

# THIRD RAIL

**A number of electric roads are currently in testing, mostly in Sweden, Germany and China. Invited by a Swedish Transport Administration official, Tim Wynne-Jones reports from Frankfurt's ERS conference in May 2019**

This past February, Jan Pettersson, strategic development director of the Swedish Transport Administration, presented 'Electric Road Systems' (ERS) at MOVE, the mobility conference at ExCeL London. For many it appeared to be the re-invention of the electric trolley-bus. However, for those working in electric vehicle (EV) charging infrastructure, it solves the problems of charge station space, recharging time, and the fear of running flat. Here was a mechanism to charge your EV while on the move, using smaller batteries.

Pettersson invited the author to the annual ERS conference in Frankfurt, held in May this year, of which he was the only British representative.

Modern ERS started in South Korea. The Korea Advanced Institute of Science and Technology (KAIST) developed OLEV (on-line electric vehicle) for public transport using a 'recharging' road in March 2010. Although unfortunately OLEV was unsuccessful due to a public funding controversy, it alerted Sweden, Germany and China to the possibility of grid-powered heavy transport. In October 2017 the German chancellor and Swedish prime minister signed a declaration of joint cooperation and funding to develop the best ERS system.

The opportunity to capitalise this new technology is linked to two events, both in 2022: the Swedish-German government's final decision on Electrified Road Systems (ERS), and the Beijing Winter Olympics, where

many of China's ERS innovations will be showcased.

So, who is taking an active lead in ERS and where? What is the technology and how much does it cost? To date, seven countries are developing ERS, and four of those are building test tracks. Only Sweden, Germany and China have actually put ERS on to public roads.

The first ERS test track other than OLEV was built in Sandviken, Sweden. The test track, developed by Siemens and Scania for the Swedish Transport Administration, runs for 2km on the E16 public road. Despite the pictures - main and inset - it is not being used commercially. The technology is similar to light rail, with contact lines 5.4m over the roadway. The truck has a current conductor on the roof that feeds 750V DC to the truck's hybrid electric system. The system is bi-polar, which means that two pantographs simultaneously pick up +/- 375V. The current conductor can connect automatically at speeds up to 56mph. Other road traffic is unaffected.

It is just one of four Swedish electric roads. The eRoad Arlanda project near the Stockholm airport of the same name uses a rail with electrical conductors embedded in the road and is used commercially (pictured, p13).

Electrifying 20,000km of roads in Sweden with conductive feeds is expected to cost about SEK 80 billion (£6.4 billion, or £555k/mile). Today there is a 2km test track which delivers 800V AC - that amounts to 200kW per vehicle.

Also, the Swedish Transport Administration recently announced that



it has asked Elonroad to build a 500m surface test track in Lund (pictured inset, p14). Another 500m recessed track will also be built. The two tracks will be used to prove the concept of powering a converted vehicle from the Polish bus manufacturer Solaris. In early prototypes developed by Elonroad and Lund University, the dynamic charging system used a 100kW onboard charger and a 56kW battery. Installed on public road, the Lund track will use a voltage of 600V DC with up to 250kW/vehicle.

As well as sponsoring Elonroad, the Swedish Transport Administration recently announced it would also support installing a 900m bi-directional ERS between Visby airport and Visby city centre on the island of Gotland, using the inductive concept from Electreon,



an Israel-based company. The route (on a public road) will be utilised by ERS heavy goods vehicles and ERS shuttle buses. Until now, Electreon has been fitting roof-mounted cycle racks on to a Renault Zoe, off which hang inductive pick-ups. The principle is almost identical to the South Korean OLEV system. Plate-sized inductive coils are buried in series 7cm under the road surface (pictured under construction, p14, main image). A 100m inductive stretch of road is then energised with 200kW at 800V and 20kHz. Plate-size pick-ups fitted to the vehicle up to 17cm above the road surface are then able to transfer 25kW each. The more pick-ups, the more transfer, up to the maximum energy capacity of the road (200kW).

Without a doubt, inductive ERS has

many benefits, however alternative ERS systems offering capacities of 2-3MW per vehicle (2,650-3,950bhp) present stiff competition.

Findings from the South Korean OLEV development suggest an

induction transference of 85% with remarkably low electromagnetic compatibility, despite the possible 25cm gap due to conical fields.

Both Elonroad and Electreon systems can identify ERS road users with a smart access control built within the system. This big advantage makes it possible to solve energy metering issues and user charging. To date, neither Siemens nor road electrification system supplier Elways has solved access control, so they may face legal challenges according to both national and EU regulations.

#### GERMANY

The first of Germany's ERS systems is up and running just outside Frankfurt airport. German local and federal

government decided to support the first ERS concept that came along. This was a railway-style pantograph proposed by Siemens and supported by Scania (part of VW corporation Tracton Group). Siemens would have liked to use high voltage to provide 10-12MW, however road regulations only allow low voltages, restricting power. A catenary erected over 5km of the inside lane on both sides of the number 5 motorway heading south delivers 670V DC bi-polar.

The system, and several prototype goods vehicle towing units, were launched on 7 May to coincide with the ERS conference. The primary purpose of the demo and research is to show that ERS can work alongside conventional traffic on a motorway carrying 400,000 vehicles per day. The Frankfurt project is run by a consortium called ELISA which translates as 'Electrified, Innovative Heavy Freight Transport on Highway'. As the catenary system can carry 600A, the concept is that 400A is for propulsion, while the rest charges the onboard battery. However, these figures are shared by all the vehicles occupying the same 2.5km substation, so sharing the space with three means 133A for driving and 67 for charging.

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The prototype tractor is powered by a 350kW diesel engine supplemented by a 260kW electric motor; it also carries a 150kWh battery. VW, the vehicle designer, admits that such a vehicle needs at least 330kW to tow effectively.

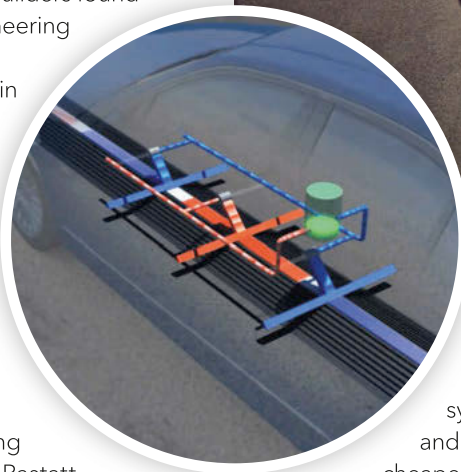
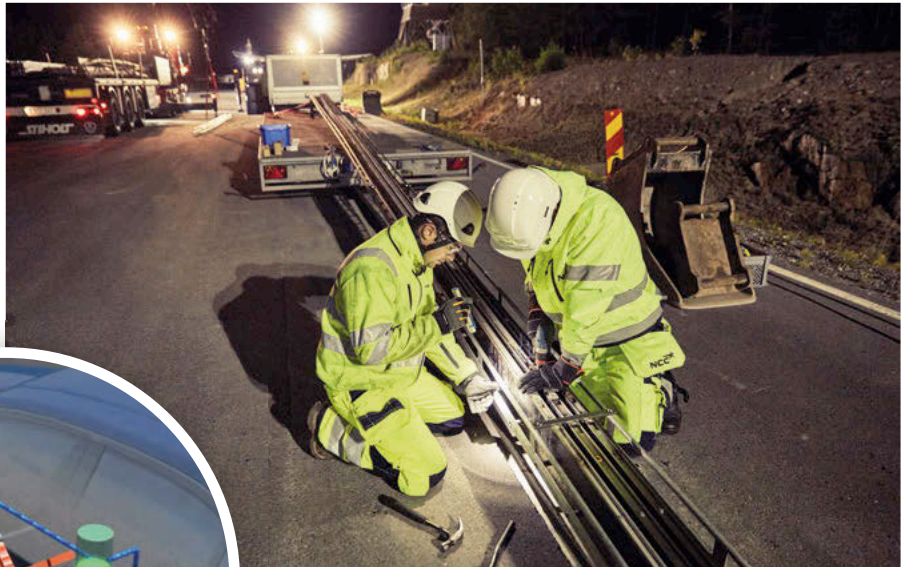
An identical system is being built 60km north of Hamburg on the number 1 motorway in the direction of Lubeck. Here, the consortium is known as eHighway. Builders found combining road engineering with rail electrification challenging, resulting in the launch date being delayed.

The third trial in Germany is being carried out in the southern state of Baden-Württemberg under the consortium eWay-BW. The route follows the A 462 along the river Necker from Rastatt North to Hilpertsau, 18km away.

The system is almost identical to that being trialled in Sandviken, Sweden. In this case the challenging route follows the rise and fall of the Black Forest landscape, as well as negotiating towns and tunnels. The route is planned to be ready in 2020.

### ASIA

Honda appears to be the only Japanese firm looking at ERS. Here the emphasis is on high speed (up to 150km/h) and dynamic charging. Currently the system is only installed on Honda's Motegi F1 R&D facility; another is being built at Japan's Automobile Research Institute. According to a presentation made by Takamitsu Tajima, Honda is still exploring the options for the ultimate ERS system. Today, the 375m test circuit provides a vehicle with 450kW using a 750V DC side arm that touches an electrified track in the crash barrier. A considerable



amount of effort has gone into learning from other ERS system mistakes, and developing the cheapest, most effective system. One interesting feature

is the mono-pole 750V DC track; unlike many other ERS systems, Honda earths the other DC pole.

In ERS, China remains an unknown quantity. The lack of information exchange between China and the rest of the world means that very little news on technical innovations reaches other countries. Chinese development companies also have the tendency to develop as they build. Of significant importance is the official announcement by China that Zhang Jianjun, China's most successful and productive bridge building project director, has been appointed to lead the Chinese Highways' Smart and Electric Transformation. In 2018 he managed a budget of US\$1.3 trillion.

It does seem clear that China will not waste any time or money on 20th century technology like trolley bus systems or any device that relies

on physical contact to transfer ERS energy. Instead China will focus entirely on induction energy transfer ERS. Meanwhile, ERS roads and motorways have been appearing spontaneously all over China.

### CONCLUSION

Electric vehicles' charging problems can be resolved by ERS. Li-ion batteries have very poor power densities at 0.25kWh/kg, and take a long time to safely charge. Even with a step change in batteries' power density to 2.5kWh/kg, battery technology is in third place behind hydrogen and ERS.

Such systems with physical connections are very expensive and will ultimately become redundant as China paves the way in dynamic induction vehicle charging. **TE**

### ABOUT THE AUTHOR

Tim Wynne-Jones is an operational excellence and supply chain management consultant with 35 years' industrial experience. He has supported many international automotive and railway firms in technology and quality breakthroughs.