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eHighway

Indo-German Workshop

siemens.com/eHighway

Agenda

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Political momentum for electrified motorways is growing with the recognition that long-haul heavy duty trucks need to go electric

Germany- Transport Ministry

India - Ministry of Road Transport and Highways

IEA: India Energy Outlook

Minister Gadkari has championed idea of eHighway in India since 2018

Youtube

eHighway designated as a key clean truck technology, to be strongly supported and internationally promoted

Source: BMVI concept *Climate-Friendly Commercial Vehicles*

- Trucks India's biggest transport CO_2 source
- Truck vkm to more than triple in next 20 years
- Even IEA's Sustainable Development Scenario (SDS) results in „*a doubling in emissions from heavy-duty trucks.*" SDS foresees 40% of all trucks to be electric by 2040

Source: IEA India Energy Outlook 2021

Time is right for an Indo-German cooperation for the electrification of Indian truck motorways

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139th anniversary of ERS (Electric Road Systems)

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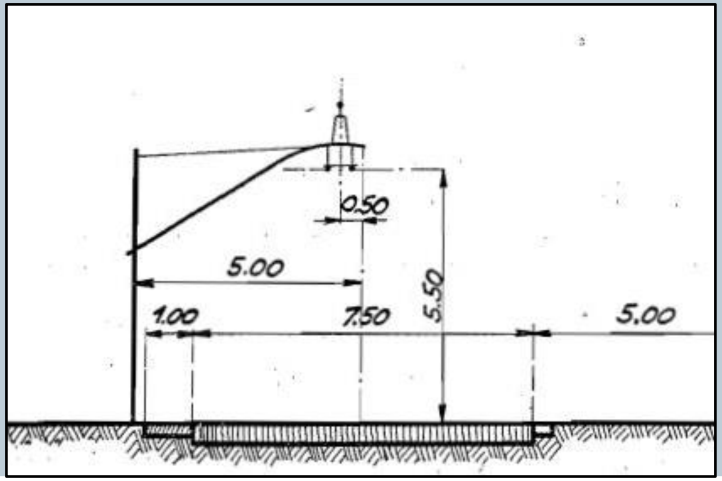
Siemens Elektromote (1882)

German Highway Concept (1936)



Electric mining truck

- Road applications date back more than 130 years
- About 300 trolleybus systems (incl. long-distance up to 100 km for inter-city traffic) operative world-wide
- Road applications demand early standardization to allow for common interfaces to base vehicles
- Electric traction systems can be beneficially used on highways as well
- Applicable to trucks/long-distance busses
- May be combined with energy storages
- DC power supply (600 ... 750 V nominal), catenary type contact lines

eHighway System is based on well proven technology and subsystems

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The complete system

… and its subsystems

1	Vehicle	Pantograph Drive System Energy Storage Control System
2	Power Supply	Substation Contact Line
3	Drive Way	Infrastructure Traffic Mgt.
4	Operation	Maintenance SCADA

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eHighway - Power supply at test track

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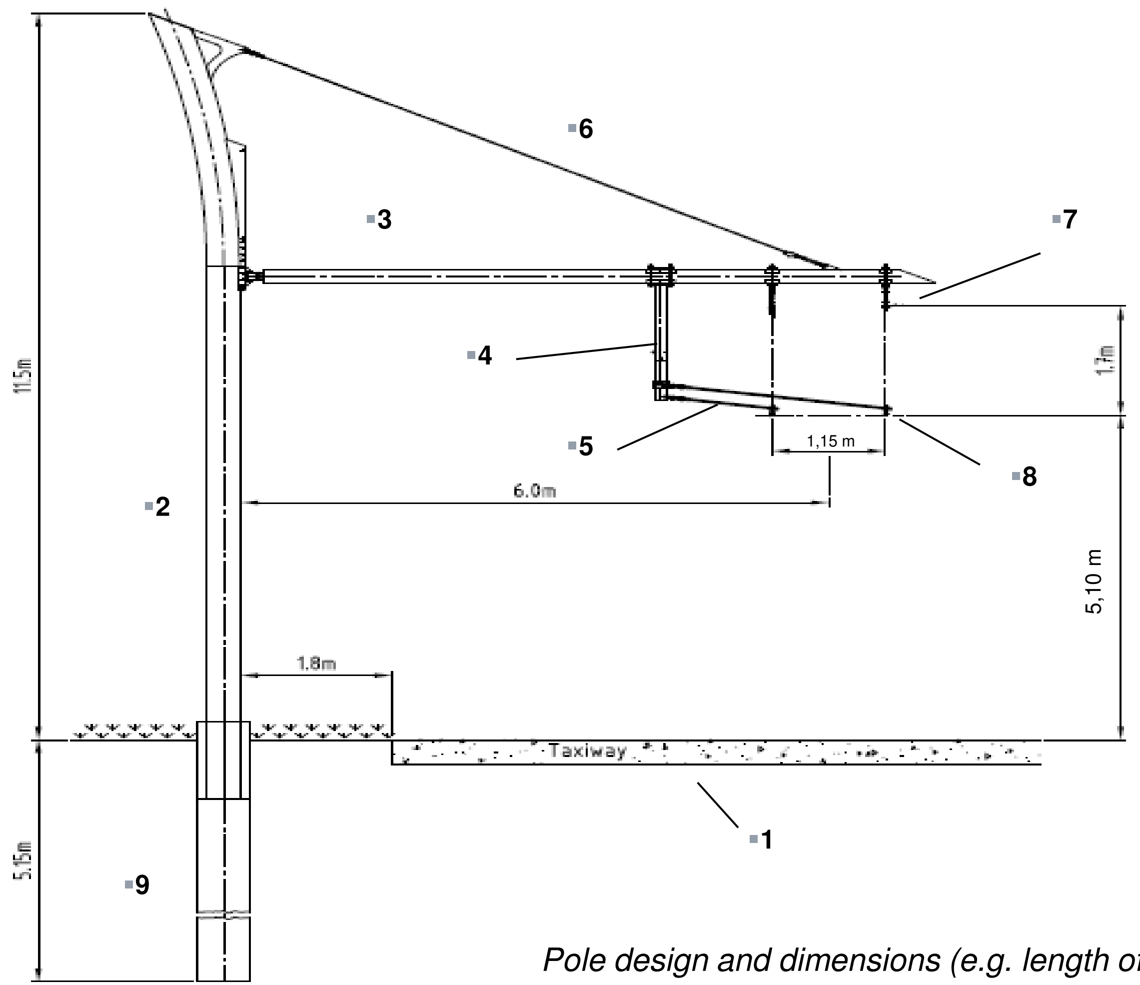
Design example with wooden housing.

Exemplary configuration of substation for power supply (e.g. at test track Groß Dölln)

- 0,5 MVA Rated power
- Connection to 10-kV public grid
- 660 V DC no-load voltage on the catenary
- Prefabricated in container
- Inverter for recuperation to grid in separate container

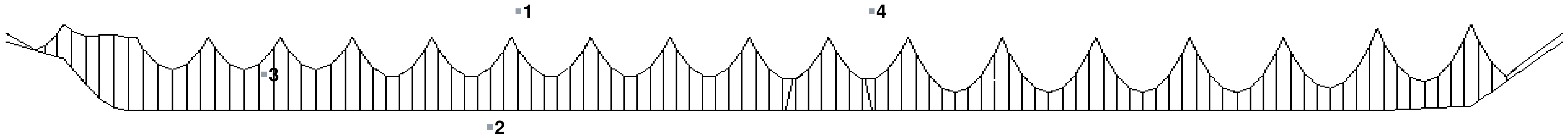
eHighway - overhead contact line
Cross profile



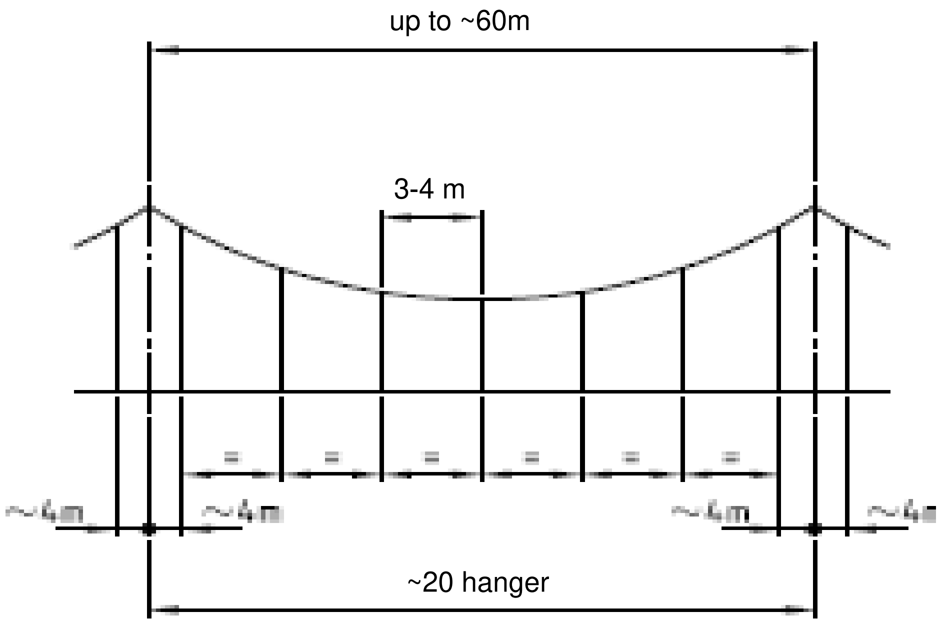
1 Lane
2 Pole
3 Traverse beam
4 Droper column
5 Steady arm
6 Toprope
7 Messenger wire
8 Contact wire
9 Foundation

Pole design and dimensions (e.g. length of traverse beam) may vary depending on actual installation.

eHighway - overhead contact line
Catenary system



1 Messenger wire
2 Contact wire
3 Dropper
4 Z-Dropper



eHighway - overhead contact line
Curve design

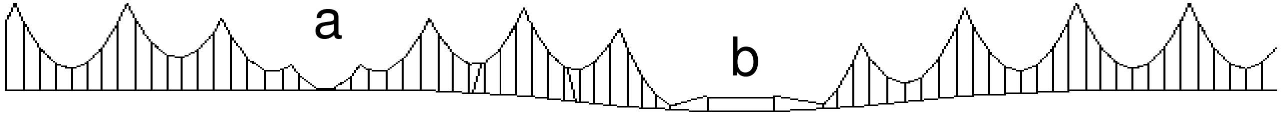
Warped contact line construction possible for curves.

Messenger and contact wire are not vertically aligned. Instead of forming a straight axis the contact wire is forced to follow the gradient of the curve.

eHighway - contact line constructions at gantries and bridges

a) Lowered system heights at standard contact wire height

b) Lowered contact wire heights



Minimum height of constructions

Without fixation at the construction, the contact wire may be lowered to 4,63m, which results in a minimum height of the gantry of 5,1m.

With additional constructions / fixations at the structure (bridge), the minimum height of the structure is 4,76m.

5,1m

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German field trials lay the foundation for the next step in the development of the system

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Information and routing

	Federal State of Hesse Infrastructure project awarded to Siemens	**Federal State of Schleswig Holstein** Infrastructure project awarded to Siemens	**Federal State of Baden-Wuerttemberg** Infrastructure project awarded to Siemens
Track length/ amount of trucks:	5 km/ +7 km (South-bound) 5 +7	5 km/ 5	2,6-3,4 km/ 5
Construction:	Apr – Nov 2018	Oct 2018 – May 2019	June 2020 – Feb 2021
Demonstration:	Official start May 7, 2019	Started in Dec 2019	Planned start: Summer 2021

Project homepage ELISA

Project homepage FESH

Project homepage eWayBW

ELISA project: Delivered on time and on budget – with minimal disruption to traffic flow

Ground investigations

Setting foundations

Erecting poles

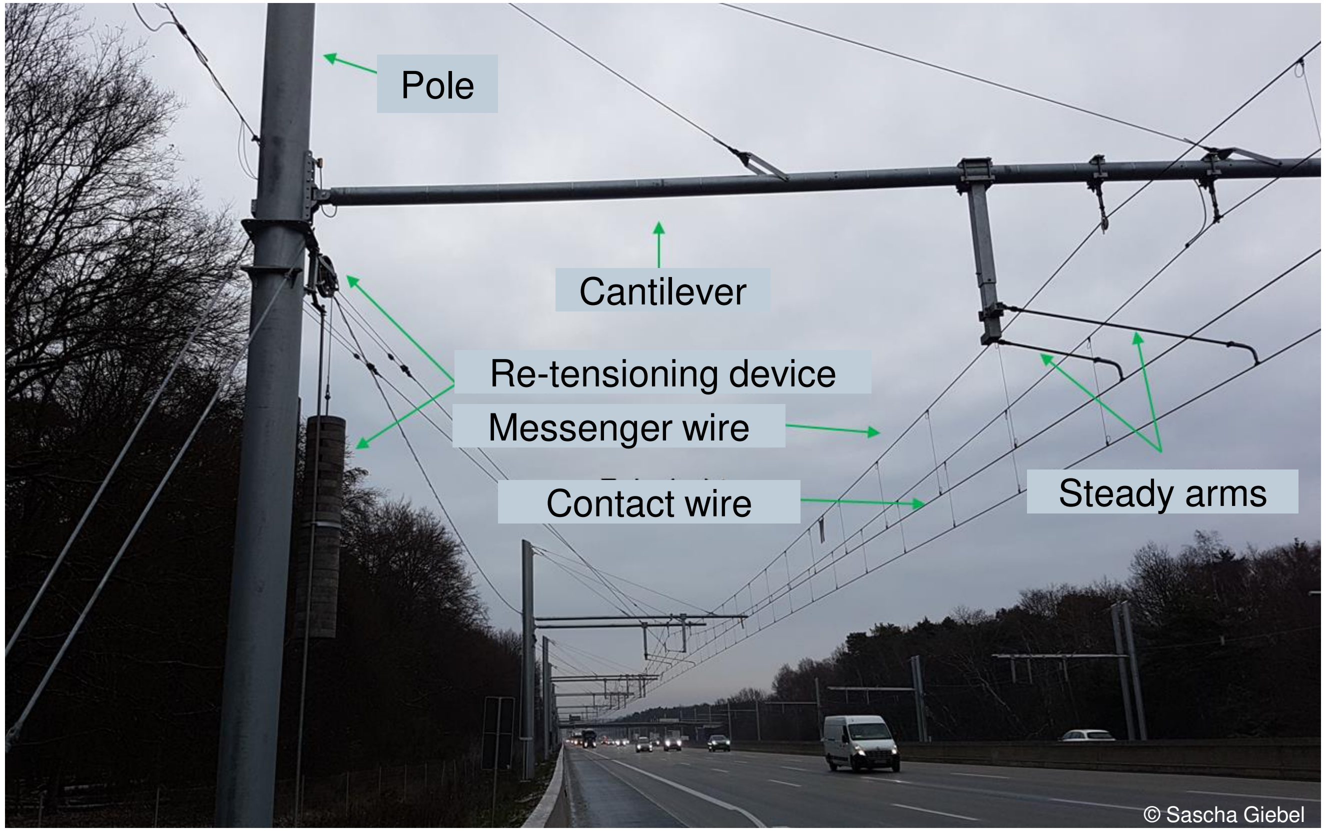
Attaching cantilevers

Pulling the contact line

Installing the substations

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)

Feed-in pole

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

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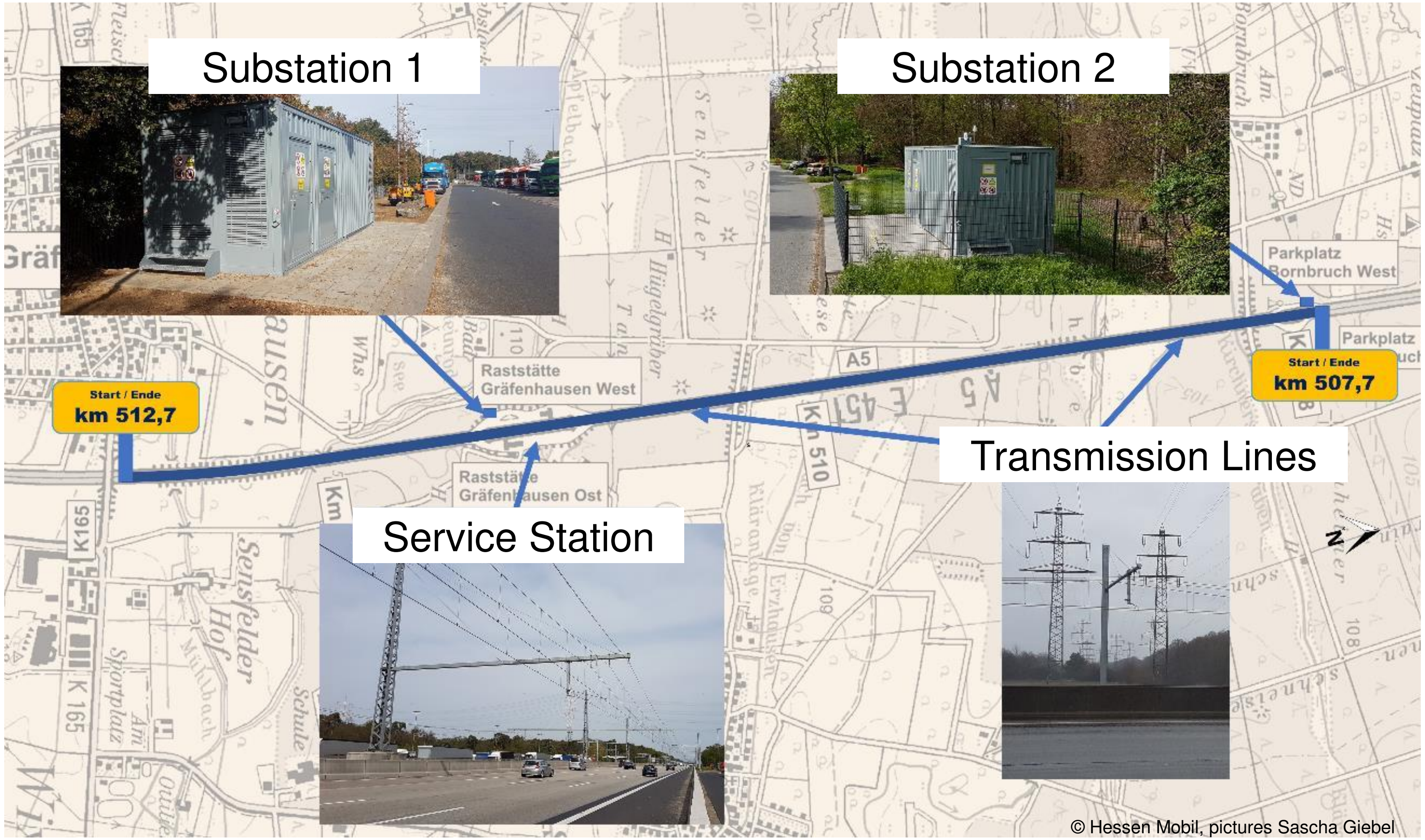
Parameter	Project ELISA
Medium Voltage 3AC	20 kV
Nominal Voltage DC	670 V
Nominal Power per Substation	1,000 kVA
Number of Substations	2
Length of Electrical section in each driving direction	5 km
Number of poles	223 + 6 Poles in Middle strip



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

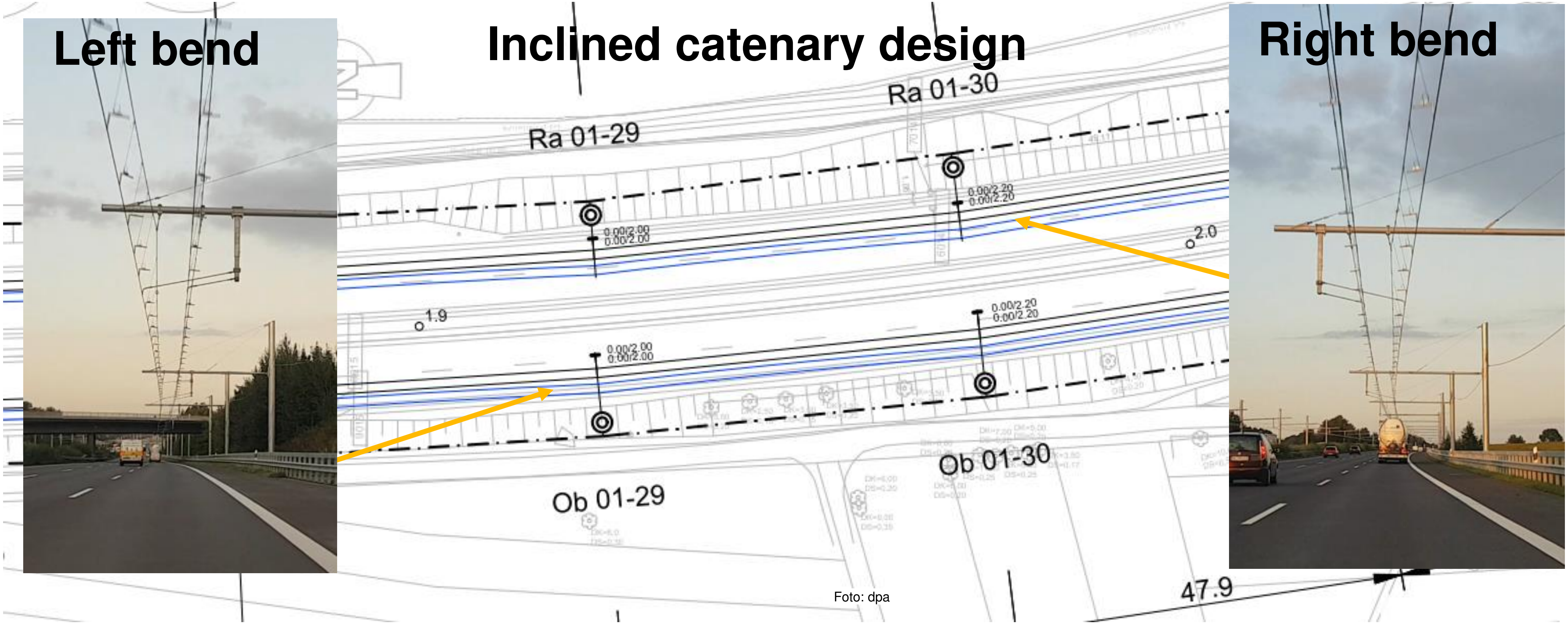

Foto: dpa

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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

- Tractor truck (2 axles)
- Tractor truck (3 axles)
- Rigid truck (2 axles)
- Rigid truck (3 axles)
- Rigid truck (4 axles)

Drive system

- Parallel-hybrid
- Serial-hybrid
- Full electric

On-board source of electricity

- Battery (small)
- Battery (medium)
- Battery (large)
- Fuel cell

Combustion engine

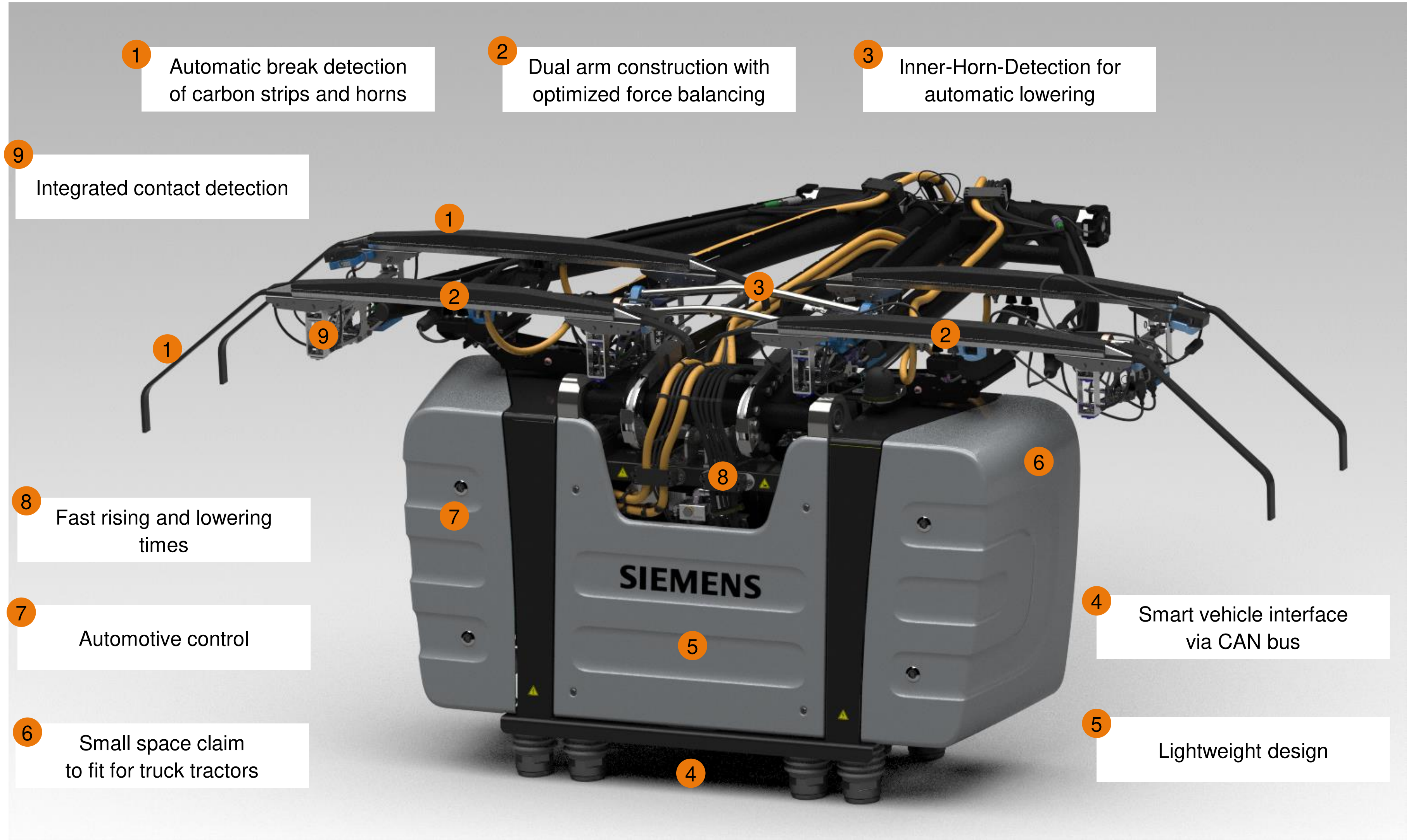
- Engine (small)
- Engine (medium)
- Engine (large)

Non-electrical source of energy

- Diesel
- Bio fuel
- CNG/LNG
- Hydrogen

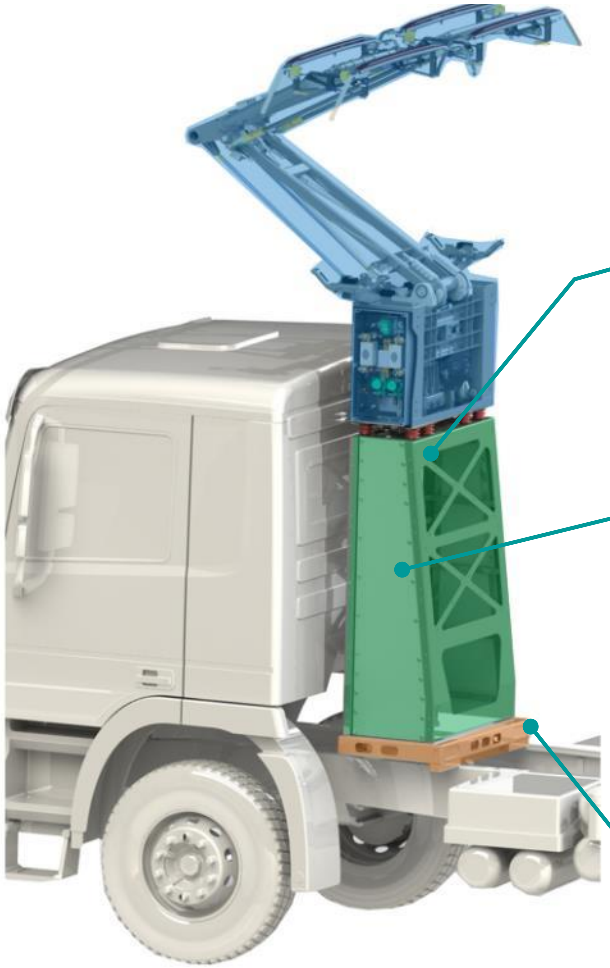
Showing combinations already realized in projects so far

Features of the eHighway pantograph



eHighway Pantograph: Developed with ease of integration in mind

Development view



Pantograph
- Arms & Collector head
- Main frame
- 650 VDC / 24 VDC system
- Sensor system
- Pneumatics
- Isolation system
- Drive & Control

HTE (Hybrid truck Equipment)
- Base frame
- Control
- Switches
- Choke
- DC/DC

Truck adapter

Realization

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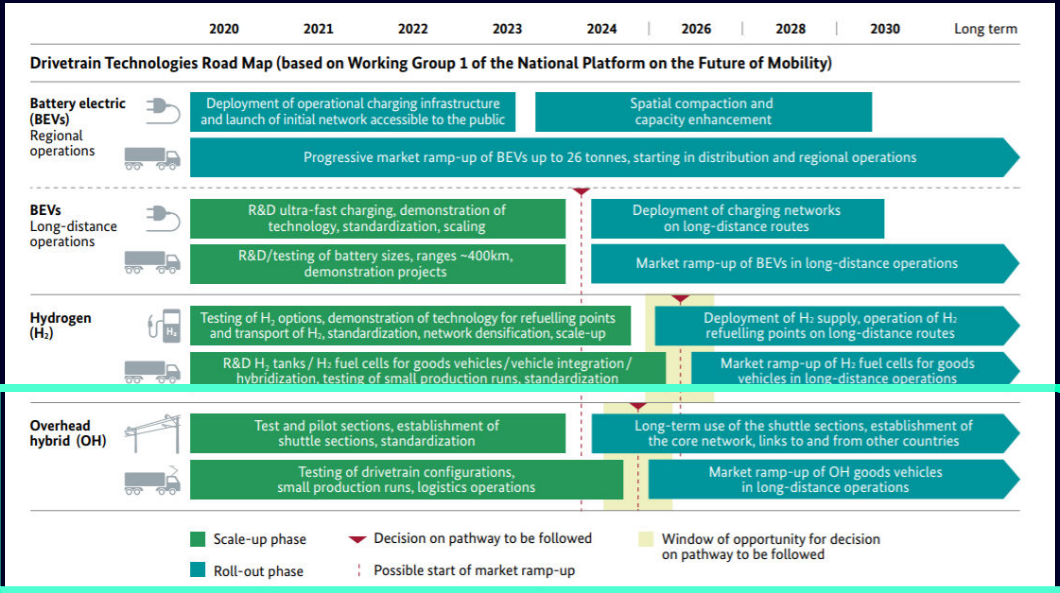
German transport ministry (BMVI) is driving the implementation of catenary

Several hundreds of km planned for the coming few years

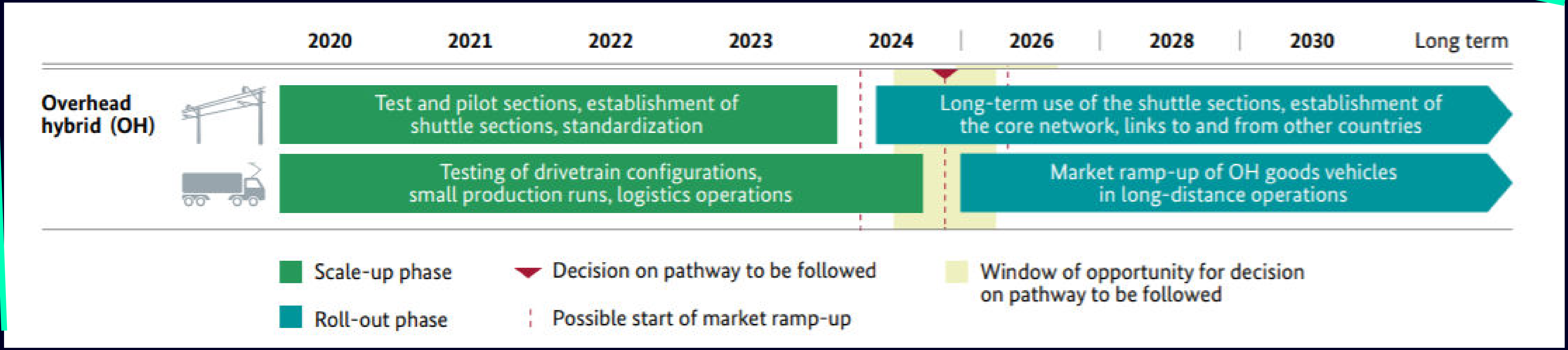


BMVI via the „Energie- und Klimafonds“ (EKF) already have funding available for 2021-2023:

1.16 Bn. EUR to support vehicles, incl. All kinds of overhead-contact line trucks

4.1 Bn. EUR for infrastructure for alternative fuels for road transport

Use cases to be identified based on truck tolling data by Summer 2021



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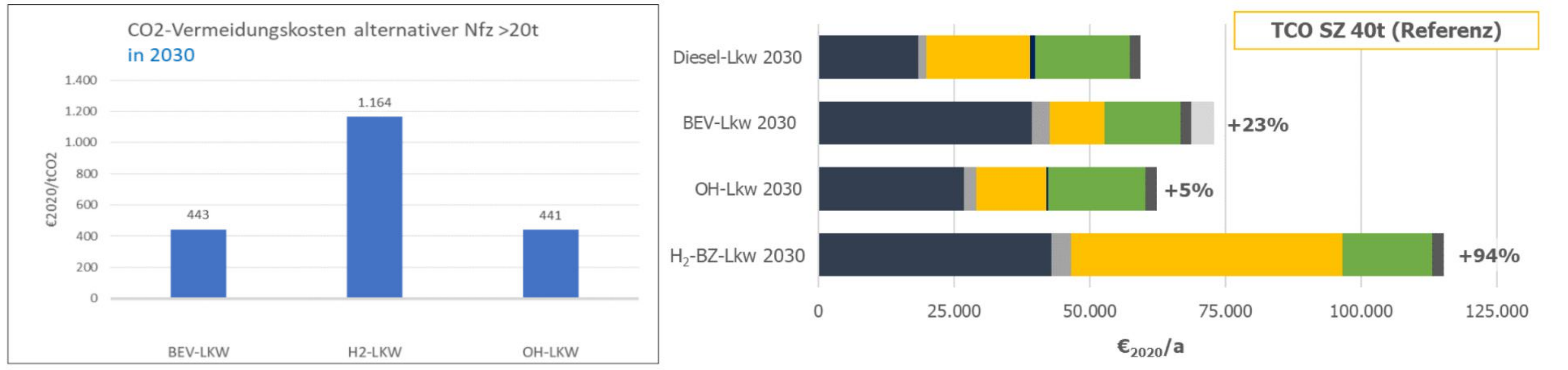
2) Page 15, https://www.bmvi.de/SharedDocs/EN/Documents/overall-approach-climate-friendly-commercial-vehicles.pdf?__blob=publicationFile

Overhead contact lines are a necessary part of the technology mix

Helps reach emission reduction targets as cheaply and quickly as possibly

Germany‘s expert commission for future transport (NPM) confirm economic advantages[1]



Intelligent combination

Contact lines on the core corridors help to solve the range problem of battery-electric trucks and lower the fuel cost of hydrogen trucks. Sustainable fuels (e.g. e-fuels) are complemntary for the existing vehicle fleet

1) https://www.plattform-zukunft-mobilitaet.de/wp-content/uploads/2020/12/NPM_AG1_Werkstattbericht_Nfz.pdf

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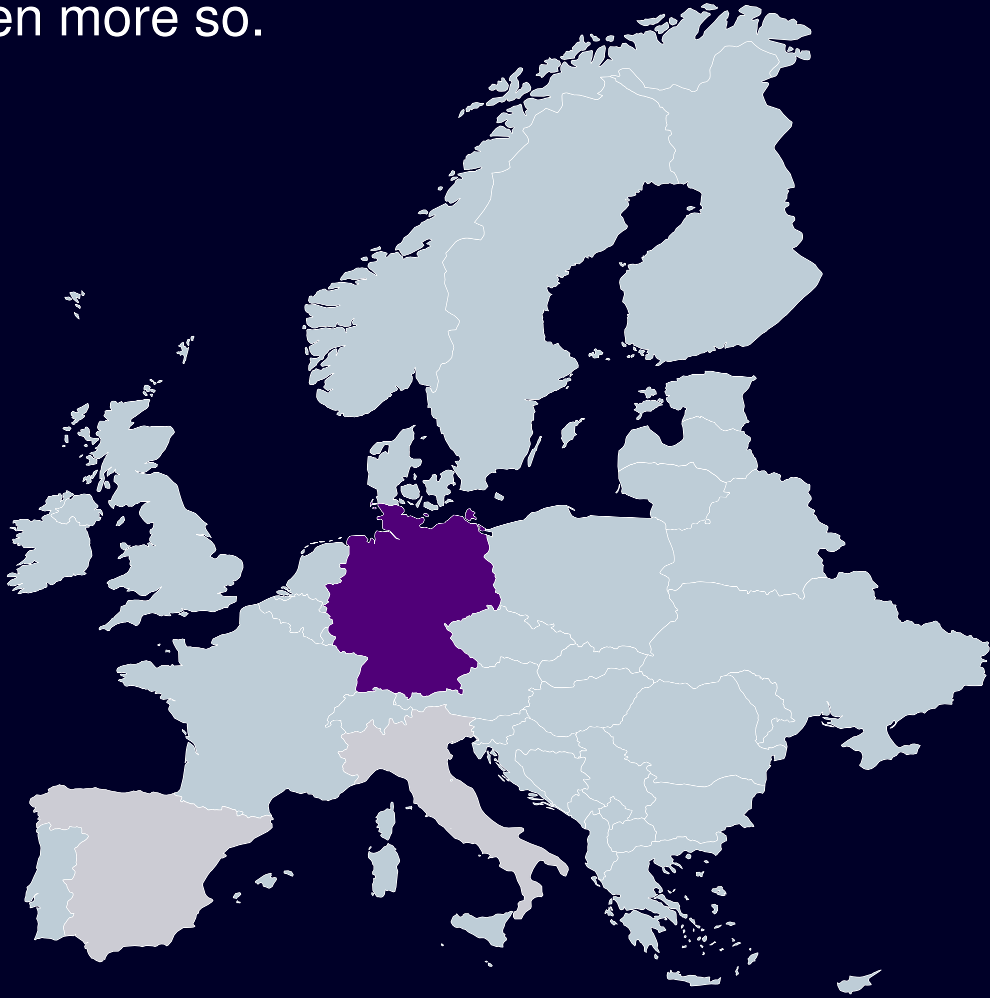
BMVI wants to facilitate a shared view on implementation
- A purely national system is profitable. An international one even more so.



- BDI study found that a national eHighway network in Germany would be a sound investment. Cross-border expansion would bring additional benefits (EUR, CO_2)
- Standardization: Technical specification (CENELEC EN 50119) for contact lines on motorway published. Technical specification for interface between contact line and pantograph expected to be published in first half of 2021
- BMVI will reach out to International partners to exchange experiences and analyses, in order to develop a coordinated implementation plan

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International interest in ERS is growing, e.g. in Europe

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Enabling zero emission trucking on TEN-T corridors by 2050

1 – Sweden
- Transport minister requested plan for 2.000 km of electrified motorways for trucks by 2030
- Report from National Transport Administration show ERS on 2.400 km by 2037 beneficial

2 – UK
- 20-40 km catenary pilot with 50-150 trucks being considered by DfT

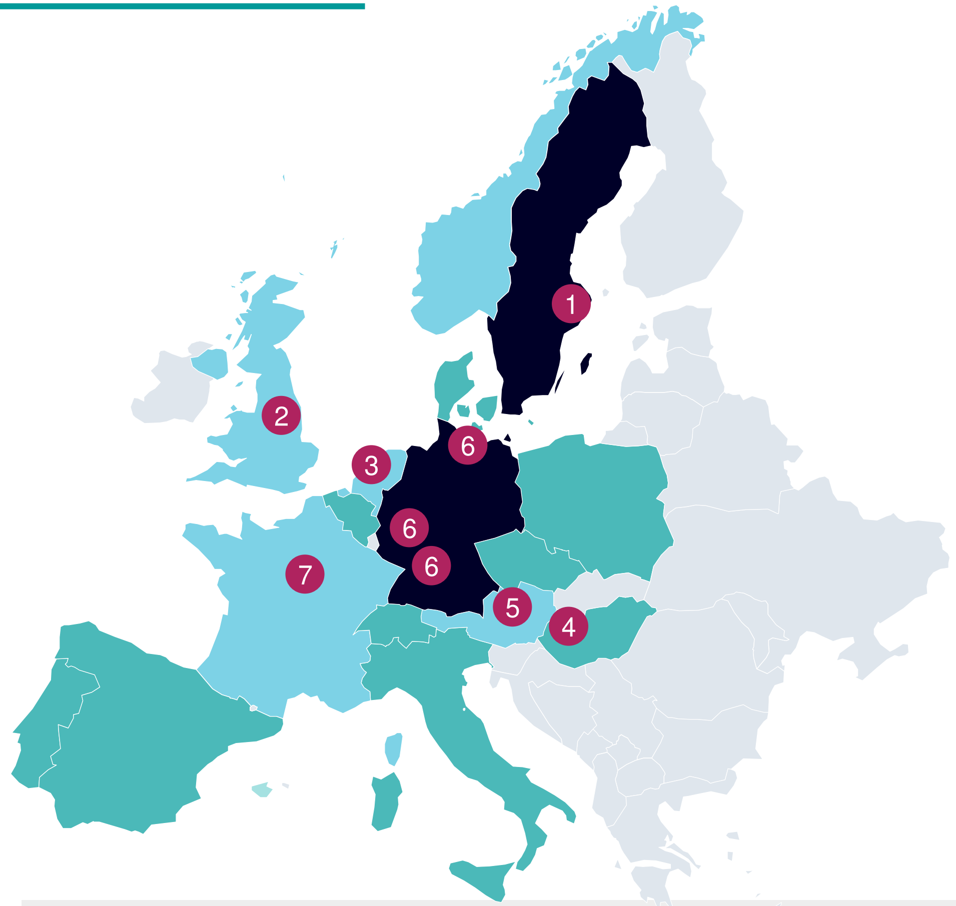
3 – Netherlands
- Recent study finds ERS most economical. Stresses importance of linking up with Germany

4 – Hungary
- Transport minster keen on implementing catenary pilot project

5 – Austria
- Environment Agency considers catenaries highest potential measure to road freight CO_2
- Overhead contact lines part of new coalition agreement

6 – Germany
- 2018 – 2022: Three fields trials on motorways A1 and A5 and national road B462
- 100kms shuttle pilots by 2023 and perspective of 4.000 km large network by 2030

7 – France
- Government to government Partnership on electrified roads with Sweden and Germany
- Ministry leading three working groups on ERS: potential, technology and pilot



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

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eHighway is an essential solution for climate protection in heavy road freight transport

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…combines the benefits of electric railways with the flexibilty of trucks

…can quickly be rolled out

…highway landscape change

…is the most economical solution

$-CO_2$

…makes it possible to reach the climate protection goals

…can be realized in a international context

…is flexibly compatible with other technologies and fuels


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Thank you for your attention

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Back up slides

Proven in daily trucking operations on German motorways

Motorway owner’s experience of field trial	Experiences of an eHighway-truck driver
 	
https://www.youtube.com/watch?v=gAUff-fz_MM&t=0s	https://www.youtube.com/watch?v=NHSofIc31rw

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

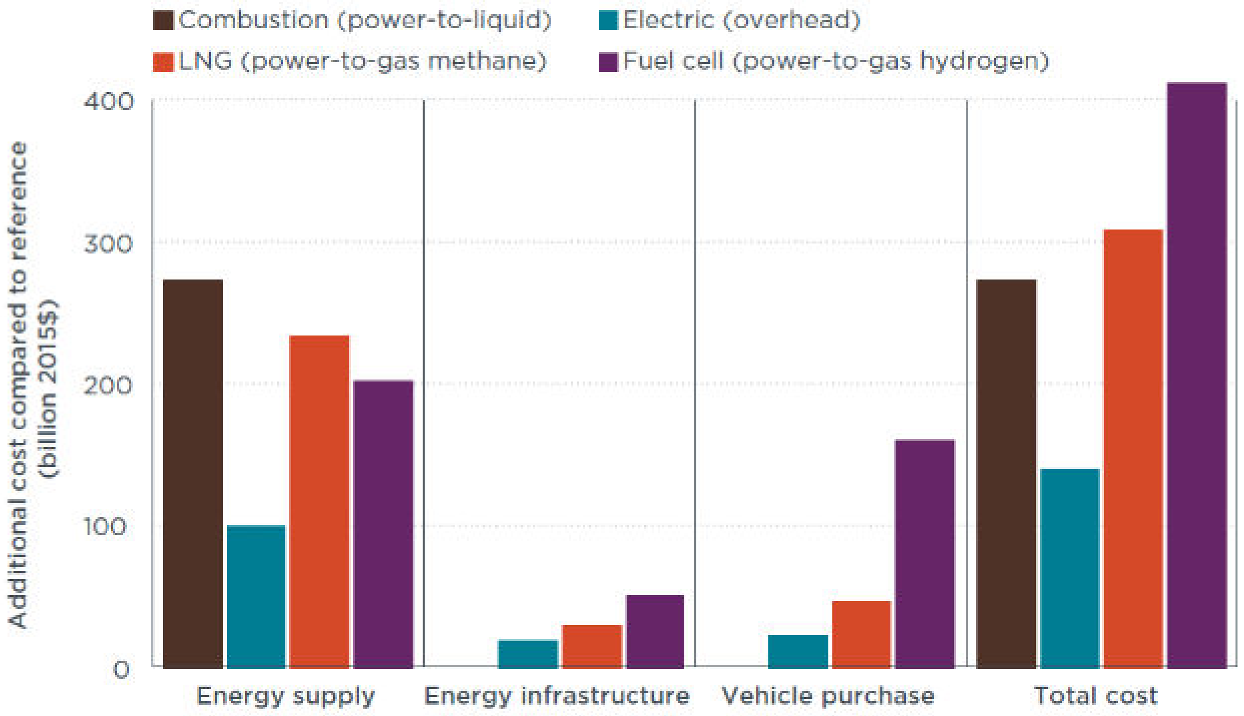


Figure 5. Additional cost for four different greenhouse gas reduction scenarios compared to the reference case (all fossil fuel use) for the long-haul heavy-duty freight transport sector in Germany (based on Kasten et al., 2016).

Key take-aways

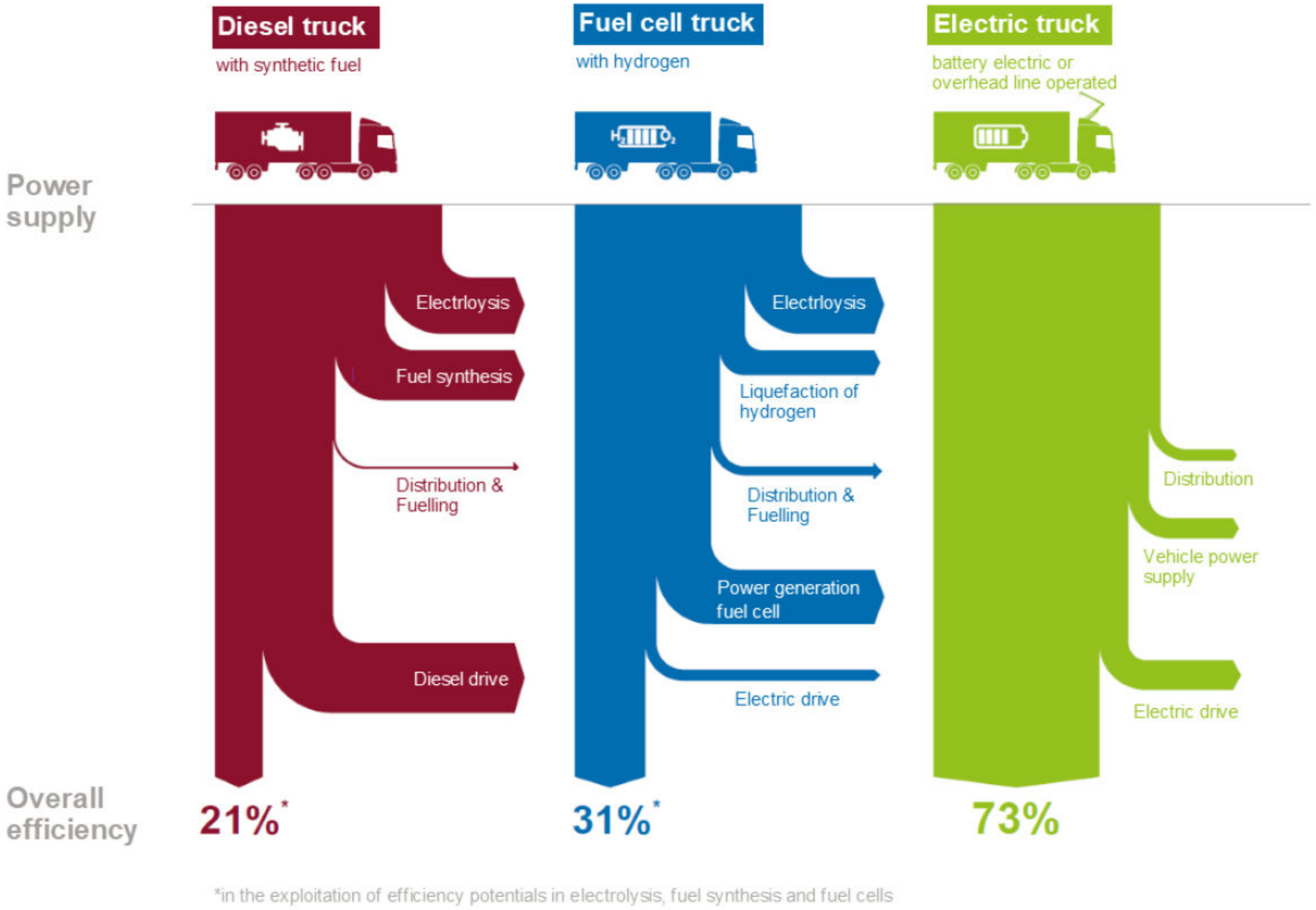
- Cost of energy has the greatest impact on total system cost, so energy efficiency should guide decision making
- Up-front costs, like additional vehicles and infrastructure, also factor in, but too a much lower degree
- The cost of refueling (quickly) still deserves to be assessed carefully

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

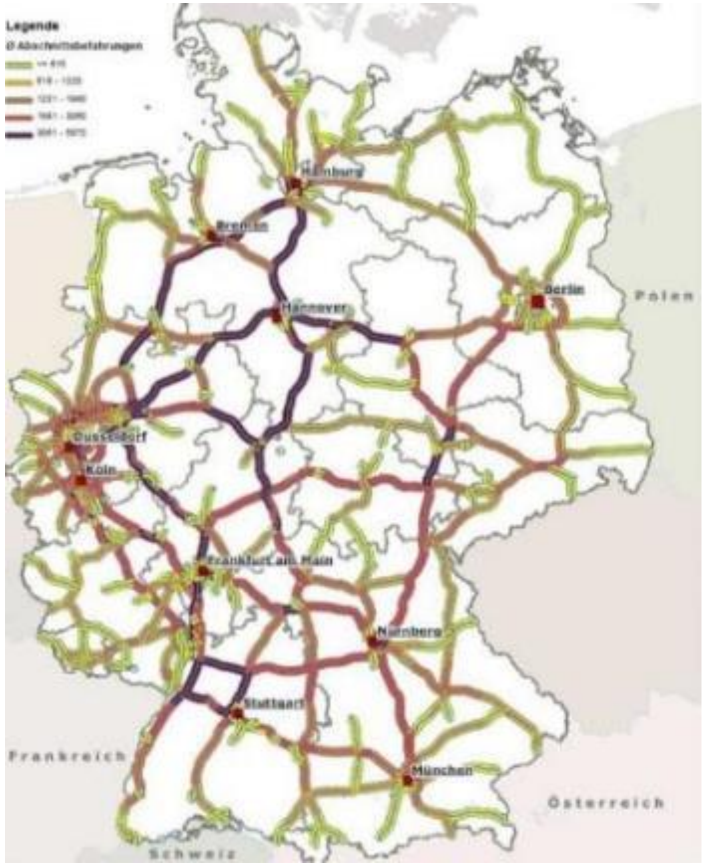
Source: ICCT – Transitioning to zero-emission heavy-duty freight vehicles (2017) page 23

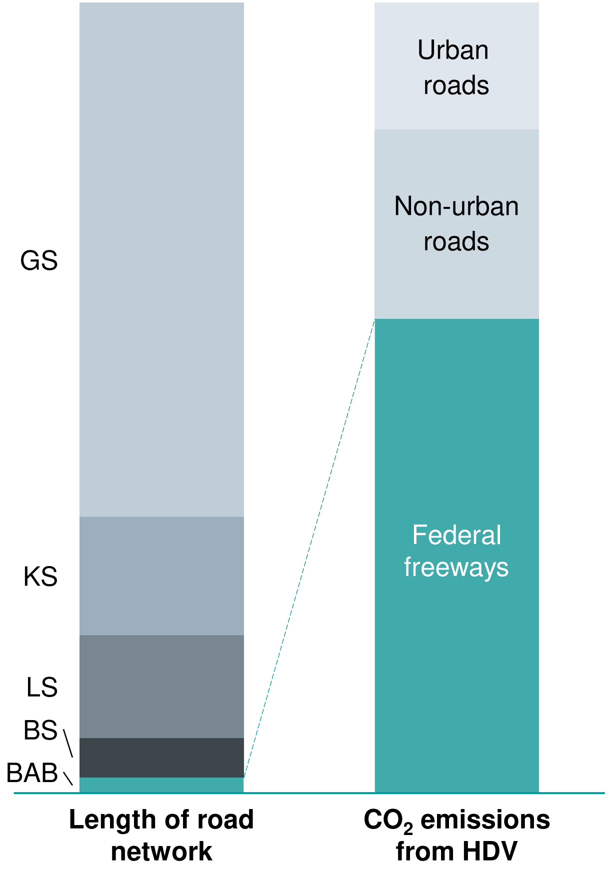
Zero-emission trucks are possible with renewable energy, but efficiency varies greatly



Source: Öko-Institut (2020) – StratON

Long-haul road transport is highly concentrated to the highway network, as illustrated by German data





The analysis of the German road network leads to the following key messages

1 **60%** of the HDV emissions occur on 2% of the road network (BAB = 12,394 km)

2 The most intensely used **3,966 km** handle **60%** of all ton-km on the BAB

3 **89%** of truck trips after leaving the highway are **≤ 50 km**

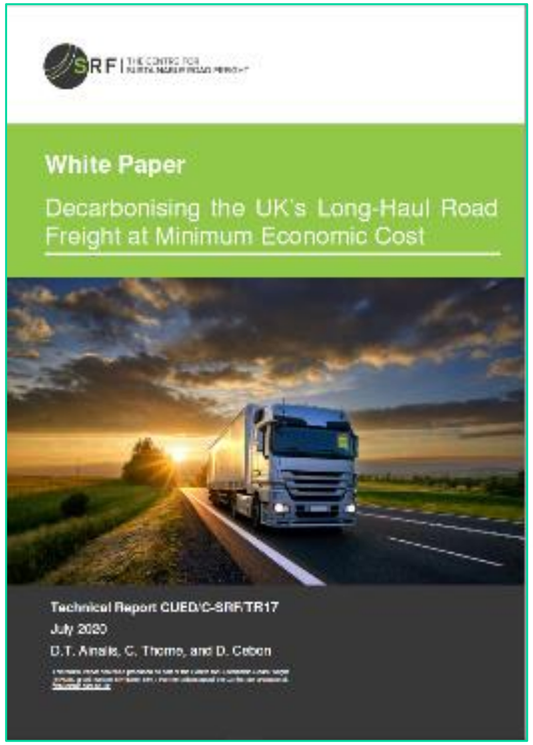
The use case logic is analogous to railway:

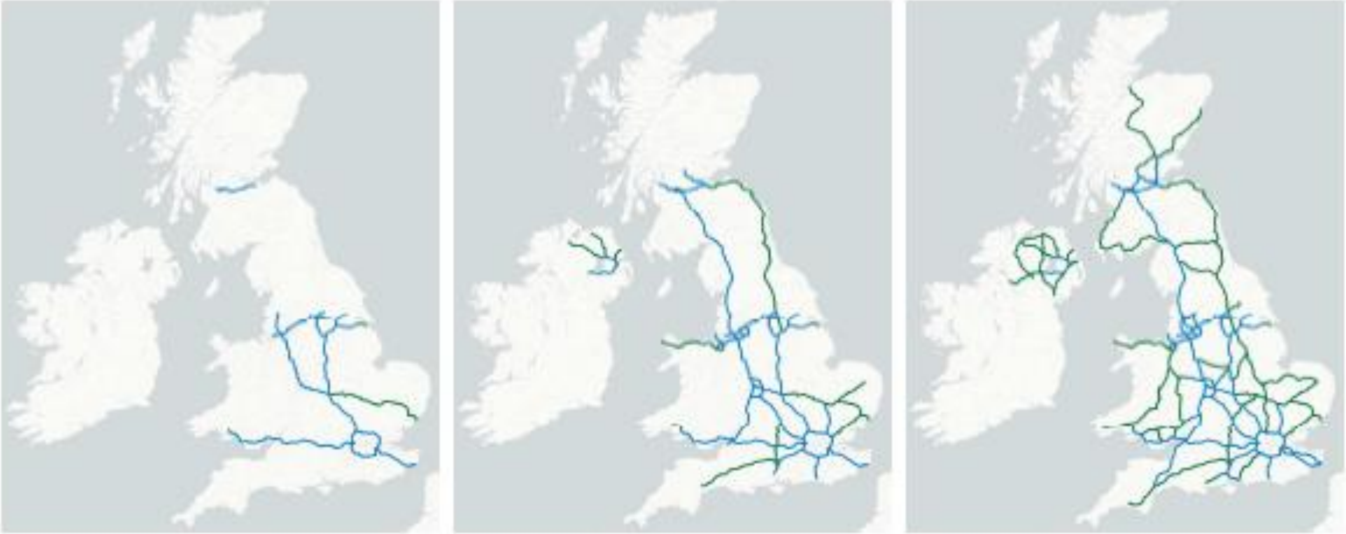
- Direct electrification wherever possible
  - Catenary on busy routes
  - Battery on less busy and short routes
- Elsewhere e-fuels can play a role

BAB = Federal freeways (12,394 km), **BS** = Federal roads (40,400 km)**, LS** = State roads (86,600 km), **KS** = District roads (91,600 km), **GS** = Municipal roads (>420,000 km)
Image: HDV density on BAB-network | **Source:** Verkehr in Zahlen 2012; TREMOD 2012; BMVI website. Study available here

Analyses for other countries reach same conclusion Example: UK report on published July, 2020

*"Overhead catenaries and compatible HGV's are the **most energy-efficient and cost-effective solution** to fully decarbonise the UK's road freight network. Their deployment is essential if the UK is to achieve its Carbon budgets through to net-zero GHG emissions by 2050. **The technology is proven and the transition** from the current diesel-centric approach to catenary-powered electric vehicles **can be handled with hybrid vehicles**."*





Phase 1	Phase 2	Phase 3
Distance [lane-km]: 3,261 km	Distance [lane-km]: 4,247 km	Distance [lane-km]: 6,300 km
Construction time: 2.0 years	Construction time: 2.6 years	Construction time: 2.5 years
Infrastructure cost: £5.6 Bn	Infrastructure cost: £5.1 Bn	Infrastructure cost: £7.1 Bn
HGV-km coverage: 31%	HGV-km coverage: 50%	HGV-km coverage: 65%

Source: [Centre for Sustainable Road Freight]

Only the combination of alternative drives and fuels can make sustainable heavy road freight possible

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Overhead contact lines on the core motorways
where the volume of trucks justify the installation of the infrastructure

Fuel cells on the non-electrified routes
where long range is needed but electrification is not economical

e-fuels as addition
to achieve partial decarbonization of the combustion engine vehicles that are still part of the vehicle fleet in 2030

Battery and Megacharger for Urban and distribution
which should occassionally be able to travel longer distances, however not servicing the classic long-haul transport

The most economical way to reach the climate goals for road freight is the clever combination of alternative technologies

- Conventional drive technologies are not compatible with the climate goals
- The directe energy supply via overhead contact lines is the most economical solution, is possible to realize in the near term, and should be applied wherever possible.
- Overhead contact lines are most economical on routes with a high volume of truck traffic
- On routes where electrification is not appropriate and in urban areas other solutions are necessary
- BEVs have special advantages in urban areas
- Especially on long routes that cannot be electrified, fuel cell trucks show their advantages. By equipping those vehicles with a pantograph they can greatly reduce their energy costs on routes with overhead contact lines
- For the part of the vehicle fleet using combustion engines, e-fuels can make a large contribution to climate protection