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Ultracapacitor based on-board energy storage system for railway

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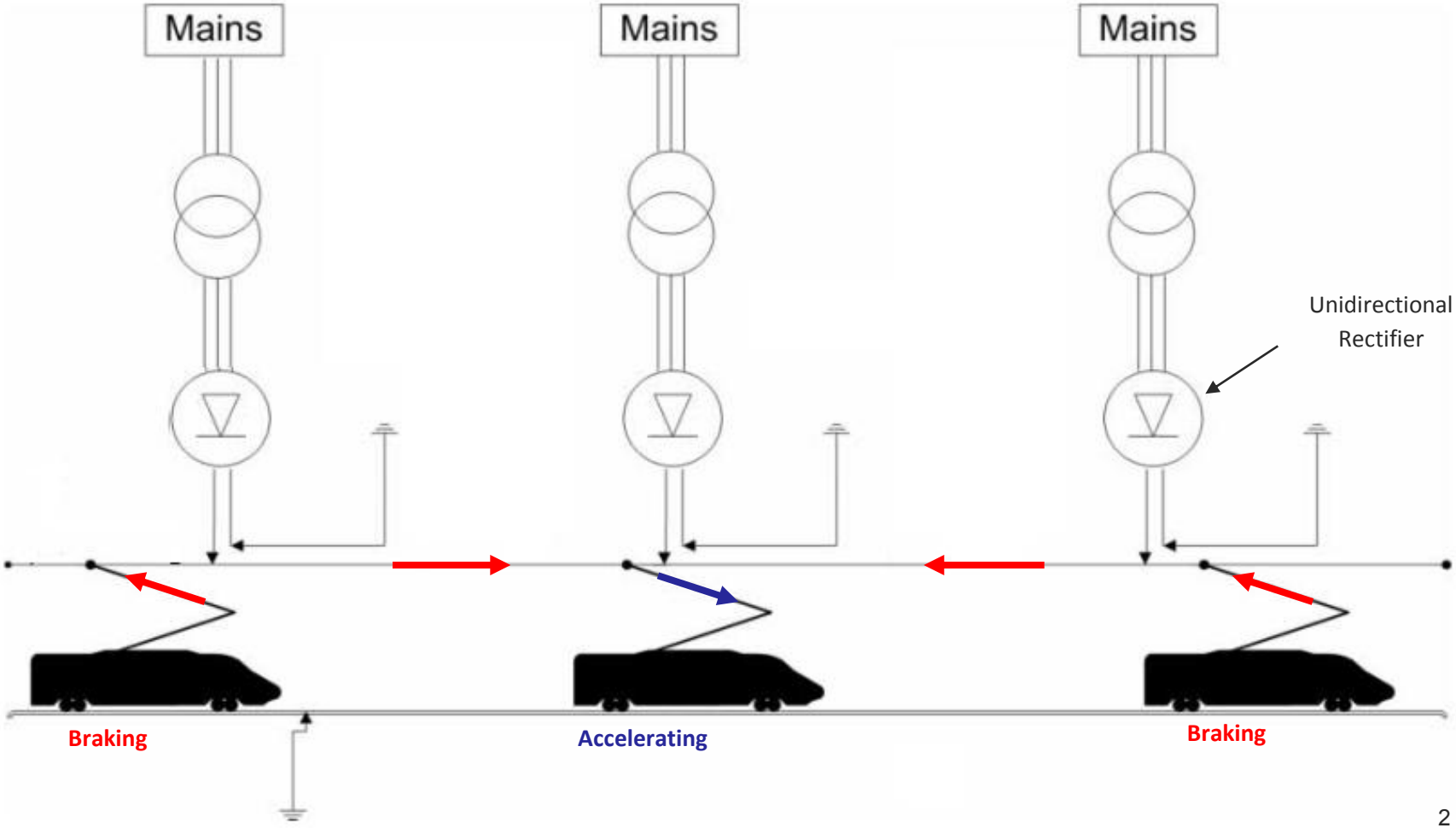
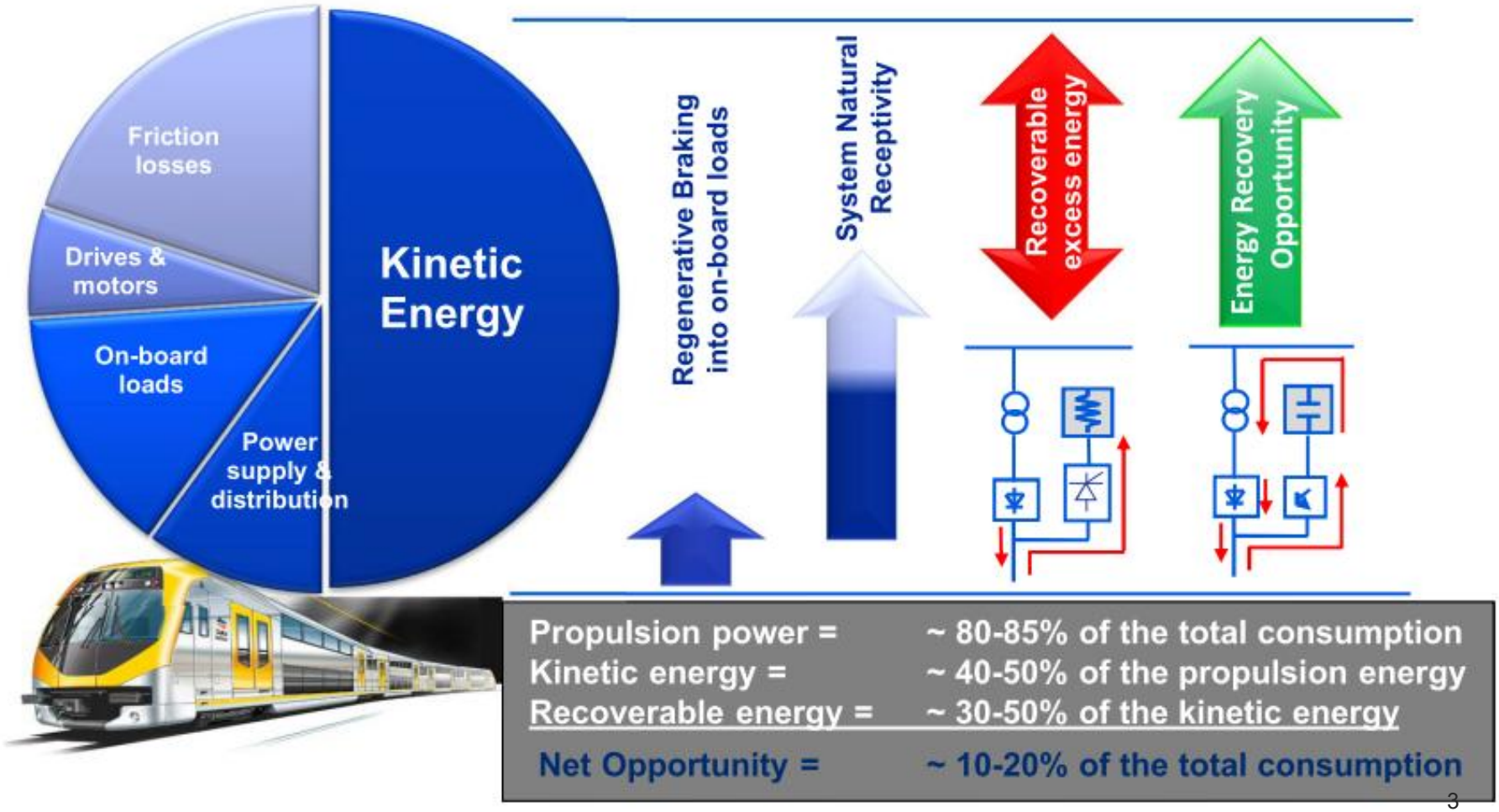
Ultracapacitor based on-board energy storage system for trams



Ultracapacitor based on-board energy storage system for trams



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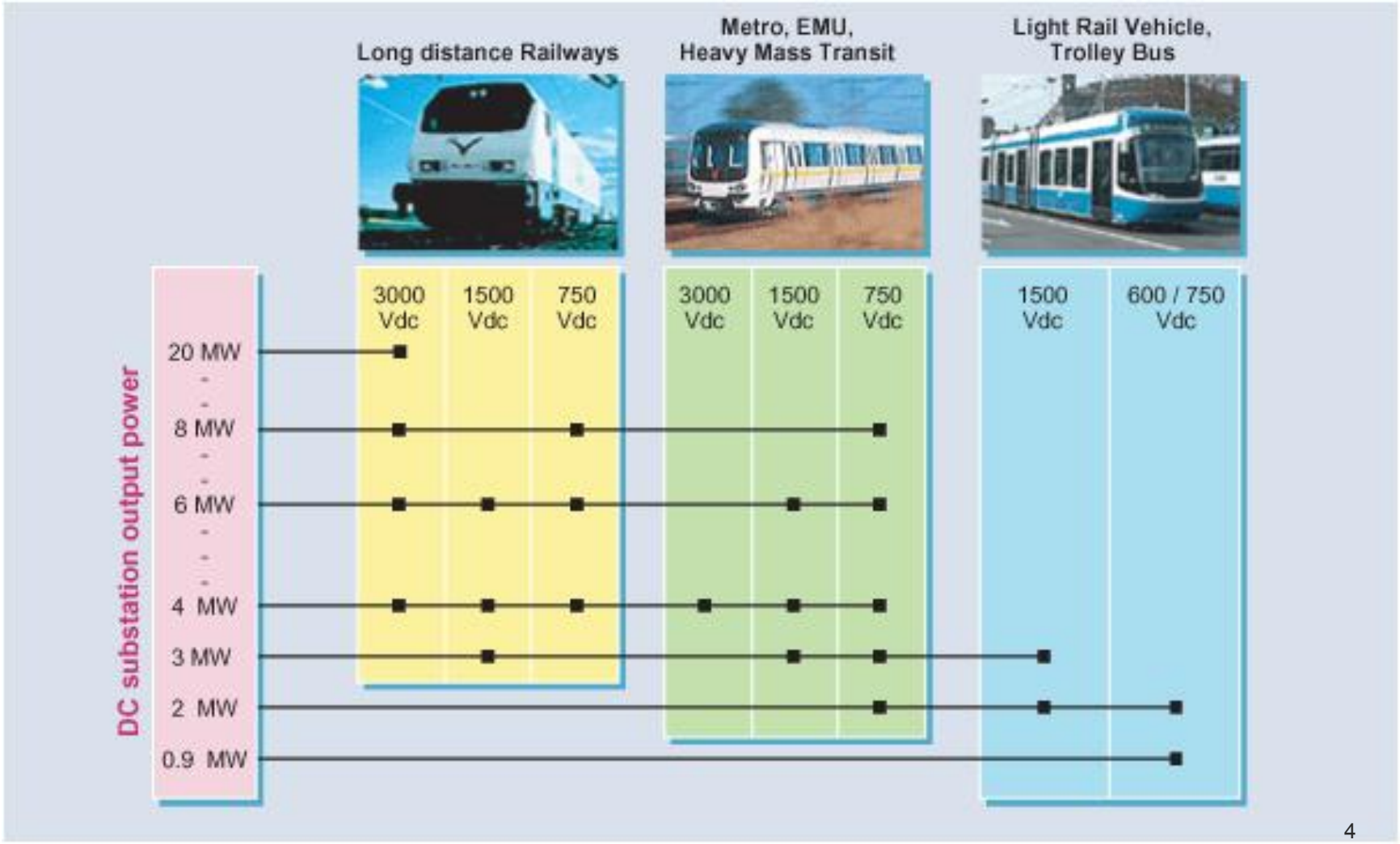

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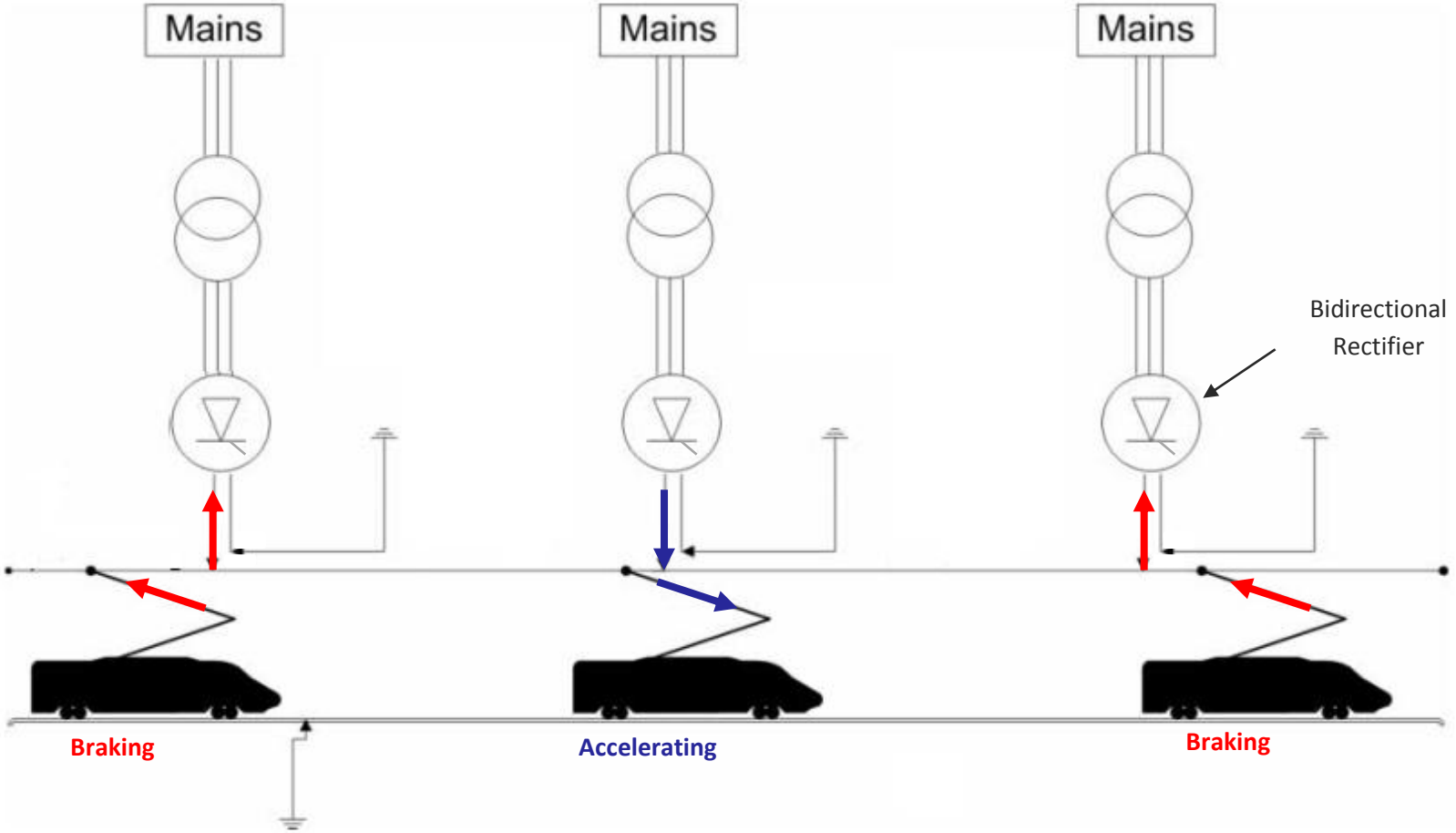

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- Necessity to perform significant substation modifications, including power transformers replacement or addition;

- Simple low cost reversible rectifiers, based on thyristors, possess low power factor and draw distorted currents from the AC supply, while transistor based converters, operating with high power factor and drawing sinusoidal currents, are relatively complicated and expensive;

- Addition of bidirectional converter does not shave the peak energy consumption. On the contrary, bidirectional power flow may even increase the consumption peaks, leading to escalated voltage fluctuations at the DC overhead line.

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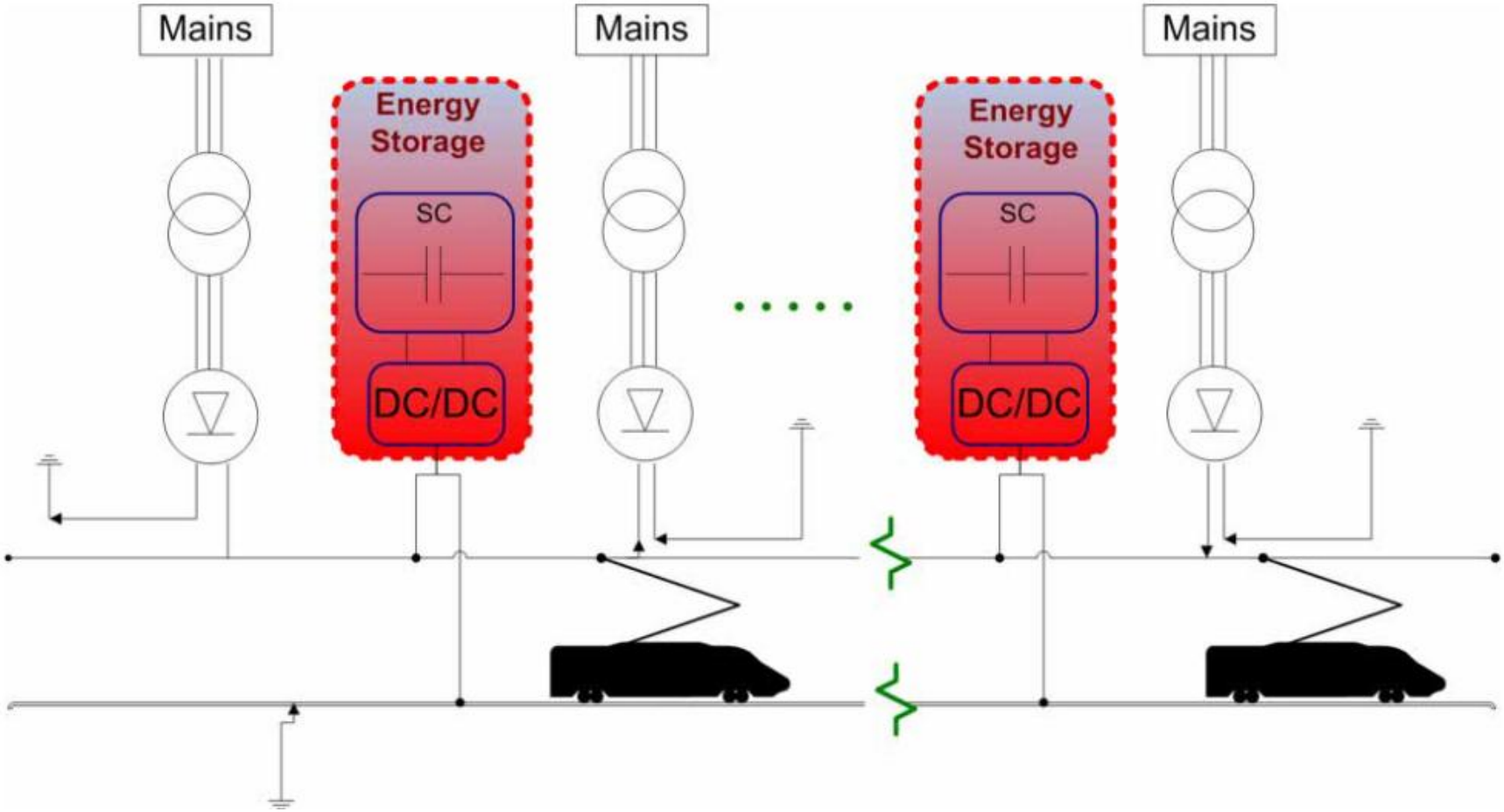

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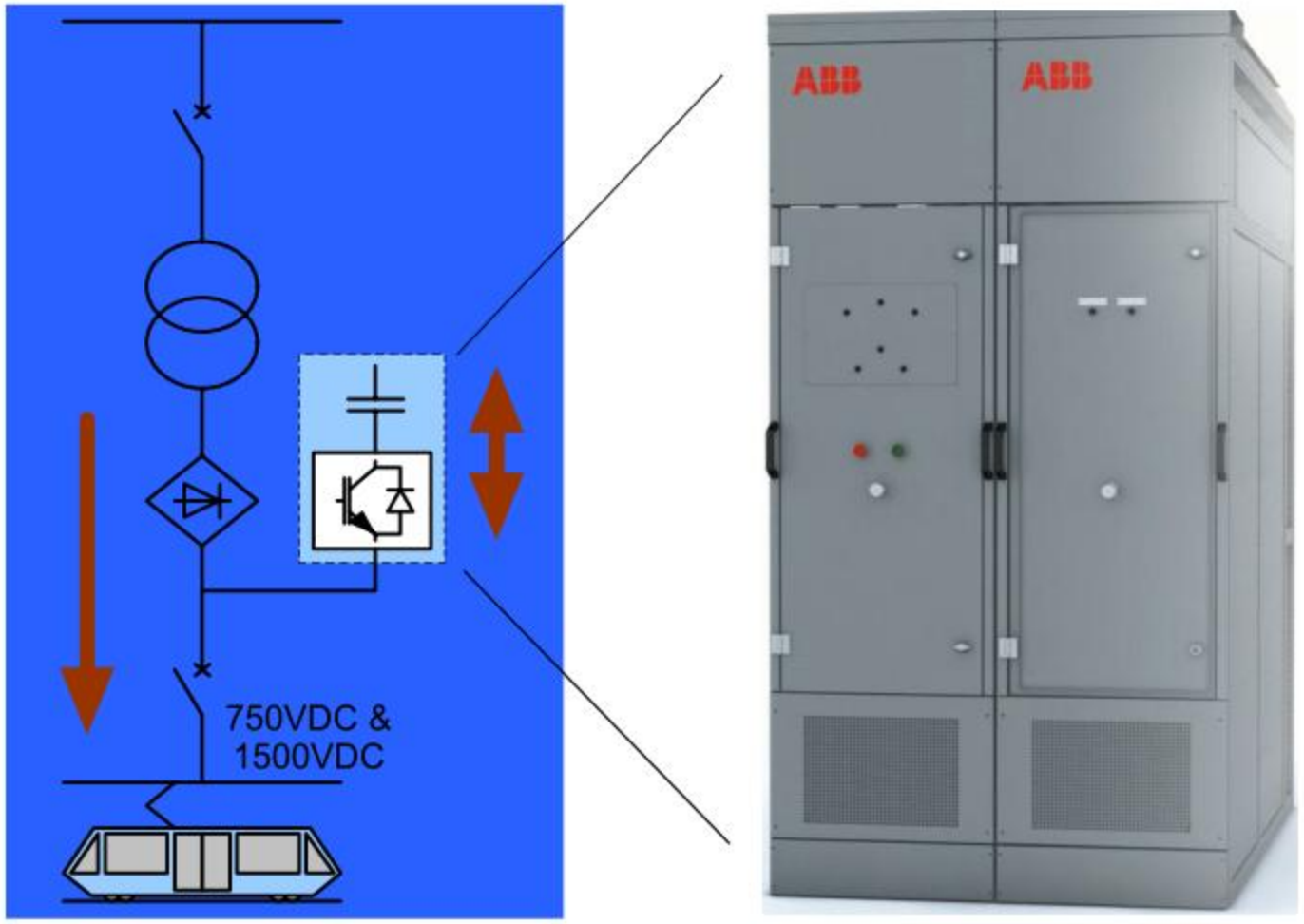

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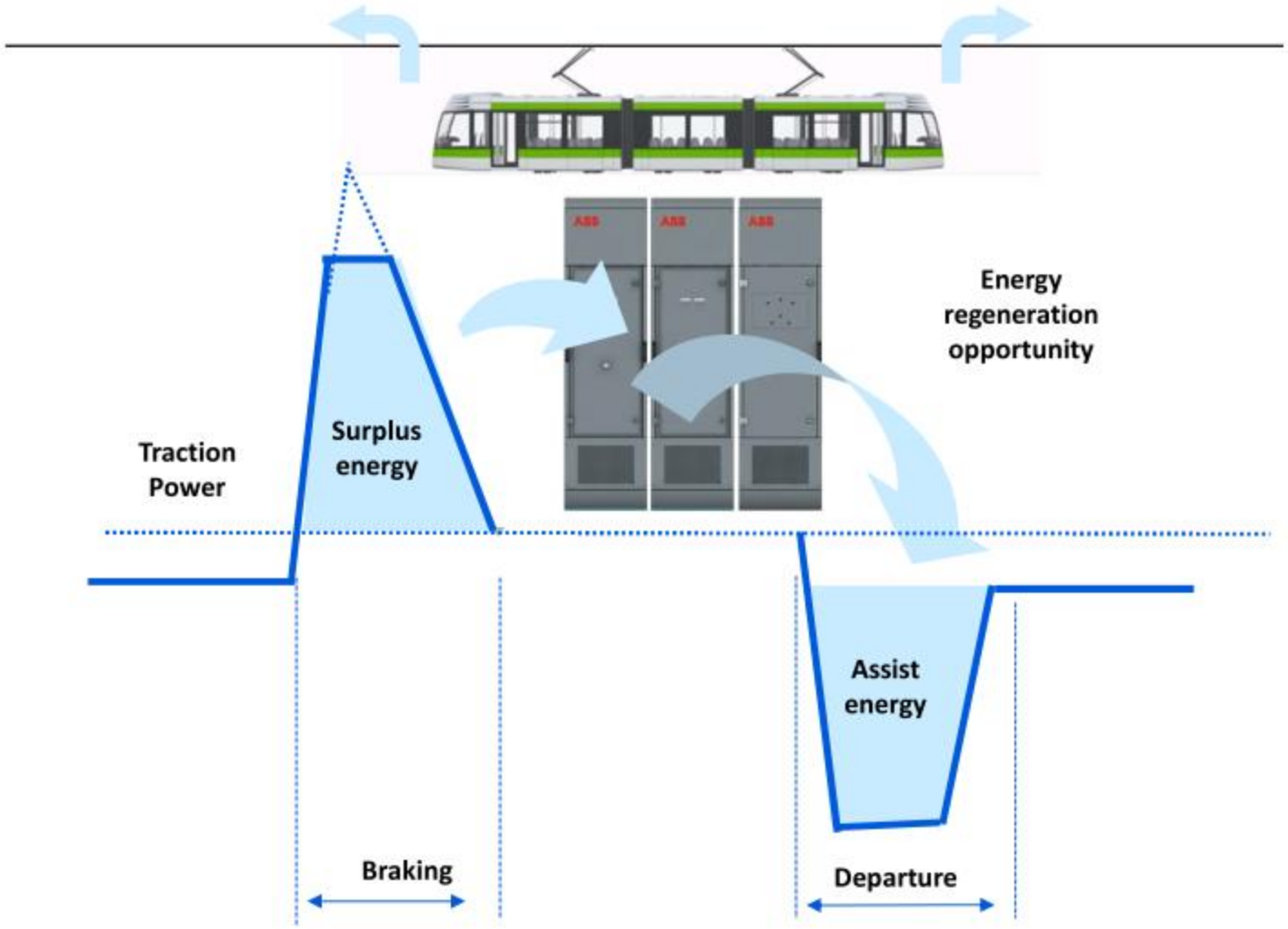

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- On one hand, placing the ESS outside the vehicle decreases its weight and thus decreases the energy consumption.

- On the other, energy transfer between vehicles of between a vehicle and a substation at a distance of several hundred meters up to few kilometers is associated with considerable energy losses.

- While heavy rail transport possesses predictable acceleration and deceleration patterns (mostly near stations, curves, hills etc.), LRVs moving in the city traffic conditions are characterized by random braking, acceleration and different speed zones along the transport network.

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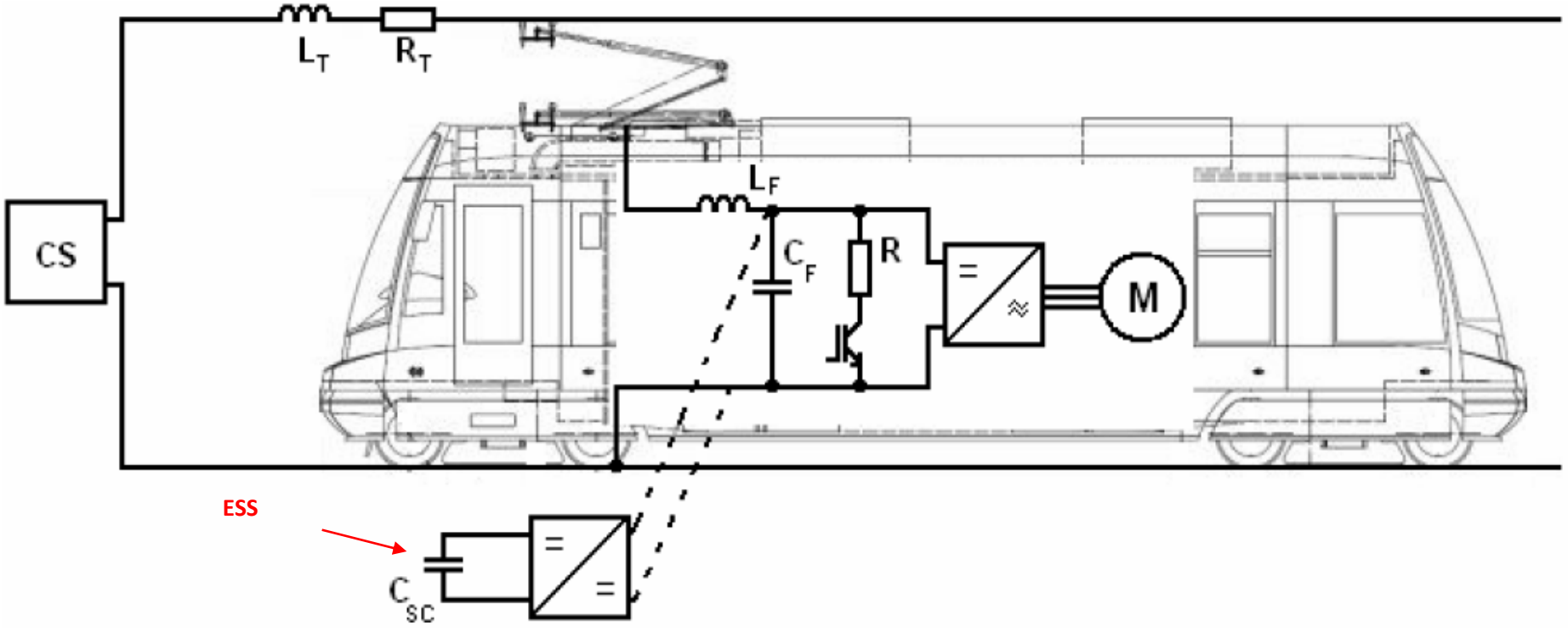

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Modern trams are characterized by enhanced dynamic behavior and increase average speed, resulting in higher current demands, leading to significant overhead line voltage dips. Moreover, high starting power demands a powerful feeding network, otherwise the dynamic performance deteriorates. Overhead line resistance increases as the distance to the substation rises, causing permanent undervoltage far from the substation. Onboard ESS provides direct stored energy, applied at the consumption point, allowing maintaining the dynamic behavior in weaker network points of improved dynamic behavior in well-fed network points. In addition, the onboard ESS allows increasing the number of simultaneously operating trains without substations addition.

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An additional advantage of an onboard ESS is the autonomous traction feature, restricted by the ESS capacity only, allowing to travel a short distance without being connected to the overhead line. This allows improving the panoramic view of historical and central location by eliminating the need for overhead lines.

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The on board energy storage system with Ultracapacitors for tram vehicles presented in this report seems to be a reliable technical solution with an enormous energy saving potential. The traction energy saving of up to 40% and a reduction of the peak power demand of up to 60% were confirmed in practice. In addition, running the energy storage device on board of a tram brings the following benefits:

- a dramatic reduction of the peak power demand, resulting on considerable benefits in the infrastructure, such as either substation rating (Note that the mass transit operator pays energy costs as well as peak power costs, both reduced by the energy storage system on board of the vehicle) or substation amount reduction, thus leading to very good return of investment;
- "catenary free operation" on several hundred meters without power supply from the catenary.

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The most challenging operating conditions for storage devices on board of traction vehicles are:

- high number of load cycles during the vehicle lifetime;
- relatively short charge/discharge times;
- high charge and discharge power values.

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Reduction of the line current causes an identical reduction of the line voltage drop. It is obvious that storage devices onboard of traction vehicles stabilize the catenary voltage.

This significant advantage of a system with energy storage can be exploited in different ways:

- Increasing of the distance between substations for the planned new lines;
- Reducing of time intervals between following trains at existing lines;
- Acceptance of longer trains on existing lines.

There are also some disadvantages of the energy storage on board of traction vehicles, e.g.:

- Increase of the train mass;
- Additional space is necessary to accommodate the energy storage container.

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