

Towards more efficient, Silicon Carbide-based traction systems

Novel electric propulsion systems for trains, trams, and metros offer an opportunity to reduce energy consumption, weight, volume, and maintenance costs.

THE CHALLENGE

The electronic technology currently used in traction drives is based on silicon (Si) materials, which face some significant limitations. High losses, frequent failures and requires large, often heavy equipment.

HOW DO WE DO THIS?

Silicon Carbide (SiC) is emerging as a new alternative to Si materials. Enabling high-speed switching and lower losses, SiC-based devices are being investigated for their ability to optimise traction systems.

With the goal of paving the way towards more efficient traction system architectures, the Traction System Technical Demonstrator (TD) developed 5 SiC-based demonstrators.



- Dual system tramway AC traction system
- Metro traction system
- Suburban rail AC traction system
- Regional train full traction sub-system
- High-speed train (HST) traction system integrated in train based on independent rotating wheels



DUAL SYSTEM TRAMWAY AC TRACTION SYSTEM

How a SiC metal-oxide-semiconductor field-effect transistor (MOSFET) affects an AC traction system used for dual system tramways, with a specific focus on how it impacts energy consumption, weight, and volume.



Key Finding

Use of SiC-based converters resulted in **2x** the power density of a Si-based system and a **25 – 30%** reduction in losses.

Conclusion: SiC MOSFETs have the potential to improve traction systems.

Who benefits:  Railway operators and  Suppliers

TRL reached: TRL 5 (technology validated in relevant environment).



METRO TRACTION SYSTEM

1. How the use of SiC-based technology can reduce volume, weight, and maintenance costs while also increasing energy savings and reliability.
2. The benefits of using SiC devices in other stages of the powertrain, including the DC/DC and input AC stages.



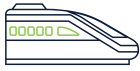
Key Finding

Results obtained were better than expected, with an improvement of approximately **4%** (expected improvement was 2.43%).

Conclusion: Using SiC technology offers significant opportunities to improve efficiency at different stages of the traction system.

Who benefits:  Railway operators and  Suppliers

TRL reached: TRL 7 (system prototype demonstration in operational environment).



SUBURBAN RAIL AC TRACTION SYSTEM



Optimising the main transformer, as well as the traction motor, as a means of minimising energy losses and reducing the motor's weight.



Key Finding

The optimised system's total losses, including SiC-based traction inverters, was **24%** lower than the base system.

Conclusion: The prototype AC traction system for suburban applications addresses key customer requirements, including reducing maintenance, energy and overall costs; decreasing volume, weight and noise; and increasing reliability.

Who benefits:  Railway operators and  Suppliers

TRL reached: TRL 3 (experimental proof of concept).



REGIONAL TRAIN FULL TRACTION SUB-SYSTEM



A prototype consisting of newly developed components covering the full traction SiC sub-system – from the pantograph to the wheels – for an AC catenary voltage.



Key Finding

Energy consumption measurements confirmed the theoretical energy saving of **13%** (train), with energy savings on a regional route profile being **12.8%**.

Conclusion: The new full traction sub-system based on SiC high-power density converters, high efficiency transformer and high-speed motors and gear box can improve the performance of the entire traction system.

Who benefits:  Railway operators and  Suppliers

TRL reached: TRL 7 (system prototype demonstration in operational environment).



HIGH-SPEED TRAIN (HST) TRACTION SYSTEM INTEGRATED IN TRAIN BASED ON INDEPENDENT ROTATING WHEELS


Evaluated a 350 kW motor on wheel solution designed for direct drive configuration with high efficiency.



Key Finding

The motor on wheel solution provided up to **60%** of the maximum brake required in emergency, reaching 2.6 kNm during 100 seconds per wheel without sustaining any damage.

Conclusion: While the motor's measured efficiency is lower than expected, it nonetheless achieves the desired speed/torque performance – positioning it as a potential solution for achieving improved traction system performance at the train level.

Who benefits:  Railway operators and  Suppliers

TRL reached: TRL 6 (technology demonstrated in relevant environment).



PAVING THE WAY TO MORE EFFICIENT TRACTION SYSTEMS

By developing new, SiC-based traction components and subsystems, the TD successfully paved the way towards more efficient traction system architectures, including for use in metro, regional, and high-speed trains.

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Solutions developed by Shift2Rail,
Europe's Rail's predecessor programme

