Primove for Washington Streetcar

2013.04.18

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Agenda

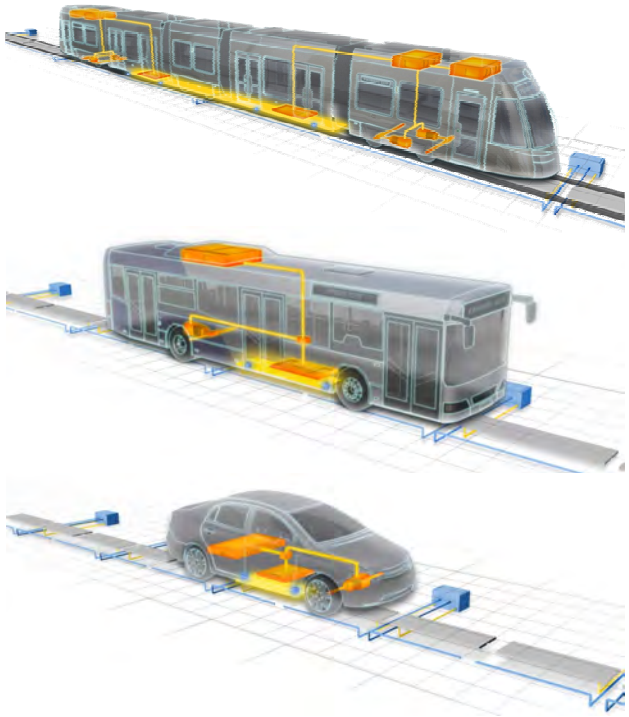
- INTRODUCTION TO PRIMOVE
- ANSWERS TO QUESTIONS

Contactless and catenary-free electric operation

primove e-mobility

Game changing solution for all types of electric vehicles

- One infrastructure for all electric vehicles
- Wireless inductive power transfer
- Unlimited mobility and no recharging hassles
- Underground – safe, invisible and tamper-proof
- Zero emissions and low maintenance



Project partners:

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primove e-mobility

Ready now!

Augsburg, Germany

Phase 1 – Tram:	2010 - 2012
Phase 2 – Minivan:	since Q1 2012

Lommel, Belgium

Phase 1 – Bus:	since Jan 2011
Phase 2 – Car:	since Q1 2012

Mannheim, Germany

Phase 1 – Test lab:	since Sep 2011
Phase 2 – Minivan:	since Sep 2011
Phase 3 – Bus:	since 2011

Application to trams, buses, cars and commercial vehicles

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primove *Rail*

The most advanced caternary-free technology available

Invisible, no visual pollution.

Components hidden under the vehicle and beneath the track

Safe inductive power transfer (IPT)

Non-contact, no wearing of parts

All-weather performance

Customizable to specific needs of every city, including:

- diverse performance expectations
- varying distances
- Different topographical conditions
- Brownfield or greenfield

Easy to Install

Same performance as with catenary system

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Advantages of primove *Rail:*
Safe

The *PRIMOVE* system is compliant to all applicable codes and standards for electromagnetic compatibility

No health or safety hazard to passengers and pedestrians as all electric devices are fully isolated

No interference with other systems and equipment

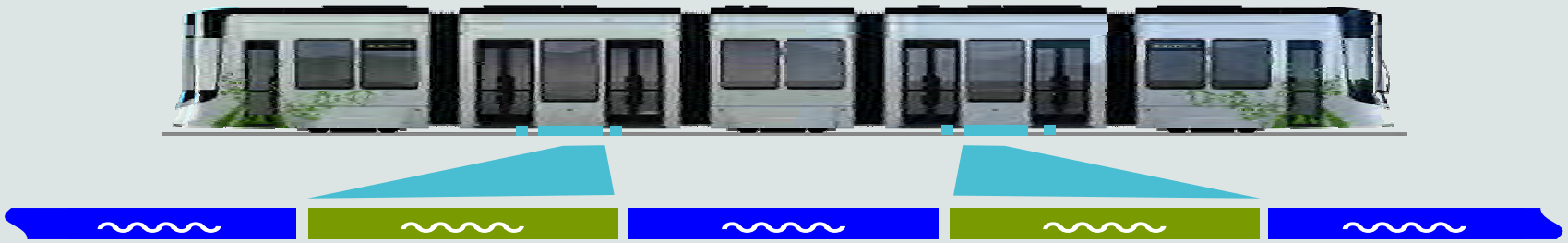
No impact on electrical appliances like mobile phones or heart pacemakers

- Bombardier works closely with independent assessors to establish top standards for safety

Pacemaker Testing

Advantages of primove *Rail:*
Safe

Electromagnetic fields are only created under the vehicle



← *NOT* like primove

Antennas, such as for mobile phones, spread magnetic fields all around
Comparable with a sprinkler where everything in the vicinity gets wet

← *Like* primove

primove technology directs the magnetic fields to the vehicle – the magnetic field is contained

Comparable to a tap where water comes out in a flow without watering everything around

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Advantages of primove *Rail:*
Safe

- Safe to touch
- No exposed wiring like third rail or catenary
- Multiple redundant safety systems
- Even in catastrophic failure the magnetic field exposure does not lead to injury.

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Advantages of primove *Rail:*
Reliable

- Vehicle operation even under adverse weather and ground conditions
- No risk of power loss due to contact break – unlike other ground power supply technology

- Redundancy of overhead lines and poles clears the view for impressive cityscapes, landmark buildings or green areas

Advantages of primove *Rail:*
Reliable

Runs in sand, snow, salty slush

primove *Rail*
Options: Full CFO or CFO+Catenary

Complete CFO system

We recommend:

- primove at stations, on grades, or at crossings, where needed
- Straight-forward and cost effective approach, especially for new systems

Catenary and CFO combination

We recommend:

- Energy storage solution for CFO needed between a few stops only
- primove plus energy storage where CFO is desired on longer distances

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primove *Rail*
Applications: Greenfield or Brownfield

Greenfield or long CFO

We recommend:

- primove at stations, on grades, or at crossings, where needed

Brownfield or short CFO sections

We recommend:

- Energy storage plus catenary for short CFO sections
- primove system plus energy storage for wireless operation

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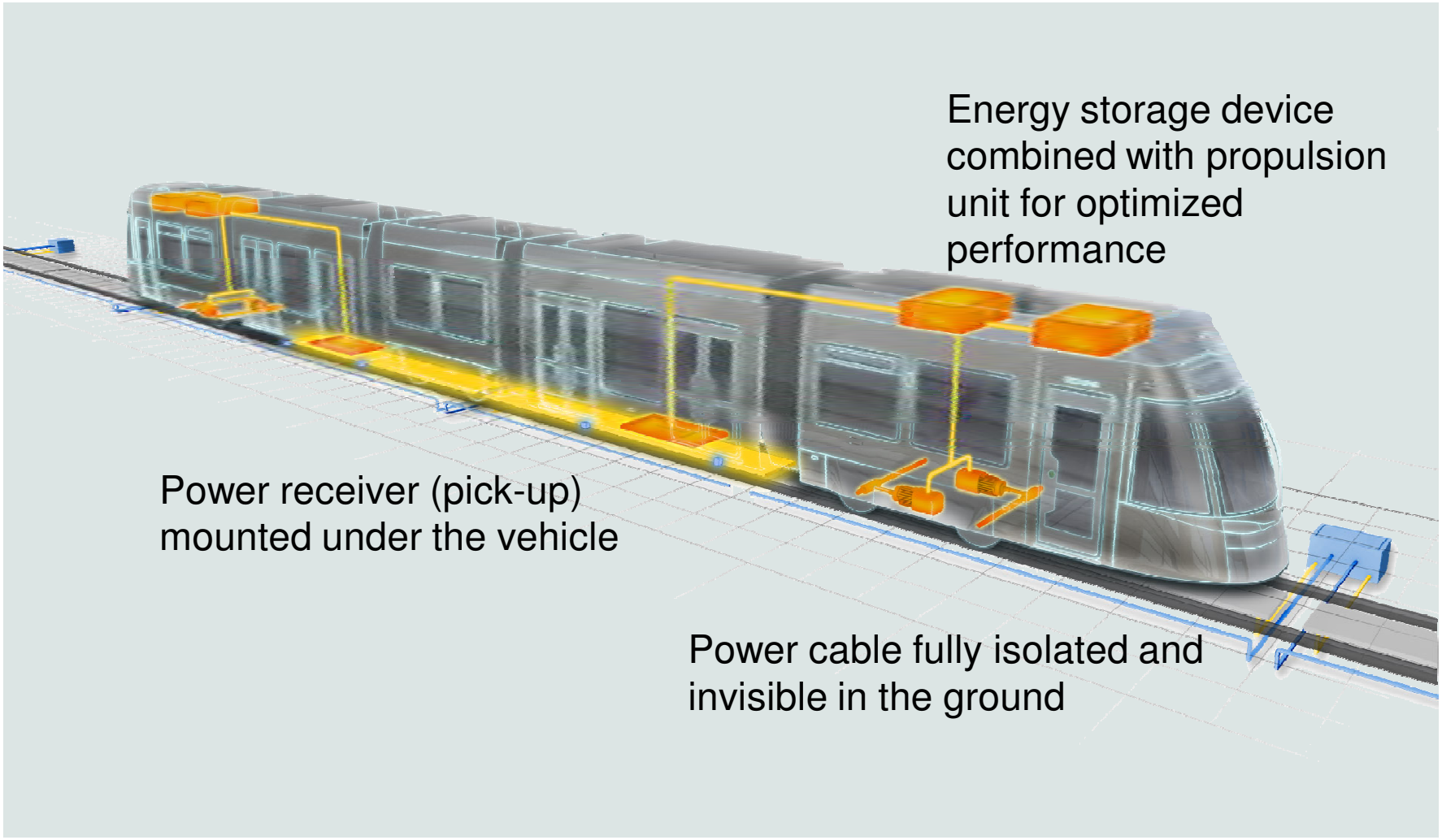
primove *Rail*
Inductive Power Transfer Technology



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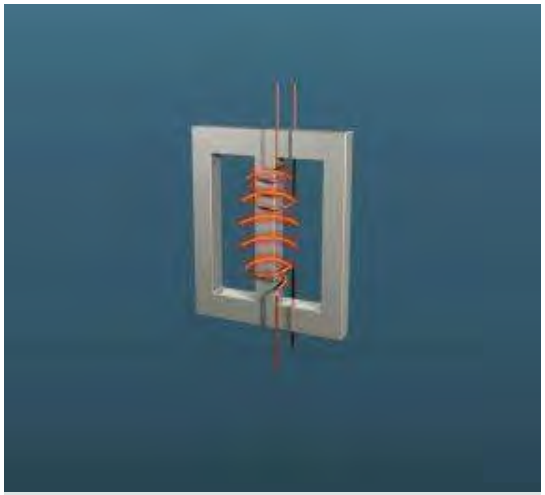
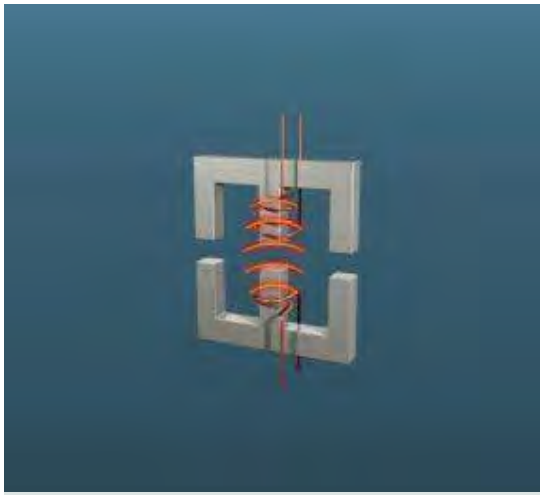
Fundamental Principle

The inductive principle has been well known for many years. It can now set new standards in electric mobility:



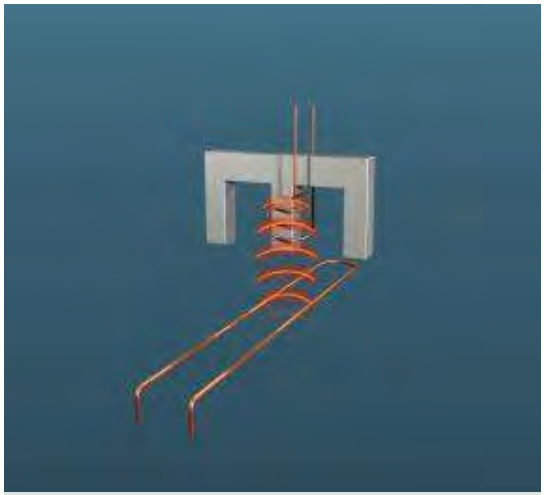
Schematic principle of a transformer

- Iron core
- Primary and secondary windings



Iron core can be split

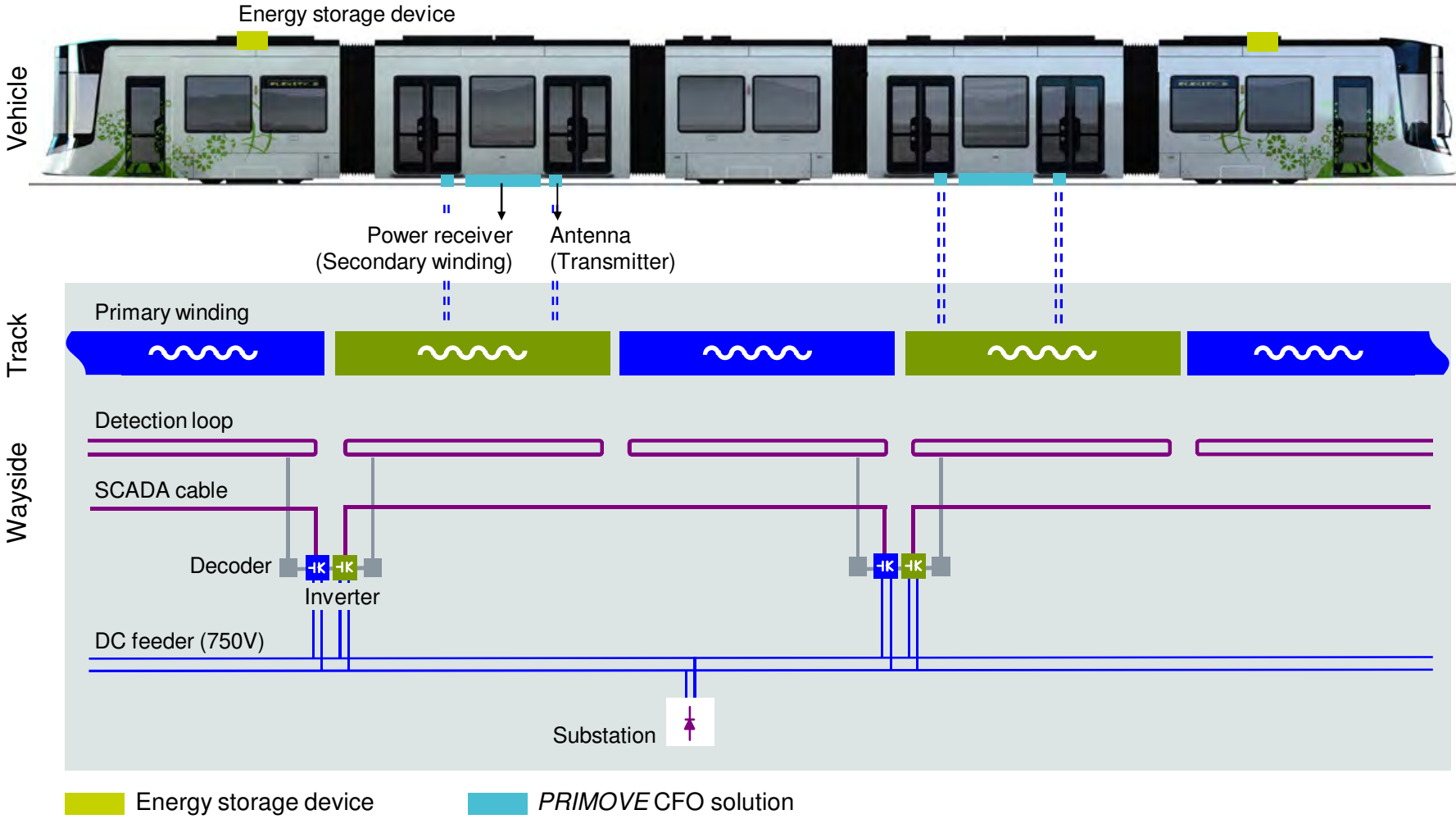
- Air gap between primary and secondary winding possible



Primary side can be modified

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

primove *Rail*
System Components



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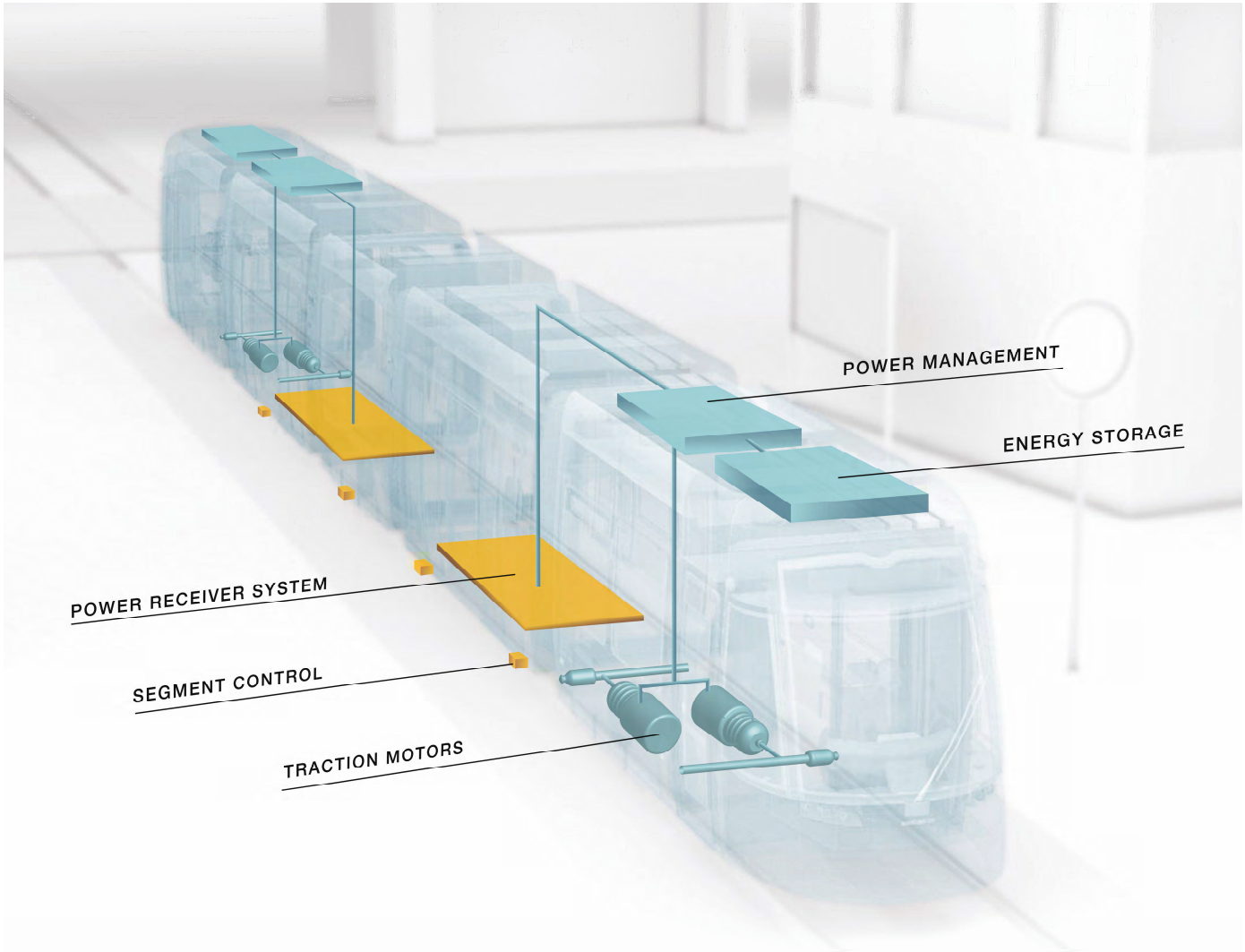
Vehicle Components



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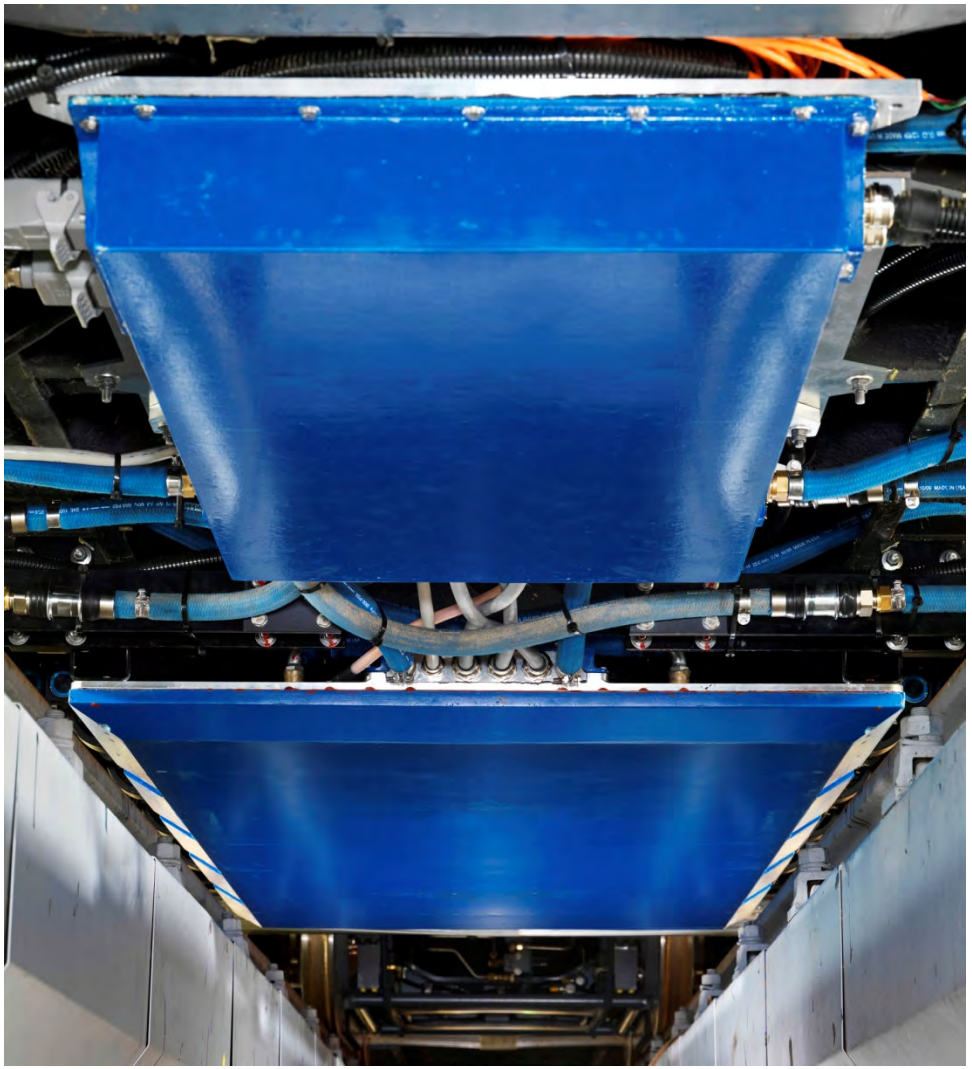
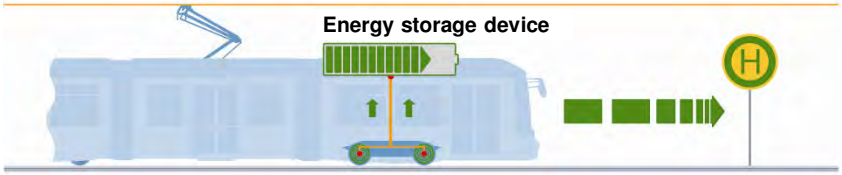
primove *Rail*
Vehicle Power Receiver (Generation 2)



primove *Rail*
Energy Saver on Vehicle

Energy storage device stores electrical energy released when braking

- **Energy savings up to 30% for light rail systems**
- **Boost to the vehicle's power for higher acceleration**
- **Optimization of power supply**
- **Reduced infrastructure investment**
- **Catenary-free operation for short distances and as a part of the primove solution for longer distances**



Storing energy while braking

Using stored energy during acceleration

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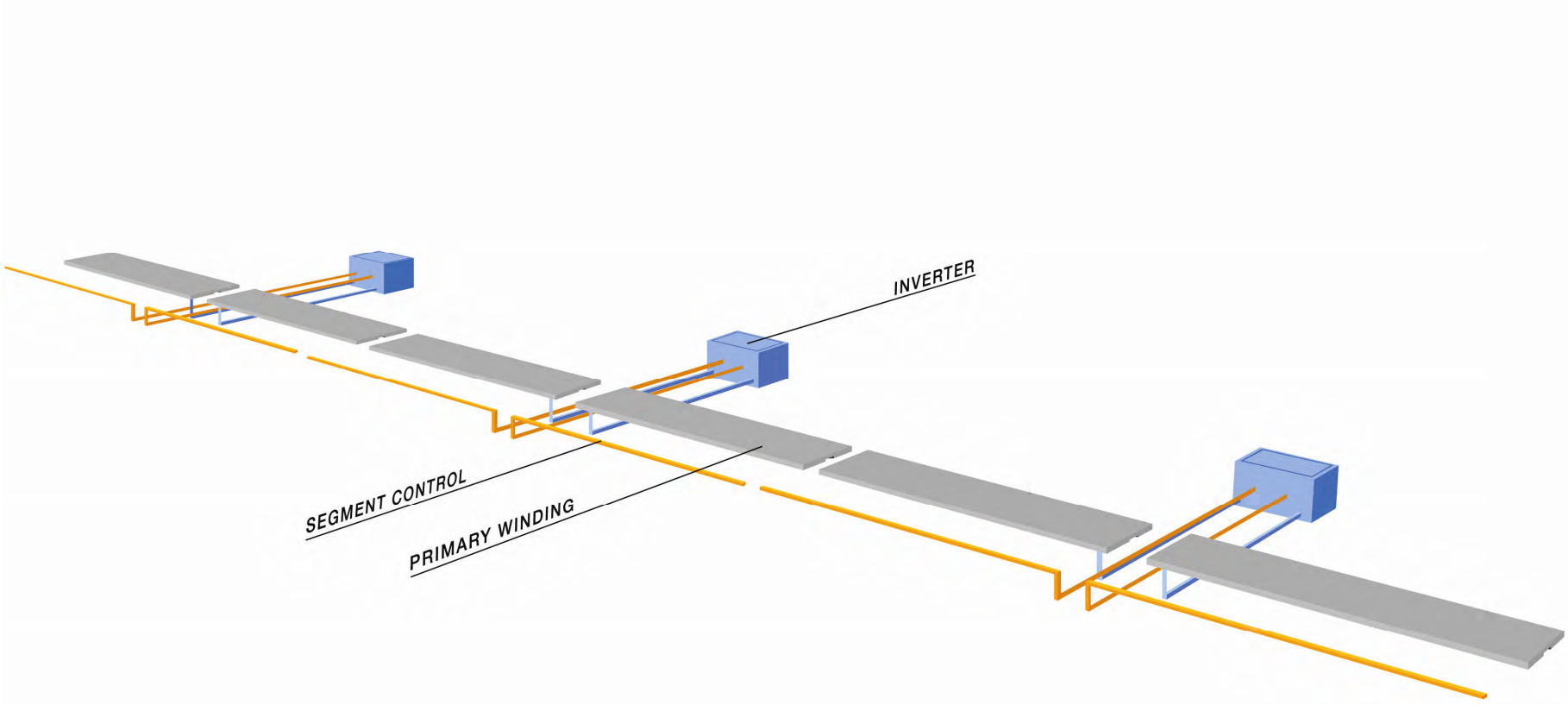
primove *Rail*
Wayside and Track Elements, Schematic



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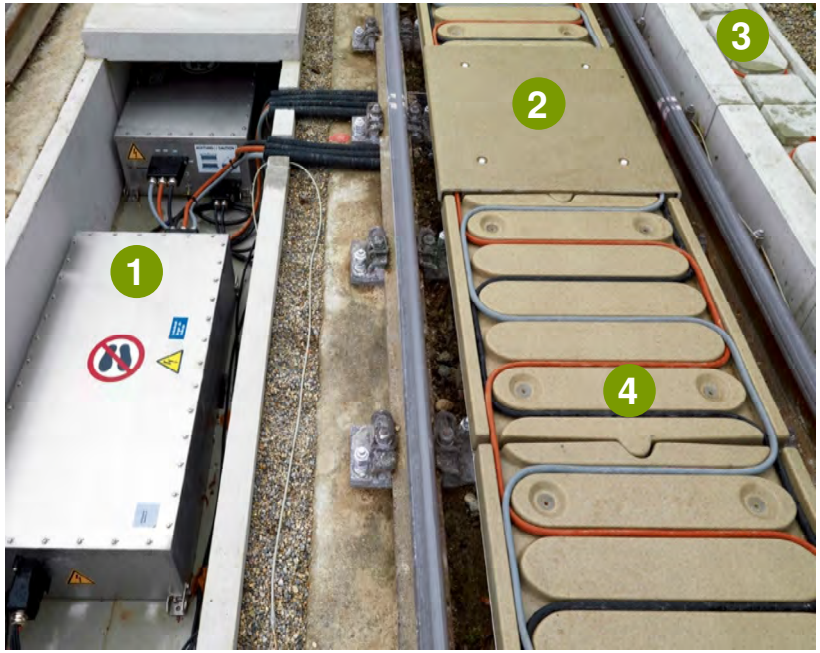
primove *Rail*
Wayside and Track Elements, Actual



1. Inverter
2. Cover
3. Detection loop
4. Cable support

- Windings are easy to install
- All components are pre-tested and certified prior to commissioning
- Existing tracks can be easily modified to allow installation of wayside components
- Track and wayside components are completely covered to allow movement of normal traffic over the track area

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primove *Rail*
Wayside and Track Elements, Installation

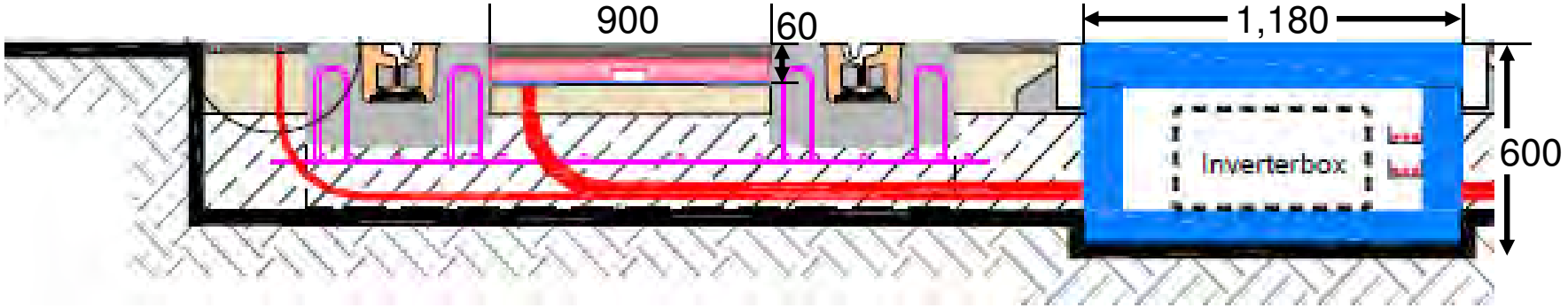
All *PRIMOVE* wayside components fit completely in the envelope of the vehicle

No additional foundation required

- Maximum depth below top of rail: less than 600mm

Primary windings fit completely between rails

Less land surface needed than for catenary systems



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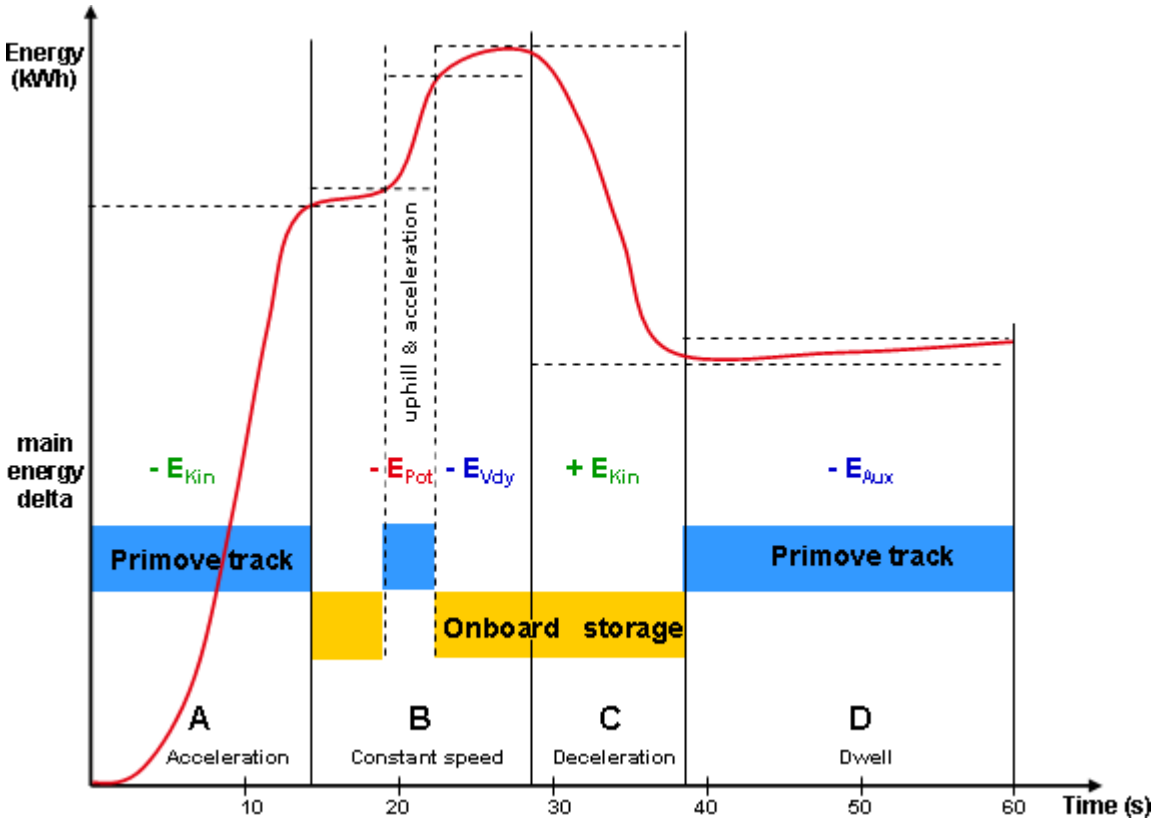
primove *Rail*
primove Energy Management



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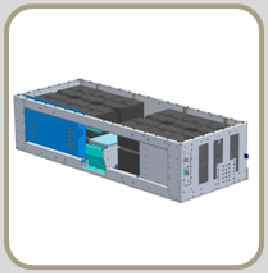
primove *Rail*
Batteries and Supercaps

MITRAC Energy saver (Supercaps)

- Energy saving (ES) operation with good efficiency.
- Cost-effective solution for ES.
- CFO for short distances.
- Series product since 2009
- Over 3 million km driven to date.



Traction battery

- Battery is a good solution for CFO applications due to the large amount of stored energy – long range.
- Battery is cost effective for CFO.

Answers to questions are on the following pages

Questions & Answers

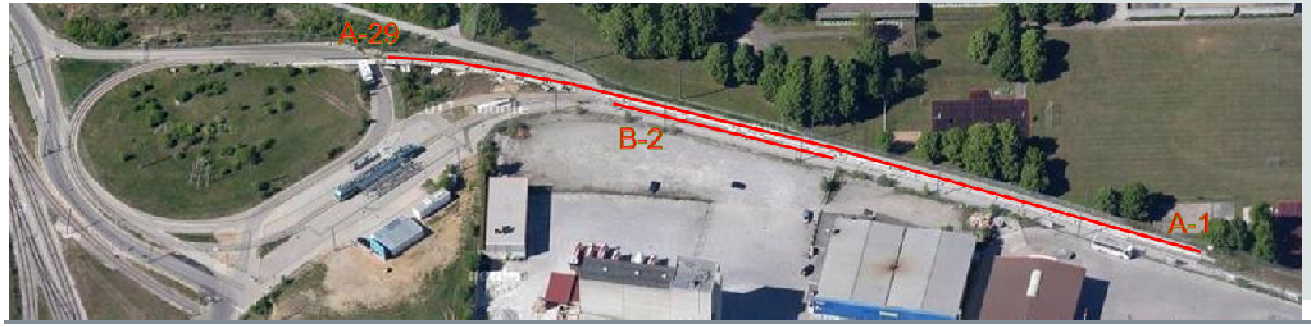
Question #1: CFO Reference projects

Rail: Augsburg Germany (more on next page), projects pending

Bus: Lommel Belgium, Brugge Belgium, Braunsweig Germany, Mannheim Germany

primove *Rail*
Augsburg Pilot

Demonstrated the system's technical capability and compliance with all standards for electromagnetic compatibility under real conditions of operation in urban environment



Bundesministerium für Verkehr, Bau und Stadtentwicklung

Co-funded by the German Federal Ministry for Transport, Building and Urban Development (BMVBS)

Realised in cooperation with the Augsburg Transport Authority (Stadtwerke Augsburg Verkehrs GmbH)

Stadtwerke Augsburg

Continuous power transfer, dynamic & static

2x100 kW power max

Safe

Question #2: PS&D*, mixed catenary & CFO operation

Primove can be installed in three configurations: 100% primove wireless and catenary-free power transfer, primove charging at stops and critical locations, or mixed caternary and CFO, no primove charging segments.

Primove – 100% CFO

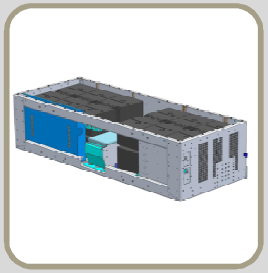
- Invisible
- Reliable under all weather conditions
- Charging can be located where needed , for exp. Crossing, slope ...
- Safe

+

Partial Catenary 10- 90% CFO

- Visible at the station and beyond depending on topography of the line
- Mature technology

+



Traction battery

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*Power Supply and Distribution

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Questions & Answers

Question #2: PS&D, mixed catenary & CFO operation

More details:

With a battery pack, the key is to keep the discharge depth to a minimum to increase battery life

Question #3: Winter operation: in-street conductor, salt, corrosion, and snowplows

Winter operation in Augsburg Germany

In-street primove cabling is sealed beneath asphalt - based wear material.

Questions & Answers

Question #4: Has the in-street conductor been installed in mixed use traffic lanes? Has it been installed in reserved lanes with normal traffic operating at right angles across it? Have there been any issues related to cleanliness resulting from contamination with rubber tire, oils, or autumn leaves?

Bombardier's primove system is not based on in-ground conductor technology but on in-ground inductive power transfer technology. As such, the power transfer elements are buried in the ground and sealed off from the elements, providing a system entirely immune from the weather, rubber tire, oils, autumn leaves, etc…

Wear testing of the in-ground wear component is underway at an independent test lab in Europe, simulating traffic conditions on an intermediate highway. We are 4 months into six months of the 10-year (equivalent) test with no damage visible.

Questions & Answers

Question #5: In-street conductor, turnouts, crossings, vertical curves, clearances to adjacent steel items

Gaps can be left where necessary for continuous primove, this is not an issue for partial primove or catenary/battery. Steel items under the tracks are not affected because primove naturally shields them.

Questions & Answers

Question #6: Batteries: type, vehicle acceleration & speed

Vehicle performance is identical to catenary operation (acceleration typically limited by customer specification). The maximum design speed of the vehicle is 80 km/h

Bombardier is using Li-Ion cells widely used in automotive and military applications, manufactured by one of the biggest battery manufacturers.

Bombardier is using a similar system on a prototype bus system running in the Mannheim area.

Our overall activities in energy storage technologies for CFO operation is longer than 10 years, with several prototypes in long term operation. We have 19 vehicles with onboard energy storage based on double layer capacitors running in daily commercial operation since 2009.

The system concept for CFO operation with Li-Ion battery system is based on this experience with more then 5 million km travel distance

Questions & Answers

Question #7: Battery operation: What are the design limits and emergency limits for charge/discharge levels of the batteries on your vehicles? Is the battery management system provided by the battery manufacturer, third-party specialized supplier, or incorporated into the propulsion system? Are the individual cells monitored?

Bombardier prefers to discharge to 50% and charge to 80% in normal operation to maximise the battery life and maintain reserve power. Further discharge is possible occasionally and complete charge is delivered at locations where there are long stops.

The battery management system is provided by the battery supplier. Each cell voltage is monitored and temperature is also monitored in several places in the module.

The battery module and monitoring system are modularised for effective supervision and redundancy.

Questions & Answers

Question #8: The operating environment in DC has a temperature range of -15^{0}F to 106^{0}F. What will be used for the cold temperatures to ensure proper operation of the system? Do the high temperatures with added solar heat gain prove detrimental to the batteries? Is a heating and cooling system typically provided for the batteries?

The system is designed for operation in ambient temperature from -20 to +110°F.

Bombardier utilizes design and a thermal management system to optimize battery function, especially at temperature extremes.

Questions & Answers

Question #9: There is a concern with impacts damaging Li batteries with fires resulting days later. This was observed during crash testing of the Chevy Volt. Are the batteries located in an area susceptible to impacts in traffic accidents? Have you established criteria for maximum impact shocks and have the criteria been validated by the battery manufacturer?

The batteries are located on the roof of the vehicle and are not susceptible to impacts in traffic accidents.

The Bombardier system is more robustly designed than the system in the Chevy Volt, and our standard procedure is to drain the battery after an incident.

The Chevy Volt incident was caused by when the battery system was not discharged after the crash (discharging reduces the reactive behavior of the battery system dramatically) and a hole caused by the accident allowed the heated battery cells to ignite the interior of the car.

Criteria have been established for shock and abuse from cell level to system level (e.g. nail penetration test on cell level and crush test on system level). In addition we have criteria for shock and vibration on a charged battery system corresponding to 30 years operation.

Validation activities are in progress.

Questions & Answers

Question #10: If a streetcar traveled three miles off wire with 6 stops on an average 2% grade how long would the vehicle need to travel on wire to fully recharge?

What would be the maximum current draw for battery recharging?

Bombardier does not recommend to run 3 miles off wire on a 2% grade as today's battery technology does not allow a reasonable depth of discharge for such a power draw. Bombardier believes that battery life would be compromised by such operation.

The above statement also assumes that this operating scenario is also valid while using full HVAC.

In order to meet this demanding grade, the battery size would be such that it is likely the axle load of the vehicle would be exceeded.

Questions & Answers

Question #11: If a stationary vehicle draws the maximum current for battery recharging in addition to the vehicle's maximum auxiliary power requirement on a 106^0F day in full sun with no wind, is it possible to heat a 350 kcmil overhead contact wire to the 160^0F annealing temperature of the copper? If so, what measures may be taken to mitigate this concern?

The largest issue is the contact shoe welding to the catenary in static charging. Special pantograph technology is required. Charging with primove does not have this issue, nor does dynamic charging from the catenary.

Questions & Answers

Question #12: What is the time required to recharge fully depleted supercapacitors at a stop? What level of current and voltage is this time based on?

The supercaps take less than 30 seconds to charge from fully discharged. In normal operation the discharge would be limited to extend the supercap life so typically 15 second charge time. The vehicle bus is nominally 750 VDC.

Bombardier does not recommend supercaps for extended CFO operation.

Questions & Answers

Question #13: For a discrete charging system, would your firm recommend a traditional supply system with distribution via underground conduit or smaller discrete chargers at predetermined locations? If discrete chargers are possible, what is the range of AC supply voltages that could be accommodated? Can a one-line diagram of such a discrete charger be provided?

For this application catenary charging of on-board energy storage is recommended.

However discrete primove charging segments at stations and critical locations is also a good choice.

The PS&D layout will depend on the alignment and grid connections available.

A/C voltage from the local medium-voltage grid supply can be accommodated, or from the transit system DC supply.

Questions & Answers

Question #14: If station spacing of one-half mile (800 m) on a 2% grade and the streetcars stops for traffic signals every 500 ft (150 m) is used, would your standard vehicle be capable of passing a stop without charging while operating with the maximum auxiliary load, including HVAC? What would be the anticipated charge level remaining at the second stop?

Bombardier's recommended maximum distance while running on battery and full HVAC is about 2 km on level track (segregated right of way also recommended). Primove segments can be installed on extended grades to ensure no issues with battery depletion.

Please supply the alignment details and we can provide analysis and recommendations for the optimum CFO solution.

Questions & Answers

Question #15: Under lane-sharing scenarios, a Streetcar could be delayed considerably in traffic resulting in insufficient remaining charge to reach the next charging area. What is your strategy for minimizing this risk? Would additional storage capacity or capacity monitoring and load shedding (HVAC) be used? What is the possibility of recharging the vehicle in the street and what equipment would be recommended?

Bombardier is sizing the batteries such that their life is not compromised. This means that there is still energy in the batteries that can be used on CFO portions of the line should the vehicle get stuck in traffic.

In the case of extended delays the preferred scenario is to enter into load shedding modes according to a pre-determined sequence of events such as 100% HVAC to 50 % HVAC to Ventilation.

In the very unlikely event that a vehicle does get stranded then normal vehicle recovery techniques will be employed.

Primove charging segments can be installed in high congestion areas to mitigate any risk.

Questions & Answers

Question #16: The District currently owns three T12 streetcars manufactured by Inekon and has three American-built versions of the Skoda T10 streetcars on order. These vehicles use the standard Czech width of 8 ft (2.46 m). What are the implications of continuing to use such European dimensions? Would you be interested in proposing on a small order of 8-10 cars with this width requirement? If no, what is the minimum order size you would be interested in? Would you prefer using the typical US width of 8 ft 8.3 in (2.65 m)?

The consequences of using a vehicle of that size and in particular the narrow width is that this infringes on the capability to adapt to higher ridership in the future as boarding stations will not accommodate a larger standard vehicle.

In order to preserve battery life and to be able to run in traffic with the likelihood of being stuck in traffic in a CFO portion of the line, a small 2.4 x 20 m streetcar is incompatible with the required battery size as it lacks the space and axle load carrying capacity of the larger vehicle.

Bombardier normally bases its CFO offering on a vehicle that is of the following size:
2.65 m x 30 m bi directional

This allows for the battery to be installed on the roof of sufficient capacity.

Questions & Answers

Question #17: The District's current vehicle design criteria limit the length of the vehicles to 72.2 ft (22 m). Does this length permit sufficient space to mount energy storage devices on your standard vehicles? If not, what is the minimum length of vehicle your firm would be interested in providing?

As per question 16, Bombardier is recommending a 2.65 m x 30 m long vehicle

Questions & Answers

Question #18: The District currently has vehicles with lengths of 66 ft (20 m) and width of 8 ft (2.46 m). If these vehicles are to be operated on lines with wireless sections they will need to be retrofitted. What would be the approximate space requirements if your technology were to be retrofitted? Are there any proprietary components that would be required? Do you have any experience retrofitting the system to older vehicles manufactured by you or others? Would you be interested in performing the retrofit work as part of a new procurement?

To be discussed at the meeting.

Difficulties:

1. Roof & undercar layout
2. Electrical interface
3. Propulsion – may need to retrofit
4. Axle load

Questions & Answers

Question #19: What specialized equipment will be required to maintain your proposed energy storage and/or enhanced propulsion technology options? Will additional shop equipment or storage/charging rooms be required? Will test and troubleshooting procedures be impacted, particularly for high voltage storage devices on the vehicles? Please elaborate on the specific function and purpose of such equipment.

Standard equipment: Battery tester, hi-pot

Questions & Answers

Question #20: Will additional specialized training for vehicle maintainers, wayside maintainers, or vehicle operators be required? Will specialized personnel in any of these areas be required or would a typical maintainer/operator with a high school diploma and standard maintainer/operator training be sufficient?

Operational training is required, as is training for maintenance personnel on HV battery maintenance and safety. Bombardier recommends that qualified technicians perform all LRV maintenance.

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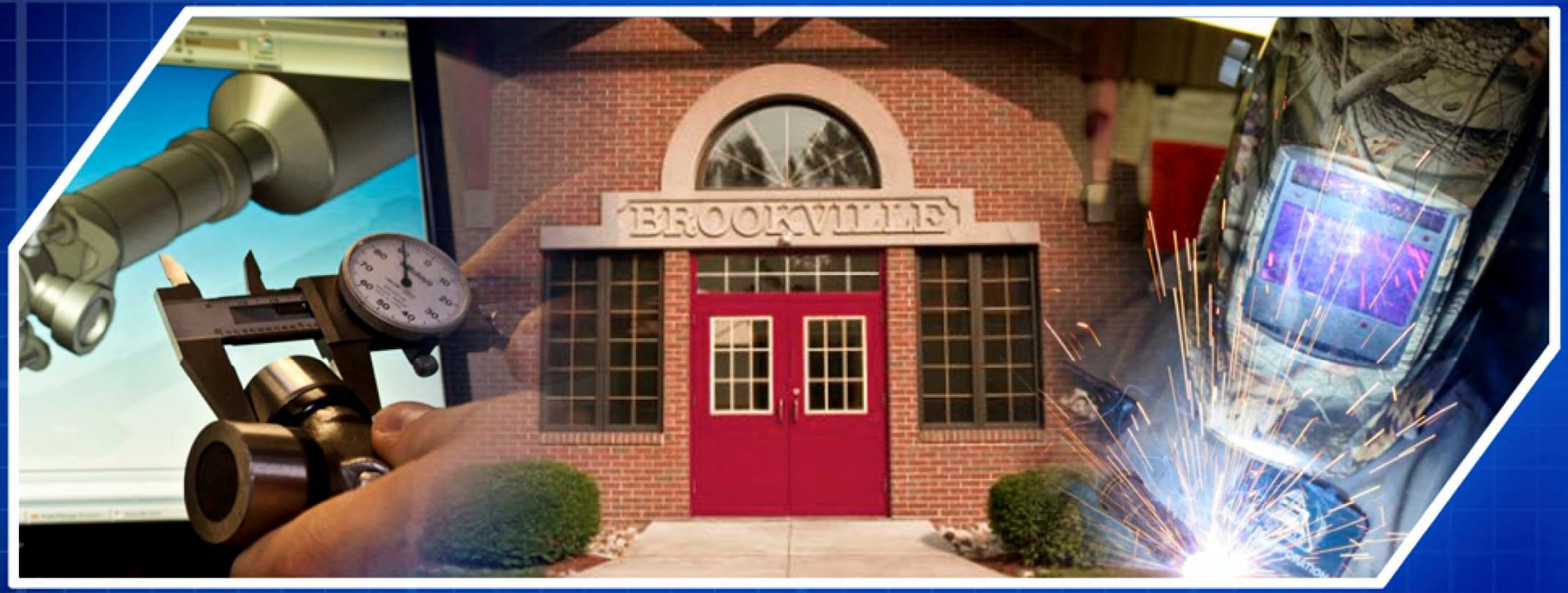
http://primove.bombardier.com

Brookville

BROOKVILLE



Brookville is ...

A WORLD CLASS AMERICAN MANUFACTURER

Brookville Equipment Corp.

Question #1

The District will consider designs which allow for the use of an in-street conductor which supplies power to the vehicle continuously while operating, a system with long gaps in the overhead supply and wired areas for recharging while operating (batteries), or a system which charges an on-board storage system only when stopped at station platforms (supercapacitors or flywheels). Which of these types of systems have you supplied vehicles (rail, bus, or other transport) for? Or, are in the process of supplying? Do you have any comments on the advantages or disadvantages concerning the three system types?

Response

We currently have supplied rail vehicles with on-board ESS battery systems. The ESS systems have been charged by overhead wire, or by non-contact inductive transfer charging. We are currently in the process of supplying a lithium-ion ESS solution to the city of Dallas in a Modern Streetcar. The current Dallas alignment has a 1 mile off-wire section, with total system length of 1.6 miles.

- Supercaps advantage gives you a higher power output for short duration accelerations compared to a battery solution. Supercaps recoup braking energy more efficiently than battery, and charge at higher rates. They have a higher cost per kwh and lower energy density.
- Batteries advantage give you a higher energy capability for longer duration off wire systems.
- Possible combination of super caps and batteries for a multiple start/stop wireless section. Areas of concern with combination are cost, space, and complexity.

Brookville Equipment Corp.

Question #2

A traditional streetcar is designed to operate from an overhead supply system operating continuously at either 600 or 750 Vdc. Would your company's offering place any special or additional requirements concerning integration of the electrification system? Would your technology operate with a pantograph when not on a wireless section?

Response

We would not require any additional requirements from the electrification system. Our streetcar would operate with a pantograph when not on a wireless section.

Brookville Equipment Corp.

Question #3 – In Street Conductor

Has the in-street conductor been utilized in areas which normally experience snow and ice in the winter? What material would you use for fabricating in-street conductors? Would the material show corrosion for the application of de-icing road salt? What provisions are made to prevent snow plow blades from damaging the rail?

Question #4 – In Street Conductor

Has the in-street conductor been installed in mixed use traffic lanes? Has it been installed in reserved lanes with normal traffic operating at right angles across it? Have there been any issues related to cleanliness resulting from contamination with rubber tire, oils, or autumn leaves?

Question #5 – In Street Conductor

How is the conductor installed in the street? Are there any restrictions on horizontal or vertical curvature of the pavement? How are crossings or turnouts implemented with the conductor rail? What clearances are required for other structures such as manholes and metallic covers?

Response

Not Applicable. The current Liberty Streetcar ESS system does not utilize an In Street Conductor

Brookville Equipment Corp.

Question #6 – Batteries

Which battery type do you have experience in applying, Lithium (Li) or Nickel Metal Hydride (NiMH)? What is the maximum acceleration rate and maximum speed normally used in these applications?

Response

We currently have experience with Lithium-Ion battery technology. Our current design utilizes a 2.0 mphps acceleration rate for weights between AW0 and AW2 for speeds between 0-15 mph on level tangent track. Maximum speed maybe limited.

Brookville Equipment Corp.

Question #7 – Batteries

What are the design limits and emergency limits for charge/discharge levels of the batteries on your vehicles? Is the battery management system provided by the battery manufacturer, third-party specialized supplier, or incorporated into the propulsion system? Are the individual cells monitored?

Response

Although the Lithium-Ion Battery can discharge or charge at very high C-rates, we are limiting our battery to a maximum discharge rate of 4C-5C, and a charge rate of 1C. At higher discharge or charge rates the cells will produce more heat, which is detrimental to the overall life of the cell.

Brookville Equipment Corp.

Question #8 – Batteries

The operating environment in DC has a temperature range of -15°F to 106°F. What will be used for the cold temperatures to ensure proper operation of the system? Do the high temperatures with added solar heat gain prove detrimental to the batteries? Is a heating and cooling system typically provided for the batteries?

Response

Our design utilizes a thermal management system which has the capability of heating or cooling the battery dependent upon the ambient/battery module temperatures.
High temperatures are detrimental to the batteries. The Lithium-Ion batteries optimal operating temperature range is from 85 F to 95 F.

Yes a thermal management system is provided with our battery solution.

Brookville Equipment Corp.

Question #9 – Batteries

There is a concern with impacts damaging Li batteries with fires resulting days later. This was observed during crash testing of the Chevy Volt. Are the batteries located in an area susceptible to impacts in traffic accidents? Have you established criteria for maximum impact shocks and have the criteria been validated by the battery manufacturer?

Response

Due to the design of the Chevy Volt cooling system, in which coolant was in direct contact with the cells, the coolant leaked, crystallized, and shorted the cell which was the cause of the fire. Our thermal management system does not have the coolant in direct contact with the battery cell.

Our batteries are located undercar on the A/B end carbodies. The battery enclosure is centered under the carbody. A crash analysis is being performed to determine the need for impact protection to the ESS system.

The battery manufacturer impact/shock criteria, which are being incorporated into our ESS system design.

We have incorporated several design features which maximize the safety of the Lithium-Ion battery. For example we operate at a lower SOC, battery management system monitoring, high voltage disconnecting contactors, and battery module construction

Brookville Equipment Corp.

Question #10 – Batteries

Batteries will be discharged during overhead gaps and recharged while operating in wired sections. As a "ball-park" approximation, if a streetcar traveled three miles off wire with 6 stops on an average 2% grade how long would the vehicle need to travel on wire to fully recharge? What would be the maximum current draw for battery recharging?

Response

Without specific alignment details, stop durations, speed, etc it is very difficult to determine the energy we would need for this specific scenario. However, making some "ballpark" assumptions we estimate the need to charge for 30-45 minutes to recharge the batteries keeping the 1C charge rate.

We would need approximately 133 amps from the overhead supply for battery recharging.

Brookville Equipment Corp.

Question #11 – Batteries

If a stationary vehicle draws the maximum current for battery recharging in addition to the vehicle's maximum auxiliary power requirement on a 106°F day in full sun with no wind, is it possible to heat a 350 kcmil overhead contact wire to the 160°F annealing temperature of the copper? If so, what measures may be taken to mitigate this concern?

Response

Our pantograph is designed for a maximum stationary current of 200 amps. Our typical stationary current draw with maximum auxiliary power and battery charging will be approximately 150 amps.

If required, further investigation would have to be conducted with our pantograph supplier.

Brookville Equipment Corp.

Question #12 – Supercapacitors

What is the time required to recharge fully depleted supercapitors at a stop? What level of current and voltage is this time based on?

Question #13 – Supercapacitors

For a discrete charging system, would your firm recommend a traditional supply system with distribution via underground conduit or smaller discrete chargers at predetermined locations? If discrete chargers are possible, what is the range of AC supply voltages that could be accommodated? Can a one-line diagram of such a discrete charger be provided?

Question #14 – Supercapacitors

If station spacing of one-half mile (800 m) on a 2% grade and the streetcars stops for traffic signals every 500 ft (150 m) is used, would your standard vehicle be capable of passing a stop without charging while operating with the maximum auxiliary load, including HVAC? What would be the anticipated charge level remaining at the second stop?

Response

Not Applicable. The current Liberty Streetcar ESS does not have supercapacitors.

Brookville Equipment Corp.

Question #15 – Batteries & Supercapacitors

Under lane-sharing scenarios, a Streetcar could be delayed considerably in traffic resulting in insufficient remaining charge to reach the next charging area. What is your strategy for minimizing this risk? Would additional storage capacity or capacity monitoring and load shedding (HVAC) be used? What is the possibility of recharging the vehicle in the street and what equipment would be recommended?

Response

Utilizing the battery management system we constantly monitor the State of Charge (SOC) of the battery. Our vehicle controller will utilize this information to start shedding loads at predetermined setpoints thus minimizing the risk of the car being stranded on a section of unpowered rail. Also, acceleration and speed limits will be reduced at a predetermined SOC level to help conserve battery power.

The vehicle is provided with emergency stowable couplers that can be used to move the car to a powered section of rail.

Brookville Equipment Corp.

Question #16 – Vehicle Design Criteria

The District currently owns three T12 streetcars manufactured by Inekon and has three American-built versions of the Skoda T10 streetcars on order. These vehicles use the standard Czech width of 8 ft (2.46 m). What are the implications of continuing to use such European dimensions? Would you be interested in proposing on a small order of 8-10 cars with this width requirement? If no, what is the minimum order size you would be interested in? Would you prefer using the typical US width of 8 ft 8.3 in (2.65 m)?

Response

The Liberty Streetcar is currently offered in two standard vehicle widths. The narrow 8 ft (2.46 m) vehicle and the 8 ft 8 in (2.65 m) vehicle.

Brookville Equipment Corp.

Question #17 – Vehicle Design Criteria

The District's current vehicle design criteria limit the length of the vehicles to 72.2 ft (22 m). Does this length permit sufficient space to mount energy storage devices on your standard vehicles? If not, what is the minimum length of vehicle your firm would be interested in providing?

Response

The Liberty Streetcar has a standard length of 66 ft which permits sufficient space for the mounting of our ESS solution.

Brookville Equipment Corp.

Question #18 – Retrofit of Existing Vehicles

The District currently has vehicles with lengths of 66 ft (20 m) and width of 8 ft (2.46 m). If these vehicles are to be operated on lines with wireless sections they will need to be retrofitted. What would be the approximate space requirements if your technology were to be retrofitted? Are there any proprietary components that would be required? Do you have any experience retrofitting the system to older vehicles manufactured by you or others? Would you be interested in performing the retrofit work as part of a new procurement?

Response

Due to the many unknowns of the existing vehicle structural designs, areas available for ESS components, and the integration of the ESS into the existing electrical systems we do not feel this is feasible.

Brookville Equipment Corp.

Question #19 – Specialized Equipment

What specialized equipment will be required to maintain your proposed energy storage and/or enhanced propulsion technology options? Will additional shop equipment or storage/charging rooms be required? Will test and troubleshooting procedures be impacted, particularly for high voltage storage devices on the vehicles? Please elaborate on the specific function and purpose of such equipment.

Response

No specialized equipment is required to maintain our ESS system.

Depending upon if spare battery modules/pack are purchased an intelligent battery charger maybe required for maintenance during storage.

Special test and troubleshooting procedures will be provided for the ESS system. The ESS system has midpoint contactors that reduce the voltage for safe trouble shooting.

PPE will be required at a minimum may be rubber gloves and cotton clothing, etc.

Brookville Equipment Corp.

Question #20 – Training and Education

Will additional specialized training for vehicle maintainers, wayside maintainers, or vehicle operators be required? Will specialized personnel in any of these areas be required or would a typical maintainer/operator with a high school diploma and standard maintainer/operator training be sufficient?

Response

Additional training for vehicle maintainers and vehicle operators will be required.

Typical electrical technicians will be required to maintain the ESS system.