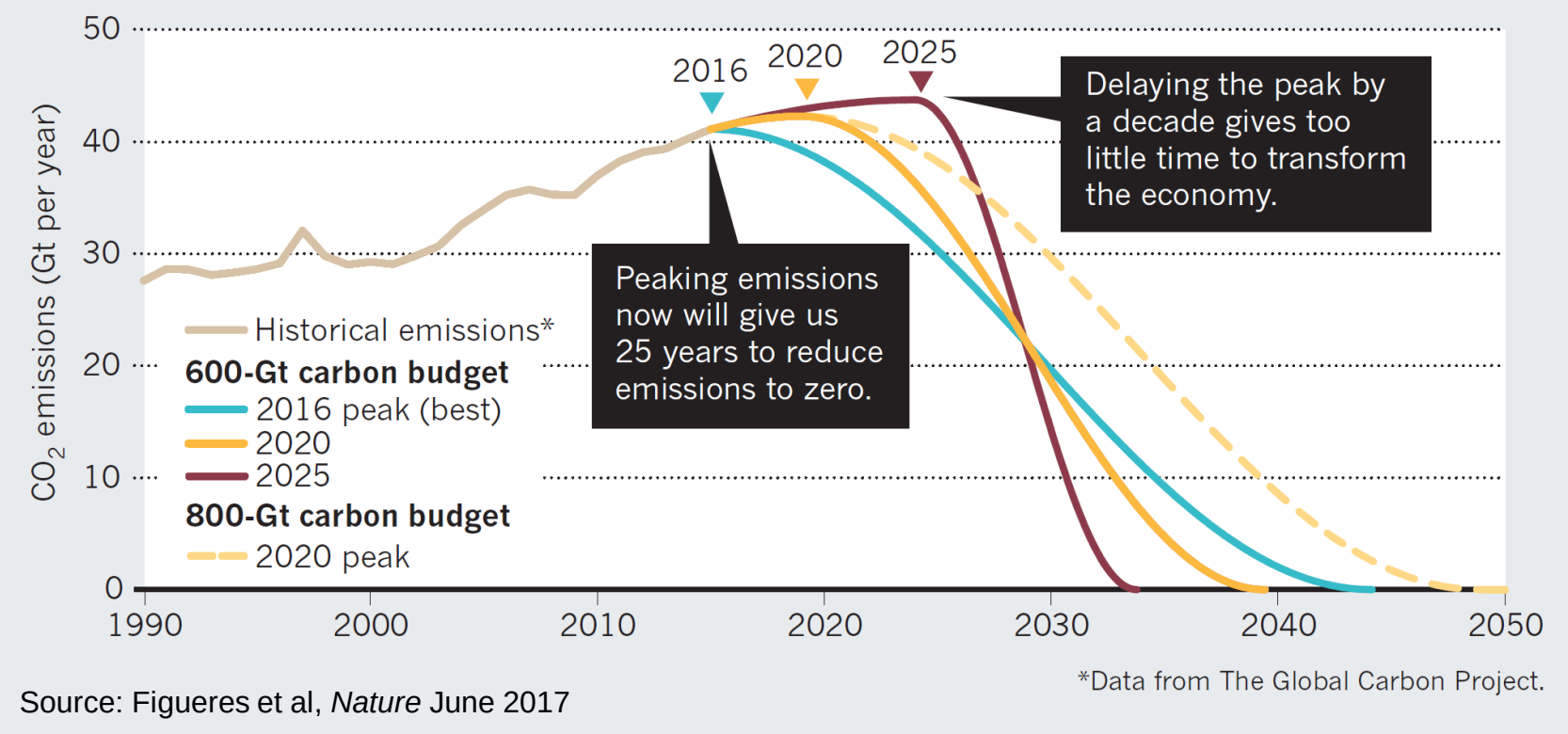
eHighway

Sustainable road freight transport

siemens.com/mobility

Climate action is urgent, because waiting makes the necessary transition to zero carbon emissions much shorter and disruptive

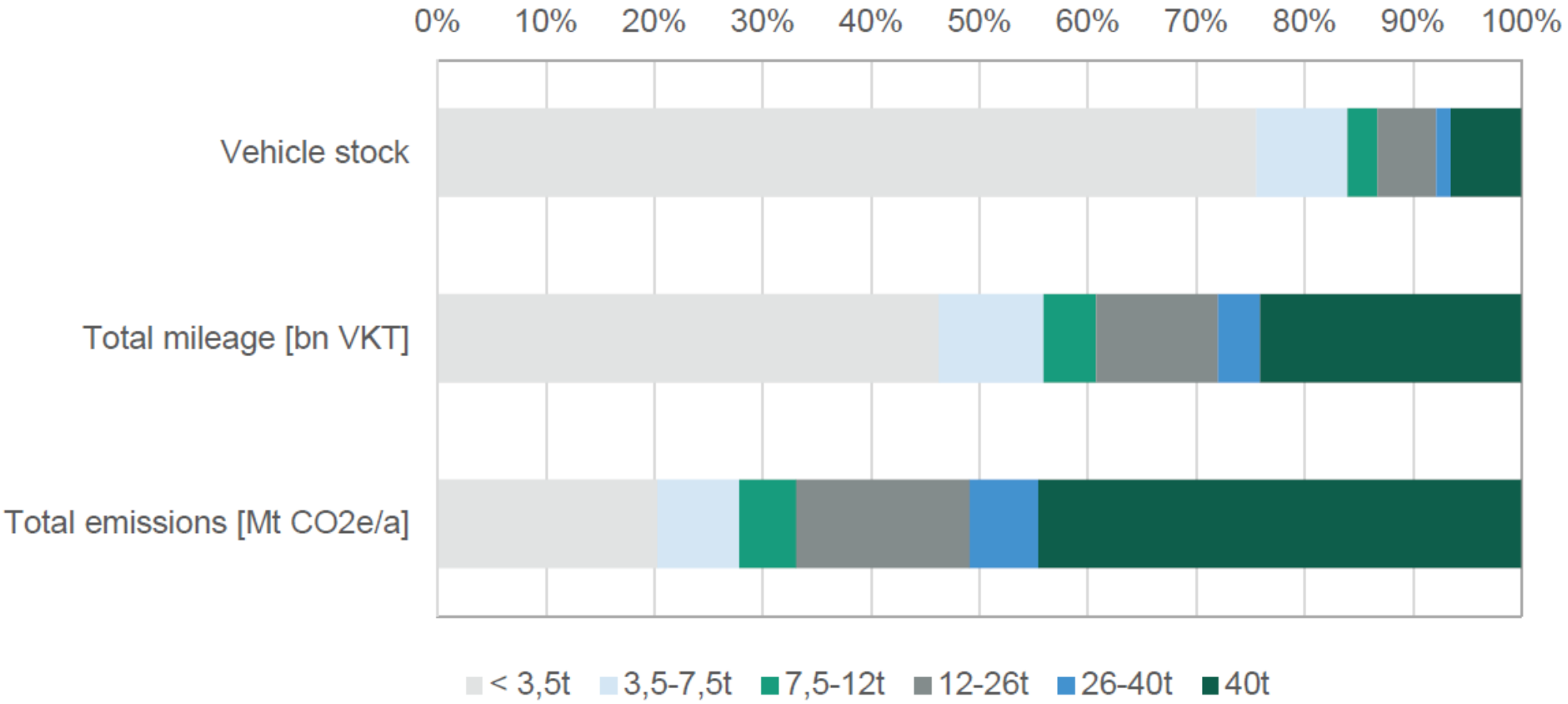


Source: Figueres et al, *Nature* June 2017

We need to put emissions, including those from road freight,

- on a path towards zero
- with minimium total emissions getting there

Road freight decarbonzation is particularly a challenge for the few vehicles that emit the majority of CO2



Source: Oeko Institute, Fraunhofer ISI & IFEU – *Alternative drive trains and fuels in road freight transport – recommendations for action in Germany*

Road freight emissions trends make it clear: Solutions for decarbonization are needed

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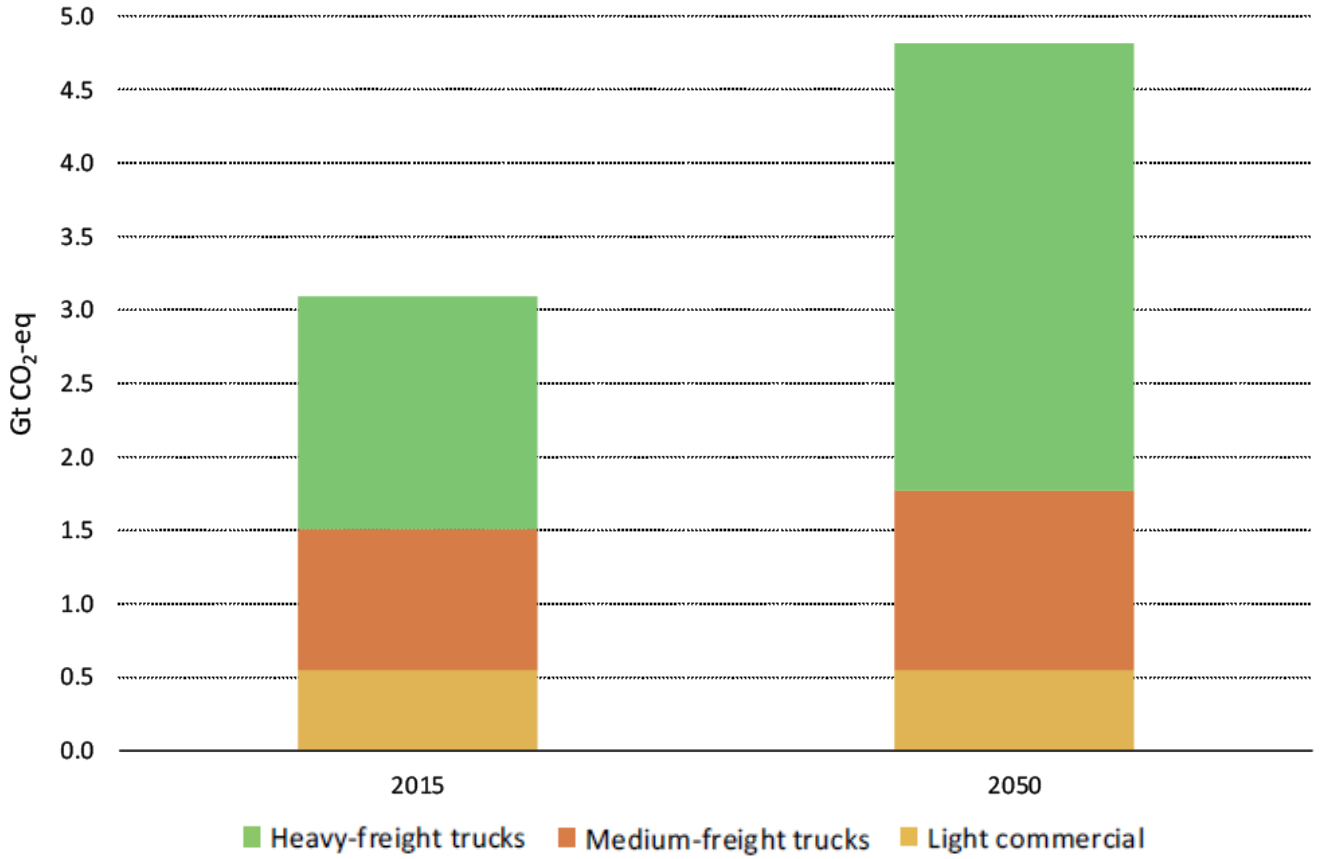
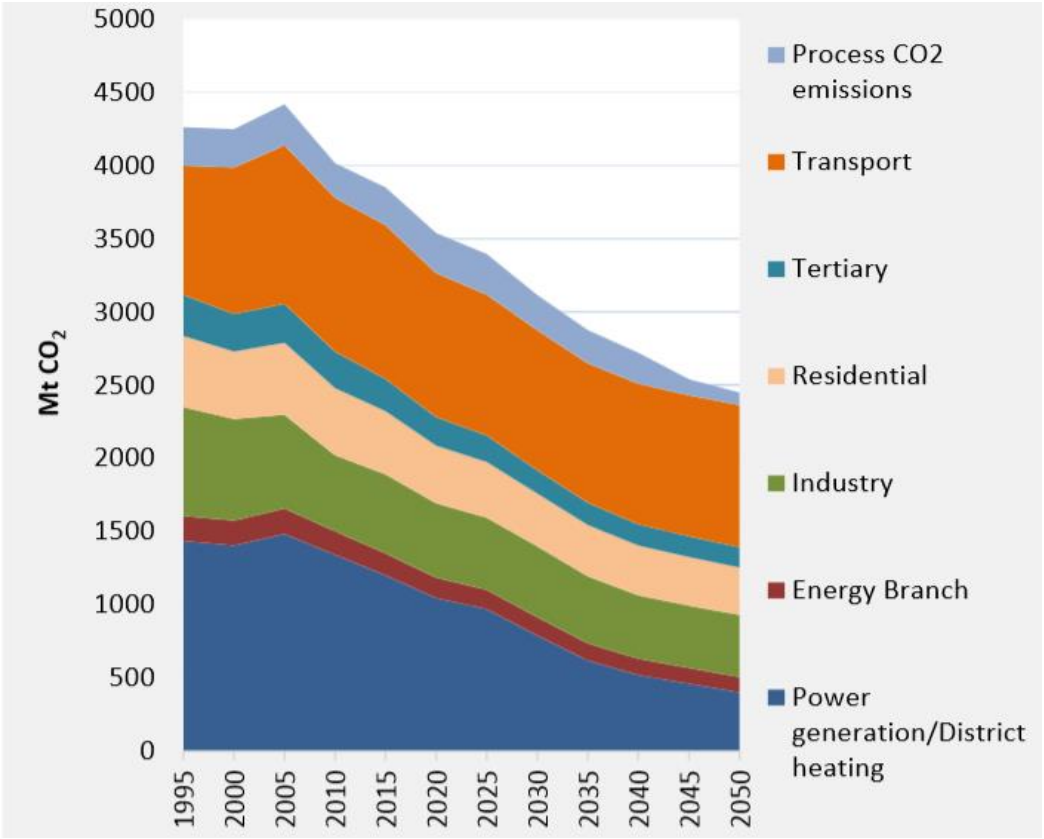
Based on latest policy announcements, **global heavy road freight** is forecast to emit 3 Gt CO_2 by 2050.



Source: IEA - The Future of Trucks (2017) page 117

Transport will increasingly be the biggest challenge for decarbonization in **Europe**.



Source: European Commission reference scenario for 2050 (2013) page 53

Surface freight density: 2010
Shows high density of freight on European corridors

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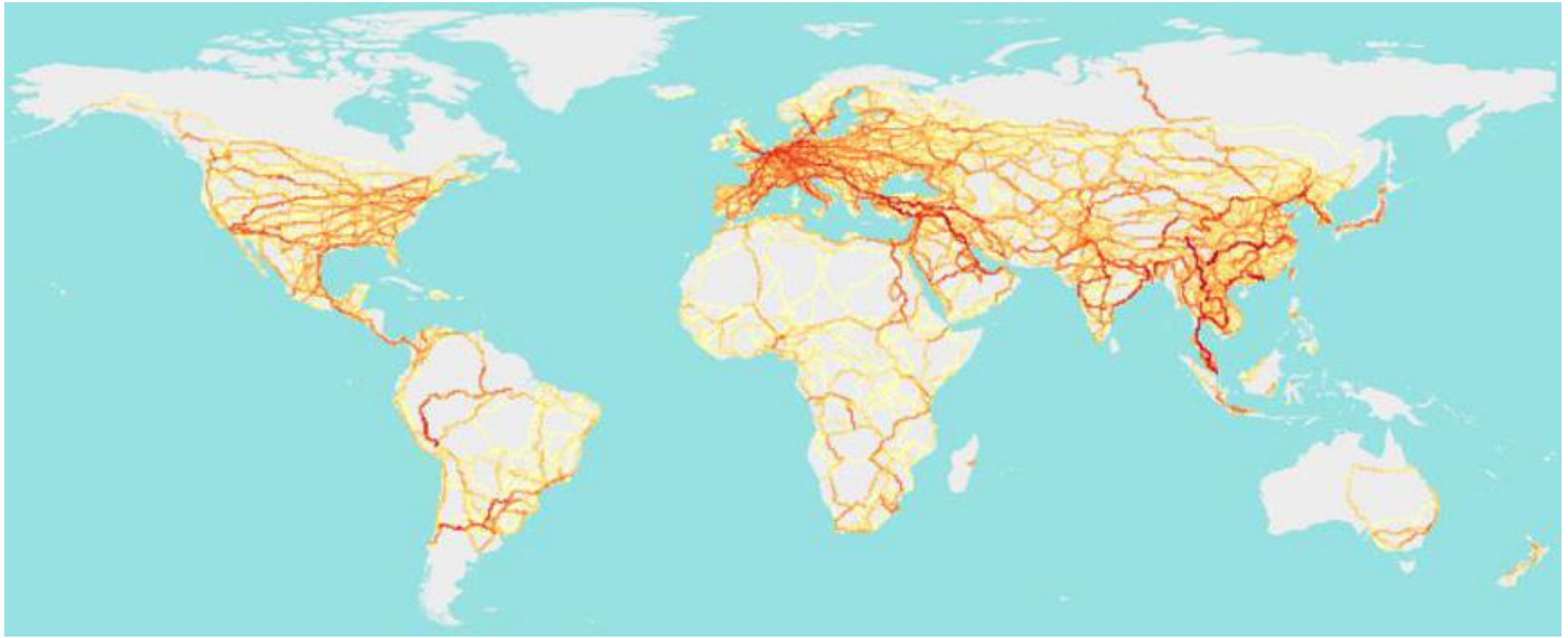

Source: ITF - Transport Infrastructure Needs for Future Trade Growth (2016) page 31

Surface freight density: 2050
Shows global need for road freight sollutions suitable for corridors

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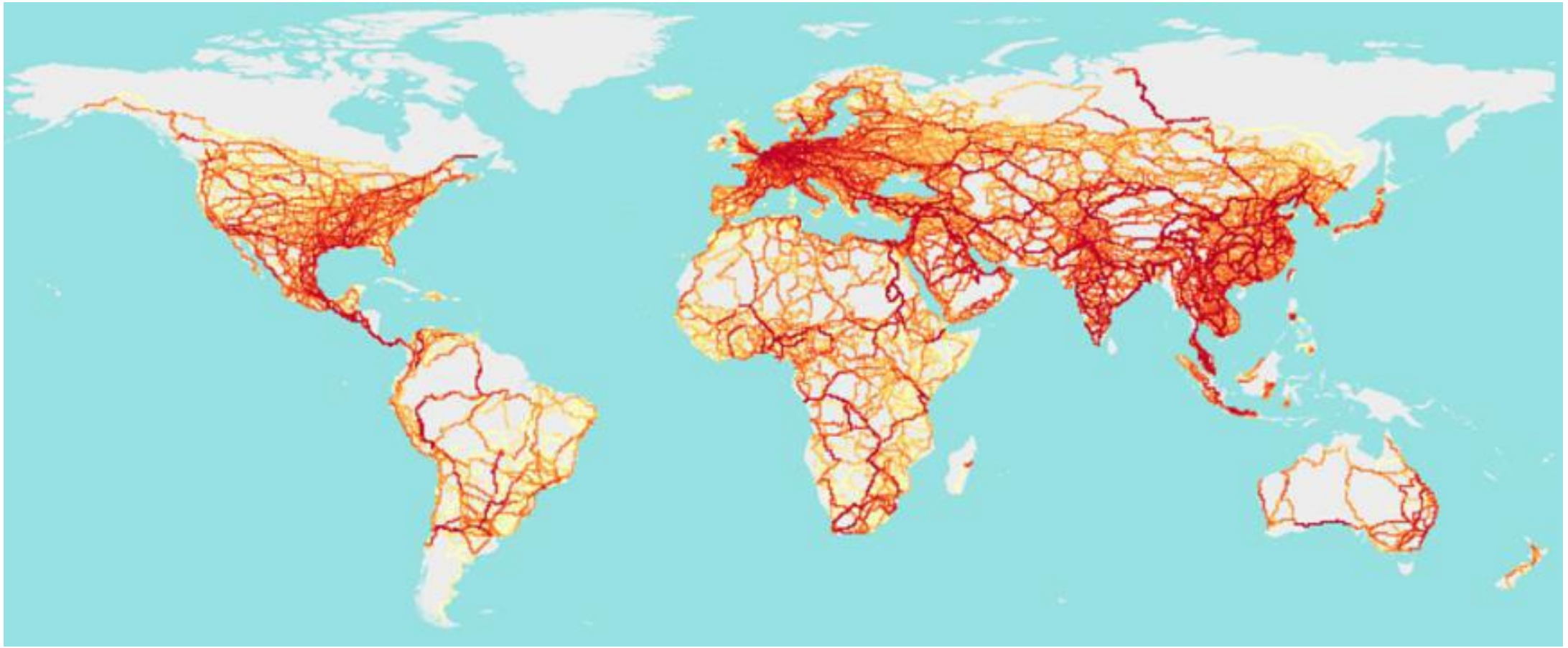
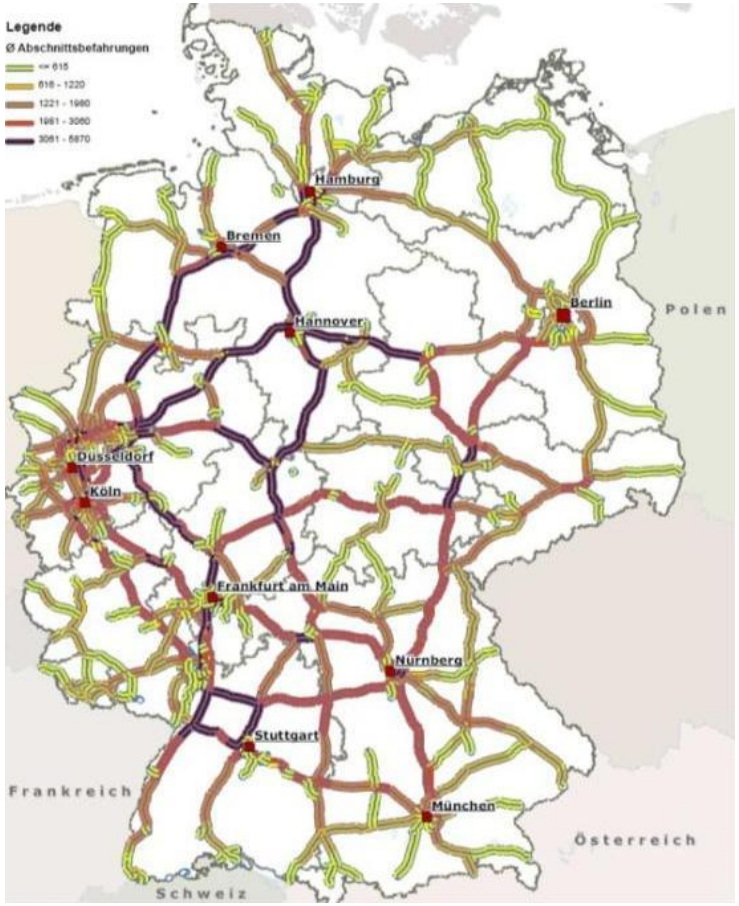
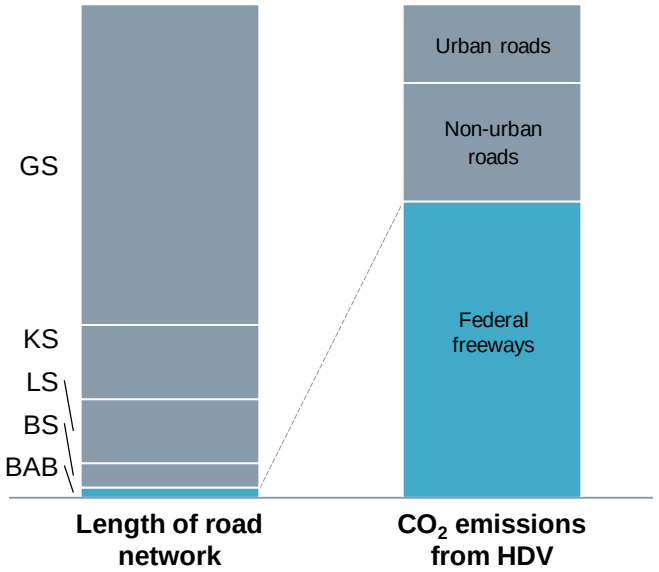


Source: ITF - Transport Infrastructure Needs for Future Trade Growth (2016) page 31

Long haul road transport is highly concentrated to the highway network





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

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. **89 %** of German truck trips after leaving the highway are **50 km or less**

Source: BMVI website. Study available here

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Electrified road freight transport – contributing to a sustainable transport sector

4,000 km
network of contact lines on German autobahn is recommended by the Federation of German Industries (BDI) as a cost-effective decarbonization measure

11 %
of expected truck toll revenue (Lkw-Maut) would cover the investment in a 4,000 km network

16,000 €
of fuel savings can be achieved by a 40-ton truck driving 100,000 km on the eHighway (based on 1.25 €/l diesel and 0.15 €/kWh electricity)

80 %
of heavy duty trucks would have an economic incentive to switch to contact line, given that the busiest 4,000 km of autobahn are electrified

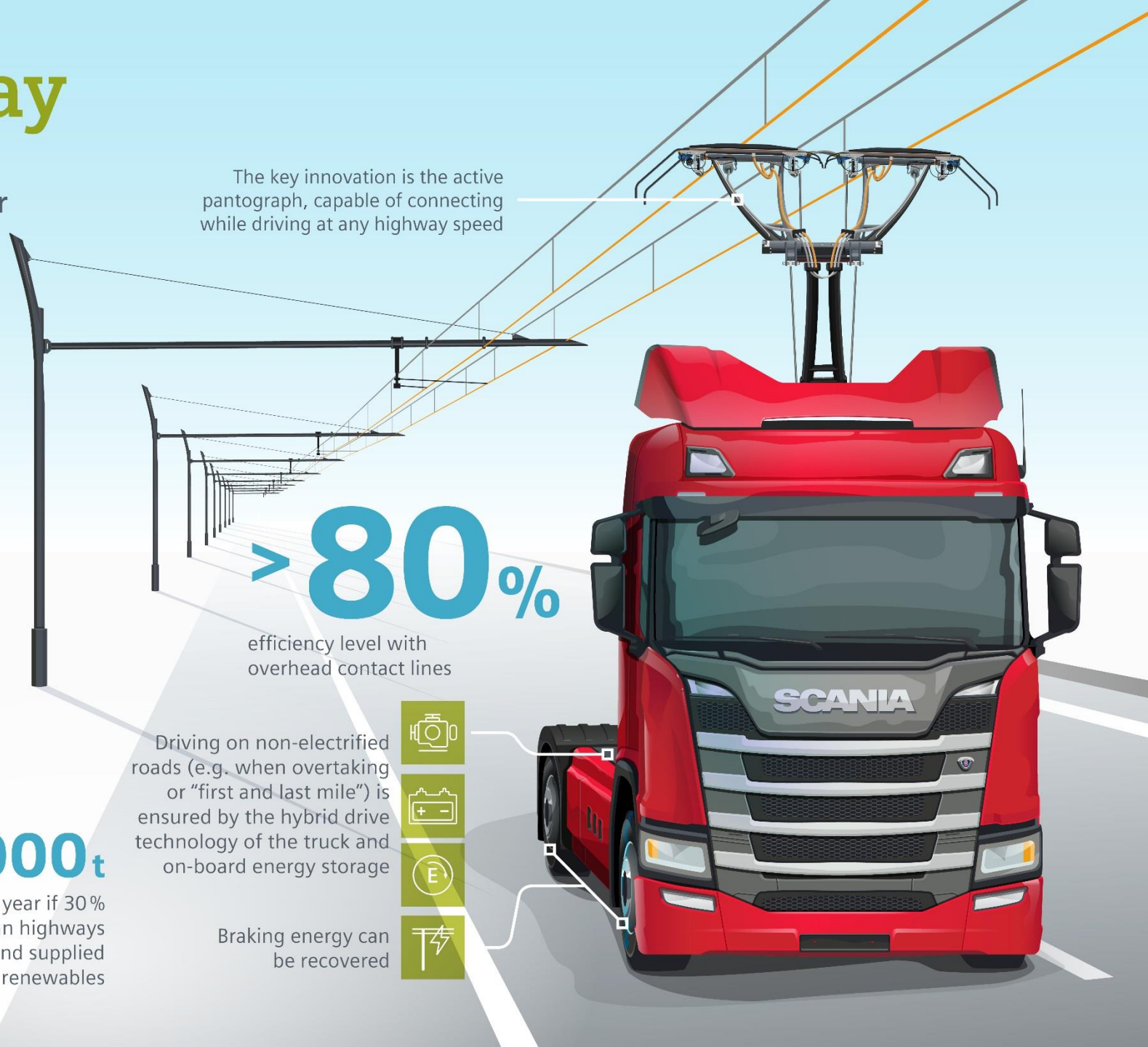
> 7,000,000 t
of CO_2 savings per year if 30 % of truck traffic on German highways is electrified and supplied with renewables

The key innovation is the active pantograph, capable of connecting while driving at any highway speed

> 80 %
efficiency level with overhead contact lines

Driving on non-electrified roads (e.g. when overtaking or "first and last mile") is ensured by the hybrid drive technology of the truck and on-board energy storage

Braking energy can be recovered




1
2
eHighway
Elektrisch in die Zukunft
3

How an eHighway for HDVs works

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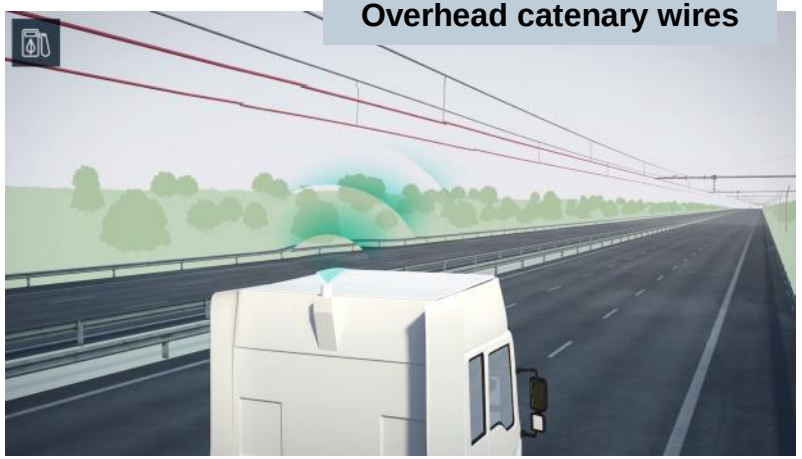
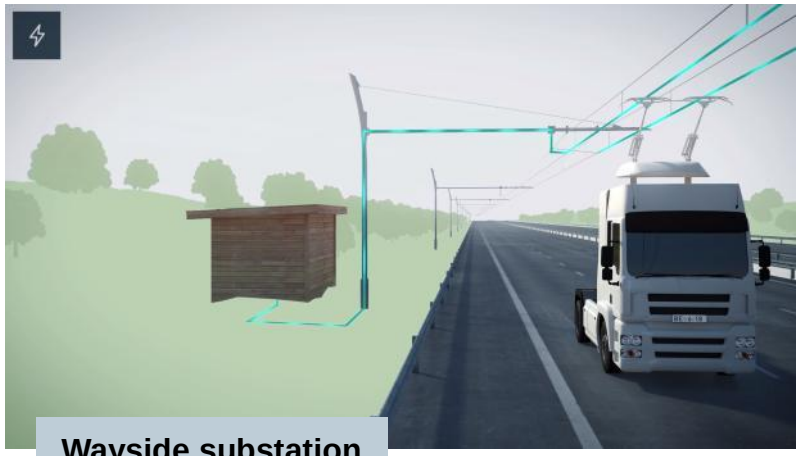
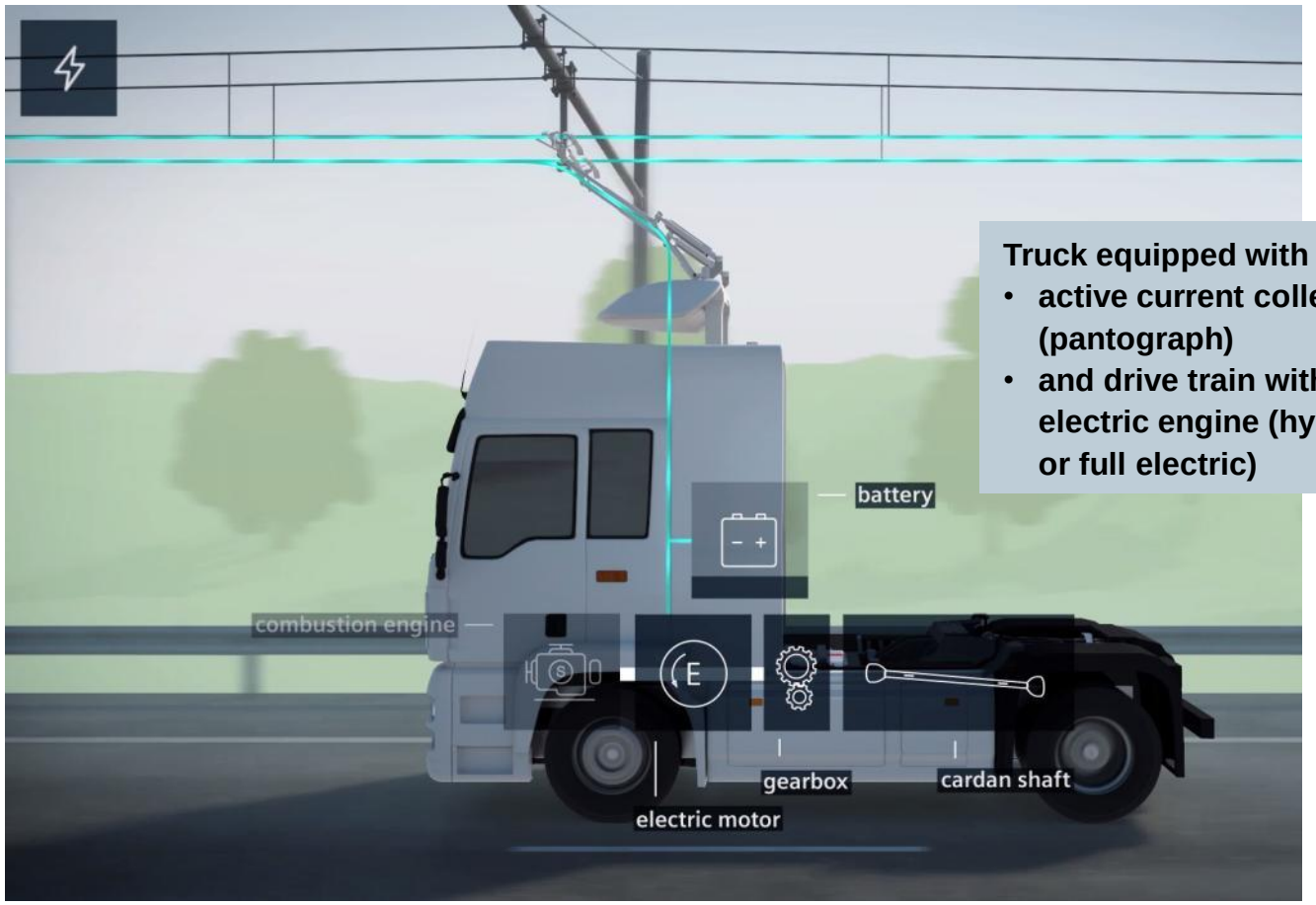


Overhead catenary wires



Wayside substation



Truck equipped with
- **active current collector (pantograph)**
- **and drive train with an electric engine (hybrid or full electric)**

https://www.youtube.com/watch?v=zV2yZkRFBK0

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)

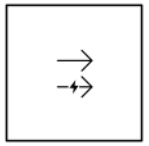

Tractor truck (3 axles)

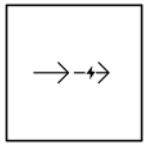

Rigid truck (2 axles)


Rigid truck (3 axles)


Rigid truck (4 axles)

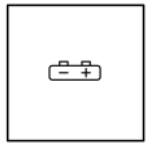
Drive system

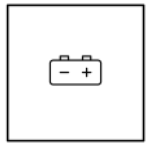

Parallel-hybrid

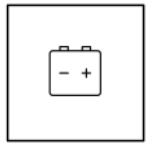

Serial-hybrid

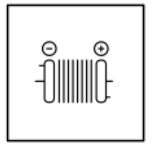

Full electric

On-board source of electricity

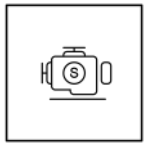

Battery (small)


Battery (medium)

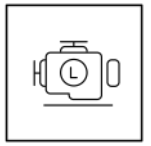

Battery (large)


Fuel cell

Combustion engine


Engine (small)


Engine (medium)


Engine (large)

Non-electrical source of energy


Diesel


Bio-fuel

CNG/LNG

H_2

eHighway Trucks – from Proof-of-Concept to Field trials

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Development of the eHighway vehicle technology

2010 — **2019**

1. Generation
Proof of concept

2. Generation
Demonstration projects

3. Generation
Field trials

Operations up to 100 km/h possible

Connection and dis-connection to catenary in motion

Recharging of onboad energy storage while driving

No limitations for first and last mile

Demonstration projects on public roads since 2016

California: https://www.youtube.com/watch?v=3s1Vopg3vUc

Sweden: https://www.youtube.com/watch?v=fmcMmYdF6lA

German field trials in 2019 are a necessary near term step for the development of the system

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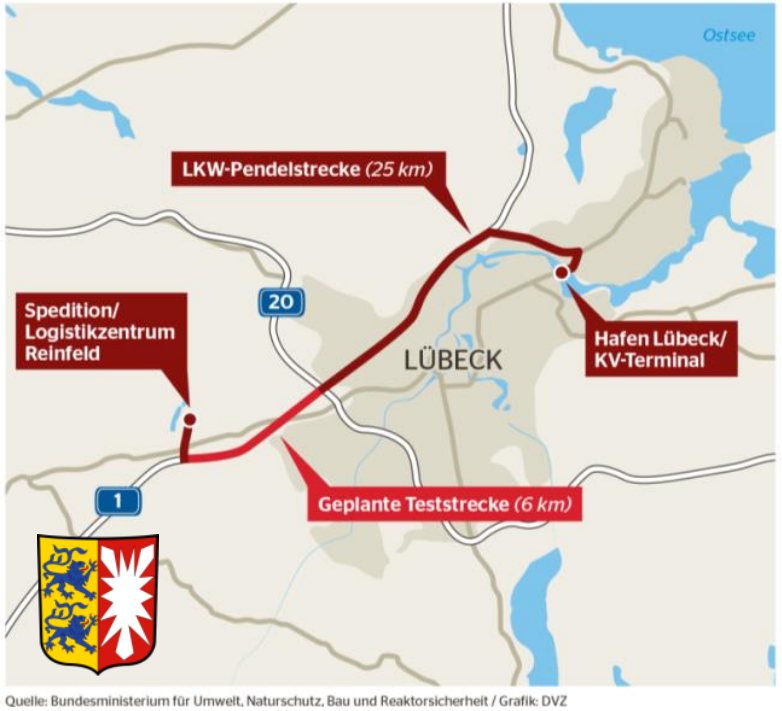
Information and routing

Federal State of Hesse
Infrastructure project awarded to Siemens
Track length / Amount of trucks: 5km / 5
Construction: April-Nov 2018
Demonstration: Official start **May 7** 2019

Project homepage: ELISA

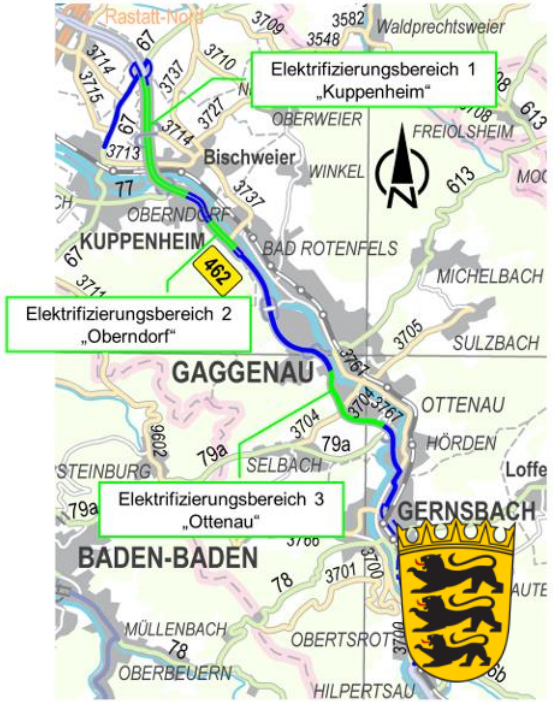
Federal State of Schleswig Holstein
Infrastructure project awarded to Siemens
Track length / Amount of trucks: 5-6km / 5
Construction: Started Oct 2018
Demonstration: Start in 2019



Quelle: Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit / Grafik: DVZ

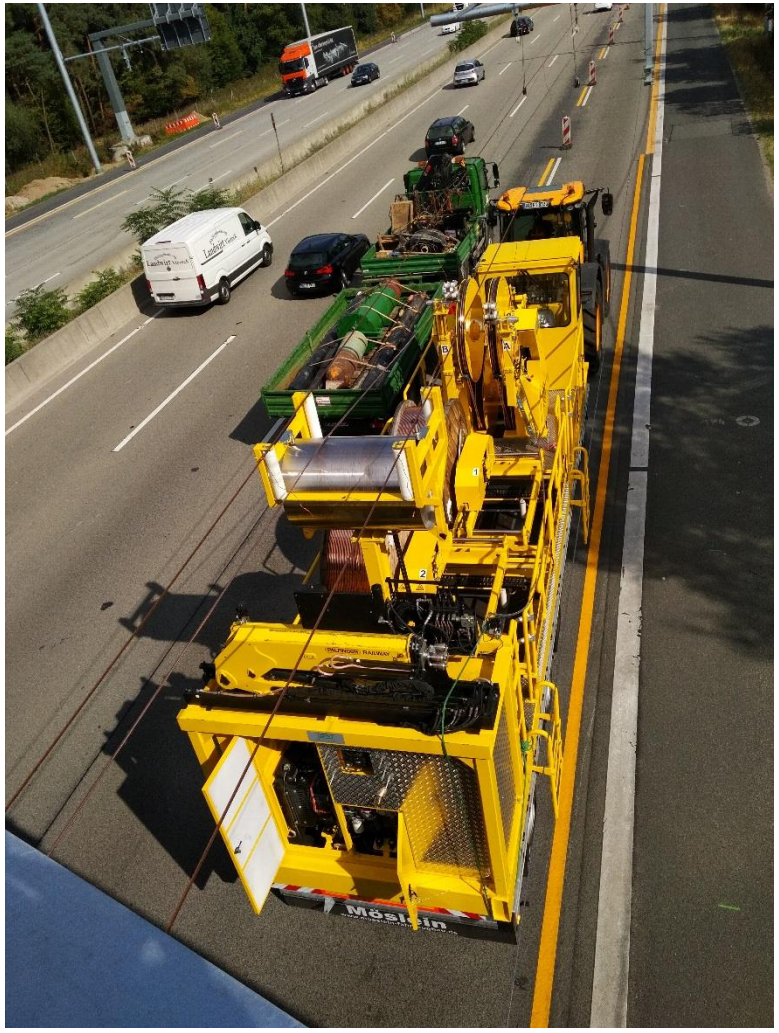
Project homepage: FESH

Federal State of Baden-Wuerttemberg
Tender published Nov 2018
Track length / Amount of trucks: 5-6km / 5
Customer's targeted start of Demonstration: 2019



Project homepage: eWayBW

Scenes from the construction



Many pictures available at: https://mobil.hessen.de/verkehr/elisa/baustellen-news

Scania will deliver 15 trucks for German field trials
This represents the third generation of eHighway trucks

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Latest Scania truck and third generation of pantograph
See Scania press release

The next steps should be pilot projects proving that zero-emission heavy road freight is both economical and practical

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CEO of Scania, CTO Volvo Group & Johan Rockström

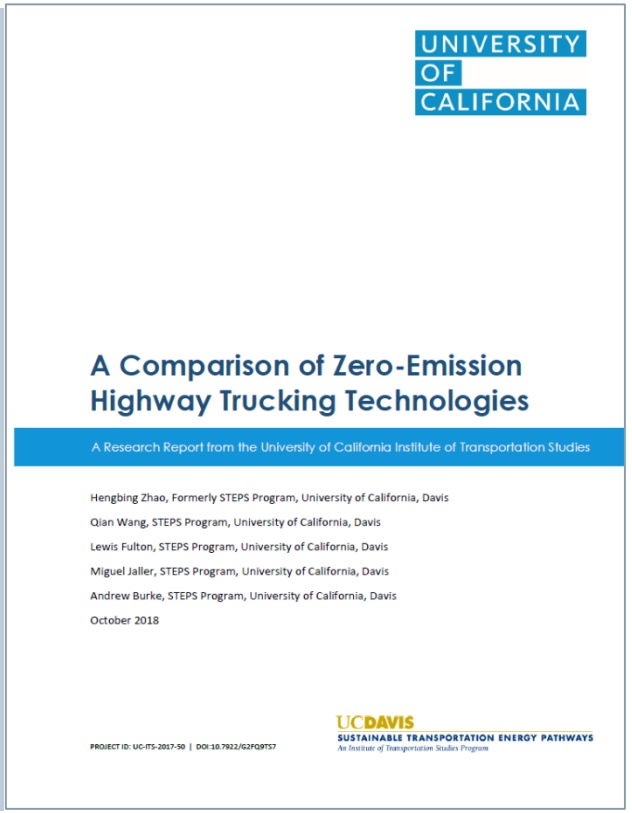
Sweden should conduct pilot projects where whole fleets of trucks can show how the transition to sustainable road transport can happen.

For example scaling up of the existing eHighway demonstration project in Gävle.

Source: https://www.di.se/debatt/volvo-scania-mfl-sverige-ska-bli-en-fossilfri-varldsutstallning/ (April 2018)

UC Davis

„Considering technology readiness, energy efficiency, and capital cost, the most feasible approach for the zero-emission technologies for long-haul trucks may be to deploy local or regional catenary systems. “


UNIVERSITY OF CALIFORNIA

A Comparison of Zero-Emission Highway Trucking Technologies

A Research Report from the University of California Institute of Transportation Studies

Hengbing Zhao, Formerly STEPS Program, University of California, Davis
Qian Wang, STEPS Program, University of California, Davis
Lewis Fulton, STEPS Program, University of California, Davis
Miguel Jaller, STEPS Program, University of California, Davis
Andrew Burke, STEPS Program, University of California, Davis
October 2018

UCDAVIS SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

Source: A Comparison of Zero-Emission Highway Trucking Technologies (Oct 2018)

Independent institutes in Germany have identified early shuttle applications and how to scale up to a full system

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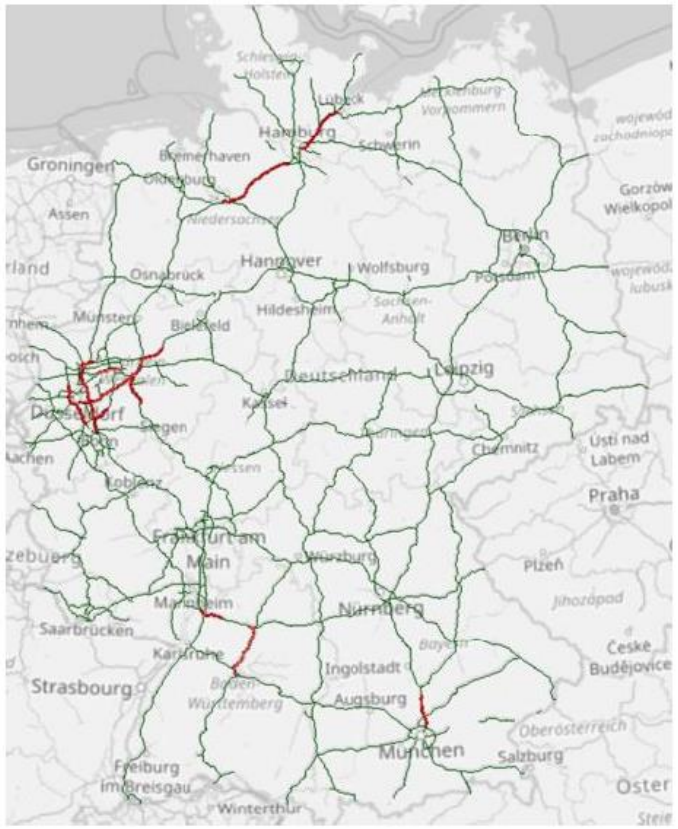
Selected recommendations

- Suitable first applications are on routes around Hamburg, in Ruhr area and southern Germany
- With a comperehensive network of catenaries it is possible that 65% of the vkm by heavy duty trucks could be commercially viable to switch to catenary-trucks
- Using electricity with a carbon footprint of 412 g/ kWh this would help reduce the total GHG emissions from heavy duty trucks in Germany by 17%
- Without a transparent development plan for the infrastructure the risks of faced by OEMs and trucking companies during the transitions are too big

Identified routes based on freight goods flow suitable for catenary systems usage



#	Name	BAB	Distance
1	Essen/Gladbeck – Dreieck Heumar	A3/A2	85 km
2	Düsseldorf – Kreuz Kamen	A46/A1	81 km
3	Neckarsulm - Stuttgart	A81/A6	57 km
4	Hamburg – Lübeck	A1	49 km
5	Krefeld – Köln	A57	45 km
6	Schwerte – Lüdenscheid-Süd	A45	32 km
7	Essen – Dortmund	A40	26 km
8	Kreuz Kamen – Hamm-Uentrop	A2	23 km
9	Pfaffenhofen – München	A9	20 km
10	Bremen – Hamburg	A1/A261	81 km

Source: IFEU, PTV – *Roadmap OH-Lkw Potentialanalyse 2020-2030* page 22 and 30

Interest in further projects is spreading internationally

Potential Italian highway project

Towards a 'zero impact' eHighway

17 SEPTEMBER 2018

News | Sustainability | Sustainable transport

After Sweden and Germany, Italy to be next country to start electric road trials.

The A35 Brebemi autostrada in northern Italy is set to become the latest location for road electrification technology, and Scania trucks fitted with Siemens pantographs and power connections are in line to carry out the initial trials.

To begin with, the project will focus on a six-kilometre stretch of the autostrada between its Romano di Lombardia and Calcio exits, yet those behind the initiative have even more ambitious plans.

Source: https://www.scania.com/group/en/towards-a-zero-impact-ehighway/

French government interest

*"France and Germany will work together on a **cross-border test track for an electric e-highway**, thereby sending out a signal for innovative solutions for sector coupling and for the decarbonization of the transport sector." Franco-German Energy declaration 180713*
By Nicolas Hulot, Minister for Energy & Environment

Source: https://www.bmwi.de/Redaktion/DE/Downloads/C-D/draft-franco-german-energy-declaration.html

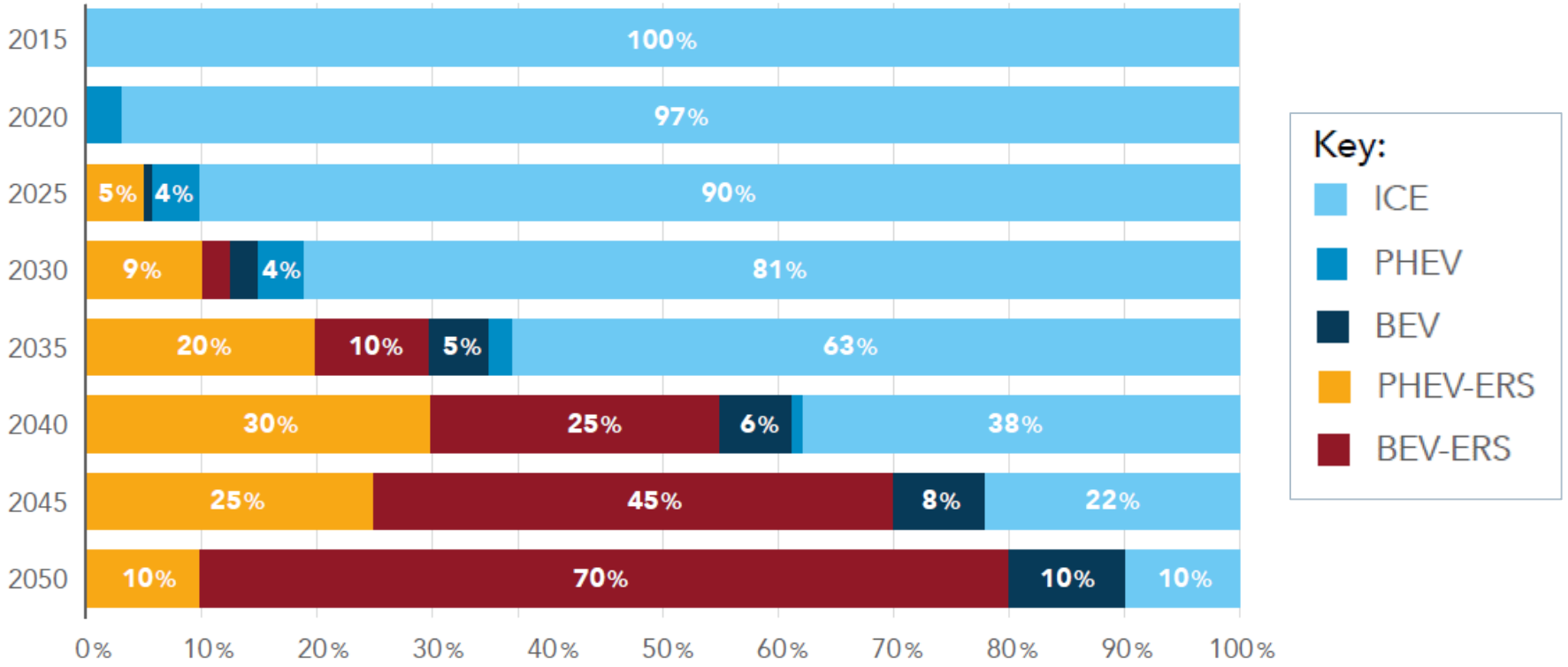
*"aim to explore the possibility to **include France in the German-Swedish partnership for Electric Road Systems**. First step would be to organize, by the end of 2018, an unconditional information meeting between ministries in France, Germany and Sweden" – FR-SE Innovation partnership 180619*
By Elisabeth BORNE, Minister for Transport

Source: https://www.government.se/49e1fd/globalassets/regeringen/dokument/naringsdepartementet/pdf-i-genvagsblock/180619-communique-borne-eneroth.pdf

The systemic transition to zero emission road freight requires breaking out from early shuttles to large scale network

- Possible important role of hybrids (driving a very high share on electricity) as users of partial infrastructure network
- Nearly completed network will facilitate transition to fully zero-emission mobility

New vehicles sales by technology type in an Electric Road Systems scenario



Source: European Climate Foundation – Trucking into a Greener Future (2018) page 9

Providing the right infrastructure is a necessary precondition for zero emission long-haul trucking

Thank you for your attention

Patrik Akerman
Head of eHighway Business Development

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Mobility
Technology & Innovation
eHighway

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E-mail: patrik.akerman@siemens.com

www.siemens.com/ehighway

#eHighway

ICCT assesses that electrification with contact lines can contribute the most to deep decarbonization of HDVs

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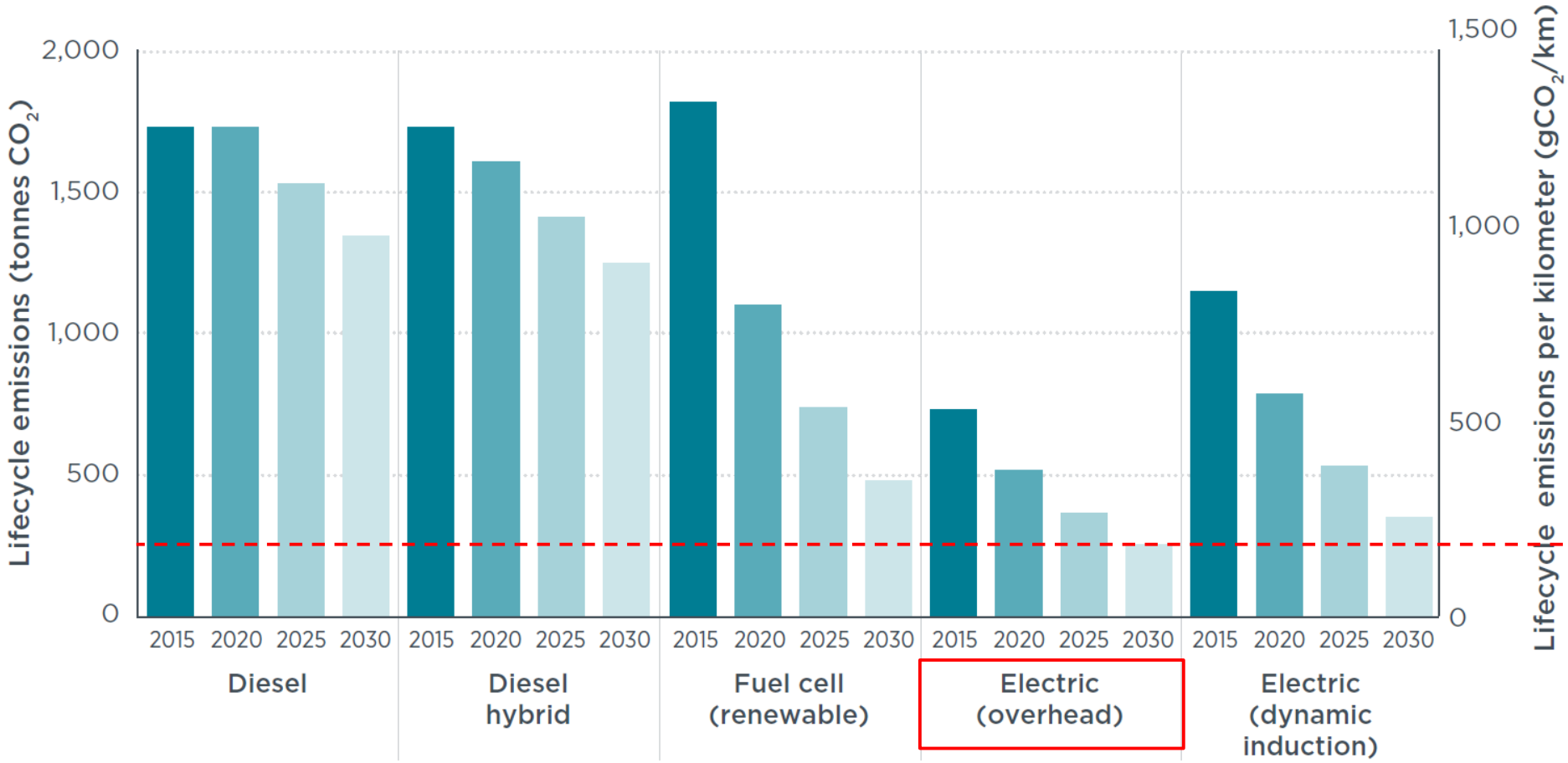

Figure 12. Long-haul tractor-trailer lifecycle CO_2 emissions over vehicle lifetime (left axis) and per kilometer (right axis) by vehicle technology type.[29]

- Greatest reductions in GHG emissions in all time periods

Source: ICCT – Briefing: CO2 emissions and fuel consumption standards for heavy-duty vehicles in the European Union (2018) page 12

System cost assessment shows that efficiency of energy supply plays a far greater role than vehicle and infrastructure costs

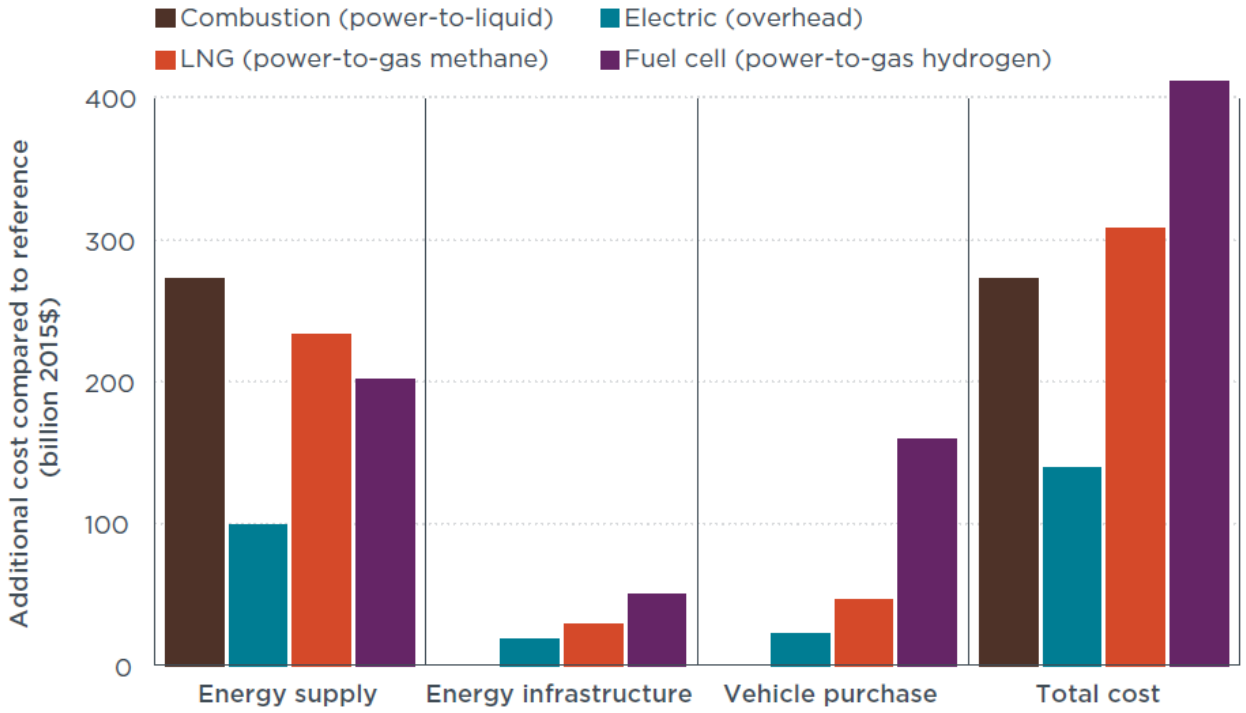

Figure 5. Additional cost for four different greenhouse gas reduction scenarios compared to the reference case (all fossil fuel use) for the long-haul heavy-duty freight transport sector in Germany (based on Kasten et al., 2016).

- Business case for zero emission need to assess several factors, in addition to vehicles
- It is equally important to assess cost of refueling (quickly).
- Especially cost of energy appear to impact total system cost significantly

Key assumptions:

- Length of electric network: 4,000 km; Infrastructure costs: 2.2 million €/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

Independent institutes in Germany have also found that catenary would be the most effective way to reach climate goals for trucks

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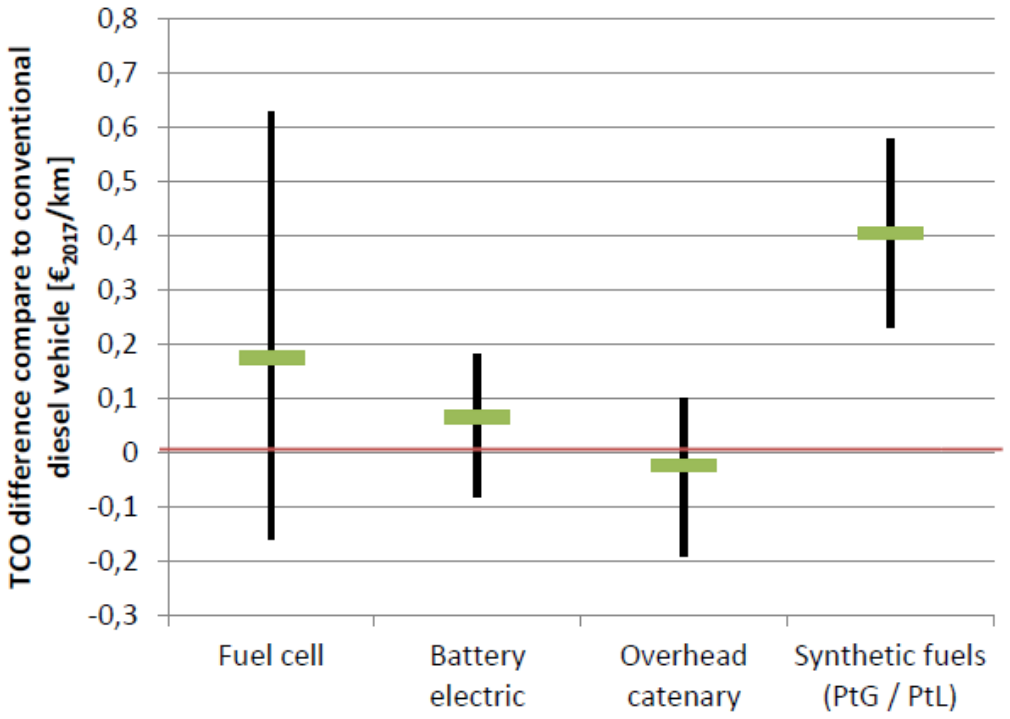
Key recommendations

- The diversity of conceivable drive train alternatives hinders policy decisions by actors in road freight transport.
- Electric drives have the crucial advantage of low operating costs for trucks
- Alternative drive trains require early infrastructure investment.
- Catenary trucks have advantages in terms of energy economy, as the electricity requirement is comparatively low and is distributed more evenly over the route network.
- The switch to alternative drives requires political action today
- Infrastructure development can be carried out at limited cost, but must be pre-financed by the state.
- Large demonstration projects help to gain practical experience and create acceptance.



Variation in TCO of different alternative drives / fuel options relative to fossil diesel vehicles in the period 2020 – 2030 (mean value (in green) and bandwidth between different studies).[12]

Source: Oeko Institute, Fraunhofer ISI & IFEU – *Alternative drive trains and fuels in road freight transport – recommendations for action in Germany* page 10

German industry association BDI recommends 4.000 to 8.000 km of overhead catenary lines as a cost-effective climate action for HDVs

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Background

- BDI published in 2018 an independent report looking at **all sectors of the economy**
- It investigated the most **cost effective ways** to reach German climate goals: **-80% and -95% GHG**
- Involved 68 BDI-member associations and companies, 200 industry experts and 40 workshops

Major findings

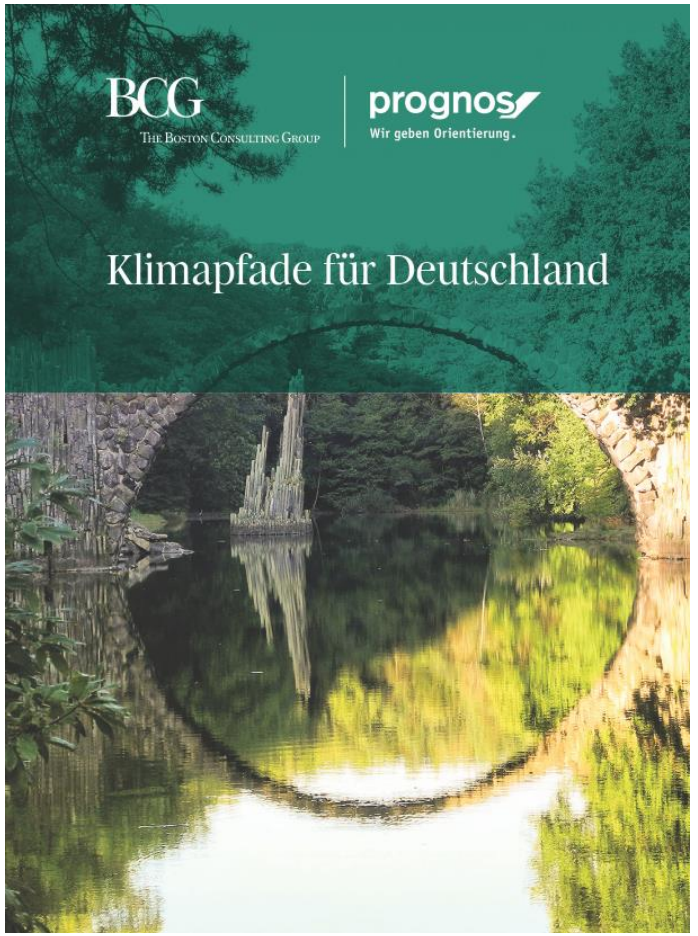
- Reaching **the 80% reduction is possible** by pushing existing technologies to the max. Has economically **positive effects, even if Germany acts alone**.
- Reaching the **95% reduction goal** touches the limit of what can be expected from technology and citizens. **Only in joint action with G20 economies** would this be economically manageable

Transport highlights

- Shift to rail leads to an i**ncrease by 88% of ton-km of freight activity on rail** by 2050
- **No additional biofuels** for transport**,** because other sectors will be prepared to pay more
- **PtX only in 95% scenario.** Imported from Middle East & North Africa, and it will still be very pricey

eHighway

- Building **overhead catenary is the cheapest solution** for HDVs, despite high infrastructure costs.
- Recommends building **4.000 km** overhead contact line in the 80% scenario and **8.000 km** in 95%
- Based on GER perspective. **EU solution** brings **large synergies** and is even more cost-effective
- Investment decision needs to be made by 2025, leading to first 400 km in operation by 2028.



Source: https://bdi.eu/publikation/news/klimapfade-fuer-deutschland/

eHighway offers efficient and low cost electricity supply, thanks to smooth load profiles and high connection voltage

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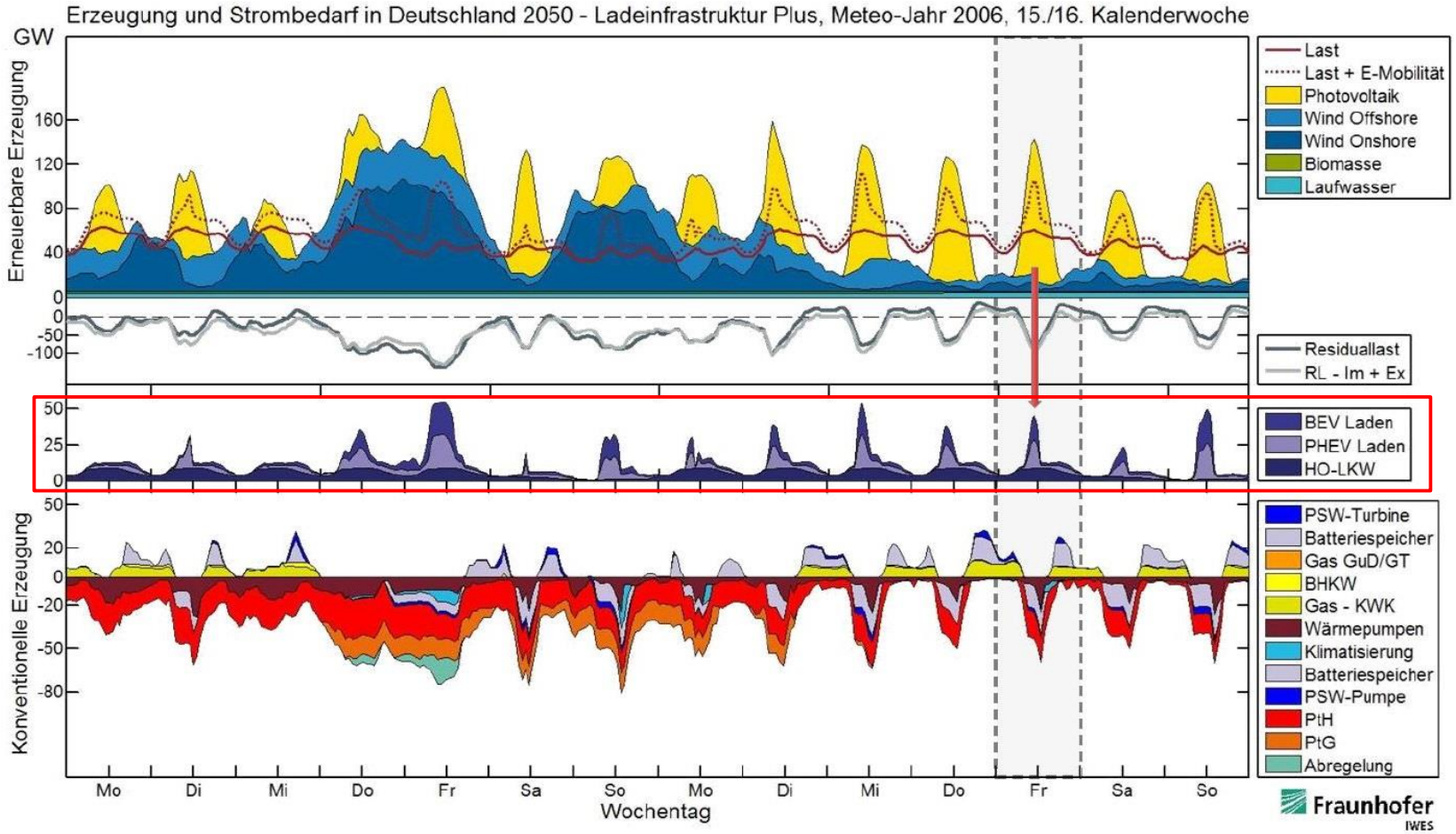
Detailed load profiles from BEV, PHEV and eHighway, and supply though conventional and renewable generation in Germany



- **Flexible distributed loads are essential** for an energy supply based mainly on fluctuating renewable based generation
- The charging of BEV and PHEV vehicles leads to daily peak loads. **eHighway exhibits a smoother load profile.**
- **eHighway-enabled trucks** using hybrid drives (e.g. combustion engine using sustainable biofuels) can contribute to system peak load reduction (active load management/deferrable load).
- Grid connected eHighway truck systems enable a more **efficient use of energy**.

Source: http://www.energieversorgung-elektromobilitaet.de/Kernaussagen.html