

SIEMENS

Ingenuity for life



eHighway

Innovative electric road
freight transport.

[siemens.com/mobility](https://www.siemens.com/mobility)



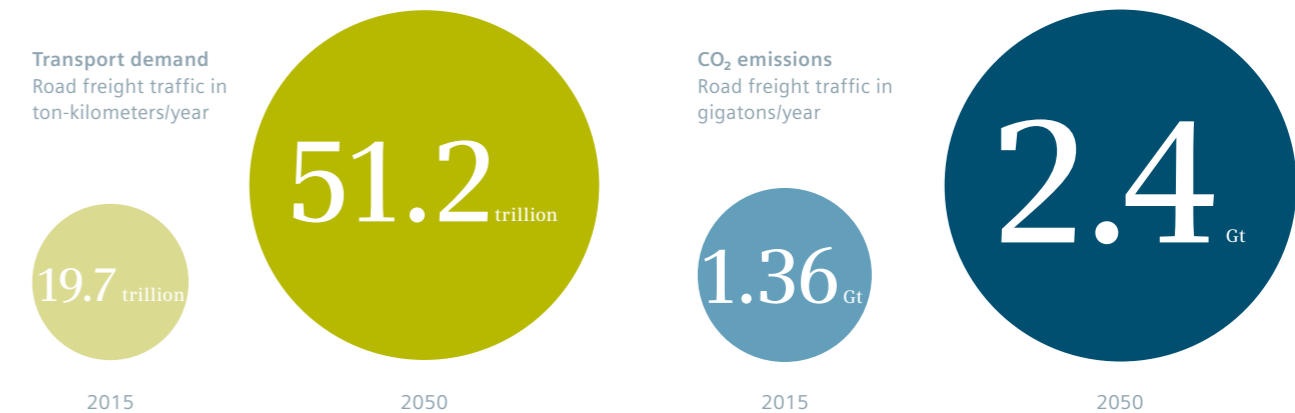
Road freight challenges

Transport remains the last sector where fossil fuel dependency has not been substantially mitigated, which makes it a leading source of green-house gas (GHG) emissions. Due to the expected growth in demand for transport, the International Transport Forum (ITF) estimates that global emissions from road freight transport will grow from 1.36 gigatons of CO₂ in 2015 to 2.40 gigatons by 2050. Furthermore, according to the ITF and other organizations, total emissions caused by surface freight transport are expected to overtake those of surface passenger transport.

To counter the trend of growing GHG emissions caused by road freight transportation and to achieve significant

reductions in line with defined climate goals, there are several policy options. Avoiding road transport and shifting freight to other transportation modes, such as electric rail systems, may provide an opportunity. However, road freight is anticipated to remain a large and faster growing segment of the transport system.

Solutions to improve its efficiency and performance of road transport are therefore essential in order to achieve the climate goals that have been set. Increased vehicle efficiency as well as the use of bio-fuels are options: but they do not provide the necessary impact considering the huge gap between predicted emissions and the reduction goals.



Source: ITF Transport Outlook 2017

Electrified solutions

Electromobility offers a variety of benefits, including improved local air quality, fuel diversification into renewable sources to reduce dependency on fossil fuels, and increased energy efficiency, that lower operating costs.

Given that several countries already have a very low carbon footprint for electricity, and that the global trend is toward the decarbonization of power generation as part of the climate change mitigation measures, it makes sense to explore solutions that utilize electricity for freight transport.

The main obstacle to use batteries for electrified road freight has been the size and weight required for on-board storage of electrical energy. Contrary to an application in passenger cars operational aspects such as cycle times, transported loads and distances driven, constitute significant hurdles when it comes to the use of battery solutions for heavy duty vehicles and long haul applications. In addition, there is the challenge of charging such batteries

in an acceptable period of time, without damaging the battery or disrupting the grid.

Another way to utilize renewable electricity in road freight transport is through electrolysis to create hydrogen for either the use in fuel cells or as basis for liquid or gas based fuels. However, any conversion of energy is associated with notable losses and consequently negative impacts on the well-to-wheel efficiency. This in turn significantly increases the requirement of renewable energy input and thus the required investments.

These problems can be solved by providing electrical power directly and conductively to the vehicle while it is driving. Losses are limited to conventional electricity distribution and the on-board power electronics and the outstanding efficiency of the electric machine can be utilized to full extent. This advantage in system efficiency translates into significant benefits in operating costs.

Hybrid-drive technology and smart power supply

The eHighway combines resource-efficient railway technology with the flexibility of road transport. The eHighway adapted hybrid trucks are supplied with electricity from overhead contact lines via an active pantograph, which can connect and disconnect with the overhead contact line at speeds up to 90 km/h.

The eHighway system – Safe, reliable and efficient



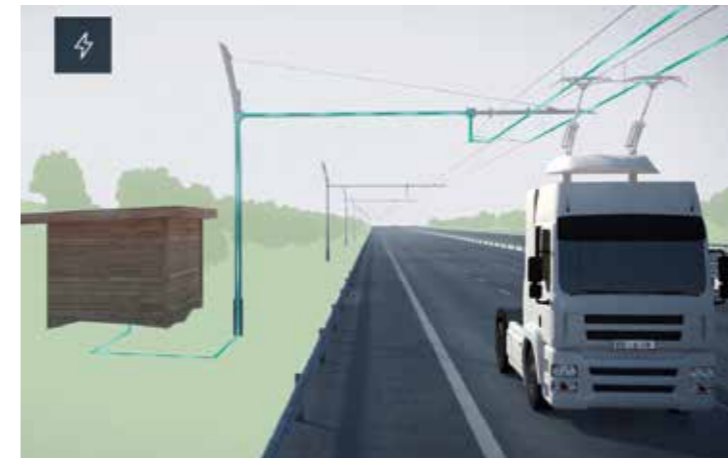
The direct transmission of electric energy safeguards an outstanding efficiency: 80 to 85 percent from substation infeed to the wheel. This is twice as high as that of conventional diesel engines. The eHighway also makes it possible to recover braking energy and store it on-board, feed other trucks on the system or even let the electricity flow back into the public grid. These energy savings translate into even higher system efficiencies, lower emissions, and lower energy consumption.

When implemented on routes with sufficient traffic volumes, the savings can cover the cost of investment

while providing healthy returns. Such densely trafficked routes are especially sensitive to disruptions, therefore the eHighway system is based on proven, reliable, and open-standard contact-line technology that does not interfere with the road surface. This minimizes disruption during installation, operation, and maintenance of the eHighway, and allows road operations to continue as usual. By using long sections of proven contact-line technology, the lifetime cost of the infrastructure can be kept low and stable. A study by the German Federal Environment Agency (UBA) found that an overhead contact line system constitutes an essential backbone of the most economical solution for carbon neutral long-haul road freight, when comparing all options. An additional operating cost reduction comes from reduced truck maintenance expenditures.

In collaboration with the Technical University of Dresden and the Federal German Highway Research Institute (BASt), an elaborate analysis of traffic- and road-specific aspects influenced by the introduction of an eHighway System was performed. This research examined safety issues as well as the adjustment of the electrification infrastructure to a wide range of road conditions such as bridges, tunnels and gantries. The performance of the eHighway truck, the energy supply, the connection to the grid, and the maintainability of the system as a whole have also been tested. All components of the electrification infrastructure and the hybrid drive of the eHighway-adapted truck were proven to be reliable and user-friendly. The eHighway system is well-prepared to face the challenges of road freight transport. This came to good use as eHighway sought approval by the Swedish Transport Administration (Trafikverket) for a demonstration project on a public road. Approval was granted without exceptions and within the existing regulatory framework.

How eHighway works



Power supply and distribution

A constant power supply is guaranteed by the substations along the eHighway. For power distribution to the hybrid trucks, a specially designed two-pole contact-line system ensures a secure energy supply even at speeds reaching up to 90 km/h.

Active pantograph

The key innovation of the eHighway system is the active pantograph. It can connect and disconnect the vehicle to the contact lines at all speeds. The pantograph transfers energy directly from the overhead contact line to the electric motor of the eHighway adapted truck. A specially designed sensor technology allows the movable pantograph to automatically adjust its position under the contact line to compensate for lateral movements of the truck in the lane. The mechanism also minimizes wear across the pantograph to ensure a long lifespan.



Hybrid drive

The eHighway truck's hybrid drive system enables its full electrical operation within the electrification infrastructure. It also ensures flexibility by switching between electric and hybrid modes when overtaking, to bridge non-electrified parts of the road, and to cover the first and last mile of each journey. The eHighway system is compatible with and complementary to other alternative fuel technologies and open to adopt a variety of hybrid configurations such as parallel or serial concepts and combinations with on-board energy storage. During braking the electric machines act as generators, which allows otherwise unused braking energy to be fed into the on-board energy storage or back into the grid to be used as needed by other trucks on the eHighway.

Realization and applications

Proof of concept and test track

The first demonstration track of the eHighway system has been in operation since 2010 on a private road outside Berlin and until now three research and development projects partly funded by the German Federal Ministry of Environment, Nature Conservation, Building and Nuclear Safety (BMUB) have been successfully executed. The proof of the concept was achieved on this 2.1 km test track with realistic highway conditions, which enabled further development and testing: for example, tests as integrated part of a development cooperation with the global truck manufacturer Scania



Electrified shuttle transport

For the near and mid-term, the system will demonstrate its benefits in shuttle applications with a high volume of truck transportation. The eHighway is an ideal solution for high frequency shuttle transport over short and medium distances like for example the connections of ports with logistics centers. This leads to lower fuel consumption and longer lifetime as well as a reduction of air and noise pollution in these areas.



World's first eHighway in operation in Sweden

In June 2016 the world's first eHighway was opened on a public road in Sweden. For two years, a Siemens catenary system for trucks is being tested on a two-kilometer stretch of the E16 highway north of Stockholm. The trials are executed with two diesel hybrid vehicles manufactured by Scania and adapted, in collaboration with Siemens, to operate under the catenary system. As part of the demonstration, the trucks are used by a trucking company carrying cargo for paying customers. The project is amongst others funded by the Swedish Transport Administration (Trafikverket) and aims to evaluate options for Electric Road Systems prior to introduction on the Swedish road network.



Electrified mine transport

Another application for the near and mid-term involves the connections between mines and storage or transit locations. This echoes the development of rail electrification, which began in mines before eventually spreading to broader and longer-distance applications. An electrified mine transport is an economical solution allowing at the same time the minimization of harmful emissions and therefore a sustainable and clean mine operation.

Port demonstration in the U.S.

A public road demonstration of the eHighway system in Southern California includes several trucks, one of which is being provided in collaboration with Mack, a brand of the Volvo Group. The hybrid trucks in this project are equipped with various alternative fuel technologies, like for example a LNG-hybrid and a fully electric truck. Using a one-mile-long road (1.6 kilometers) with contact lines going in both directions, it will collect data and evaluate the benefits of eHighway operations for Southern California, especially for the intensely used road freight operations connecting the nearby ports of Los Angeles and Long Beach with local rail yards. Here the potential of reducing local air pollution is a major motivator for realizing the project.



Electrified long-haul transport

With the design of its infrastructure and the innovative vehicle components, the eHighway system can make a significant contribution in addressing the difficult challenge of economically decarbonizing long-haul transport. In order to achieve the environmental goals and reduce CO₂ emissions, road freight transport requires a fundamental global shift from fossil fuels to alternative drive technologies. Siemens is a leading pioneer in this field, and is providing not only the technical solution for the electrification of freight transport but is also demonstrating a strategic approach achieving a large-scale implementation on highway systems where substantial cost savings for freight carriers can be achieved.



Siemens AG

Mobility Division
Otto-Hahn-Ring 6
81739 Munich
Germany

www.siemens.com/mobility/eHighway
contact.mobility@siemens.com

© Siemens AG 2017
All rights reserved

Printed in Germany
PUB 73/41958 313701 PA 06122.
Dispo No. 22300 K No. 686
Order No. MOMM-B10004-00-7600

Photos copyright Scania AB & Siemens AG

The information in this document contains general descriptions of the technical options available, which do not always have to be present in individual cases. The required features should therefore be specified in each individual case at the time of closing the contract.