

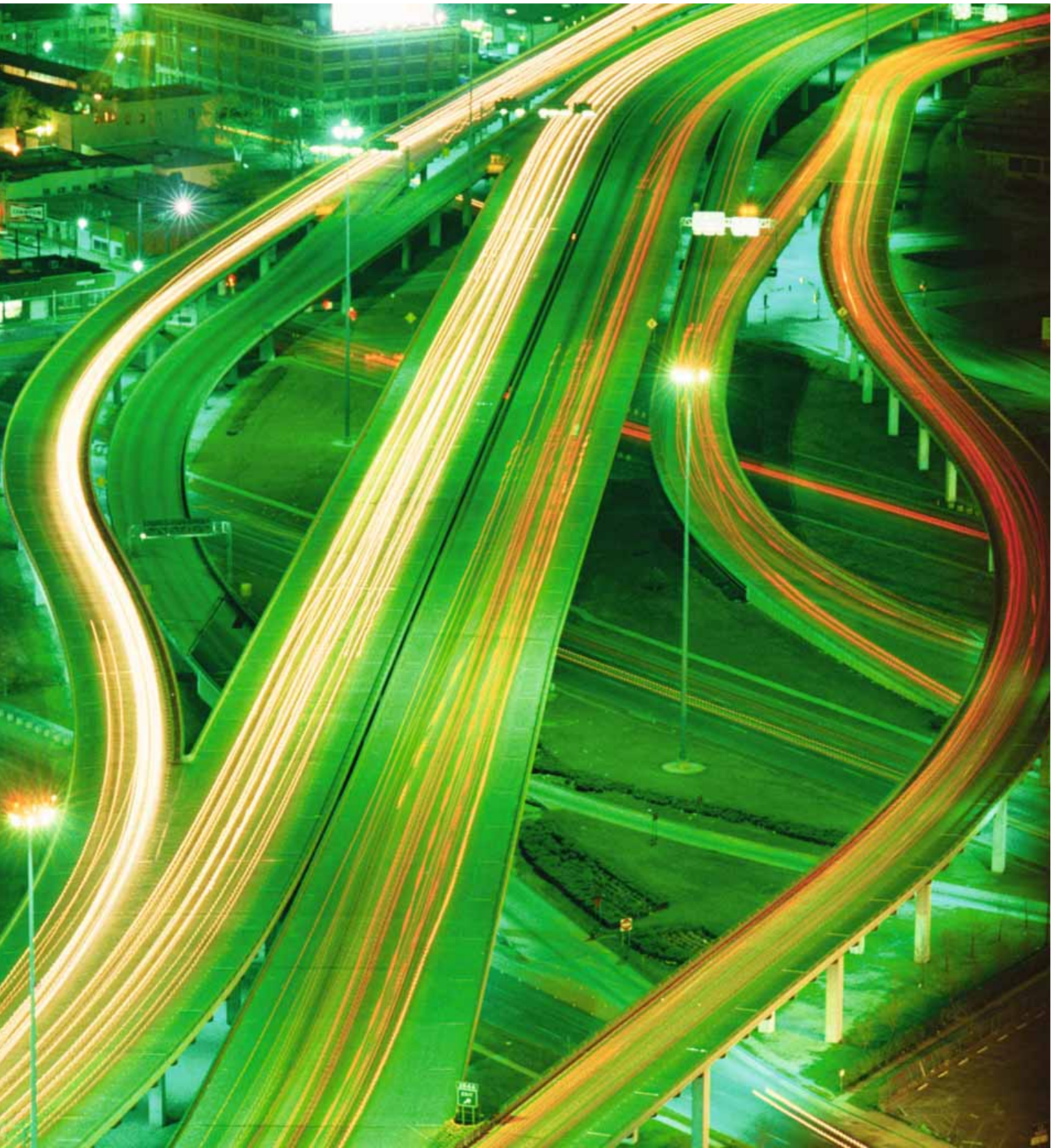
The image shows two white Mercedes-Benz trucks driving on a road. Above the road, there is a complex system of overhead power lines and support structures, characteristic of an eHighway. The trucks are positioned in the center of the road, and their headlights are on. The background is a clear sky, and the road stretches into the distance.

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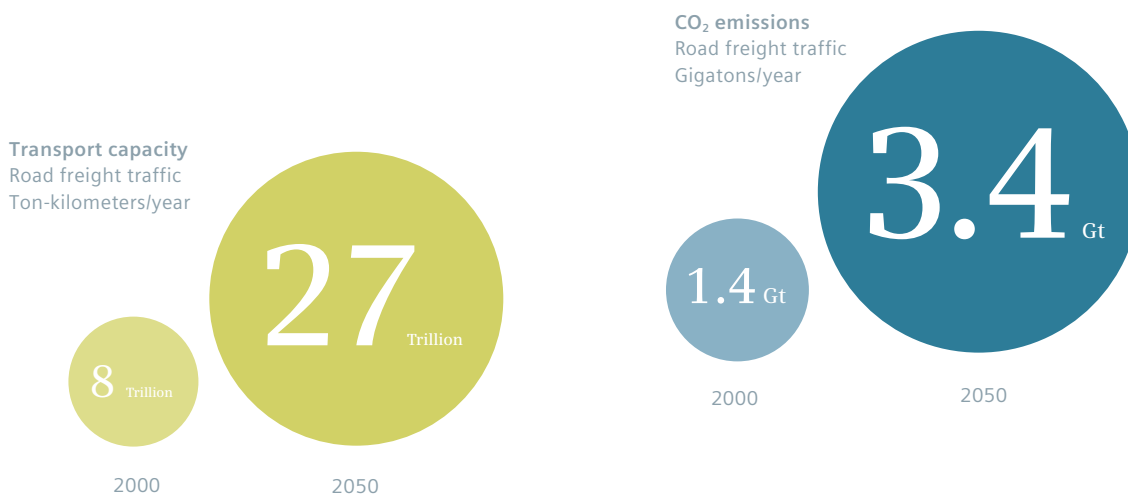
# Into the future – with eHighway

Innovative solutions for road freight traffic



# Vision of electrified freight traffic

Demographic change, urbanization, and climate change: These are the global trends of today and tomorrow. By 2050, the earth's population will reach approximately 9 billion. People will need efficient transportation and logistics solutions. Our approach: electrification of road freight traffic as a means to conserve resources.



## By 2050:

### 200 percent more transports on the highways worldwide

International freight traffic continues to increase:

The World Business Council for Sustainable Development (WBCSD) predicts that transportation services will triple worldwide between 2000 and 2050. In the future, only one third of this additional freight transport can be handled on the railways, despite a significant expansion of the rail infrastructure. This means that the largest proportion will have to be transported on roads. As a result, experts expect global CO<sub>2</sub> emissions from road freight traffic to more than double by the year 2050.

## Scarce resources,

### rising crude oil prices

Heavy dependence on oil and the unpredictable development of diesel prices have already made a significant impact on the economy and transport. Forecasts indicate that the global peak oil could possibly be reached in the near future. Innovative concepts for passenger traffic already exist – now it is time to provide a cost-effective alternative to fossil fuels for transport of goods on the highways.

## The solution:

### electrified road freight traffic

Electromobility offers a sustainable solution: The electrification of road freight traffic will enable significant reductions in CO<sub>2</sub> emissions and also ensure a sustainable energy supply. The major benefit: Electricity can be generated in many different ways – through conventional power plants as well as from renewable sources.

# eHighway is the road to the future

Siemens is developing an economical and environmentally sustainable solution for road freight traffic

This is how electric trucks will become a reality in the future: Based on proven technologies, Siemens has developed a solution – eHighway – that, with a reasonable investment, can establish the foundation for environmentally friendly, sustainable, and cost-effective road freight traffic.



### One concept – three core components

- Hybrid drive technology as well as strengthening the drive train for continuous supply with electrical energy
- Continuous power supply of hybrid vehicles through overhead contact lines, based on proven technologies from the field of railway technology, including regenerative braking to feed electrical energy back into the energy grid
- Intelligent pantographs to transmit the electrical energy from the overhead contact lines to the vehicle

### Power supply via overhead contact lines

eHighway combines resource-efficient railway technology with the flexibility of road transport: The eHighway trucks, which are equipped with hybrid drives, are supplied with electricity via overhead contact lines. A scanner constantly monitors whether the lane is equipped with an overhead contact line, and an adaptive pantograph establishes contact with the overhead contact line. This ensures that eHighway trucks can be used just as flexibly and universally as conventional trucks – because on roads that are not equipped with overhead contact lines, they are powered by their hybrid motor.

### Low infrastructure costs and fast implementation

The eHighway system can be completely integrated into the existing infrastructure – the only thing that changes is the type of engine for the vehicle. As a result, the usual operations stay the same for drivers. In general, the “road infrastructure” already exists and can be expanded cost-effectively to become an eHighway.

### Fewer emissions with more efficiency

Environmentally friendly electric drives can power trucks without emitting CO<sub>2</sub> or pollutants such as nitrogen oxide and particulates. Electric operation is not only clean, but efficient as well. An efficiency level of approximately 80 percent is achieved. The overhead contact lines allow vehicles to feed braking energy back into the grid. Then power can be used by other trucks, for example.

### Cost-effective solution for freight forwarders

Electrification can significantly reduce the overall costs associated with the operation of a typical freight traffic truck. The increased efficiency of an eHighway truck, the long lifetime of electric motors, and particularly the independence from expensive fossil fuels enable freight forwarders to achieve significant cost savings.

# Intelligent technology for clean efficiency

Fuel-efficient drive and smart power supply without being tied to a track

Electric vehicles are no longer a novelty in the passenger car market. In contrast, the field of heavy-duty commercial vehicles is still waiting for an alternative technology. In an initial field trial, Siemens combines the best of two worlds in a groundbreaking solution: railway technology that conserves resources coupled with the flexibility of road transport.

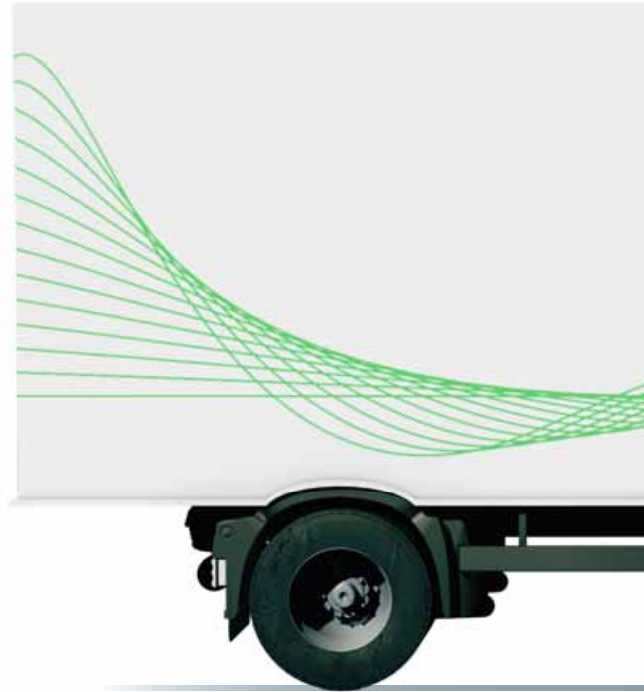


## Two-pole contact line system

Similar to trolleybuses, the contact line system is designed as a two-pole system to handle power infeed and outfeed – because, unlike railway technology, the current return circuit cannot flow via the road. Specially designed overhead contact lines are installed to ensure a secure energy supply even at speeds of up to 90 km/h.

## Efficient power supply system

A power supply station in a container provides a constant energy supply to the overhead contact line. In addition to medium-voltage and DC switchgear, a power transformer, and a rectifier, it is equipped with a controlled inverter for the feedback of the vehicle's electrical braking energy.





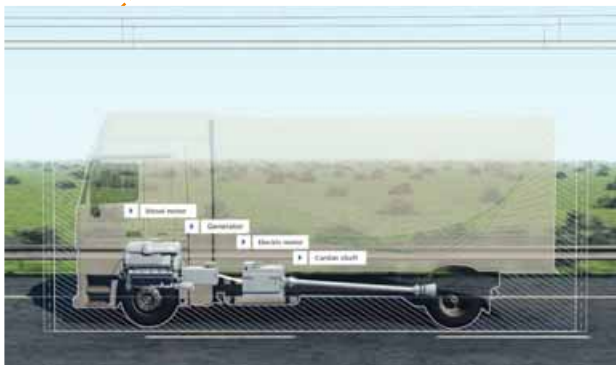
### Active pantographs

Through pantographs, energy is transmitted directly from the overhead contact lines via the power electronics to the electric motors of eHighway trucks. The movable pantographs make it easy for vehicles to connect to and disconnect from the overhead contact lines at speeds up to 90 km/h and automatically compensate for position variations in the lane. In addition, the mobility minimizes the wear at any one point on the pantographs, thereby ensuring a long life.



### Flexible control

As soon as the scanner detects an overhead contact line, the pantographs are ready to connect and, depending on the operating mode, can be extended automatically or manually by pressing a button.



### Hybrid drive

eHighway trucks are equipped with hybrid drive systems whose main components include a generator, rectifier, buffer, converter, and drive motor. A dieselelectric hybrid drive was tested during the course of the field trial; the performance of the diesel-operated combustion engine is transferred to the generator on non-electrified roads in order to drive the downstream electric motor and, with that, the cardan shaft. On electrified roads, the truck can be powered electrically via the live overhead contact lines. The hybrid drive system helps to significantly reduce energy consumption. During braking, the motors act as generators, which allow otherwise unused braking energy to be fed back into the grid and used as needed by other eHighway trucks.

# From the drawing board to the test track

## eHighway trucks show clear results in field trial

Siemens eHighway is more than just a theory: Working with and supported by the German Ministry for the Environment, Nature Conservation and Nuclear Safety, Siemens has conducted a field trial to test the first two modified eHighway trucks on a test track. The result: All objectives were clearly achieved.

### The ENUBA project

In view of the already relatively high levels of environmental pollution resulting from freight traffic as well as the projected growth of transport services, the ENUBA project (electromobility in heavy commercial vehicles to reduce the environmental impact on densely populated areas) examined alternative solutions for road freight traffic. For the study, Siemens developed evaluation models, prototypes, and the corresponding systems (electric truck, energy supply, road, and operating control points) and utilized them for the first time on a specially constructed test track.

### Objective

The mission of the ENUBA project was to determine whether the existing electrification technologies can be used for different applications in heavy freight transport on highways. In addition, the study examined the potential economic and environmental benefits of converting to an electrified freight traffic system.

### Technical results

Apart from the proven economic and environmental benefits, ENUBA provided highly promising results in terms of technology. In the field trial, the eHighway prototypes demonstrated full performance and suitability for everyday use – regardless of the weather, light conditions, and load. Thanks to innovative active pantographs, the electrified trucks demonstrated problem-free operation at speeds of up to 90 km/h. And with the usual flexibility: Thanks to the reliable connection and disconnection of the pantographs and automatic adjustments to movements within the lane, eHighway trucks are as easy to maneuver as conventional trucks.

### Outlook

Previous studies and trials have demonstrated that eHighway has the potential to provide an economical and environmentally sustainable solution for road freight traffic worldwide already in the midterm. The mission in the next phase will be to further develop the proven technology with an eye toward serial production. Siemens will cooperate with truck manufacturers to work on vehicle integration for pantographs and drive components as well as the development of suitable automation and control mechanisms for the entire system.







# Electrifying possibilities

Freight traffic with overhead contact lines offers a wide range of applications

eHighway offers significant benefits, particularly in situations where it is not possible to shift a sufficient volume of freight traffic onto the rails due to economic or space reasons. In addition to important long-haul traffic routes, this also affects other key logistical axes such as frequently used shuttle services in public spaces and the transport routes of pits and mines to transit locations.

## Electrified shuttle transport of goods

Siemens eHighway offers solutions for shuttle traffic over short and medium distances, such as connections between freight transportation centers and harbors. Large quantities of goods shipped on a daily basis are always transported over the same routes. This results in harmful emissions being concentrated in a very small area, causing significant pollution for people

and nature. The development of an eHighway system can significantly reduce these emissions and pollutants as well as the noise pollution for nearby residents. eHighway also offers economic benefits: less cost-intensive fuel consumption and a longer lifetime – with the same performance and operational capabilities offered by conventional trucks.



### Electrified mine transport

Siemens eHighway opens up new possibilities for connecting pits and mines to central storage and transit locations – particularly in areas where extraction sites do not warrant a separate rail connection. So far, exclusively diesel-operated transport frequently causes high levels of pollution in surrounding landscapes and residential areas stemming from nitrogen oxide, particulate, and noise emissions. The electrification of mine transport routes can minimize harmful emissions and reduce pollution. Mine operation can be conducted in a sustainably clean and economic way and remain independent of fluctuating crude oil prices.

### Electrified networks as a whole

With eHighway, Siemens offers an economically and environmentally sustainable alternative for road freight transport worldwide. The defined European target of an 80% CO<sub>2</sub> reduction can only be achieved with new solutions. Potential improvements resulting from the conversion of large road networks to an eHighway system were examined by the ENUBA project. The results? A significant reduction of CO<sub>2</sub> emissions and substantial cost savings for freight forwarders.



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