GLOBAL LEADER IN ULTRACAPACITOR -BASED ENERGY STORAGE

+ Transportation Applications

Target INDUSTRIES

AUTOMOTIVE

GRID

INDUSTRIAL

TRANSPORTATION

Rail & Tram Industry

Applications Overview

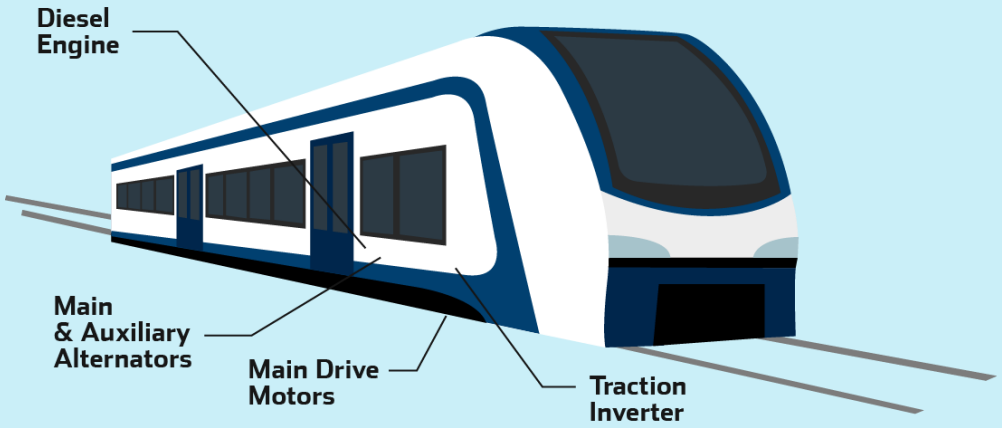
+ Hybrid / KERS

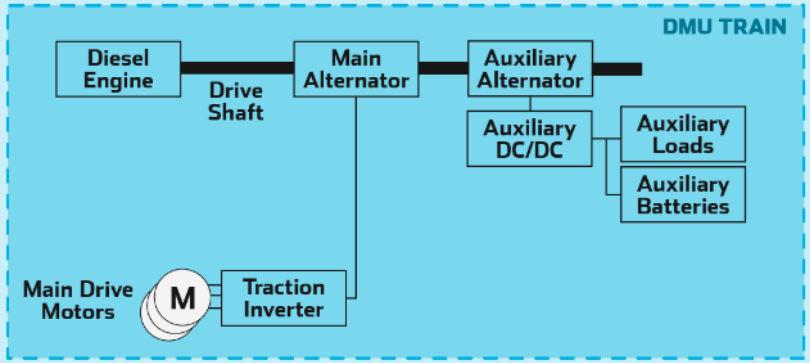
DMU

Transportation | Rail & Tram | KERS for **DMU Trains**

CHALLENGE: improving **diesel train efficiency**

SKELETON TECHNOLOGIES





BACKGROUND

+ Still no energy storage systems in many DEMU trains nowadays
+ Drastic regulation changes target resulting noise and CO2 emissions

KEY CHALLENGES

+ Catenary line is not available in all regions
+ Service cost reduction (CAPEX and OPEX)
+ Emission reduction
+ Constant energy supply from diesel engine
+ Sized diesel engine to cater for power peaks

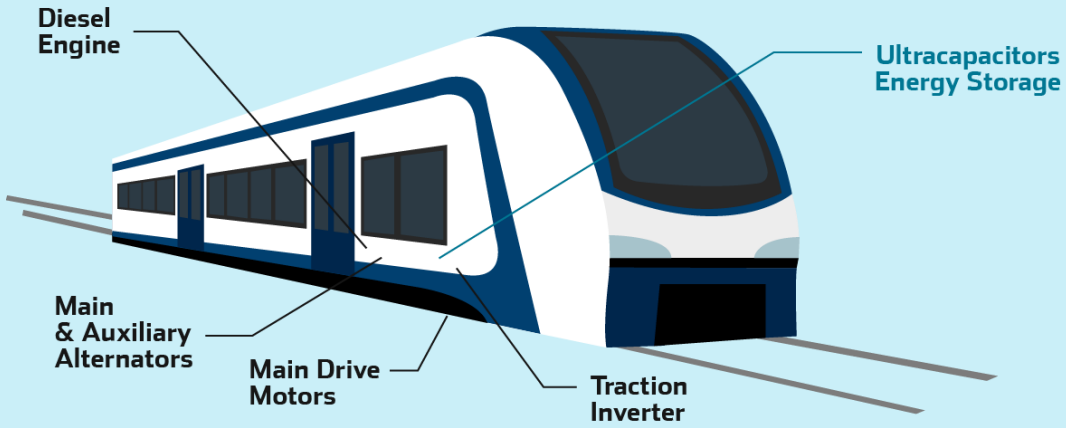
KNOWN CONSEQUENCES

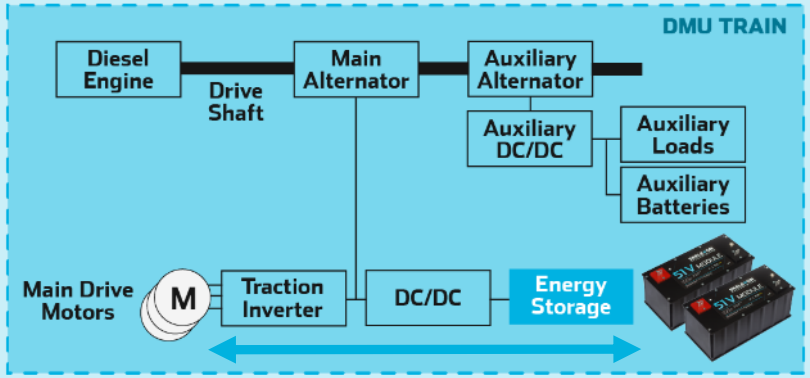
+ Penalties related to high CO2 emissions
+ High running and maintenance costs
+ Heavy wear on brakes and transmission components
+ Negative influence on railway company's image

Transportation | Rail & Tram | KERS for **DMU Trains**

SOLUTION: onboard KERS – **improved fuel efficiency** & reduced CO2 emissions

SKELE+ON TECHNOLOGIES





WHAT WE OFFER

+ KERS* onboard energy storage system, enabling energy regeneration when braking
+ Energy savings for the DEMU trains of tomorrow
+ Electric range availability in restricted areas
+ Increased dynamics

ADVANTAGES OF OUR PRODUCT

+ 100% reliable energy storage with zero maintenance
+ Over 1 million cycles & longer calendar life: 15 to 20 years
+ -40°C to +65°C operating temperature range
+ Ultracapacitors do not leak or contain acid or lead

(*) Kinetic Energy Recovery System

Transportation | Rail & Tram | KERS for **DMU Trains**

BENEFITS: improved fuel efficiency & reduced CO2 emissions

SKELE+ON TECHNOLOGIES

+ BENEFITS for our **clients**

+ Freedom for line planning
+ Increased utilization of the train even in congested & polluted areas
+ Faster acceleration & less noise
+ Service cost reduction (CAPEX and OPEX)
+ Improved fuel efficiency and reduced CO2 emissions
+ Reduced peak load demand from diesel engine when accelerating

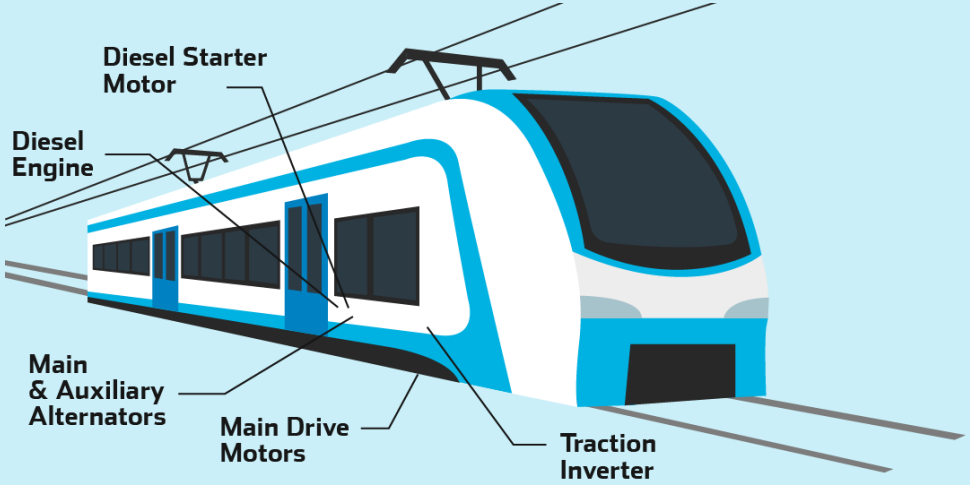
+ Engine Cranking

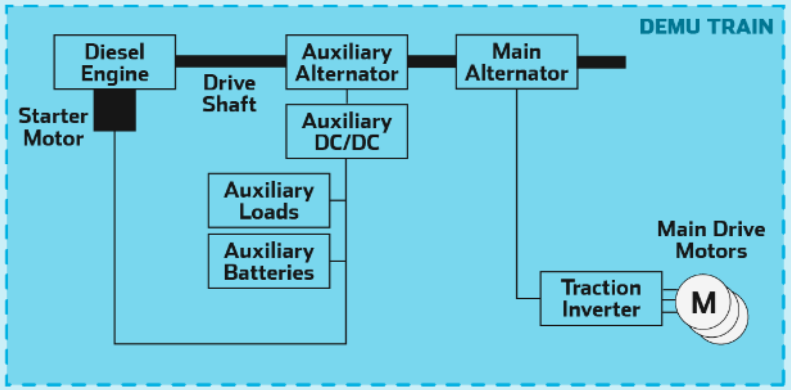
DEMU

Transportation | Rail & Tram | **DEMU** Cranking Trains

CHALLENGE: improving **diesel-electric train efficiency**

SKELE+ON TECHNOLOGIES





BACKGROUND

+ Diesel engine fails to start in cold climate conditions
+ Many batteries must be used to reach the power level to start the engine
+ Lead-acid batteries suffer from sulfation and are not reliable
+ Frequent checks and replacements to ensure the batteries won´t fail

KEY CHALLENGES

+ Reliable diesel engine start under all weather conditions
+ 100% reliability of the starter function
+ Frequent fails due to the use of lead-acid batteries

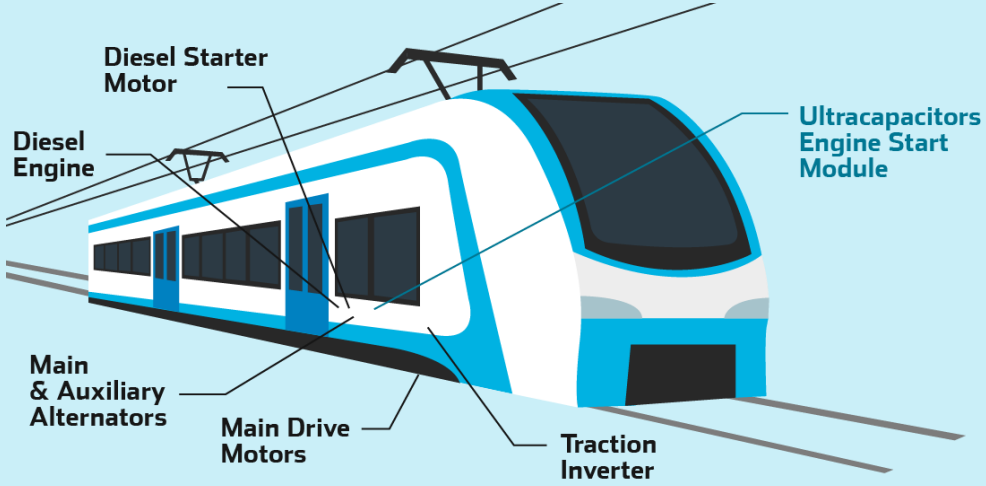
KNOWN CONSEQUENCES

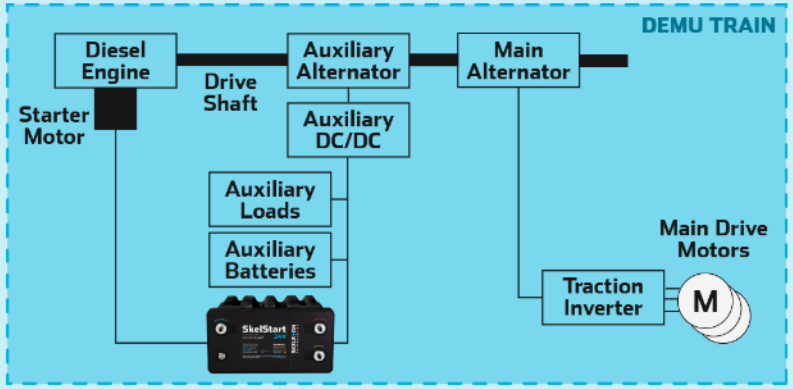
+ Costly downtime due to the failures when starting the DEMU
+ Increased maintenance costs due to preventive battery replacement

Transportation | Rail & Tram | **DEMU** Cranking Trains

SOLUTION: highest reliability – engine start **even in extreme environmental** conditions

SKELETON TECHNOLOGIES





WHAT WE OFFER

+ Engine start modules (ESM) which have the power density matching the requirements of starting procedure

ADVANTAGES OF OUR PRODUCT

+ 100% reliable & maintenance-free device
+ Over 1 million cycles & longer calendar life: 10+ years
+ -40°C to +65°C operating temperature range
+ Ultracapacitors do not leak or contain acid or lead

Transportation | Rail & Tram | **DEMU** Cranking Trains

BENEFITS: increased utilization of the train & lower costs

SKELE+ON TECHNOLOGIES

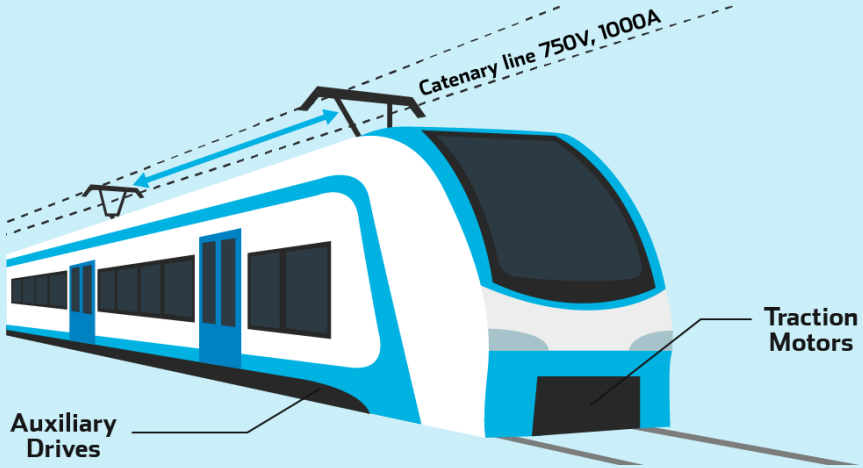
+ BENEFITS for our **clients**

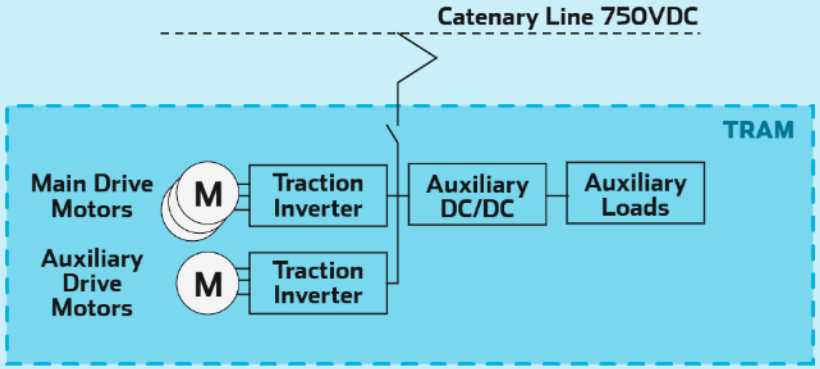
+ No battery-related start failures anymore
+ Safety & reliability even in extreme temperatures (-40°C to +65°C)
+ Ultracapacitors are considerably lighter than batteries

+ Catenary-Free Operation

Transportation | Rail & Tram | **Catenary-free** Operation

CHALLENGE: improving efficiency with a **catenary-free** onboard energy storage





KEY CHALLENGES

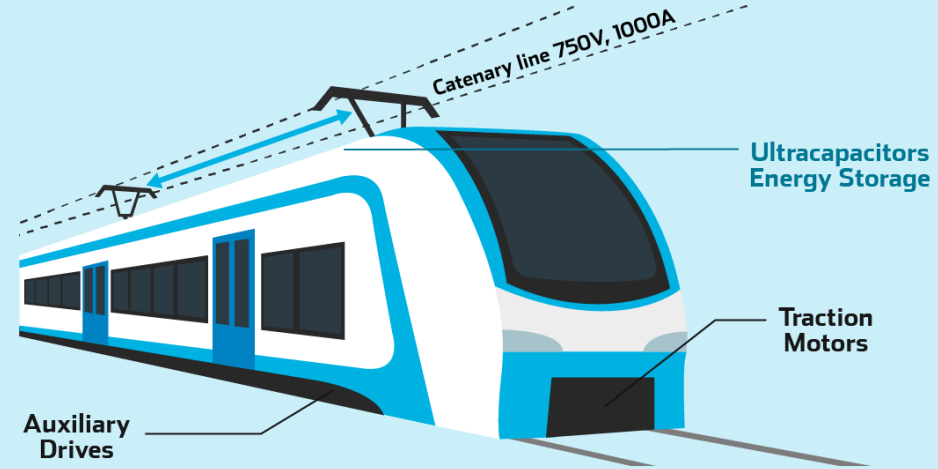
+ Catenary not entirely available for the planned route due to:
  + Limitations regarding preservation orders in certain city quarters
  + New combination of existing lines to increase public transport availability

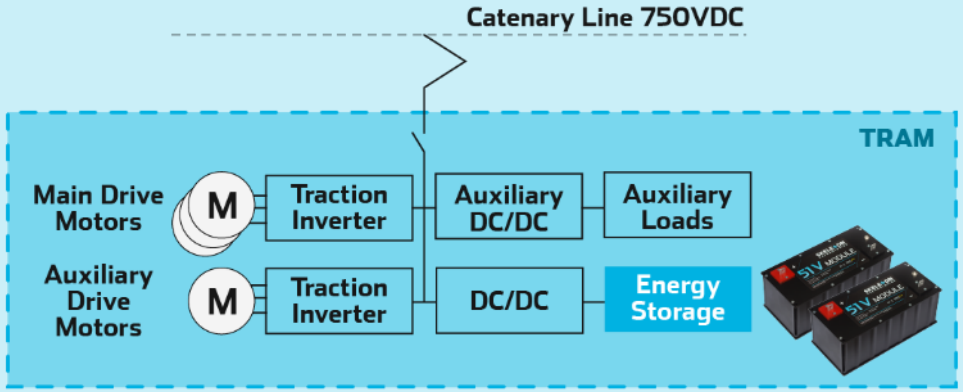
KNOWN CONSEQUENCES

+ Development and expansion of public transport limited
+ Expensive and tedious installations of catenary and grid connection points

Transportation | Rail & Tram | **Catenary-free** Operation

SOLUTION: high performance operation with an integrated compact design





WHAT WE OFFER

+ Onboard energy storage, providing energy in track sections without catenary

ADVANTAGES OF OUR PRODUCT

+ 100% reliable energy storage with zero maintenance
+ Over 1 million cycles & longer calendar life: 15 to 20 years
+ -40°C to +65°C operating temperature range
+ Advantages over Li-ion battery solutions:
  + Considerably smaller & cheaper than batteries
  + Li-ion battery needs to be oversized to cater for peak loads
  + Higher safety – no smoke, fire or flame
  + Ultracapacitors do not leak or contain acid or lead

(*) Kinetic Energy Recovery System

Transportation | Rail & Tram | **Catenary-free** Operation

BENEFITS: 100% reliable energy storage & lower costs

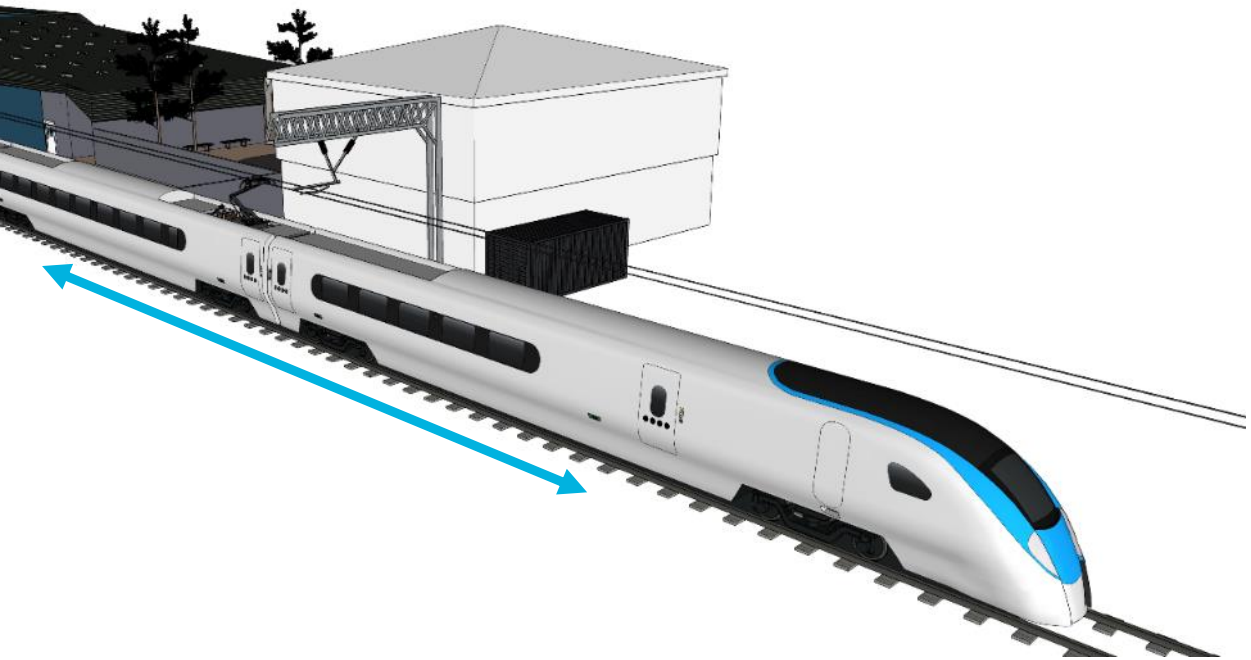
+ BENEFITS for our **clients**

+ Fastest-possible implementation – no catenary-related constructions
+ Increased energy efficiency – energy regeneration when braking
+ Compact design of the onboard energy storage system
+ Reduced peak load demand from grid when accelerating
+ Reduced public grid connection costs

+ Wayside Energy Storage

Transportation | Rail & Tram | Wayside **Energy Storage**

CHALLENGE: safe & efficient braking **energy recovery**



KEY CHALLENGES

+ Catenary systems are not capable of feeding energy back to the grid
+ Catenary systems cannot fulfill the increased demands of modern rail systems

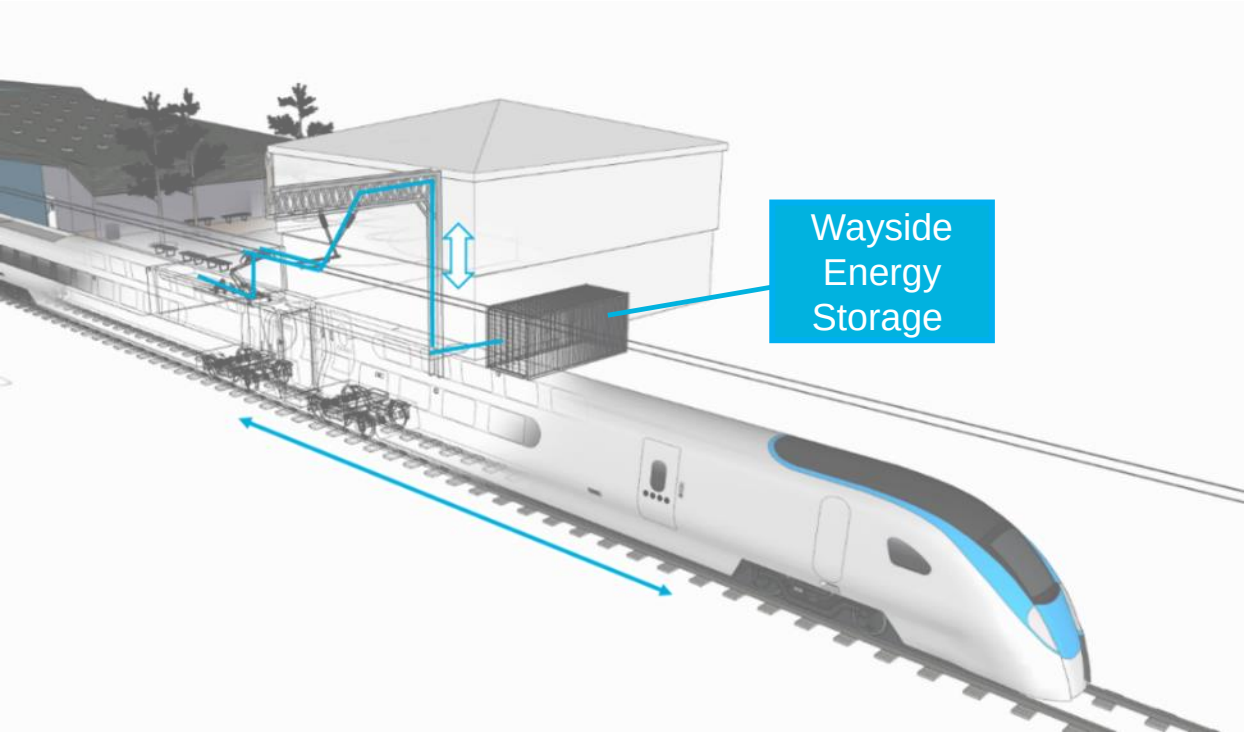
KNOWN CONSEQUENCES

+ Catenary systems are limiting the productivity due to lower peak power capabilities
+ Energy regeneration can cause power quality issues
+ The regenerated energy is burned off in brake resistors to avoid high power peaks
+ Electrical equipment must be capable to handle existing power peaks and transients

Transportation | Rail & Tram | Wayside **Energy Storage**

SOLUTION: up to **20% energy cost reduction**

SKELE+ON TECHNOLOGIES



WHAT WE OFFER

+ Wayside KERS* captures energy during braking of a train arriving at the station, and provides energy during the acceleration of a train leaving the station

ADVANTAGES OF OUR PRODUCT

+ 100% reliable energy storage with zero maintenance
+ Over 1 million cycles & longer calendar life: 15 to 20 years
+ -40°C to +65°C operating temperature range
+ Advantages over Li-ion battery solutions:
  + Smaller and cheaper vs. a solution of similar requirements
  + The battery needs to be oversized to cater for peak loads
  + Higher safety – no smoke, fire or flame
  + Longer lifetime of the wayside KERS system

(*) Kinetic Energy Recovery System

Transportation | Rail & Tram | Wayside **Energy Storage**

BENEFITS: up to **20% energy cost reduction**

SKELE+ON TECHNOLOGIES

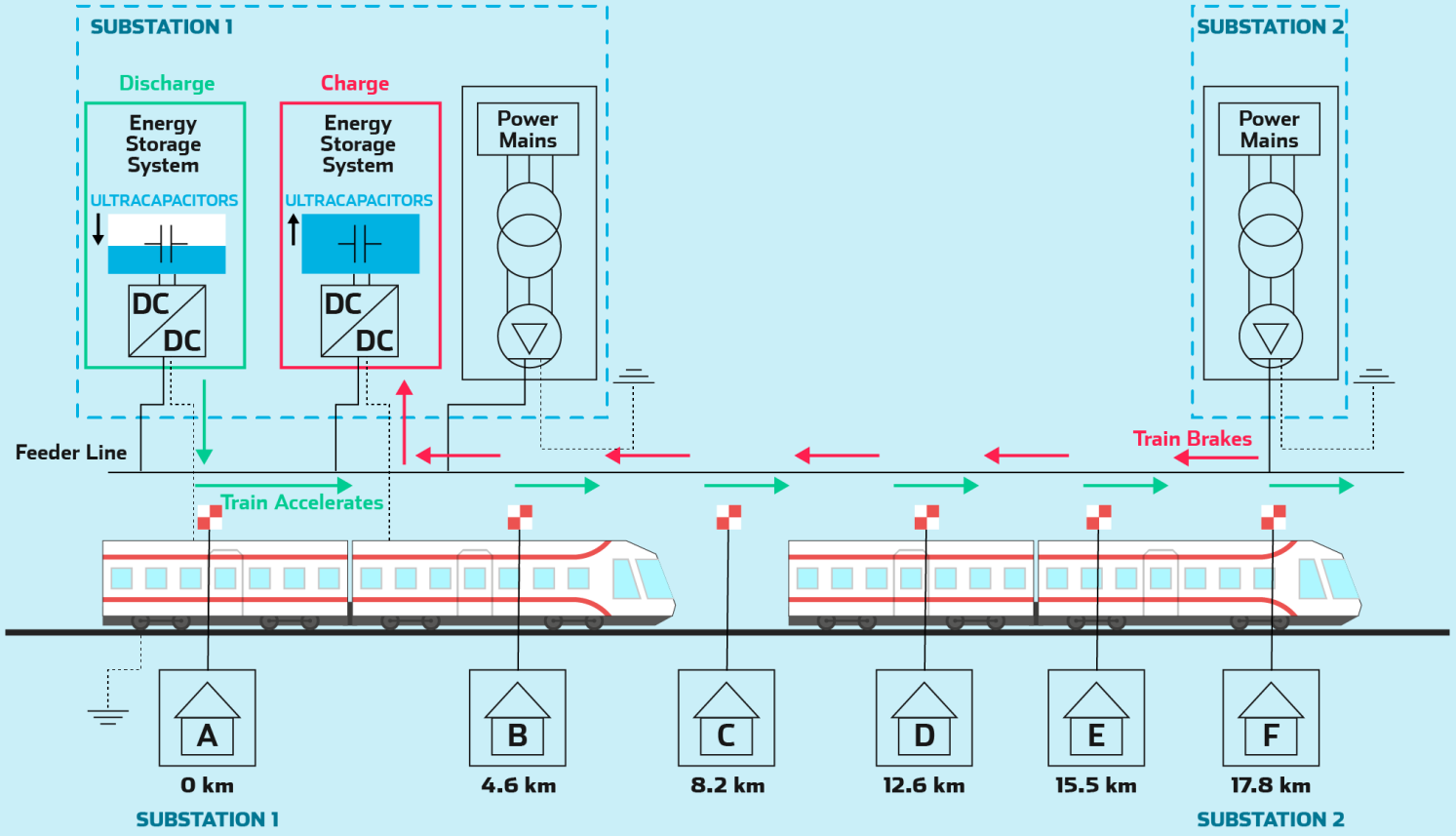
+ BENEFITS for our clients

+ Up to 20% energy cost reduction
+ Increased energy efficiency
+ Catenary supply peak load reduced
+ Lower public grid related cost

Transportation | Rail & Tram | Wayside **Energy Storage**

CASE STUDY: 1490 MWh **saved energy** per year

SKELE+ON TECHNOLOGIES



* based on: https://www.researchgate.net/publication/326664263_Analysis_of_wayside_energy_storage_devices_for_DC_heavy_rail_transport

SKELGRID ULTRACAPACITORS

Power	3,3 MW
Capacity	~11kWh
102V Modules	192 (12s16p)
Maintenance	Maintenance free cells
Lifetime	>10 years
Cycles	1 M+

15 kWh recovery for train from A to F*
(including catenary losses, auxiliary)
99,280 cycles per year*

300 C
High Discharge and Charge power

2 x smaller footprint (compared to 1C Battery)

1490 MWh
Saved energy per year

Break-even at 3 years

+

Wayside Energy Storage

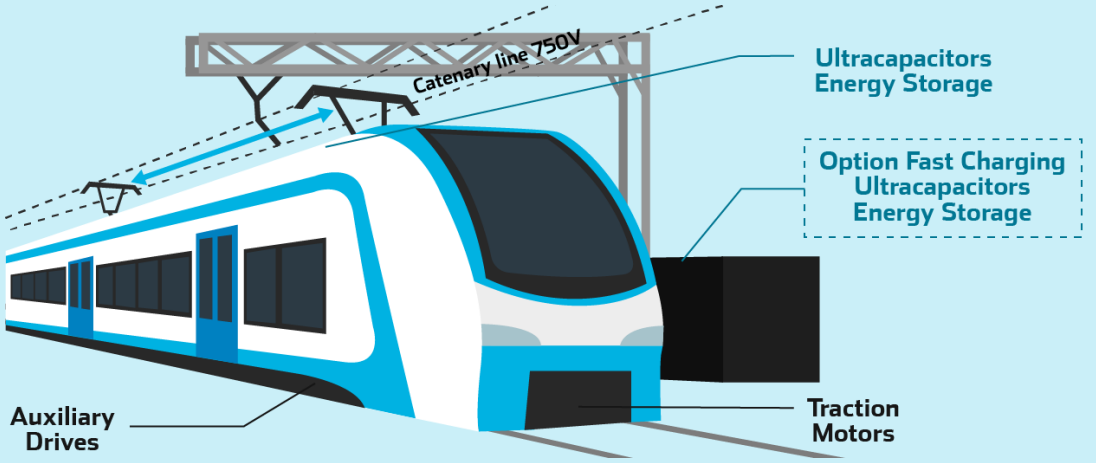
Catenary-Free Operation

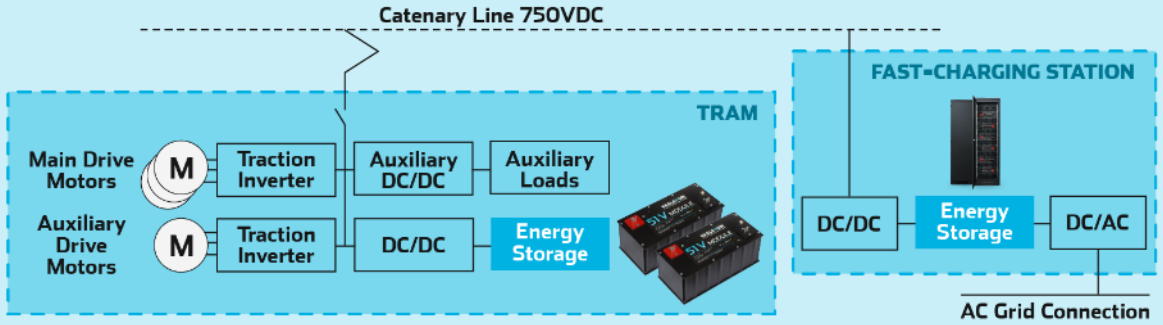
Option: **Fast Charging**

Transportation | Rail & Tram | Fast **Charging** Option

SOLUTION: fast charging **in seconds** for an increased productivity

SKELE+ON TECHNOLOGIES





WHAT WE OFFER

+ Fast charging of light rail vehicles within seconds
+ Enough energy to reach the next couple of stations
+ Energy absorption and supply to the vehicle

ADVANTAGES OF OUR PRODUCT

+ 100% reliable energy storage with zero maintenance
+ Over 1 million cycles & longer calendar life: 15 to 20 years
+ -40°C to +65°C operating temperature range
+ Higher safety – no smoke, fire or flame
+ Considerably smaller & cheaper than batteries
+ Ultracapacitors do not leak or contain acid or lead

Transportation | Rail & Tram | Fast **Charging** Option

BENEFITS: reduced energy costs & increased productivity

+ BENEFITS for our **clients**

+ Catenary supply peak load reduced
+ Increased productivity – charging when passengers are boarding
+ Offers a higher degree of freedom for line planning
+ Reduced peak load demand from grid when accelerating
+ Reduced energy costs – energy regeneration when braking
+ Reduced public grid connection costs


WE ARE
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TECHNOLOGIES
WE HELP TO SAVE ENERGY
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