Directory

Electrification & Power

ENRX

Move People, Not Batteries: The Game-Changing Public Transport Solution Hidden Beneath Your Feet

At Braunschweig train station

Cities around the world are working to reduce carbon emissions, enhance air quality and create more liveable urban spaces.

Electric buses have become a symbol of this transformation – silent, clean and capable of replacing diesel fleets. But behind the scenes, considerable hurdles remain for cities that want their own buses to be sustainable and practical for everyday work.

Oversized batteries, costly infrastructure, grid overload and limited urban space are just a few challenges that city planners and transport operators must navigate. Yet, amidst these challenges, one approach is reshaping how cities electrify their bus fleets: opportunity charging.

Two Approaches to Opportunity Charging

Opportunity charging rethinks how buses are powered by enabling them to recharge during short, scheduled stops throughout the day. Instead of relying on large batteries that require long charging sessions at depots, buses can “top up” on the way.

There are two main methods of opportunity charging:

1. **Overhead charging system or pantograph charging:** Mechanical arms connect buses to overhead chargers for rapid, high-power charging at stops. Widely used, but visible infrastructure and moving parts can require more maintenance and impact urban aesthetics.
2. **Wireless opportunity charging:** High-power energy is transferred wirelessly through pads embedded in the ground and a receiver under the vehicle. This contactless, low-maintenance system integrates seamlessly into urban environments, though it is less widely recognised than pantograph systems.

Both approaches aim to solve the same problem: enabling efficient, on-the-go charging for electric buses. However, wireless opportunity charging offers unique advantages, particularly in terms of durability, aesthetics and ease of integration.

Proven Technology Since 2002

Wireless opportunity charging might seem like a recent innovation, but it has operated successfully for over two decades. It began in 2002 in Genoa, Italy, where ENRX, formerly IPT Technology GmbH, introduced its first inductive charging system, paving the way for cities worldwide to adopt this transformative technology.

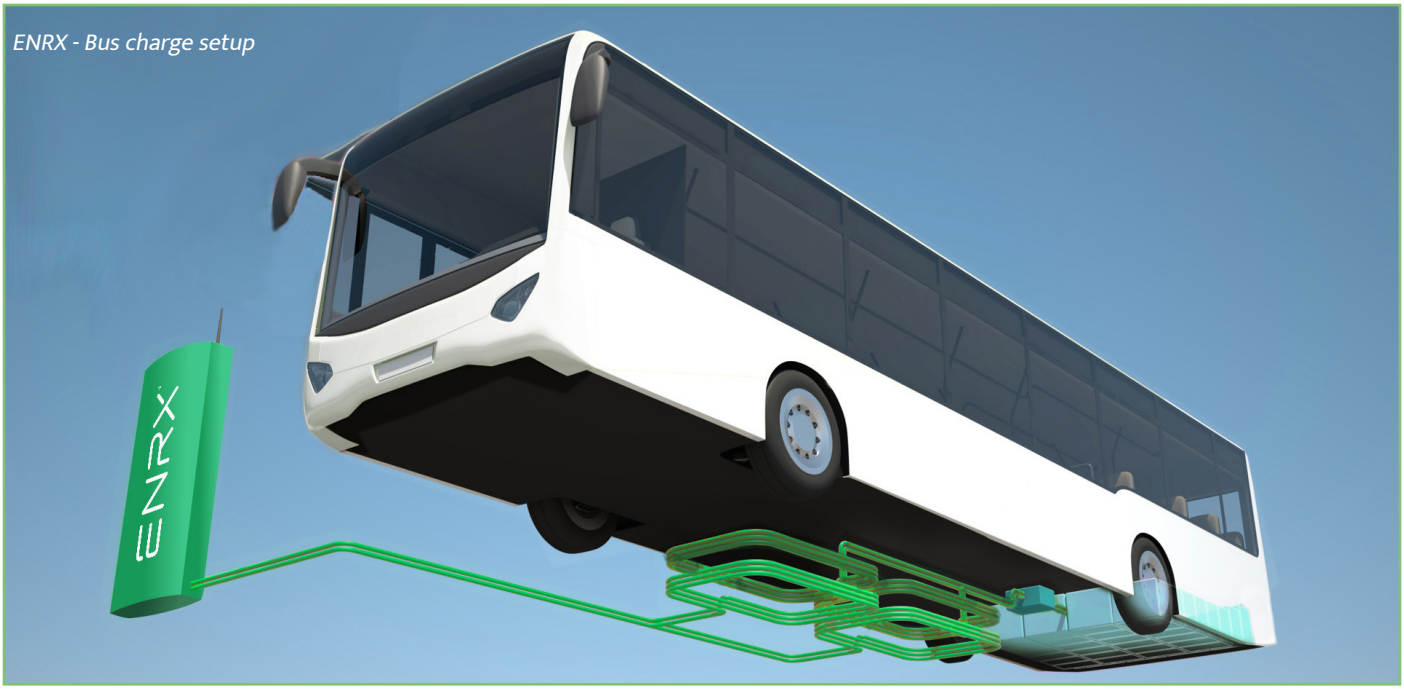
Today, ENRX systems are operational in 14 projects across Europe, highlighting their scalability, reliability and adaptability in diverse environments. Key examples include:

- **London, UK:** Wireless charging systems powered three double-decker buses, each delivering up to 100kW in a test pilot from 2015 to 2020
- **Genoa, Italy:** A pioneer in 2002, deploying eight buses equipped with wireless charging technology
- **Turin, Italy:** In 2004, Turin installed inductive charging pads for 23 electric buses
- **Madrid, Spain:** In 2018, five buses equipped with 100kW inductive systems began operation
- **Fredrikstad, Norway:** Inductive charging supports four e-ferries, demonstrating its applicability beyond buses

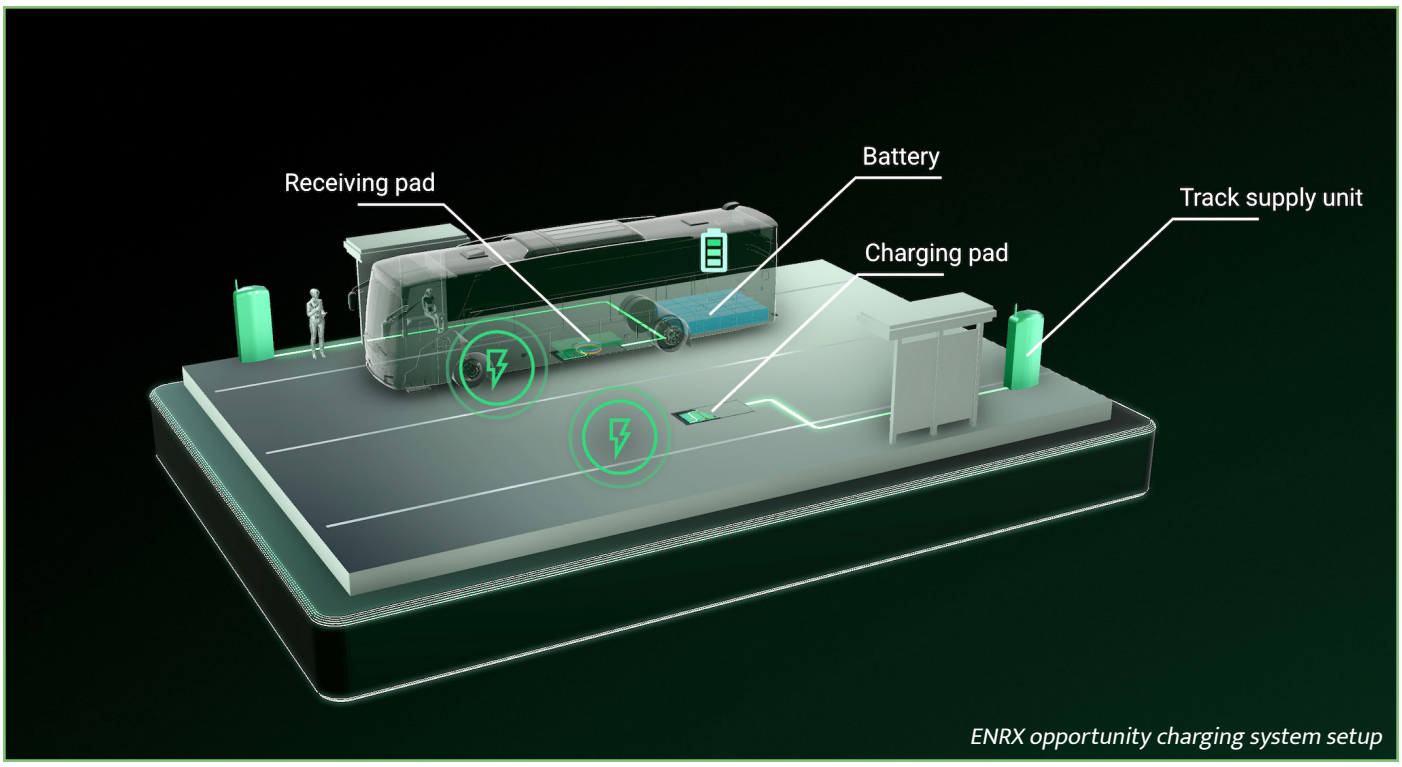
Collectively, ENRX systems have powered electric buses for over 30 million kilometres and e-ferries for more than 300,000 kilometres, demonstrating their reliability in daily operations. While not yet adopted universally, ENRX's wireless opportunity charging has proven to be a mature and effective solution where implemented.

How It Works and Why It Matters

The concept of wireless energy transfer dates to Nikola Tesla's groundbreaking work in the 19th century. It's a principle we use daily for charging devices like



ENRX - Bus charge setup



ENRX opportunity charging system setup

smartphones and electric toothbrushes – and for over 20 years, it has been delivering heavy-duty, high-power energy transfer for applications ranging from electric buses and trucks to industrial systems like forklifts and automated guided vehicles (AGVs).

Wireless opportunity charging uses magnetic resonance to transfer energy between charging pads embedded in the ground and receivers on buses. When a bus stops above a pad, a magnetic field creates an electric current in the receiver, seamlessly charging the vehicle's battery.

This contactless system requires no plugs or connectors, operates automatically and integrates invisibly into urban infrastructure. Reliable in all weather conditions – from rain to snow and sand – it delivers maximum power within a second of activation, maintaining a constant energy flow without peak loads or power fluctuations.

Success Stories: Decades of Performance

Turin, Italy: Leading the Way Since 2004

Turin adopted wireless charging in 2004, installing charging pads at key stops for its fleet of 23 electric buses. Over 17 years of operation, the results speak for themselves:

- **Battery longevity:** By maintaining batteries at optimal charge levels (30–80%), no replacements were needed during the project
- **Operational reliability:** Buses covered up to 200 kilometres daily with frequent, short charging stops
- **Cost efficiency:** Despite higher upfront costs, the system achieved a lower total cost of ownership than both diesel and conductively charged electric buses

Braunschweig, Germany: A Benchmark for Sustainability

Since 2014, Braunschweig has relied on ENRX's Primove 200kW inductive charging system to power its fleet of five e-buses: one 12-metre bus with a 60kWh battery and four 18-metre articulated buses with 90kWh batteries. By 2025, these buses will have travelled over 4.5 million kilometres, reducing CO2 emissions by nearly 3,000 tonnes.

This showcases how wireless opportunity charging combines high power and compact battery systems to deliver diesel-equivalent performance with significant environmental and operational benefits.

Economic and Operational Advantages

Wireless opportunity charging doesn't just address operational challenges– it transforms the economics of fleet electrification. By enabling cities to rethink how buses are powered, this technology offers tangible financial benefits:

- **Smaller batteries:** Frequent charging reduces the need for oversized batteries, cutting costs by up to 50%
- **Extended battery life:** Charging at optimal levels minimises battery degradation, reducing replacement frequency
- **Lower maintenance costs:** Inductive systems, with no moving parts, significantly reduce wear and tear, cutting annual maintenance costs compared to overhead charging systems, which can reach 10–15% of their purchase value
- **Optimised infrastructure:** Embedded charging pads require less space and smaller grid connections, lowering installation costs
- **Continuous operations:** En-route charging enables buses to operate 24/7, minimising downtime and reducing the need for additional vehicles to maintain service levels
- **Workforce efficiency:** By eliminating depot detours, drivers and staff can focus their time and resources on public transport operations

Addressing Scepticism

Despite its proven history, wireless opportunity charging sometimes faces questions about its efficiency and scalability. Here's how it performs:

- **Efficiency:** Wireless systems achieve over 92% efficiency and start charging instantly at full power, delivering 3.33kWh in a 1-minute stop with 200kW. In contrast, a 300kW pantograph system charges for a maximum of 30 seconds due to connection and disconnection time caused by moving parts, delivering 2.5kWh.
- **Safety:** Systems comply with ICNIRP 2010 guidelines, with emissions far below the 27µT threshold. ENRX systems operate at just 3.18µT, ensuring safety for drivers, passengers and pedestrians.
- **Standardisation:** Ongoing efforts like the SAE J2954/2 standard for heavy-duty vehicles and collaborations between industry leaders are ensuring compatibility across manufacturers, supporting seamless integration and broader adoption.
- **Power capacity:** Charging speeds up to 300kW enable rapid top-ups during short stops, keeping buses on schedule.

These features, combined with real-world success, make wireless charging a trusted solution for modern urban transport.

A Vision for the Future

Imagine a city where buses glide silently through the streets, seamlessly charging at stops without cables, connectors or bulky infrastructure. This isn't a distant vision– it's already happening in cities like Braunschweig and Madrid.

By adopting wireless opportunity charging, cities unlock a cleaner, more efficient future for public transport. This proven technology helps overcome electrification challenges while creating quieter, greener environments.

The future of public transport isn't about waiting for breakthroughs. It's here – and powered by wireless opportunity charging.

Visit **www.enrx.com** to find out more.

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ENRX Turin bus project