eHighway

Electrified heavy duty road transport

Opening questions (posed by Jari)

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- Where are we today?
- CO2-mitigation potential?
- Cost-effectiveness?
- Feasibility, timeline, Adoption rates?

Context for Electrified Roads for HDVs

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Important points from yesterday‘s workshop sessions

- Focus on profile of emission reductions getting us to the emissions goal („**at least** 60% by 2050“)
- HDVs operating outside cities constitute a large majority of diesel consumption
- Emissions from HDVs is expected to grow from 1.5 Gt to 3 Gt by 2050
- Fully implementing traditional tool box cannot get us close to reaching climate goals

→ Need to think about new solutions and a **systemic transition**, especially for non-urban HDVs

Additional context

- Power sector decarbonization
- ERS and grid synergies
- Compatible with industry trends

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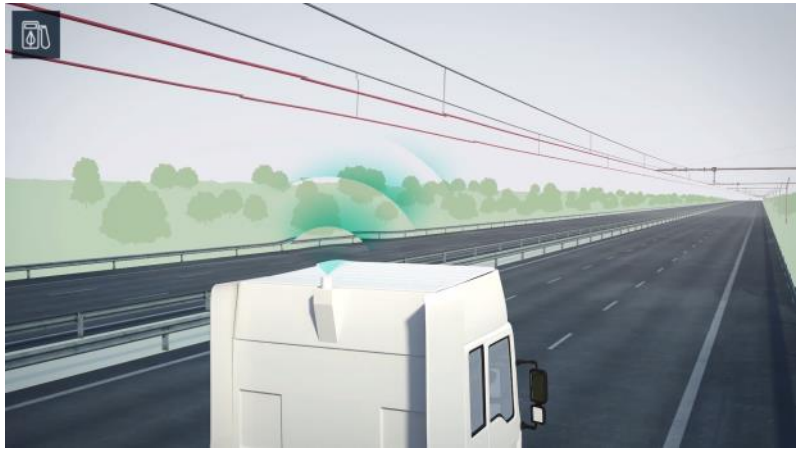
What are electrifed roads for HDVs

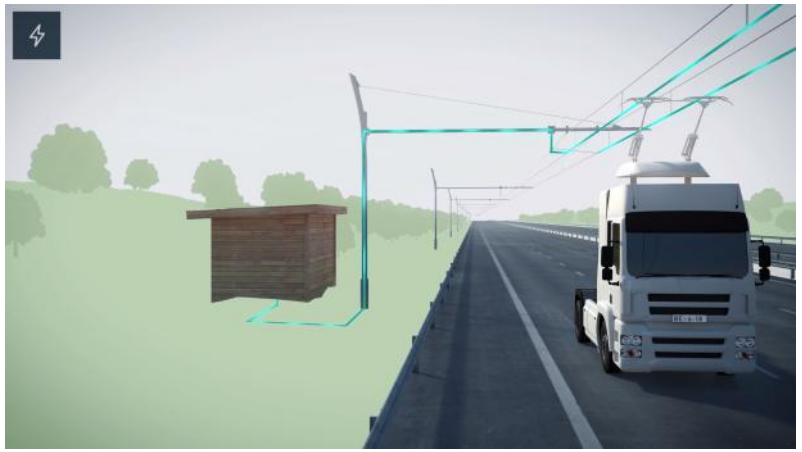
Development of eHighway

The potential benefits

Possible road map from inital deployment to system

How eHighway works





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

Compatible with and complementary to other alternative fuel technology

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The eHighway hybrid truck can be configured to suit specific applications

Truck types


Tractor truck (2 axles)

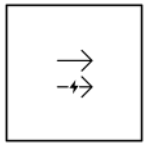

Tractor truck (3 axles)

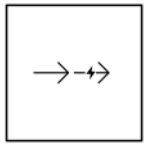

Rigid truck (2 axles)


Rigid truck (3 axles)


Rigid truck (4 axles)

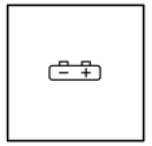
Drive system

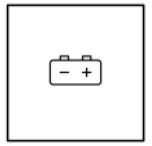

Parallel-hybrid

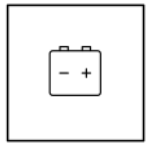

Serial-hybrid

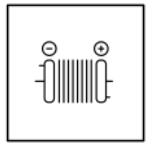

Full electric

On-board source of electricity

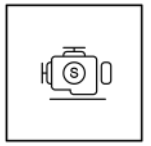

Battery (small)


Battery (medium)

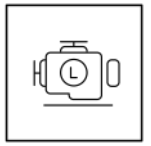

Battery (large)


Fuel cell

Combustion engine


Engine (small)


Engine (medium)


Engine (large)

Non-electrical source of energy


Diesel


Bio-fuel

CNG/LNG

H_2

Alternative concepts for climate-friendly road freight transport

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Investigated concepts comprise external power supply and on-board storage systems

On-board storage

Alternative fuels	Electricity
CNG / LNG	Battery
Bio fuels	Capacitors
	Fuel cell

External power supply

Contactless	Conductive
Inductive power supply	Ground-based contact line
Linear s. motor concepts	Overhead contact line

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Possible road map from inital deployment to system

Funded research projects supplement the currently executed projects on public roads in Los Angeles and Sweden

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Research Projects

- **ENUBA (Germany)**
  - First research project with BMUB
  - Duration: 05/2010 – 09/2011
- **ENUBA 2 (Germany)**
  - Second research project with BMUB
  - Duration: 05/2012 – 12/2015
- **ELANO (Germany)**
  - Third research project with BMUB
  - Duration: 01/2016 – 09/2019

Projects on Public Roads

Los Angeles – Port Application

- One mile demonstration as connection to near-dock rail terminals for cargo vehicles for 6 months
- Primary goal is to promote the implementation of zero emission goods movement technologies
- Cooperation with Volvo trucks and local truck converter

Sweden – Highway Application

- Two kilometer demonstration on a public road between industrial area and port for 2,5 years
- Overall aim is to evaluate Electric Road System options prior to introduction on road network
- Cooperation with Scania trucks

How it works – in reality

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

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

Field Trials in Germany are a necessary next step for the development of the system

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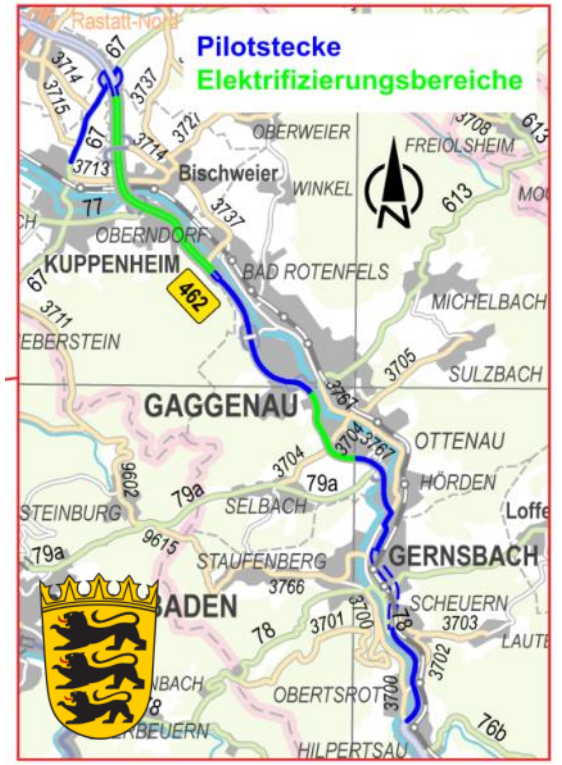
Information and routing

Federal State of Schleswig Holstein
Tender recently published
Track length / Amount of trucks: 5-6km / 5
Start of Construction/Demonstration: 2018/2019

Federal State of Hesse
Project awarded to Siemens
Track length / Amount of trucks: 5km / 5
Start of Construction/Demonstration: 2018/2019

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

Federal State of Baden-Wuerttemberg
Tender not published yet (expected 2018)
Track length / Amount of trucks: 5-6km / 5
Start of Construction/Demonstration: 2018/2019



Copyright: Straßenbauverwaltung Baden-Württemberg, 2017

Field Trials in Germany are a necessary next step for the development of the system

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Information and routing

Source:https://mobil.hessen.de/verkehr/elisa/baustellen-news

Swedish government has allocated EUR 30m for a semi-commercial pilot to take electric roads to the next level by 2021

Swedish policy actions

- 85% of Swedish parliament voted for climate law with goal of **70% reduction** of domestic **transport GHG** emissions by **2030**
- Swedish Transport Administration developing **road map for electrified roads** for next long term transportation plan (by 2022)
- As preparation for the road map a **pilot project before 2022** is planned, with government co-funding of **up to EUR 30m available**.
- Major trucking companies calling for ambitious pilots of new technologies
- Existing demonstration project has performed above expectations and has strong stakeholders in place

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

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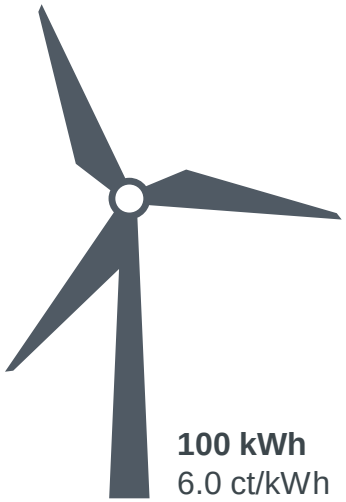

Pathway	Range Cost per km	Efficiency WTW	Example vehicle
Electric Road Systems e⁻ → Grid (incl. catenary) → e⁻ → eTruck (Catenary-Hybrid) 96 kWh, 12 ct/kWh; 1,6 kWh/km	**60 km** 19 ct/km	77%	
Battery e⁻ → Grid → e⁻ → eTruck (Battery) 96 kWh, 10 ct/kWh; 2 kWh/km	**48 km** 20 ct/km	62%	
Hydrogen e⁻ → Electro-lysis η = 70% → H_2 → H_2-network[1)] → H_2 → CH_2- fuel station → CH_2 → Fuel cell truck 2 kWh, 5 kWh 93 kWh; 65 kWh, 15 ct/kWh; 65 kWh, 18 ct/kWh; 65 kWh, 20 ct/kWh; 2.7 kWh/km	**24 km** 55 ct/km	29%	
Power-to-Gas e⁻ → Electro-lysis η = 70% → H_2 → Methanation η = 80% → CH_4 → NG-network[1)] → NG → CNG-fuel station → CNG → Gas-truck 2 kWh 98 kWh; 69 kWh, 15 ct/kWh; 55 kWh, 19 ct/kWh; 55 kWh, 20 ct/kWh; 55 kWh, 22 ct/kWh; 3.2 kWh/km	**17 km** 70 ct/km	20%	

1) Including storage
Source: German Ministry of Environment

System cost assessment, needs to include cost of energy supply as well as vehicle and infrastructure costs

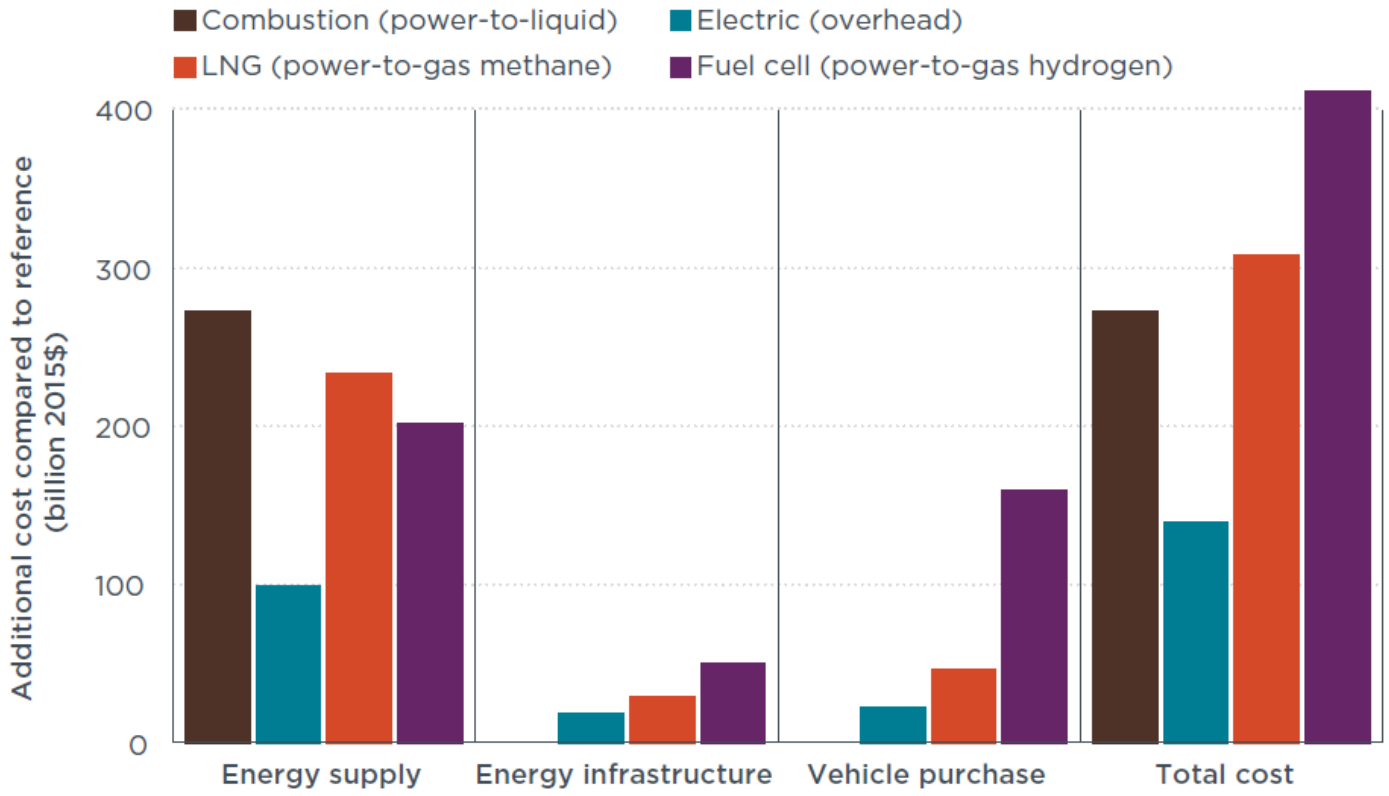

Figure 5. Additional cost for four different greenhouse gas reduction scenarios compared to the reference case (all fossil fuel use) for the long-haul heavy-duty freight transport sector in Germany (based on Kasten et al., 2016).

- 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

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

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 commissioned an independent report looking at **all sectors of the economy**
- 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

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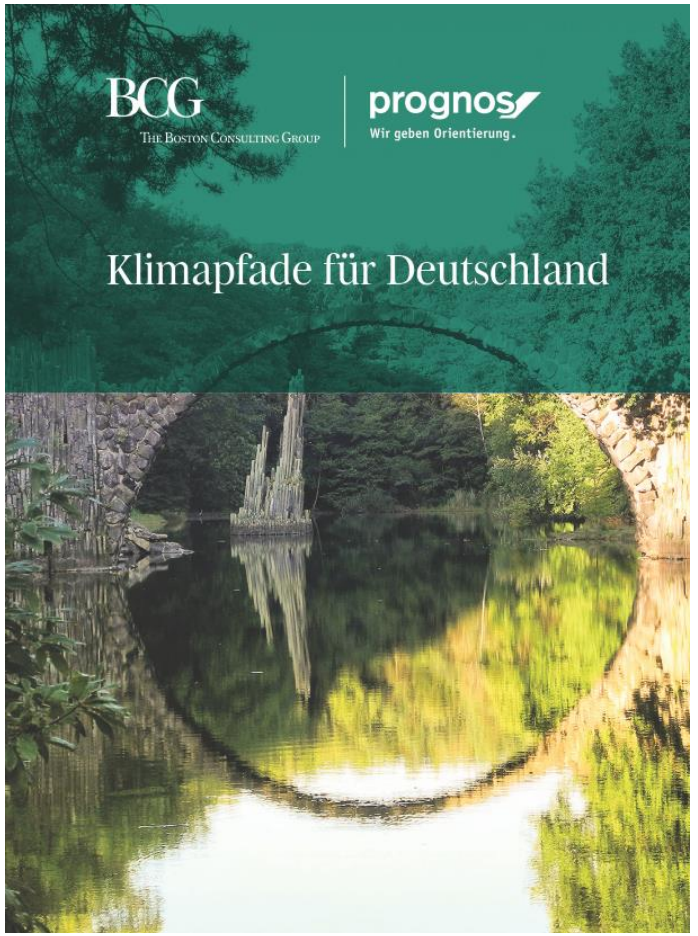
- Building **overhead catenary is the cheapest solution** for HDVs, despite high infrastructure costs.
- Recommends building **4.000 km** overhead contact line in the 80% scenario and **8.000 km** in 95%
- Based on GER perspective. **EU solution** brings **large synergies** and is even more cost-effective
- 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/

Germany electrified 6.000 km railway track in 12 years

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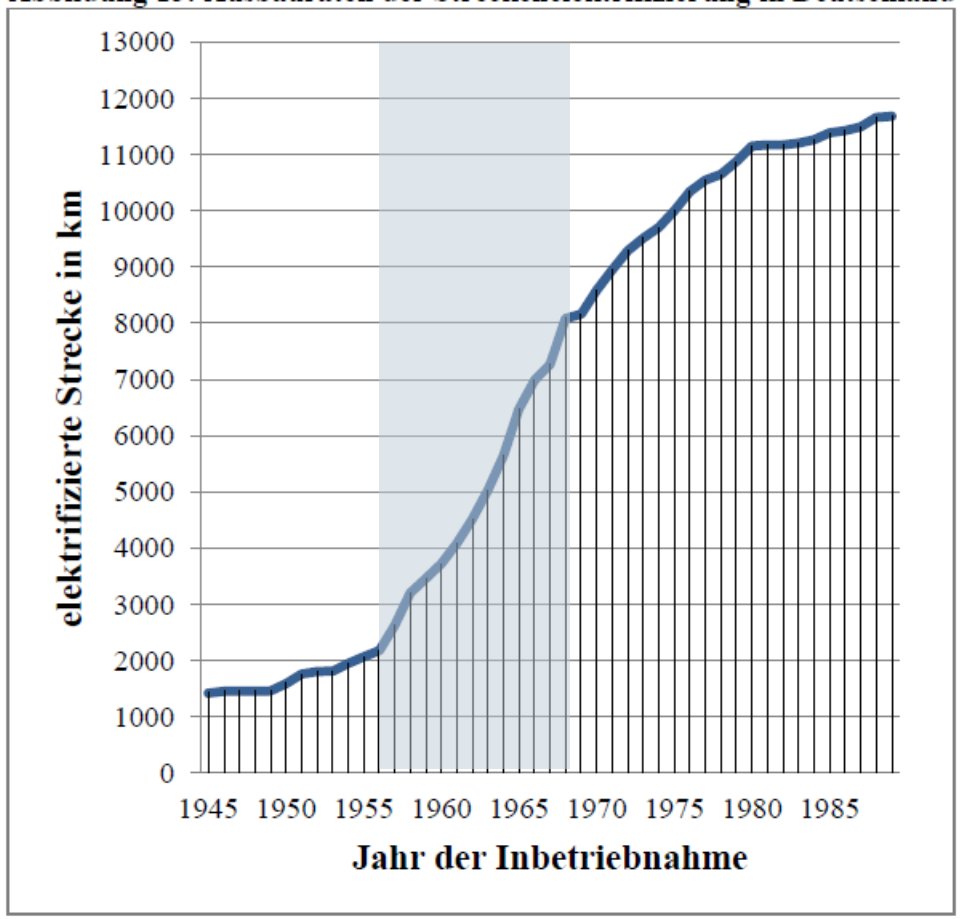
Abbildung 15: Ausbauraten der Streckenelektrifizierung in Deutschland (1945-1989)



Quelle: Eigene Darstellung nach Harprecht et al. 1990, S. 3.

Infrastructure on heavily use roads addresses significant part of heavy duty vehicle (HDV) emissions

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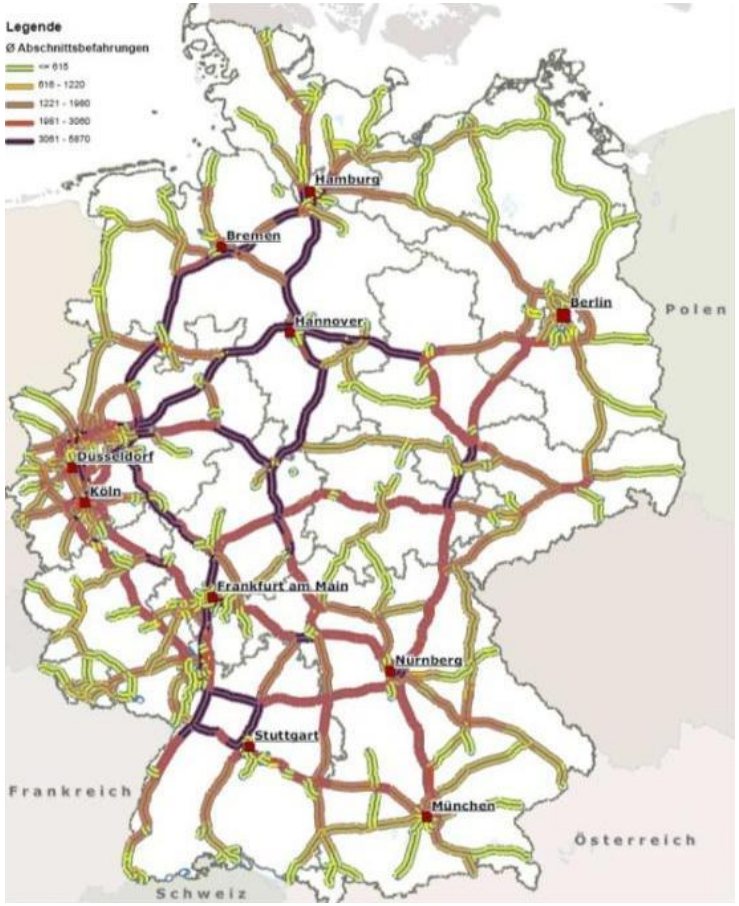
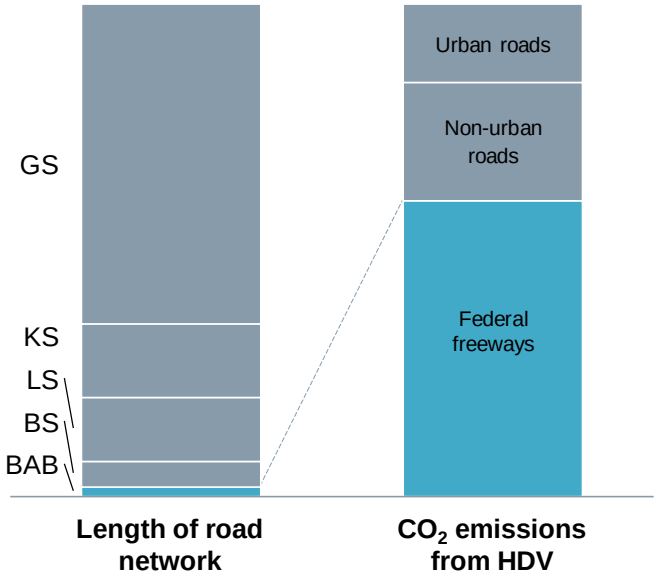




BAB = Federal freeways (12,394 km)
BS = Federal roads (40,400 km)
LS = State roads (86,600 km)
KS = District roads (91,600 km)
GS = Municipal roads (>420,000 km)

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:

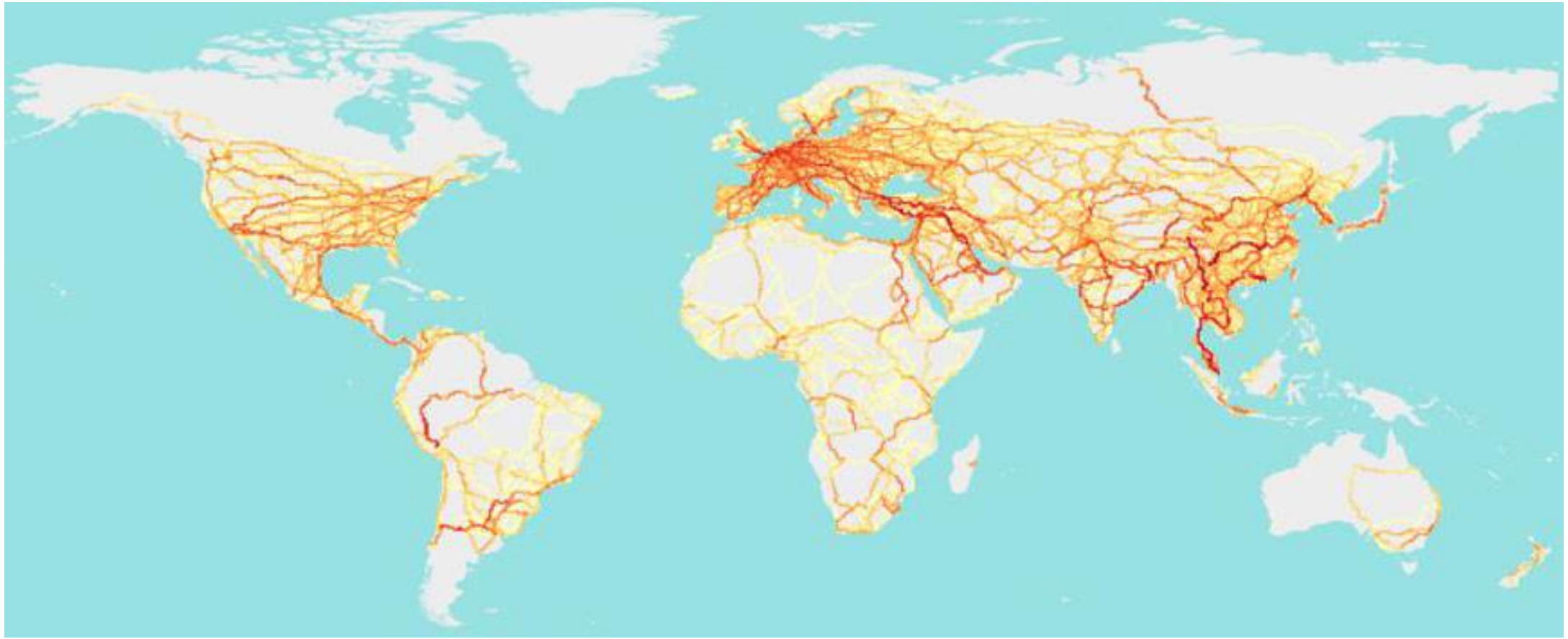
1. **60%** of the HDV emissions occur on 2% of the road network (BAB = 12,394 km)

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

Focusing first on the main freight transport routes, a significant decarbonization step can be achieved.

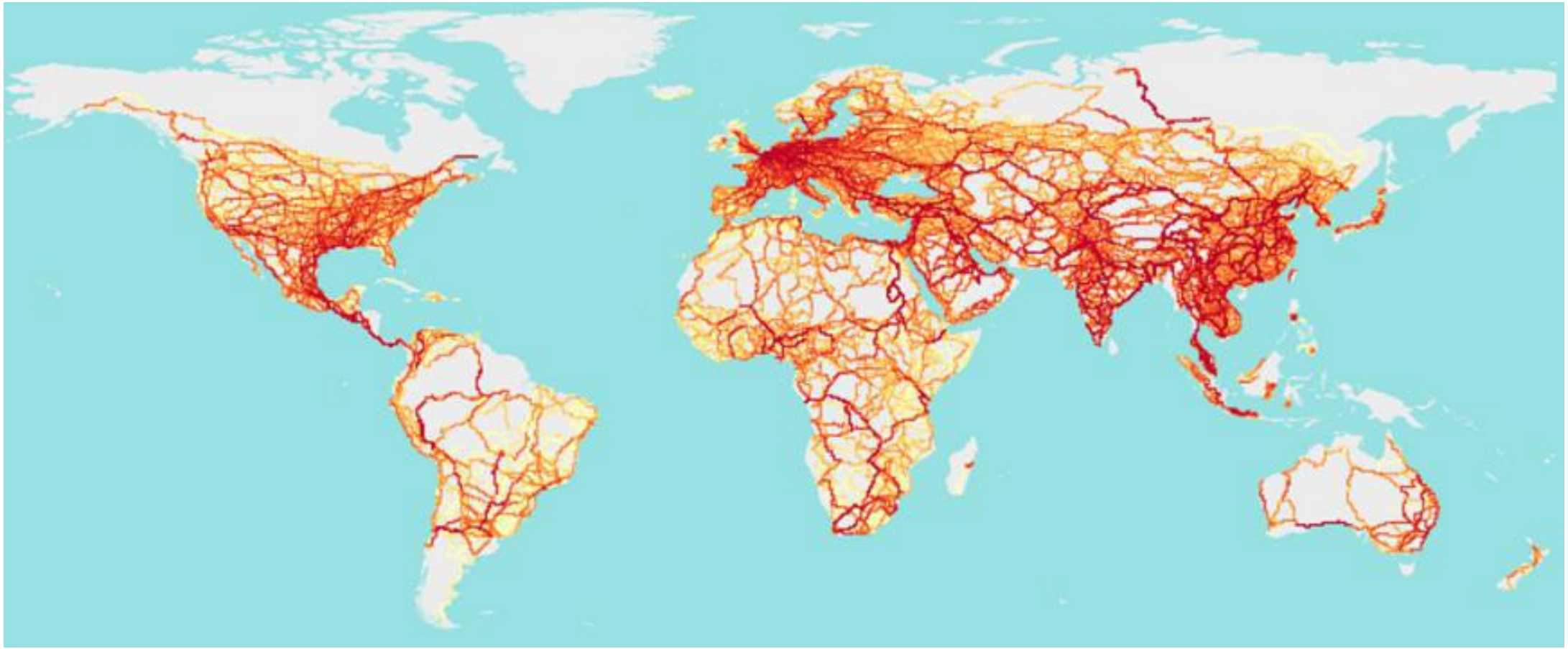
This approach can be applied all over the world.

Surface freight density: 2010



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

Surface freight density: 2050



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

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The path forward focuses on the electrification of highly frequented routes

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eHighway application fields

Near term

Shuttle transport

Mine transport

Long term

Long haul traffic

The development path of road electrification can echo that of rail electrification a century ago

Maturation of eHighway

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Installation	Characteristical operation	Purpose
Gävle demonstration	A few vehicles run by purposly hired personnel on short pieces of infrastructure	Technical demonstration and development of vehicle and infrastructure.
German field trials	5-10 vehicles with short yearly milage utilized by logstics operators replacing conventional vehicles	Technical and functional verification of vehicles and infrastructure ready for series production
Gävle extension	150-200 vehicles with high yearly mileage	Validation of concept at end customer with low volume series produced vehicles and stable infrastructure design

Private data on truck flows and energy consumption

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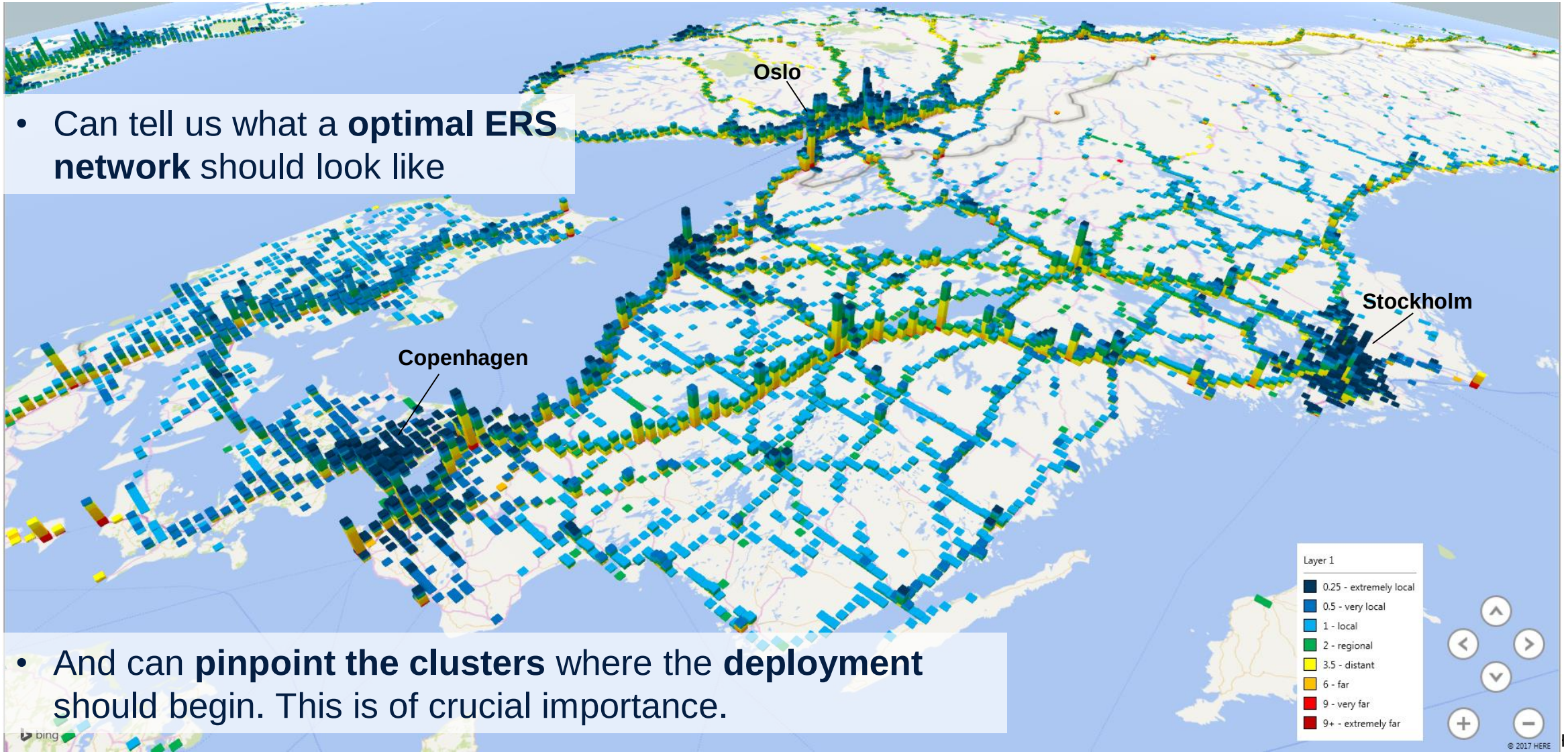
Map of Scandinavia



- Can tell us what a **optimal ERS network** should look like

- And can **pinpoint the clusters** where the **deployment** should begin. This is of crucial importance.

ERS target Sweden: 2021

- Infrastructure erected and commissioned for first cluster having 20 vehicles in operation
- Economic and functional market need for cluster installation verified
- Experience from several installation, funding and operating schemes available for other cluster establishments to use
- Vehicle volume increase to 200 vehicles in 2 years initiated

ERS target Sweden:
2025

- The first established cluster has been in operation for 5 years and has been using 150-200 vehicles from different vehicle suppliers for several years
- National rollout plan, including necessary funding, approved by Swedish government
- Conditions known for
  - ERS installations providing net value for society
  - profitable vehicle investments by private actors

2030

- The ERS ecosystem mature and growing
- Benefit analysis of ERS installation routinely evaluated by Regional and National entities
- Four to five clusters in operation
- Installation of ERS-infrastructure between clusters ongoing to form national network
- (Several interoperable clusters in operation throughout EU)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Elektrisch in die Zukunft

Thank you for your attention

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