down Pantograph
Power electronics off-board
Siemens eBus charging infrastructure
High Power Charging (HPC) - Off-board top-down pantograph

Grid Connection and switching devices
Transformer
High Power Core Charger and system controller
Save enclosure for power electronics
Mast and mast cover for pantograph
Invers mounted pantograph
WiFi communication between bus and charging station
Siemens eBus charging infrastructure
High Power Charging (HPC) - Off-board top-down pantograph

- Fast, reliable, efficient
  - Proven technology
  - Dimensioned to customer’s requirements (e.g. driving schedule and energy consumption)
  - Save weight on the vehicle for more passenger capacity
  - Small battery packs on the vehicle to reduce weight and preventive maintenance costs for vehicles

- Fully automated
  - Easily activated from inside the vehicle by using known procedures
  - Highest possible safety for drivers and passengers based on international standards

- Scalable
  - 1:n relationship of charger to vehicles (one charging station suits 5-10 buses per hour)

- Flexible
  - Charges multiple bus types
  - Flexible to different grid requirements
Siemens eBus charging infrastructure
Hamburg: First Opportunity Charging System with inverted pantograph
(in operation since December 2014)
Siemens eBus charging infrastructure
High Power Charging (HPC) - Off-board top-down pantograph
“Hamburg project” overview

Customer: Hamburger Hochbahn AG

Innovation bus line 109 with a mileage of 9 km

Four charging points connected to a medium voltage (10 kV AC)
- Two charging points connected to Metro grid
- Two charging points connected to local electricity provider
- Installed charging power per charging point of 300kW

Siemens scope of delivery:
- Two charging stations (ZOB and Alsterdorf) equipped with
  2x 300kW HPCC (High Power Core Charger)
  1x Low voltage distribution for light, electric heating and other low voltage facilities
  3x Transformer for HPCC and low voltage distribution
  1x Medium voltage with three outflows
- 4x Customer specific mast with top-down pantograph
- Sensors for positioning and safety features
- Erection, installation and commissioning
- Civil works and permits

Additional information
- 10-month project realization
- In public operation since december 2014
- Three plug-in hybrid buses from Volvo in operation
- Three full-electric buses from Solaris planned for M2016 for operation
Siemens eBus charging infrastructure
High Power Charging (HPC) - Off-board top-down pantograph
“Stockholm project” overview

Customer: Vattenfall Sweden

Busline 73 with a milage of 6,5 km

- Two charging points with low voltage power supply (400 V AC)
- Installed charging power per charging point of 150 kW

Siemens scope of delivery:
- Two charging points equipped with each
  - 1x 150kW HPCC (High Power Core Charger)
  - 1x Transformer for HPCC
  - 1x Low voltage power connexion
  - 2x Customer specific mast with top-down pantograph
  - 2x Pantograph cover
  - Sensors for positioning and safety features
  - Commissioning

Customer scope of delivery:
- Erection and installation
- Civil Works and permits

Additional information
- 10-month project realization
- In public operation since March 2015
- Two plug-in hybrid buses from Volvo in operation
Siemens eBus charging infrastructure
Gothenburg: First indoor Opportunity Charging System
(in operation since June 2015)
Siemens eBus charging infrastructure
High Power Charging (HPC) - Off-board top-down pantograph
“Gothenburg project” overview

Customer: Göteborg Energi

Busline 55 with a milage of 9 km
- Two charging points with low voltage power supply (400VAC)
- One indoor and one outdoor charging point
- Installed charging power per charging point of 300kW

Siemens scope of delivery outdoor:
- 1x 300kW HPCC (High Power Core Charger)
- 1x Transformer for HPCC
- 1x Low voltage power connexion
- 1x Customer specific mast with top-down pantograph
- 1x Coverage of mast
- Sensors for positioning and safety features
- Erection, installation and commissioning
- Civil works

Siemens scope of delivery indoor:
- 1x 300kW HPCC (High Power Core Charger)
- 1x Transformer for HPCC
- 1x Low voltage power supply
- Pantograph with roof mounted installation
- Sensors for positioning and safety features
- Installation in local cellar, commissioning

Additional information
- 10-month project realization
- In public operation since June 2015
- Seven plug-in hybrid buses and three fully electric buses from Volvo in operation
Siemens eBus charging infrastructure
High Power Charging (HPC) - Off-board top-down pantograph
“Montreal project” overview

Customer: STM (Societe du Transport du Montreal) Montreal, Quebec, Canada

Busline 34 with a milage of 10 km

- Two charging points with low voltage power supply (600VAC)
- Installed charging power per charging point of 450 kW

Siemens scope of delivery:
- Two charging points equipped with each
  - 1x 450kW HPCC (High Power Core Charger)
  - 1x Transformer for HPCC
  - 1x Low voltage power connection
- 2x Customer specific mast with top-down pantograph
- 2x cover for mast and pantograph
- Sensors for positioning and safety features
- Erection and installation
- Commissioning

Additional information
- 13-month project realization
- Public operation scheduled for March 2017
- Three full electric buses from Novabus in operation
Siemens eBus charging infrastructure
Portfolio – eBus Charging Solutions

Charging @ catenary
Power electronics on-board
Siemens eBus charging infrastructure
Charging via catenary – On-board bottom-up pantograph
“Vienna project” overview

Customer: Wiener Linien

Bus routes 2A and 3A – in public operation since October 2012
- 12 fully electric 8m-buses from Rampini (Italy) in commercial operation
- Two charging points in the city centre at end terminals
- One charging point in the depot – 2 x roof mounted rails for each serving 6 buses with grid connection to nearby metro grid
- Utilization of tram power supply
- Charging equipment on the roof of the bus incl. 2-pole-pantograph
- Charging power 60 kW

Siemens delivery scope
- 12x ELFA drives
- 12x DC-DC inverter 60 kW
- 12x “bottom-up” pantographs (2-pole)
- Installation and commissioning
- Overall project management
- Civil works

Additional information
- Siemens in a consortium with Rampini
- 10-month project duration
Siemens eBus charging infrastructure
Portfolio – eBus Charging Solutions

Plug-in Systems
Off-board
Siemens eBus charging infrastructure
Plug-in solutions with connector
“Stuttgart project” overview

Customer: Airport Stuttgart

Airport traffic solution

- 6 fully electric buses in commercial operation
- Charging power 60 kW

Siemens delivery scope

- Charging stations with plug-in connector (Combo2)

Additional information

- Public Operation since October 2015
- Besides several test operations within Europe (Airports e.g. Lisbon, Geneva, Vienna)
Siemens eBus charging infrastructure

Different charging principles are established in the market covered by Siemens eBus charging infrastructure portfolio.

**HPC System**
- **150, 300 or 450kW**
  - **Infrastructure:** Charging power electronic, mast, contact system
  - **Bus:** Contact Rails and Communication interface (wireless)
  - **Grid connection:** different solutions possible (low, medium voltage)
  - **Preferred applications:** high density city traffic

**Charging via Pantograph to catenary**
- **60 or 120kW**
  - **Infrastructure:** 2-pole DC connection (750V DC e.g. from Tram)
  - **Bus:** DCDC inverter, pantograph
  - **Preferred applications:** medium density city traffic, operation with low numbers of buses (e.g. Island traffic)

**Overnight Charging (Plug-in)**
- **System:** DC Charging (CCS) - 30 up to 120kW
  - **Preferred applications:** Airport buses, Shuttle service, buses for peak operation, Test trials

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**Time at end station/terminal**
- **1-6 min**
- **6-10 min**
- **2 to 6 hours**

**Daily Mileage [km]**
- 50 km
- 100 km
- 150 km
- 200 km
- 250 km
- 300 km
- 350 km

**Charging procedures per day**
- **15-20**
- **10 - 15**
- **1 to 5**

**Charging time per day**
- **1 – 1,5h**
- **1 – 1,5h**
- **2 to 5 h**