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eHighway

Sustainable Road Freight Transport

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eHighway status as of 2020

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- Installed on two sections of the German motorways
- Used in real transport operations
- With trucks from an OEM

eHighway truck technology –
From proof-of-concept to daily operation on motorways

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Development of the eHighway vehicle technology

2010 → **2019**

1st Generation
Proof-of-concept

2nd Generation
Swedish and US
Demonstration projects

3rd Generation
Field trials







Operations up to 100 km/h possible

Connection and disconnection to catenary in motion

Recharging of on-board energy storage while driving

No limitations for first and last mile

Catenary electrification is compatible with and complementary to other alternative fuel technologies

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The eHighway hybrid truck can be configured to suit specific applications

Truck types	Drive system	On-board source of electricity	Combustion engine	Non-electrical source of energy
Tractor truck (2 axles)	Parallel-hybrid	Battery (small)	Engine (small)	Diesel
Tractor truck (3 axles)	Serial-hybrid	Battery (medium)	Engine (medium)	Bio fuel
Rigid truck (2 axles)	Full electric	Battery (large)	Engine (large)	CNG/LNG
Rigid truck (3 axles)		Fuel cell		Hydrogen
Rigid truck (4 axles)				

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Rigid truck (4 axles)				

Showing combinations already realized in projects so far

Zero-emission trucks are possible with renewable energy, but efficiency varies greatly

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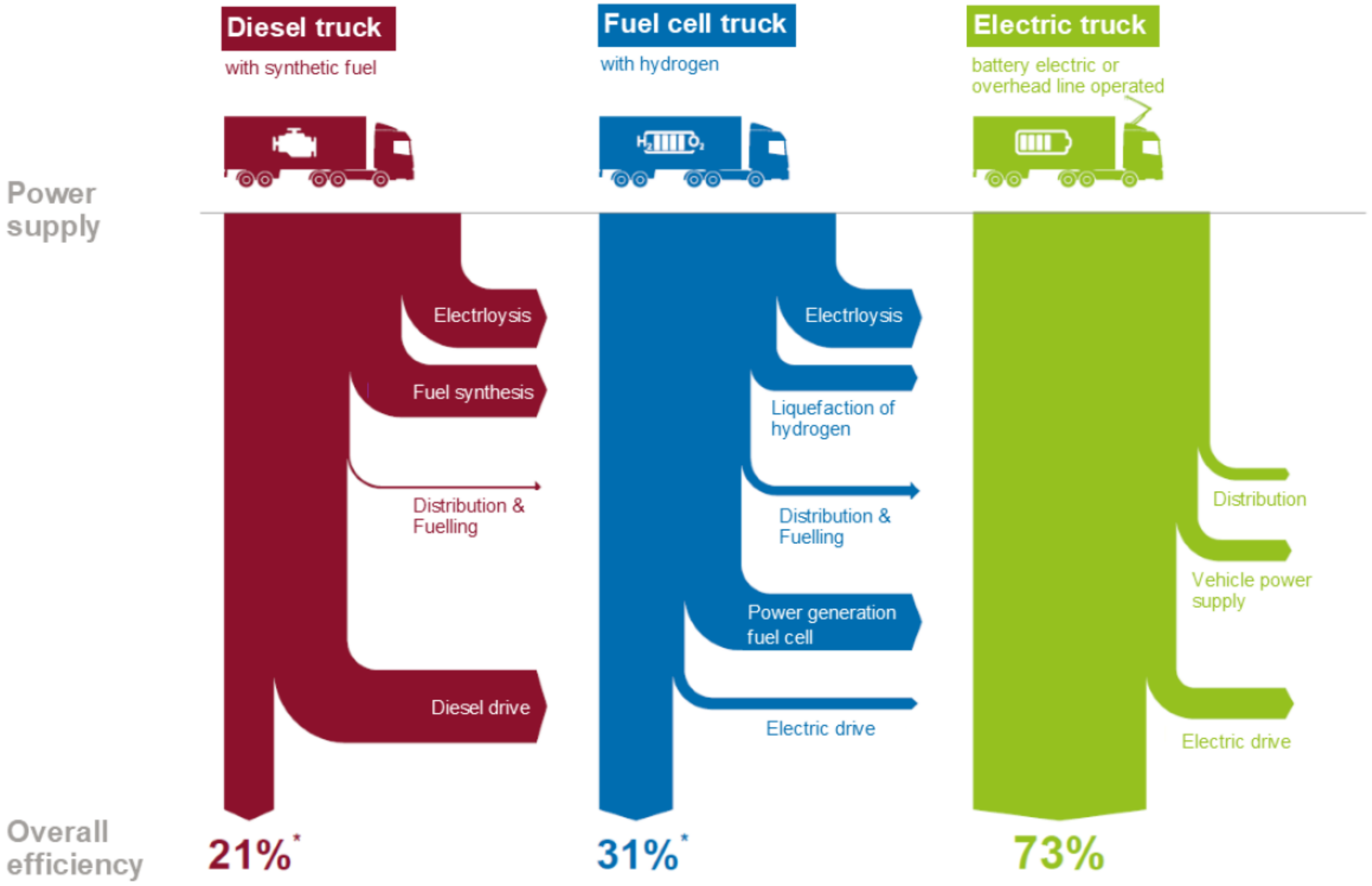

*in the exploitation of efficiency potentials in electrolysis, fuel synthesis and fuel cells

Source: Öko-Institut (2020) – StratON

Contact line trucks are the most cost effective carbon-neutral solution for German long-haul road freight

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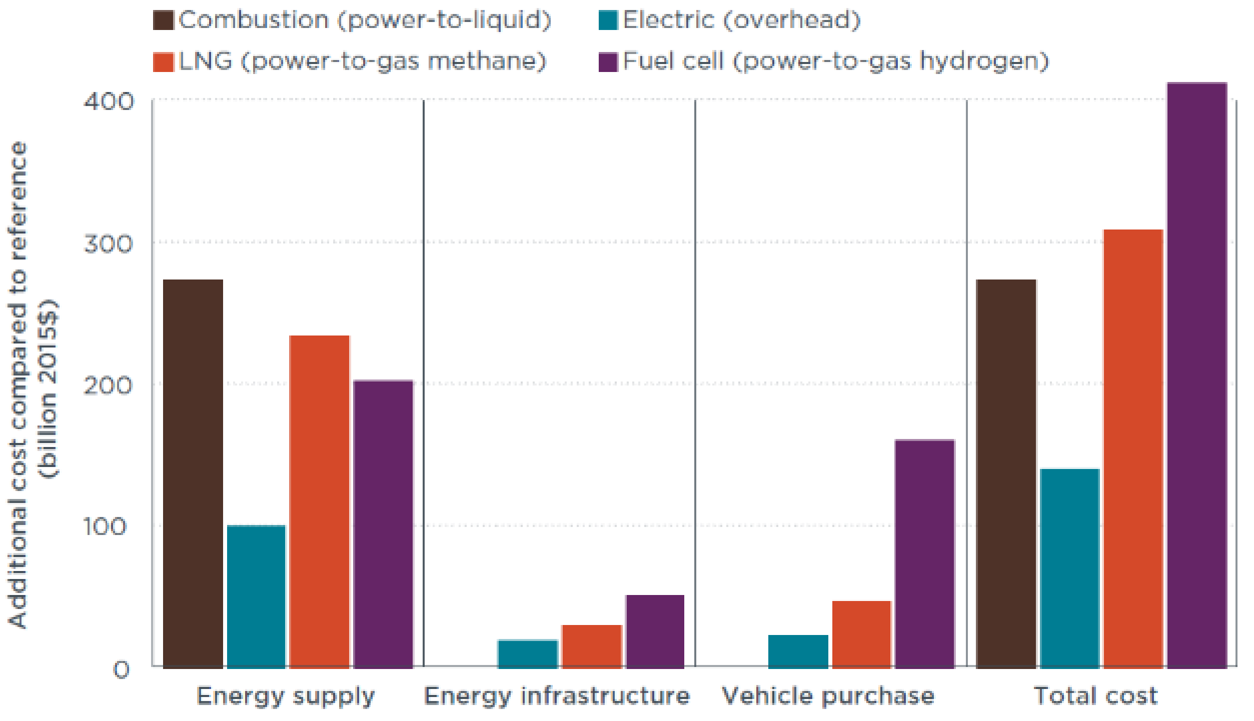

Figure 5. Additional cost for four different greenhouse gas reduction scenarios compared to the reference case (all fossil fuel use) for the long-haul heavy-duty freight transport sector in Germany (based on Kasten et al., 2016).

Key take-aways

- Cost of energy has the greatest impact on total system cost, so energy efficiency should guide decision making
- Up-front costs, like additional vehicles and infrastructure, also factor in, but too a much lower degree
- The cost of refueling (quickly) still deserves to be assessed carefully

Cost assumptions of the study

- Length of electric network: 4,000 km; Infrastructure costs: €2.2 m/km; Maintenance 2.5% of investment per year
- Additional vehicle costs: Per today €50,000/truck; per 2050 €19,000 per truck; share of direct electric traction: 60% in 2050

Source: ICCT – Transitioning to zero-emission heavy-duty freight vehicles (2017) page 23

eHighway is the backbone of a demand-oriented drive mix in heavy road transport starting with hybrid trucks

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Battery and Megacharger for distribution transport

Fuel cell trucks on non-electrified sections

eFuels to be added to the existing fleet

Overhead lines on most frequented motorway sections

The **high efficiency** of the eHighway system makes the interaction of the individual technologies the **most economical and sustainable solution**.

Climate goals can be achieved above all because the **direct use of electrical energy is already possible today**.
The overhead catenary for heavy trucks is the most energy-efficient solution.

Road map for eHighway in Europe: from early shuttles, to a network of infrastructure and catalyzing a zero-emission truck fleet

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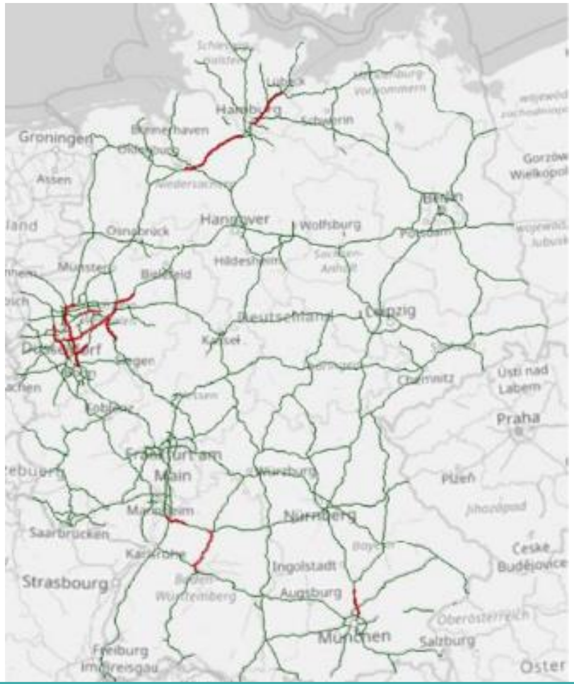

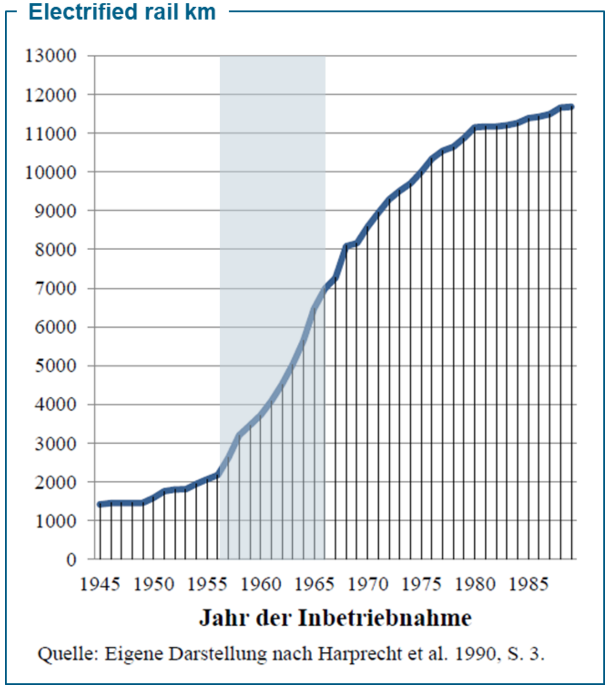

Pilots on shuttles routes	National Infrastructure network build out	Cross-border link up and zero-carbon fleet
• Each 20-100 km long and used by 100s of vehicles • Proves the entire system (e.g. including billing) commercially	• Connecting shuttles into a full national network • Possible important role of hybrids as users of partial infrastructure network	• Link into an European network • Fleet transition to zero-emission trucks accelerates as the network is expanded

Many countries showing interest in catenary and as the system spreads the economic gains will be even stronger

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Report by BDI found positive economic case for GER “island solution”. EU implementation brings large synergies and is even more beneficial

Enabling zero emission trucking on TEN-T corridors by 2050

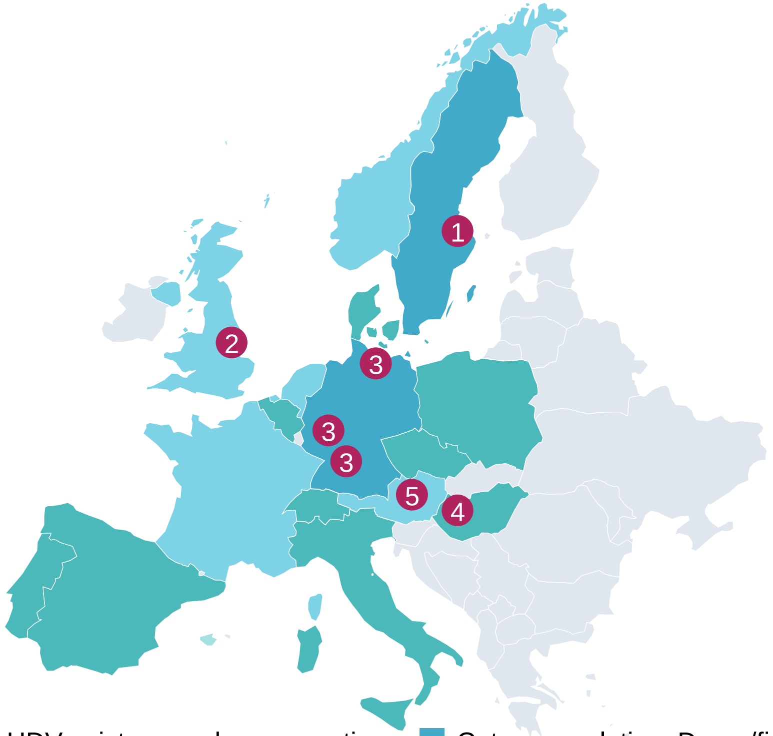
1 – Sweden
- Plans to start building 1,500 km electric highways by 2022

2 – UK
- Catenary pilot being considered by DfT

3 – Germany
- 2019 – 2024: Three fields trials on motorways A1 and A5 and national road B462 publicly funded by BMU €45.3 m
- Extension of catenary network part of climate protect. program 2030

4 – Hungary
- Transport minster keen on implementing pilot project

5 – Austria
- Federal Environment Agency considers catenary solution high potential measure to road freight CO_2 emissions
- Governmental program considers catenary solution for trucks



Interest in catenary solution exists | Study with regard to catenary solution for HDV exists or under preparation | Catenary solution: Demo/field trial realized or in preparation

International

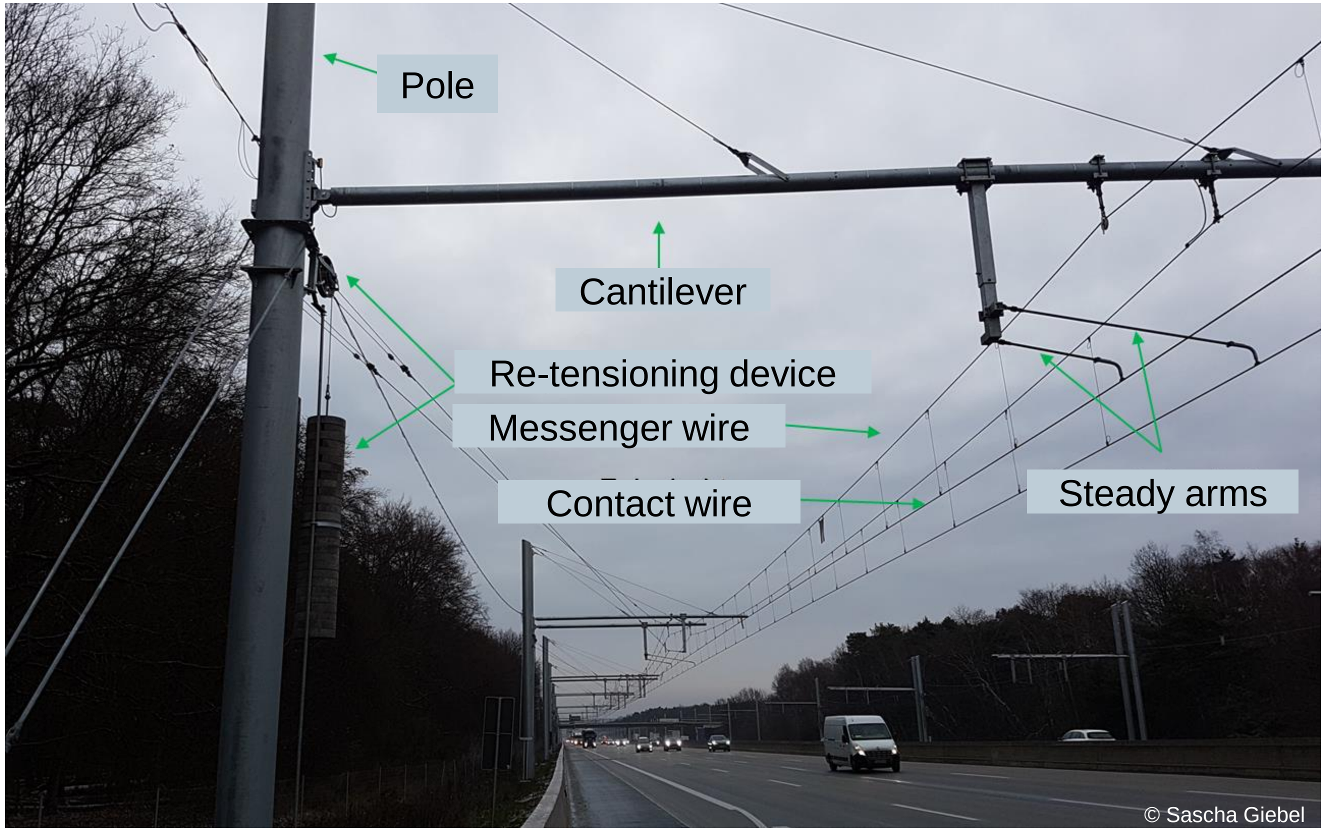
India
Minister for Road Transport and Highways Nitin Gadkari proposes plan to electrify India’s highways with catenary system

China
Deputy’s Minister for Transport is interested in the technology

USA
California study showed catenary to be the most economical solution for zero emission highway trucking

Realisation of eHighway (field trials near Frankfurt and Lubeck)

- Power distribution and supply via medium voltage network (10 kV to 30 kV)
- Substations feed the electrified sections with 670 V DC
- Infeed from the substation to the electrified section via underground cables
- Two contact lines (positive and negative) cantilever above the right lane
- Re-tensioning devices for constant tension of contact wire and suspension cable
- Supply of the track components via a suspension cable suspended from the mast
- Monitoring of the contact wire (CMS)



Realisation of eHighway (field trials near Frankfurt and Lubeck)

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Feed-in pole

Realisation of eHighway using the example of the field trial near Frankfurt (project ELISA)

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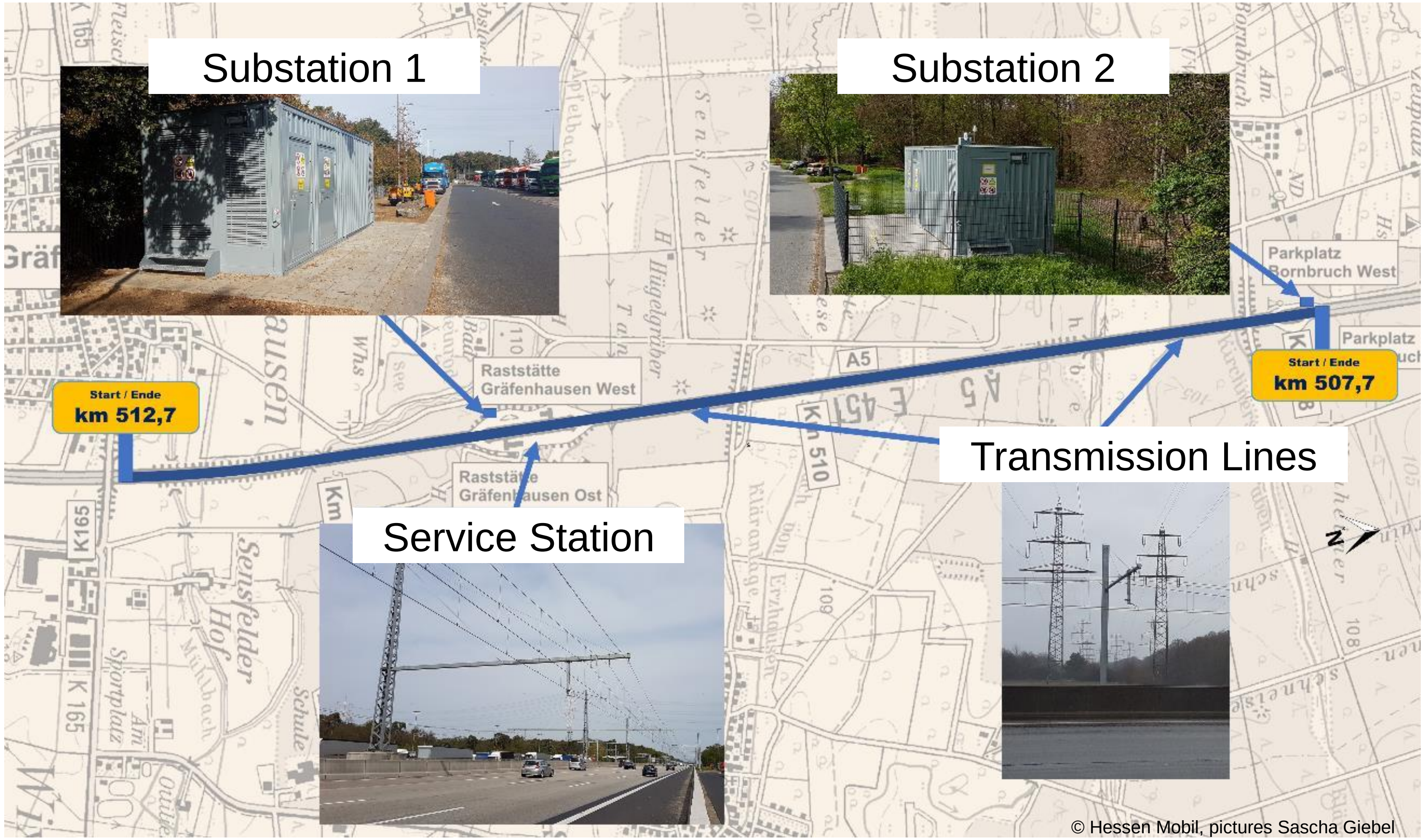
Parameter	Project ELISA
Medium Voltage 3AC	20 kV
Nominal Voltage DC	670 V
Nominal Power per Substation	1,000 kVA
Number of Substations	2
Length of Electrical section in each driving direction	5 km
Number of poles	223 + 6 Poles in Middle strip



Realisation of eHighway - project FeSH on motorway A1 near Luebeck, Schleswig-Holstein

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Implementation under a railway bridge with rigid catenary

Project eWayBW – National Road B462 near Gaggenau, Baden-Wurttemberg

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Special feature:
Inclined catenary design

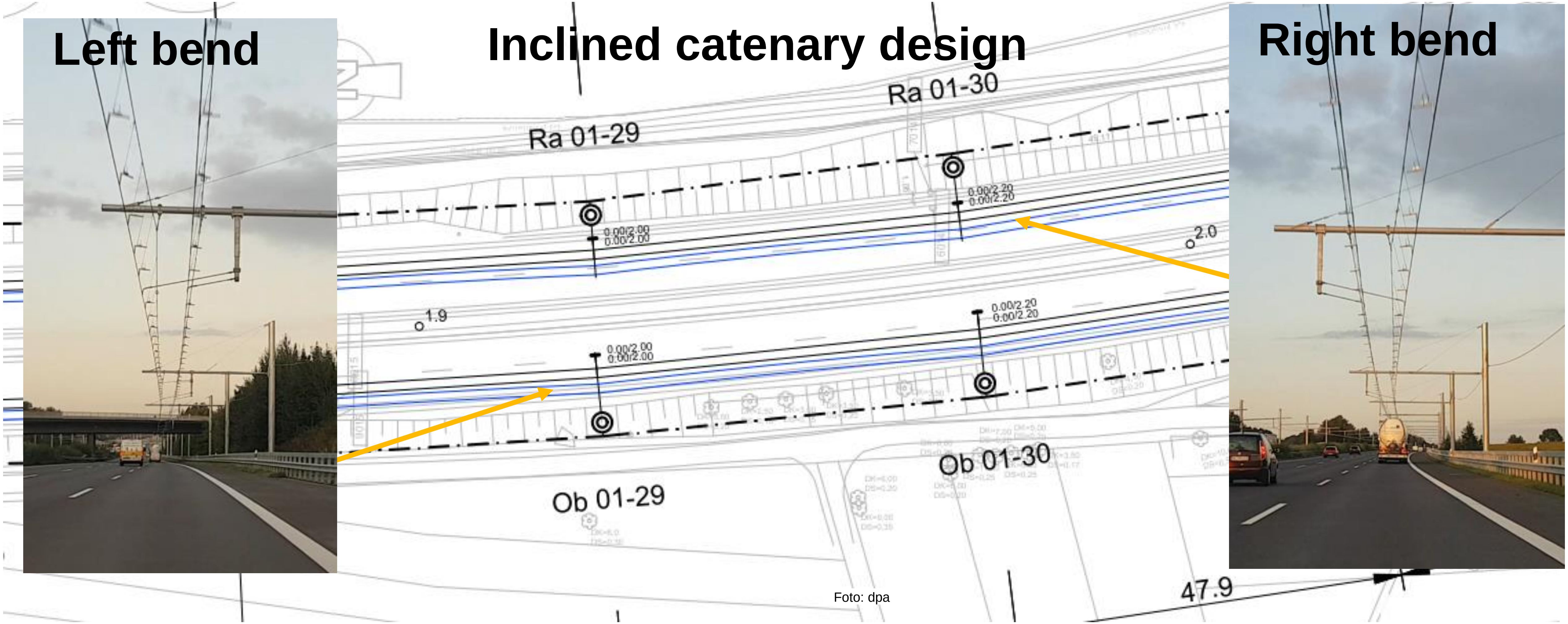

Foto: dpa

European interoperability for electrical road freight transport
Basic design criteria to be standardized

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eHighway vehicles
(industry-based domain)

- Traction voltage, tolerances, quality
- Pantograph requirements
- Electrical protection requirements
- EMC requirements

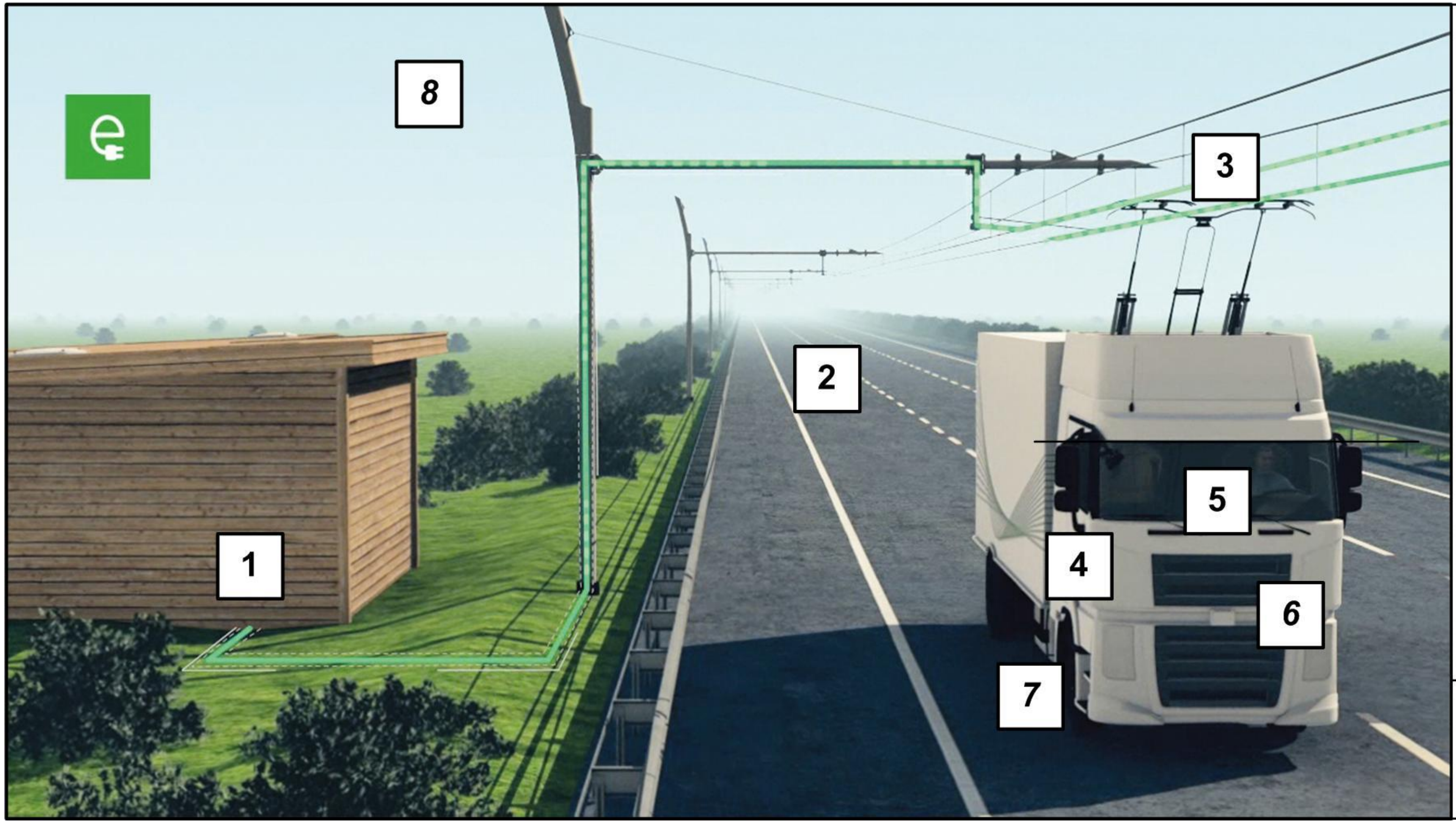
Inter-operability

Electrical Infrastructure
(railway-based domain)

- Traction voltage, tolerances, quality
- Overhead contact line geometry
- Electrical protection requirements
- Integration in public power networks

Similar criteria to be standardized for both subsystems. But in totally segregated domains.

European interoperability for electrical road freight transport
Subsystems and interfaces affected by standardization



#	interface
1	substation to overhead contact line (i. e. power supply to transfer)
2	contact line to road (power transfer to driveway)
3	contact line to panto-graph (power transfer to vehicle pick-up)
4	pantograph to electric drive (vehicle pick-up to hybrid base vehicle)
5	pantograph to driver/ truck cabin (vehicle pick-up to operation)
6	*vehicle to hybrid drive*
7	*vehicle to road*
8	*vehicle to OCC*

Organizations responsible for standardization / regulation eHighway to be allocated to the respective S&R-bodies

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1	substation to overhead contact line (i. e. power supply to transfer)
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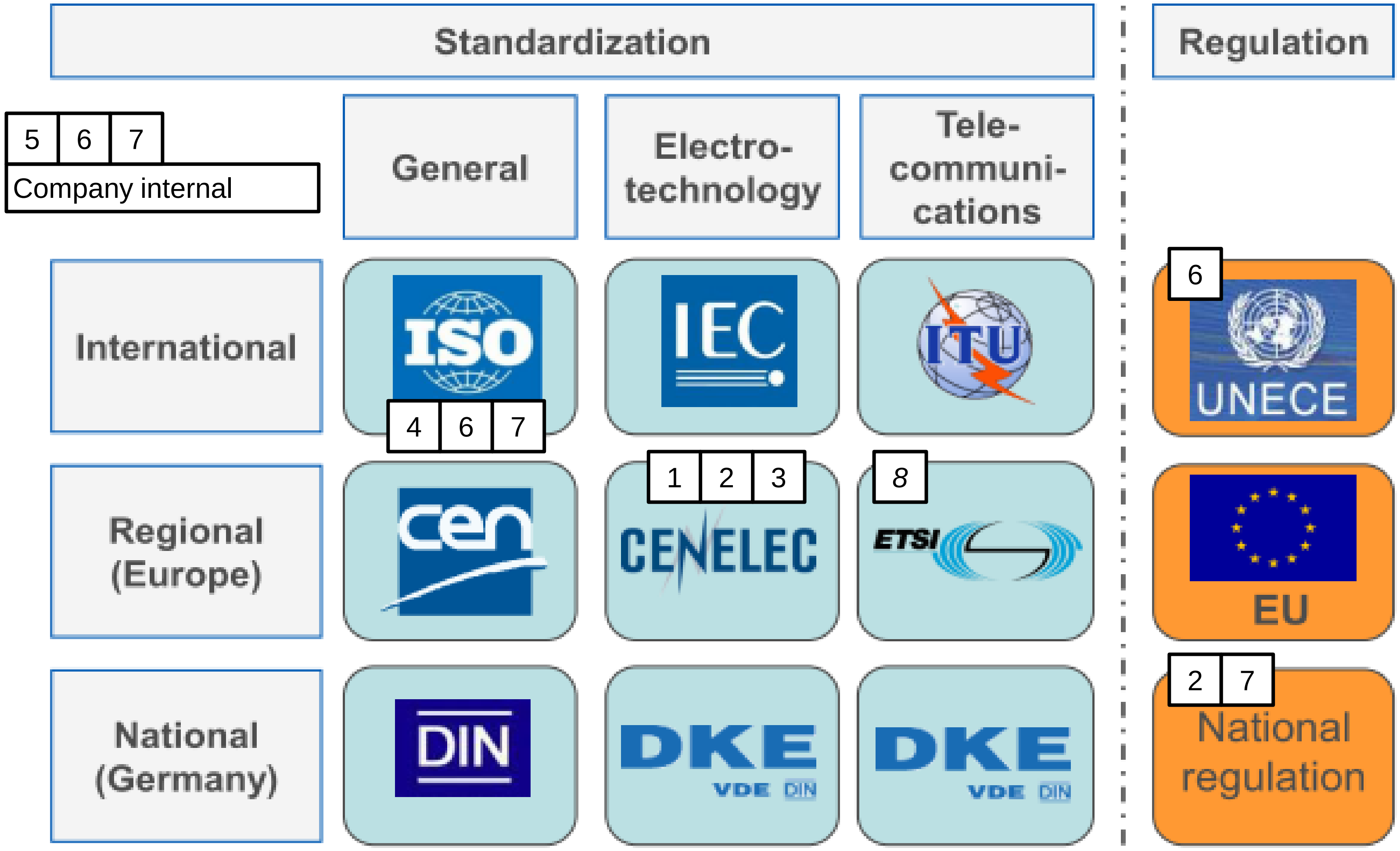

Standardization/regulation – current activities

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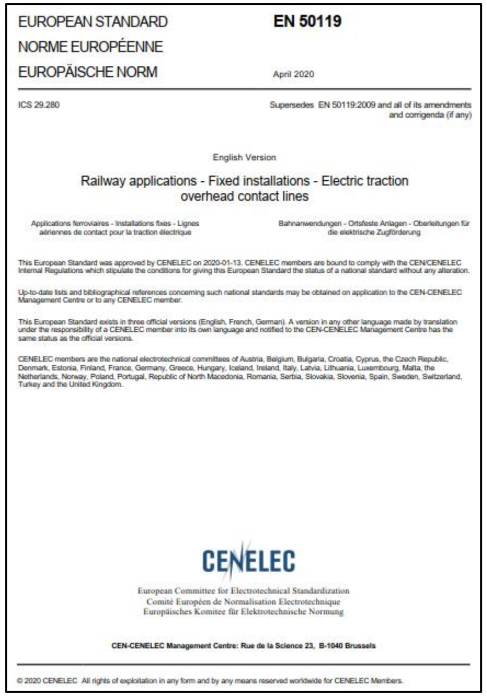
- **Basic Design Criteria**
  - *Definition of relevant parameters and design criteria for construction and operation of eHighway system*
- **Standard and Regulations Roadmap**
  - *Set of applicable standards for the eHighway system (Cenelec, ISO, OEM, other)*
- **Cenelec TC9X working group:**
  - *Technical Criteria for the interaction between pantograph and overhead contact lines on electrified roads*
- **EN50119_2020:**
  - *Annex C describes specifications for overhead contact lines for electric trucks*



EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 50119

April 2020

ICS 29.280

Supersedes EN 50119:2009 and all of its amendments and corrigenda (if any)

English Version

Railway applications - Fixed installations - Electric traction overhead contact lines

Applications ferroviaires - Installations fixes - Lignes aériennes de contact pour la traction électrique

Bahnanwendungen - Ortsfeste Anlagen - Oberleitungen für die elektrische Zugförderung

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Features of the eHighway pantograph

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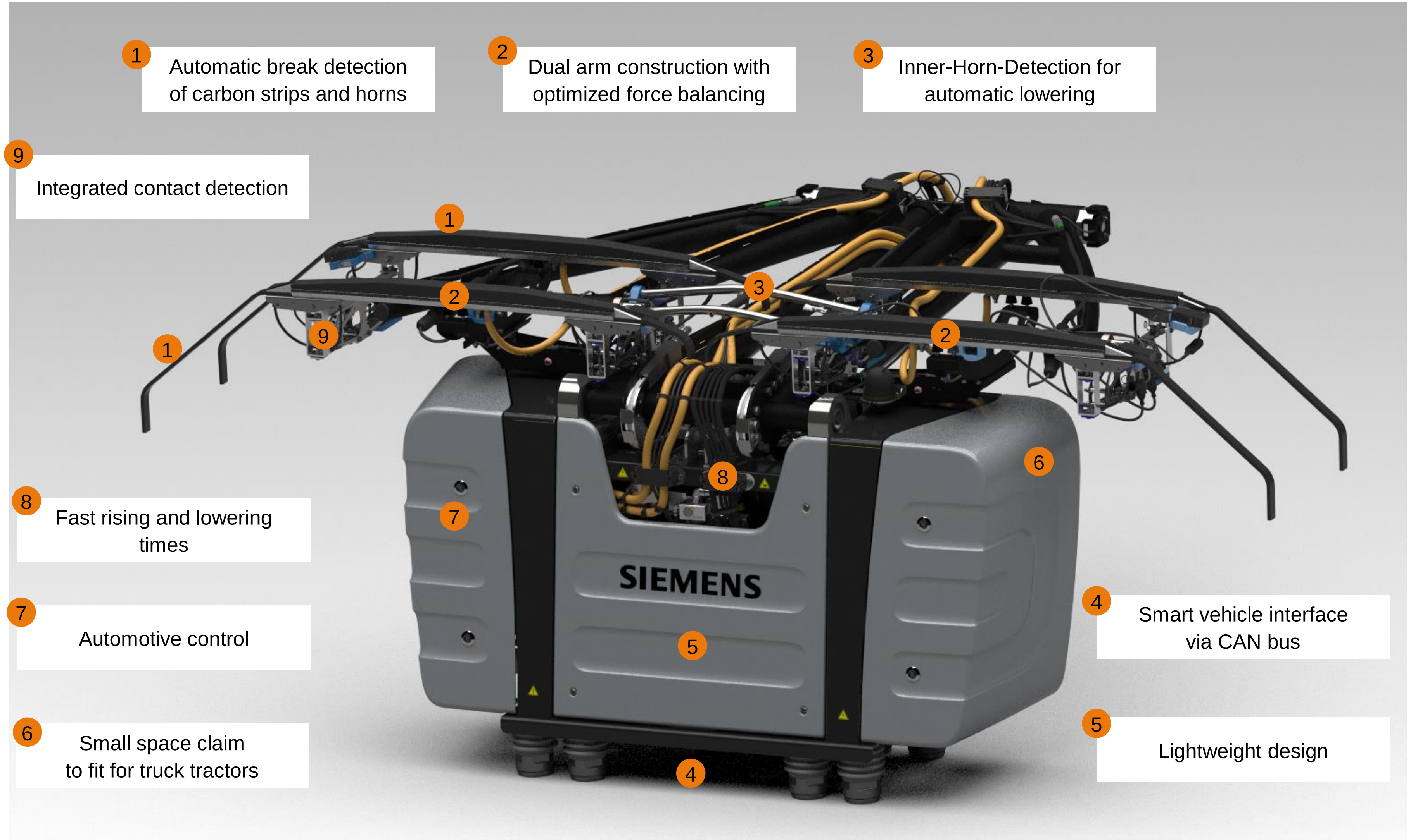


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