Siemens researchers are examining methods for the future electrification of road freight at a 1.5-kilometer test track at a former Soviet airforce base north of Berlin.

Ready to Roll

Siemens is using an old airfield north of Berlin to test hybrid-electric trucks equipped with pantographs like the ones on streetcars. The trucks could be used between logistics centers and mines or ports. Heavily-traveled truck routes in urban areas are another possibility. Either way, the technology could help to decouple rising freight traffic volume from carbon dioxide emissions.

Every day, Jörg Grützner is a witness to the ironies of history. A former long-haul trucker, Grützner climbs into the cab of an 18-ton truck and looks out on a runway that cuts right through the pine forest in the Uckermark region of Germany, some 80 kilometers north of Berlin. The irony is that Soviet bombers used to take off from this very spot until around 20 years ago.

But the Russians have gone home and the new civilian tenants of the giant military airfield have put the facility to an entirely different use, transforming it into safety proving grounds and adding a racetrack. What's more, Europe's biggest photovoltaic park is now being built where ammunition depots once stood, and the former military security zone around the airfield has been transformed into the Schorfheide biosphere reserve. "The Russians never let us get close to this place before," Grützner, 55, says with a obvious satisfaction. "But today I'm cruising around on their runway."

Grützner has been driving trucks for over three decades. But for the past year he's been working exclusively at the former airfield as a test driver in ENUBA (Electric Mobility for Heavy-Duty Commercial Vehicles as a Means of Reducing Environmental Pollution in Major Metropolitan Areas), a pilot project that is being jointly conducted by Siemens and Germany's Environment Ministry.

Since the project's inception in July 2010 Siemens engineers have been examining methods for the electrification of road freight traffic. To this end, they have crossed a streetcar with a truck in order to combine the best of both worlds — an electric drive system and the flexibility of a road vehicle.

Tests are being carried out with two standard trucks fitted with standard hybrid drive systems. In this setup, only the electric motor is used to drive the axles. The motor obtains its electricity either from a generator powered by a diesel engine or from an overhead power line, as a streetcar does. Such a line now stretches above the former runway, which Siemens researchers have converted into an

electrified test track. The 1.5-kilometer route has two parallel catenary wires on the right shoulder. These are held in place by poles placed at 65-meter intervals. Engineers equipped the trucks with a new type of pantograph that docks automatically to the wires and is able to counteract the movements of the vehicles within the dedicated lane.

When a driver hits the brakes, the energy thus released is sent back into the overhead line as electricity that can be used by other vehicles in the system. "Unlike their counterparts in trains and trolleybuses, our pantographs are truly intelligent," says Dr. Michael Lehmann, the Technical Project Manager for ENUBA at Siemens' Infrastructure & Cities Sector. "Thanks to sophisticated sensor technology, the system always knows exactly when a truck leaves the electrified lane." If that happens, the pantograph automatically retracts — and can do so reliably at speeds up to 90 kilometers per hour. If the truck goes any faster, the motor automatically shuts down.

Drive System Interplay. Grützner hits the "gas." As soon as he does, the electric motor releases its 4,500 Newton meters of torque and the colossus with a payload capacity of 40 tons begins to glide effortlessly down the track. The only sound it makes is the steady rumbling of the diesel engine that runs at an optimal rotation speed and produces electricity for the electric drive. "The additional 500 kilograms for the hybrid drive hardly make a difference here," says Grützner. "This truck actually accelerates better than a pure diesel vehicle, and it also drives just like a normal truck." Grützner is quite relaxed behind the wheel. He and his colleagues have already clocked up nearly 9,000 kilometers with the new trucks — without any problems.

An electric truck's pantograph can be activated manually with just the push of a button or automatically. It docks to an overhead line and then retracts if the vehicle leaves the electric lane.

"Now I'm going to switch her over to electric power," Grützner announces as he moves his truck onto the section of the track outfitted with overhead lines. He taps a small device mounted on the dashboard that is used for operating the pantograph manually, although the system normally functions automatically. The pantograph rises almost unnoticeably and the diesel rumble disappears. At this point, the truck sounds like a swarm of bees as it rolls down the runway. Grützner hits the blinker and switches lanes; right after that, the pantograph retracts and the diesel engine goes back into action.

Germany's Environment Ministry (BMU) would like to see such trucks on normal highways in the future — in the far right lane with an overhead line. This wouldn't be difficult to do, technically speaking, says Lehmann: "Integrating the system into the existing road network would be relatively easy, and its installation wouldn't restrict other vehicles in any way." More than anything else, the technology could help get the rising CO_2 emissions caused by road freight transport under control. Progtrans, a Swiss transport consulting firm, predicts, for example, that the volume of trucks on highways will continue to increase in the future. The company reports that freight transport (as expressed in ton-kilometers) in Germany alone will increase by 116 percent by 2050 as compared to 2005 levels. According to Germany's Ministry of Transport, nearly 3.4 billion tons of goods were shipped on the country's roads in 2011 — roughly eight percent more than in the previous year.

The expected increase in transport volume will be accompanied by a rise in annual CO_2 emissions, which are expected to climb from approximately 40 million tons today to 100 million tons in 2050 — unless major technological changes are implemented. Without such changes, the EU Commission target of an 80 percent decrease in CO_2 emissions by 2050 (as compared to 1990 levels) will become nothing more than a pipe dream.

The "tram-trucks" from Siemens could prove to be a promising option, according to the German Advisory Council on the Environment. The Council believes the technology could help decouple rising freight transport volume from greenhouse gas emissions. In its latest report, the Council recommended that all German highways with single-digit number designations be equipped with overhead power lines, which would amount to a total of 5,400 kilometers of electrified highways.

A Mixture of Solutions. Today's solutions, which call for building new rail lines, increasing drive system efficiency, and optimizing logistics systems, aren't enough to meet Germany's ambitious carbon dioxide reduction targets. An expansion of the rail network, for example, would mean that rail lines would not only have to absorb the projected increase in truck traffic but also existing highway freight traffic. This would require a fourfold increase in rail network capacity. What's more, the additional tracks would take up space that's not available in the densely populated areas where goods are ultimately consumed. According to a study conducted by Progtrans, the BMU, and the German Ministry of Transport, such measures would reduce annual CO_2 emissions to only about 60 million tons by 2050. But the EU's goal is to limit emissions to approximately ten million tons — a target that can be achieved only by electrifying road freight transport (see chart). Meeting that target, however, requires that the lion's share of the power for electric trucks must be produced from renewable energy sources, which is still a long way off.

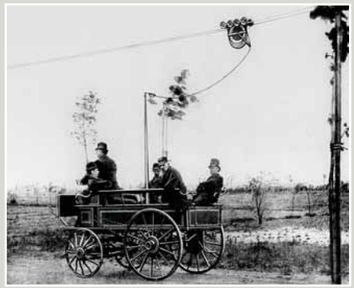
All told, implementing the new technology will take a lot of money. The German Advisory Council on the Environment estimates infrastructure costs at €1.1 million to €2.5 million per kilometer (including guard rails and overhead power lines). However, Siemens experts aren't thinking about electrifying entire highways. "We're initially examining well-traveled routes over short and medium distances," says Lehmann. "These include back-and-forth truck routes that have no rail connections — like routes between logistics centers and ports, or from mines to central storage facilities and transshipment centers." The "tram-trucks" could also play a major role in cities like Los Angeles, where the city government is looking for a zero-emission solution for Highway 710. This chronically congested 30-kilometer road runs right through the middle of Los Angeles, linking the city's port with its main logistics center. It is estimated that Highway 710 sees some 35,000 truck trips every day.

Pollutant emissions have reached such high levels that the air quality authority in LA has considered temporarily closing the road at certain times. Rail system capacity is also stretched to the limit — there's simply no room left in this crowded metropolitan area. Siemens experts therefore believe this is an ideal place to put ENUBA technology to work; they want to submit a tender to Los Angeles that would offer their electric trucks as a solution. To this end, the ENUBA team will set up an initial test system in LA in the near future.

Experts are also thinking of using the electric trucks in Sweden to shuttle cargo from an iron ore mine near the city of Kaunisvaara to a rail station 162 kilometers away. A rail connection wouldn't make sense here because the mining operation is only temporary.

Meanwhile, work continues in the Uckermark region. Scientists there plan to upgrade the test track by installing curves, overhead road signs, and electronic traffic control systems. The technology will then be optimized and tested under normal road conditions. Grützner, for his part, would also like to drive his electric truck outside the confines of the former airfield — and enjoy the quiet sound of the electric drive system for a few hundred kilometers. Doing so might be dangerous, however, as Grützner points out: "That smooth humming sound tends to put you to sleep after a while." *Florian Martini*

A Step Forward and a Look Back



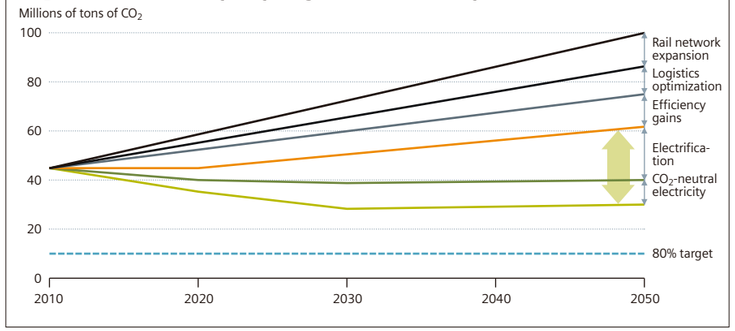
The ENUBA project in Germany's Uckermark region is taking Siemens scientists a step back into the future. It was nearly 130 years ago (and just an hour's drive away) that engineers began testing the grandfather of the ENUBA electric truck. On April 29, 1882, Werner von Siemens officially opened the world's first testing facility for an electrically powered trolleybus in the Halensee district of Berlin — just one year after the first electric streetcar entered service. The "Elektromote" (top left), as this first coach-like electric bus was called, itself had a history dating back even further, as von Siemens was already dreaming of an electric drive system as early as 1847. "If I ever have the money and the time," he wrote, "I would like to build an electric cab."

The first electric cars appeared at the beginning of the 20th century. In 1905, for example, the "Elektrische Viktoria" from Siemens began operating in Berlin as a hotel taxi. The rise of the trolleybus also began at this time. This new development was particularly useful for short-distance trips in suburbs and rural areas. Several inventors and companies came up with their own trolleybus concepts. One of them was an ex-Siemens employee named Max Schiemann, who got most of the electrical components for his trolleybus lines from his former employer. By 1913, Germany had a trolleybus route with a total length of 54 kilometers. Today such buses can be found in more than 300 cities worldwide.

The "tram-trucks" Siemens researchers are now working on are close relatives of the trolleybus. One big difference, though, is that the trucks are equipped with an "intelligent" pantograph that automatically compensates for vehicle movements. Engineers can already imagine doing away with the trucks' current diesel hybrid system. Also conceivable would be the combined use of an overhead power line and a fuel cell to drive the electric motor, which would allow the truck to drive completely emission-free in areas where no overhead lines are in place.

Electric Trucks Promise to Trim CO_2 Emissions

CO_2 emissions from heavy-duty freight traffic in Germany



Sources: BMVBS 2007, progtrans, estimates of the long-term development of freight traffic in Germany, 2005-2050, BMU — Renewable Energy in Germany, status in 2009, development of specific CO_2 emissions in the German electricity mix 1990–2008