Reaching goals in time

The potential of dynamic charging of HDVs on motorways

International Workshop in Sustainable Road Freight
Cambridge, Dec 5, 2023

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Electrified trucking on roads with Dynamic Charging (DYC)
Proven in daily trucking operations on German motorways

Motorway owner's experience of field trial

https://www.youtube.com/watch?v=gAUff-fz_MM&t=0s

Experiences of a truck driver

https://www.youtube.com/watch?v=NHSofIc31rw

Sustainable road freight solution based on overhead contact lines (OCL) – available today for deployment on long and busy corridors

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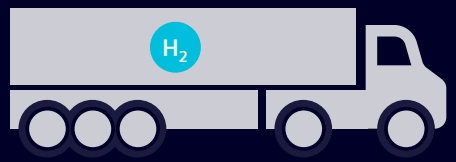
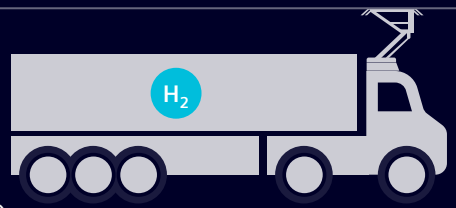
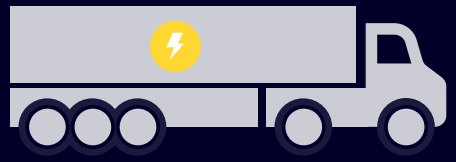
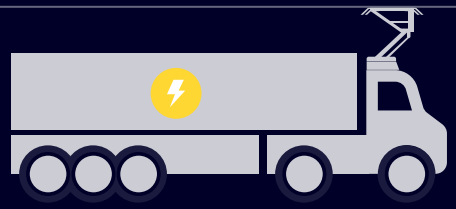
A system compatible with and complementary to other alternative technologies
Decarbonization of heavy-duty trucks is accelerated by dynamic charging

Technology options	Key characteristics	Technology options w/ OCL	Key characteristics
 Hydrogen fuel cell power	+ High range to mass ratio − High operational cost (e.g., scarce green H_2, efficiency)		+ High range to mass ratio + Reduced operational cost when using dynamic charging
 Battery electric power	+ Technology eco-system proven with light duty vehicles − Limited range, charging anxiety		+ Technology eco-system proven with light duty vehicles + Under OCL unlimited range and charging w/o stand-still
 Hybrid with synthetic/bio-fuel	+ Available infrastructure, suitable to decarbonize existing fleet − Limited availability of fuels		+ Available infrastructure, suitable to decarbonize existing fleet + Reduced demand of fuels when using dynamic charging

All three drive technologies and their business cases can be **boosted** by dynamic charging.

Modular approach enables optimized truck config. for each use case.

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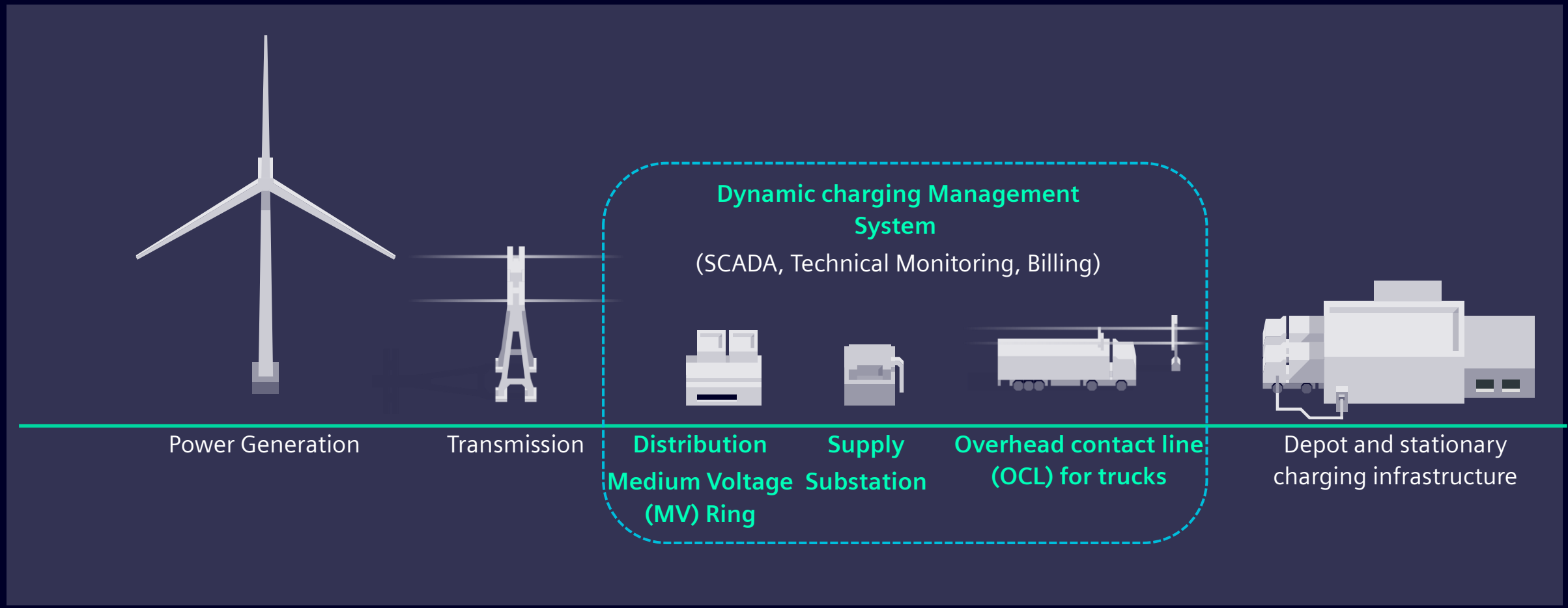
The building blocks of the dynamic charging solution

Based on extensive experience in rail electrification and years of operation



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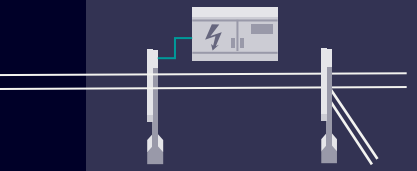
Dynamic charging (DYC) is used in real trucking operations on busy highways

Autobahn GmbH: “Proven in daily operations….OCL technology is ready for roll-out!”

DYC Infrastructure



Pantograph (current collector)

Electrified truck

Start (2010)	Today (2023)
Mature and well-known technology from rail. **Can it be built and operated on busy highways?**	• 7 years experience on EU highways • 30 km OCL on very busy roads • 96%-99.6% availability
Rail and trolley-bus experience. Need new solution: • That fits on tractor truck • Provide at least 200kW • Connect/disconnect at speed	• Fits on tractor truck • Max. power: >500 kW • Works at up to 100 km/h Conti cooperation for industrialization
• Some hybrids available • Battery-electric trucks pretty much unheard of	22 trucks (PHEV tractors & BEV rigids) have driven >2,000,000 km in **real trucking operations**

More information on field trials available: https://www.ifeu.de/publikation/current-technical-findings-on-the-ehighway-system-from-field-tests-and-accompanying-research-in-germany/
https://www.verkehr.tu-darmstadt.de/media/verkehr/fgvv/veroeffentlichungen_2/20230320_Evidenzbasierte_Forschungsergebnisse_ELISA.pdf

Autobahn company FAQ on OCL field trials: Link

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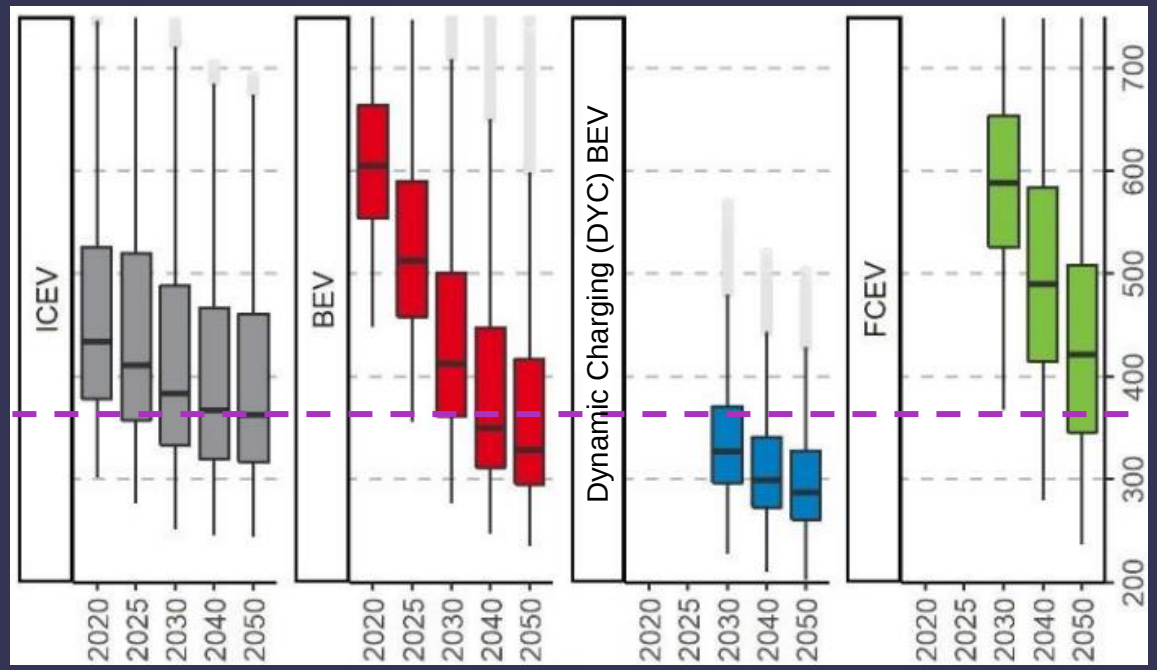
The electrified future of trucks and their infrastructure
Offering lowest Total-Cost-of-Ownership & CO_2-emissions

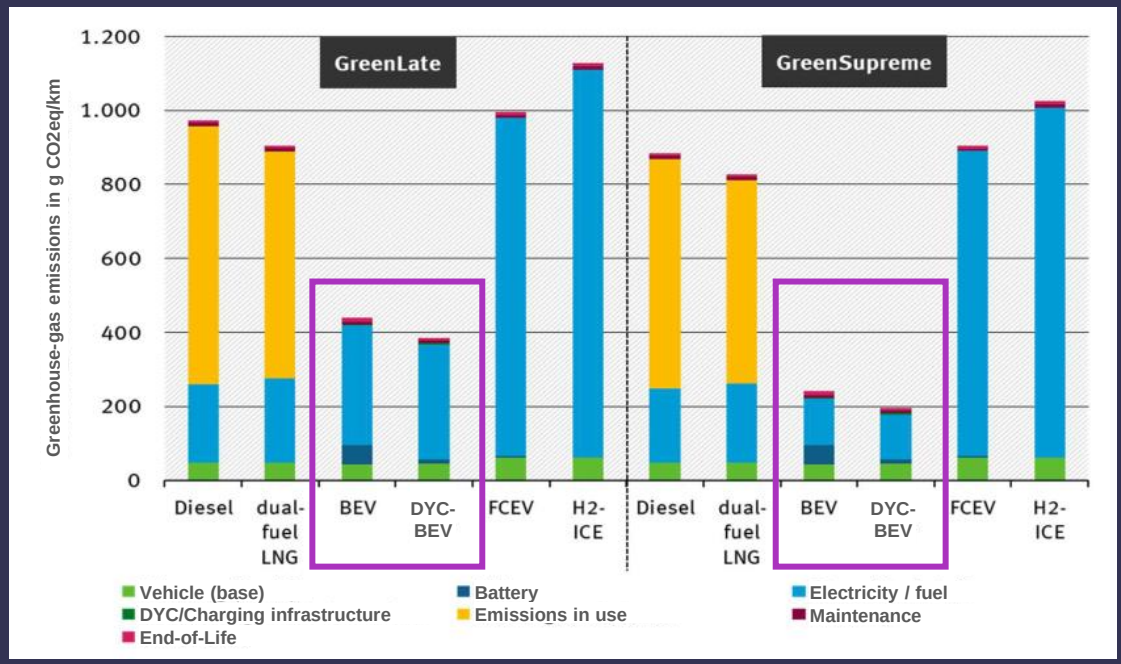
Lowest cost and uncertainty[1]

Total Cost of Ownership (TCO) in k EUR, for vehicle group 5 (4x2 tractors)



Strong CO_2 reductions already in this decade[2]

GHG-Emissions in g CO2-eq./km for tractors in 2030 (medium payload of 11 t)



1. https://www.itf-oecd.org/decarbonising-europes-trucks-minimise-cost-uncertainty Nota bene: ITF uses the term ERSV (electric road system vehicle) for DYC BEV
2. ifeu: Vorläufige Projektergebnisse „Umweltbilanz von Fahrzeugen mit alternativen Antrieben oder Kraftstoffen"; FKZ 3720 57 1010.

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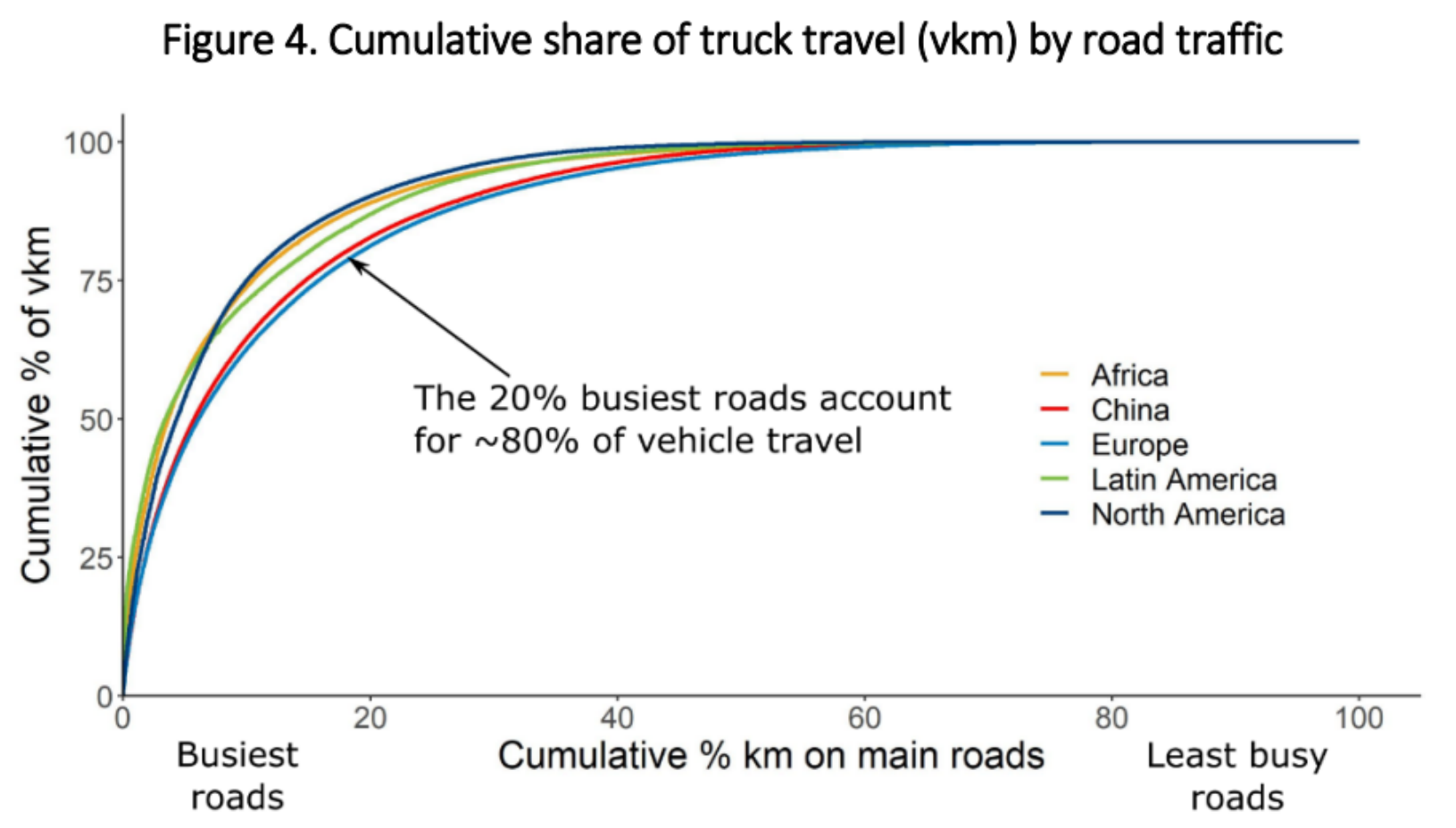
Road freight traffic is highly concentrated across the world



Source: https://www.itf-oecd.org/cleaner-vehicles-achieving-resilient-technology-transition

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Truck range need off-highway is limited

Germany: 89% of trips are <50 km

In einem Vergleich der Summenlinien (Abbildung 30) kann man erkennen, dass 89 % der Lkw-Fahrten weniger als 50 Kilometer im nachgeordneten Netz abwickeln.

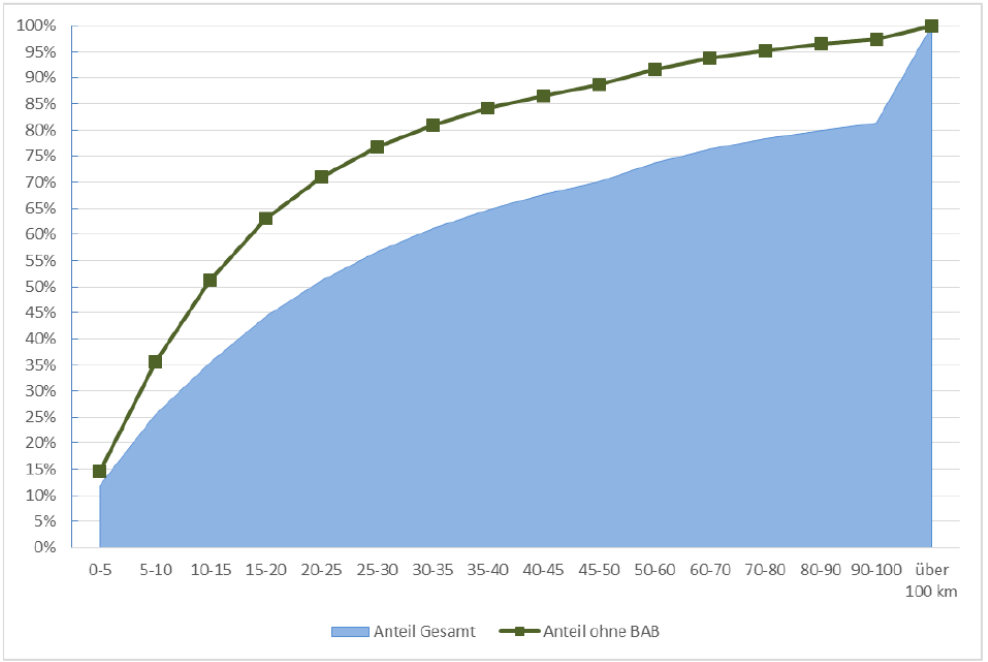
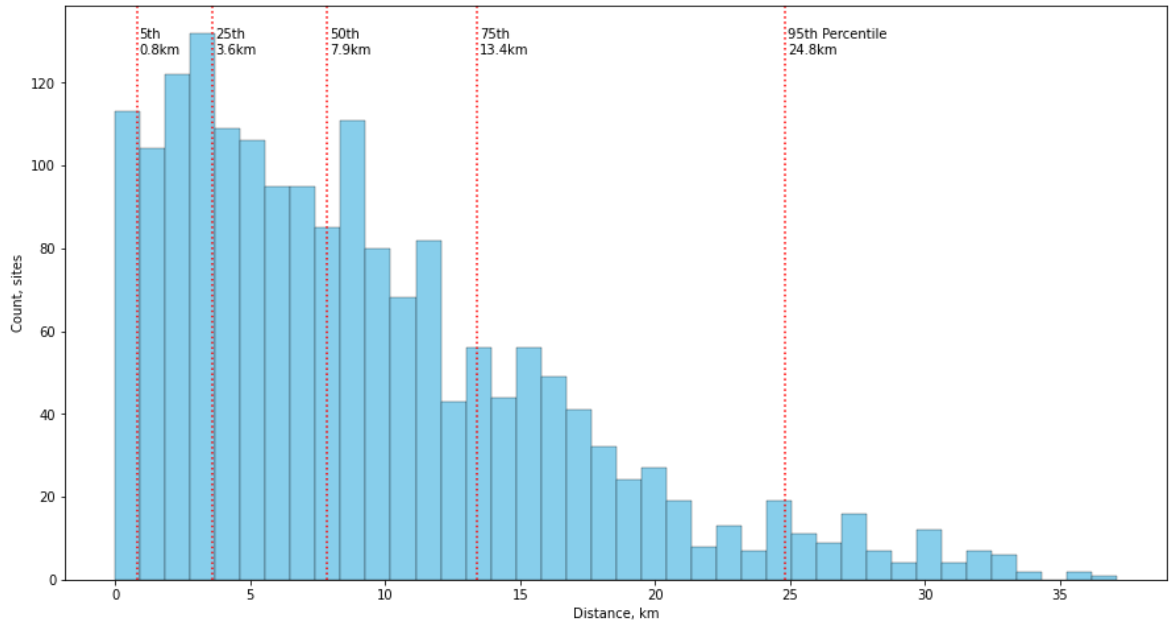


Abbildung 30: Summenlinie der Distanzklassenanteile mit und ohne BAB-Anteil

Source: Fraunhofer Study on behalf of the German Transport Ministry, page 118

Flanders (Belgium): 95% of trips are <25 km

Figure 7 – Driving distance of industrial sites to nearest motorway, Flanders



Source: University of Antwerp study Logibat project

2.000 km-scenario of Dynamic Charging in Germany – Break-even point for the system can be achieved with OCL-BEV trucks in the single-digit share of fleet

How much could a **transport operator** save and max. use as a fee for the new dynamic charging system?

35% of diesel TCO or

85ct per km

Potential savings of transport operator

TCO[1] p.a. diesel ~ 136.700 €

TCO p.a. electric ~ 89.200 €

Savings per year -35% or 47.500 €

Spread over 56.000 km/year on a 2,000 km OCL-network

0,85 €/km

Maximum Price accepted to use a new system

Key assumptions for Transport Operator

- Diesel price: **1,60 €/l** Electricity price: **0,14 €/kWh** [2)]
- Diesel Truck price: **110.000 €** eTruck price: **200.000 €** Lifetime: **6 years**
- Depreciation: **17%** O&M: Diesel **0,09 €/km; O-BEV 0,09 €/km**
- Toll: OCL-BEV pays **0,045 €/km vs 0,304 €/km** for diesel truck
- Mileage: overall **140.000 km,** 56.000 km on the OCL and 20.000 km with battery charged via OCL
- Required range off OCL ~ 200km, battery capacity 300 kWh
- No loss of freight capacity (e.g. volume or payload)

How much traffic would an **infrastructure operator** need to run the system at 85 ct. per km?

13.100 trucks or **3,6%** of the relevant German truck fleet

Break even for an infrastructure operator

Invest per km 4.0m € x **OCL network** 2,000 km

Overall invest 8bn € ÷ **Exp. lifetime** 30 years

Annuity 460m € + **OCL O&M cost p.a.** 160m €

Total cost p.a. 620m € p.a.

Max. user price (incl. energy) 0,85 € per km

13,100 user trucks w/ 0,7bn vkm on OCL

Key assumptions for Infrastructure Operator

- Forecast investement in dynamic charging infrastructure, incl. OCL, substations, protection and control. Excluding HV-connections and possibly necessary upgrading of guard rails
- Nominal financing cost of investment: **6,00% p.a.** O&M: **2% p.a.**
- Electricity sold without additional mark-up
- Mileage on the OCL: **56.000 km by each OCL-truck**
- **Curr. fleet of ~360 k** long haul trucks in GER (add. pot.: transit[3], busses)

1) Total Cost of Ownership per truck 2) Incl. 0,03 €/kWh grid connection fee 3) 47% of freight traffic in GER

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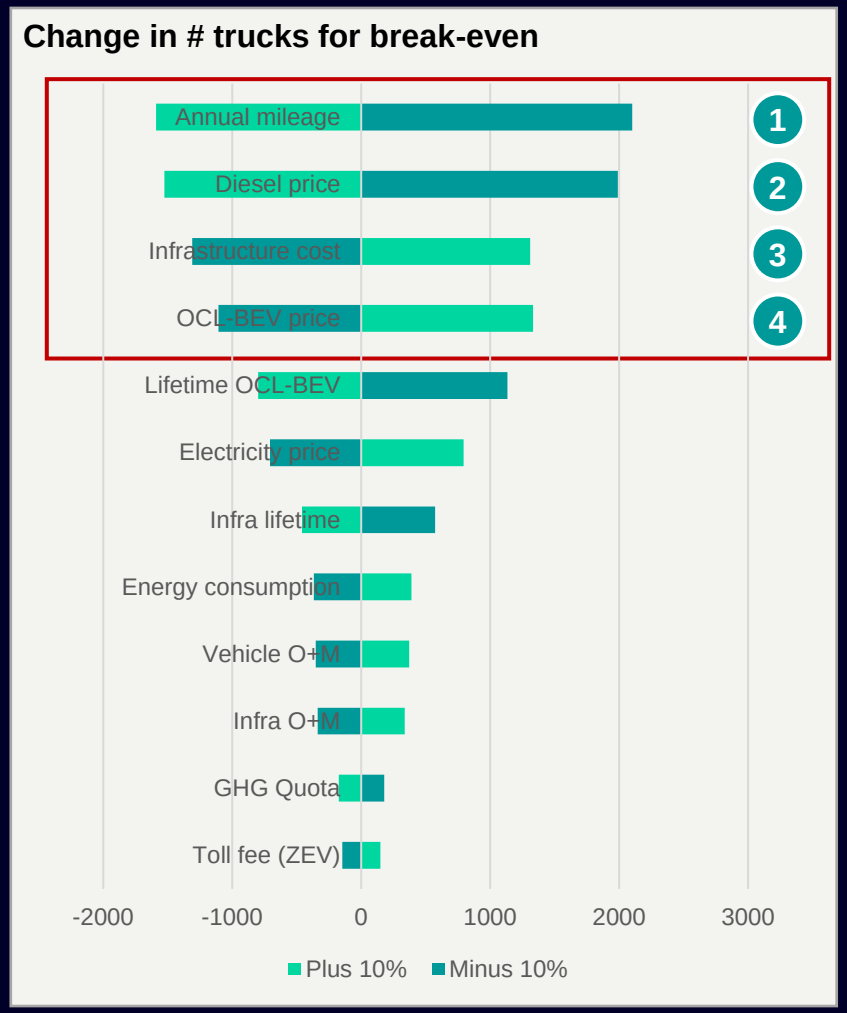
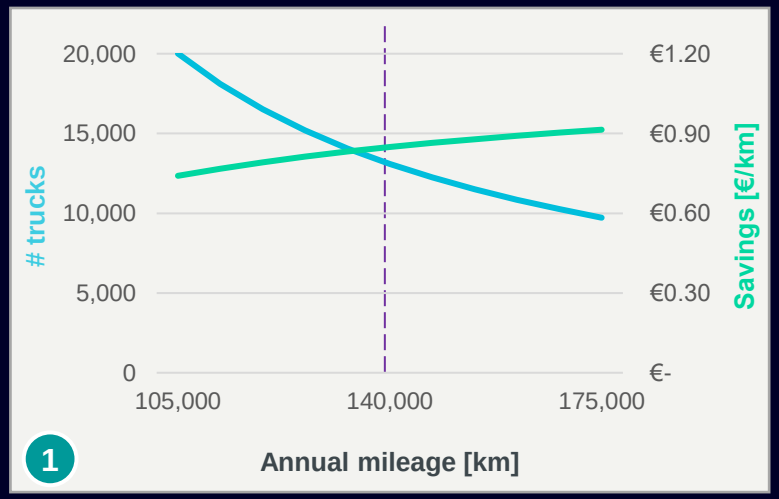
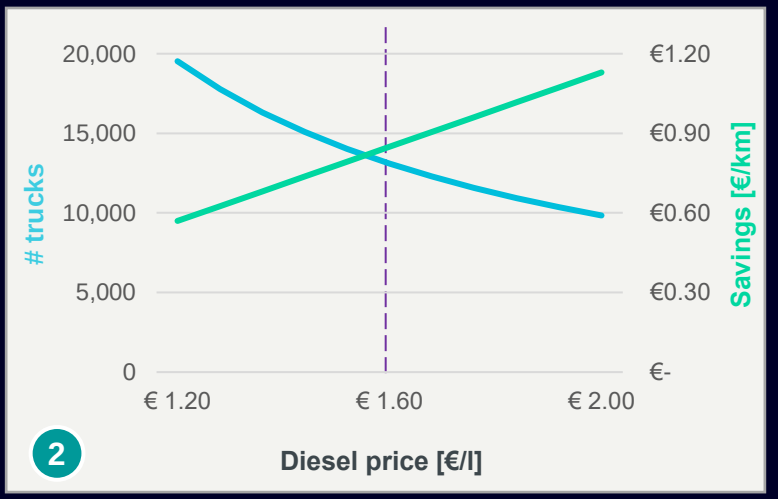
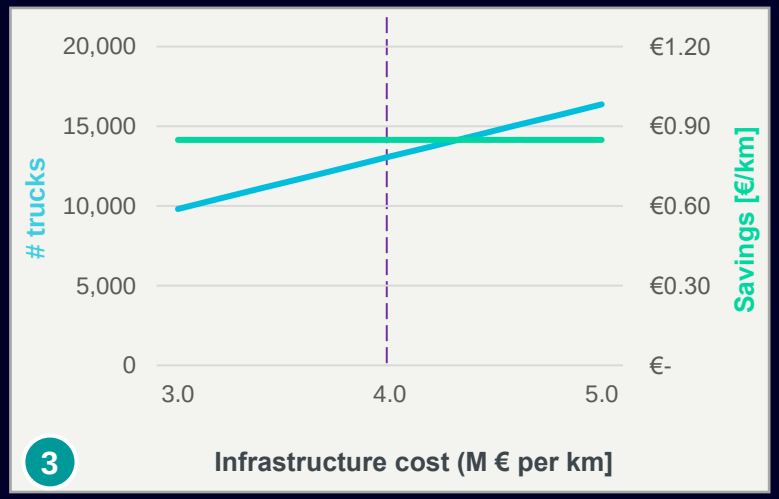
Sensitivity analysis shows robustness of the case

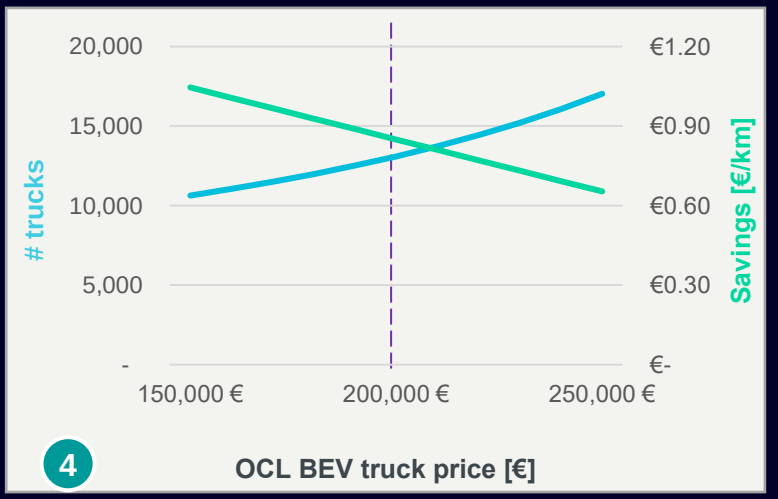
Even with Diesel near 1.20 €/l the break-even No. of truck would be only 5% of relevant fleet











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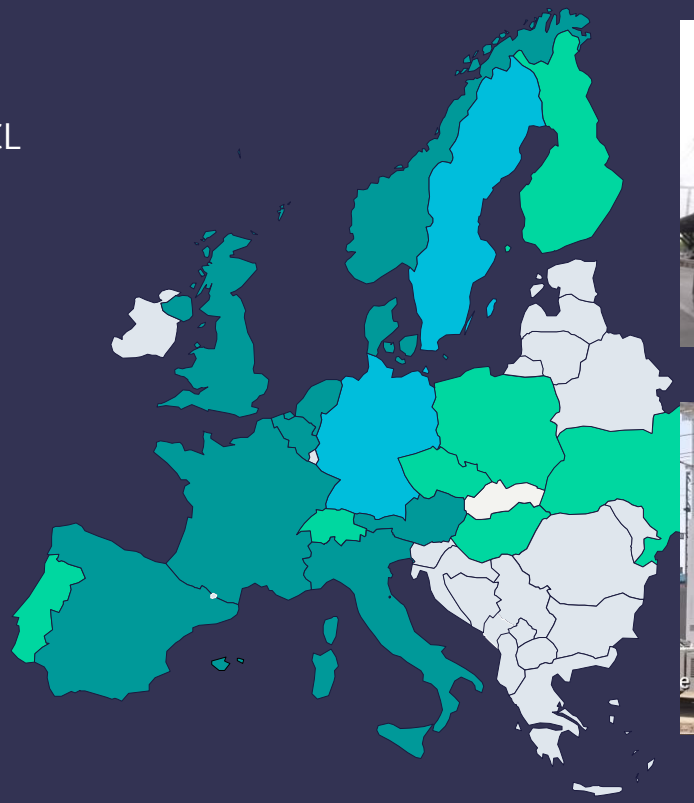
Interest in DYC for long-haul trucks is growing in Europe and beyond
Enabling zero emission trucking on core motorways

Projects and plans in EU
- DE: Climate law (2023) confirms intention for innovation clusters with OCL DYC
- SE: Tendering 20km DYC on highway (in 2024). Earlier DYC highway demo used OCL
- NL: 50m EUR allocated for DYC pilot for HDVs on highway
- FR: DYC demo projects (1-2 km) announced for highways (usage type unclear)

Studies and reports in EU
- IT: Ministry strategy for trucks focus on electrification, incl. use of OCL
- AT: Study "Energy Roads" completed seeing benefits with OCL DYC
- BE: Study finds each 1 EUR investing in OCL saves 8 EUR over next 20 years
- HU: Part of E-CORE, a multi-national corridor study, so far also with NL, DE & AT

Interest and activities beyond EU
- UK: Study finds OCL "cost-effective solution", see also podcast.
- China: Companies CRRC and SANY developed first DYC pilot using OCL
- India investigating 1,300 km long overhead contact line "e-corridor", see link
- North America: Studies in USA and Canada also find DYC highly economical.



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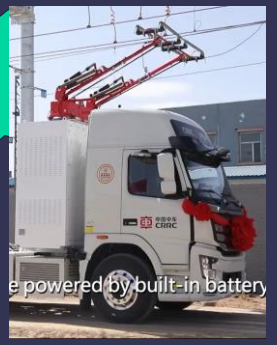

Link

DYC eases possible bottle-necks regarding batteries and stationary chargers

Thereby strengthening the case for a stronger policy focus on electrification

Acceptability - By all stakeholders

- Economical and ecological benefits
- Cut critical raw material dependency[1]
- Minimizes impact on electricity grid[2]

Scalability - In time and across geographies

- Reduced land claims[3]
- Fewer stakeholders & approvals[4]
- Based on int. know-how and strong supply chain[5]

Usability - Seamless integration in logistics

- No time lost during charging
- Improved charging experience
- Compatible with higher payloads and automation

Video source: https://ehighway-sh.de/forschungsfahrten/

1) https://www.sae.org/publications/technical-papers/content/epr2022007/ 2) Energienetz - Klimafreundliche Nutzfahrzeuge (klimafreundliche-nutzfahrzeuge.de) 3) https://trans.info/de/lkw-parkplatz-app-294955
4) https://ivr.fh-erfurt.de/aktuelle-forschungsprojekte/esob-rki 5) https://www.railwaypro.com/wp/worldwide-rail-electrification-remains-at-high-volume/

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The [DYC] technology seems very compatible with BEVs and stationary charging - it is not an either or.

Tobias Meyer, CEO DHL Group

Source: https://www.linkedin.com/feed/update/urn:li:activity:6993873117844512768?utm_source=share&utm_medium=member_desktop

We need to use technologies that are available now!

Volker Ratzmann, Executive Vice President Corporate Public Affairs at Deutsche Post DHL Group

Source: LinkedIn on Nov 22, 2023 https://www.linkedin.com/feed/update/urn:li:activity:7133098584672985088/

Foto: Christian Bendel

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Back-ups

Small dictionary:
Acronyms, vocabulary and explanations

DYC (Dynamic charging):

The **charging solution** an electrified truck gets from an ERS

ERS (Electric Road System):

The **infrastructure** built along a motorway that enables DYC

OCL (Overhead contact line):

A more than 100 years old technology, that for 7 years (and counting) is the only ERS proven

- on a highway

and/or

- to provide at least 200kW DYC to tractor trucks in regular, full-speed operations

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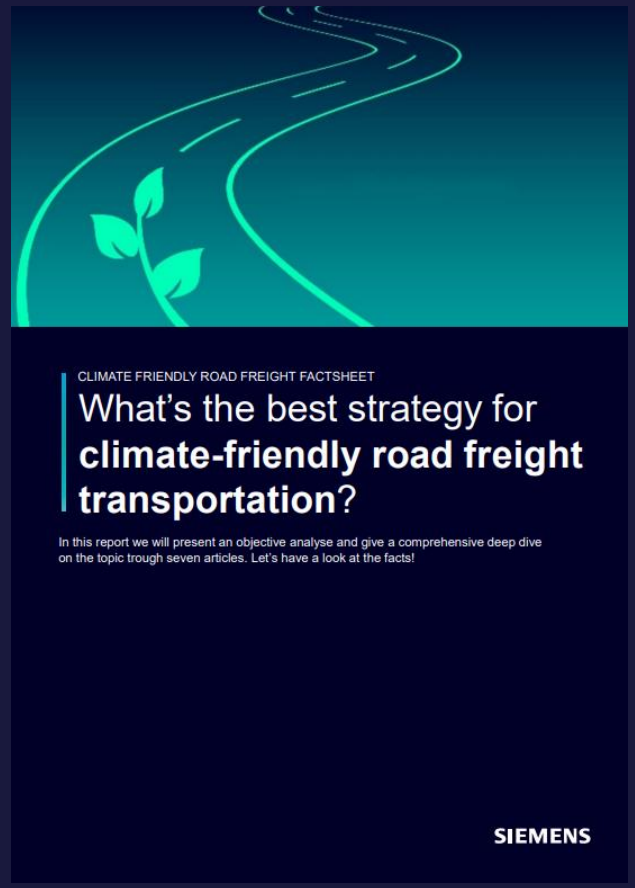
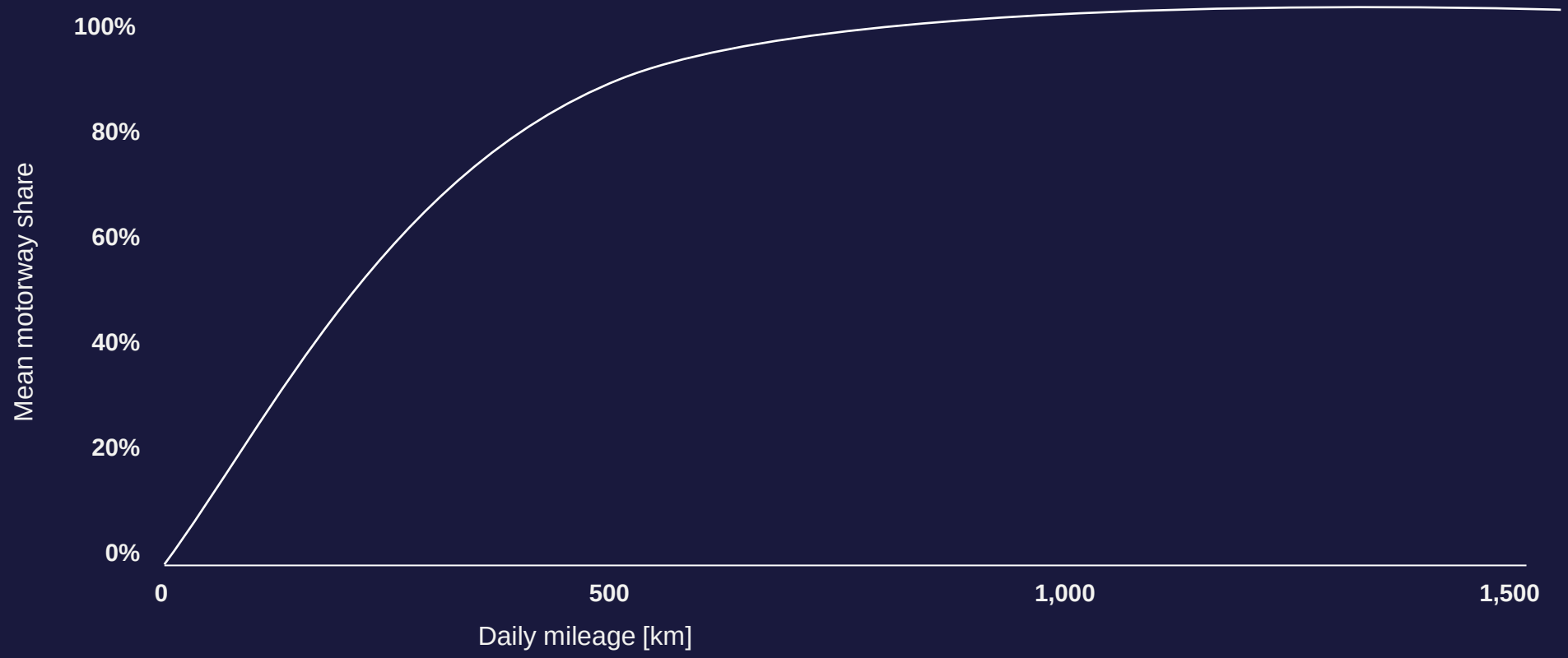
Factsheet for climate-friendly road freight



Available online

Range is especially important for long-haul operations
Long range happens almost exclusively on highways



Journeys of **500 km** or more are almost entirely on motorways **(>80%)**

BEV: Battery electric vehicle | **FCEV**: Fuel cell electric vehicles | **RF**: Renewable fuel (for combustion engine)
Source: Fraunhofer feasibility study of catenary trucking, on behalf of the German Transport Ministry, page 131

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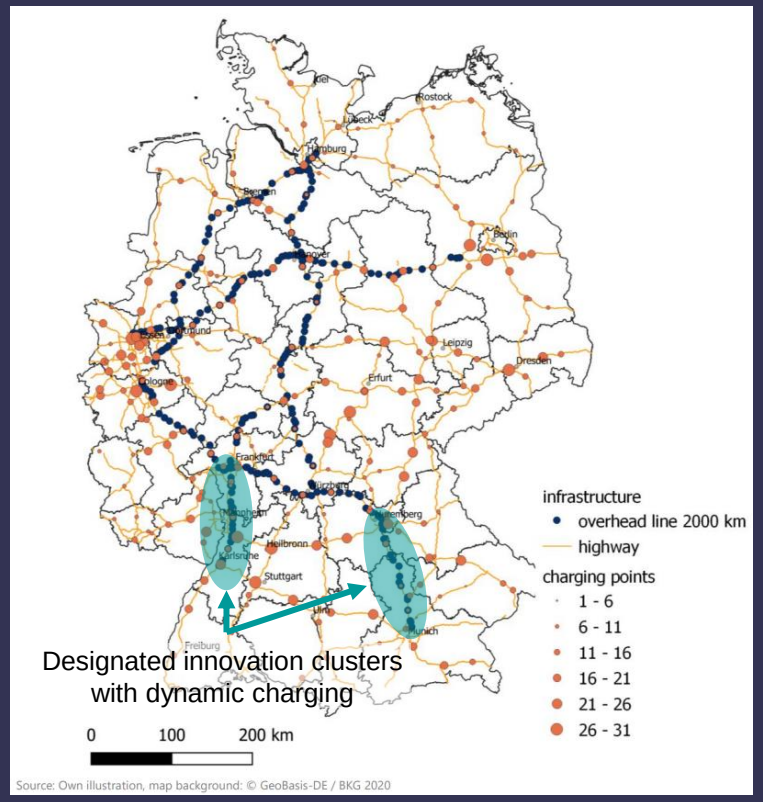
German build out scenarios:
Initial corridors that grow into a national and international network

Combined stationary & dyn. charging network



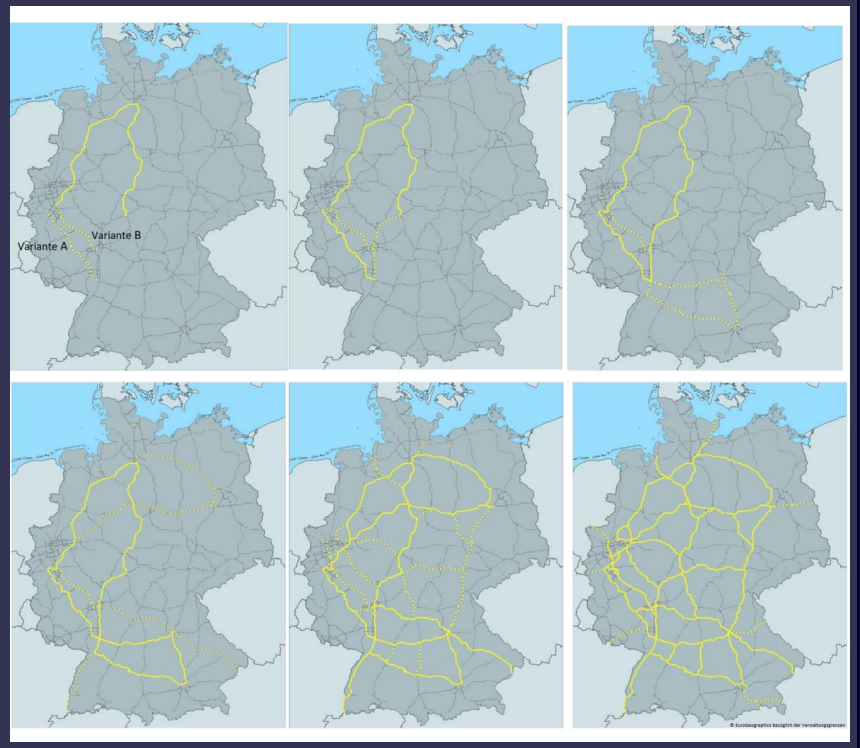
Start-up target:

- Define sufficient charging opportunities for a fast ramp-up
- Start includes a **2.000km** dynamic charging network and complementary stationary charging opportunities
- Network might be **adapted for early movers** (e.g. DHL)

Network growth:

- Reasonable growth to **4.000km** dynamic charging network expected to cover up to 90% of trips on German highways
- Important realization of **connections to other European countries** to connect long-distance corridors

Possible growth of dyn. charging network



Sources: Fraunhofer (2021) and (2022)

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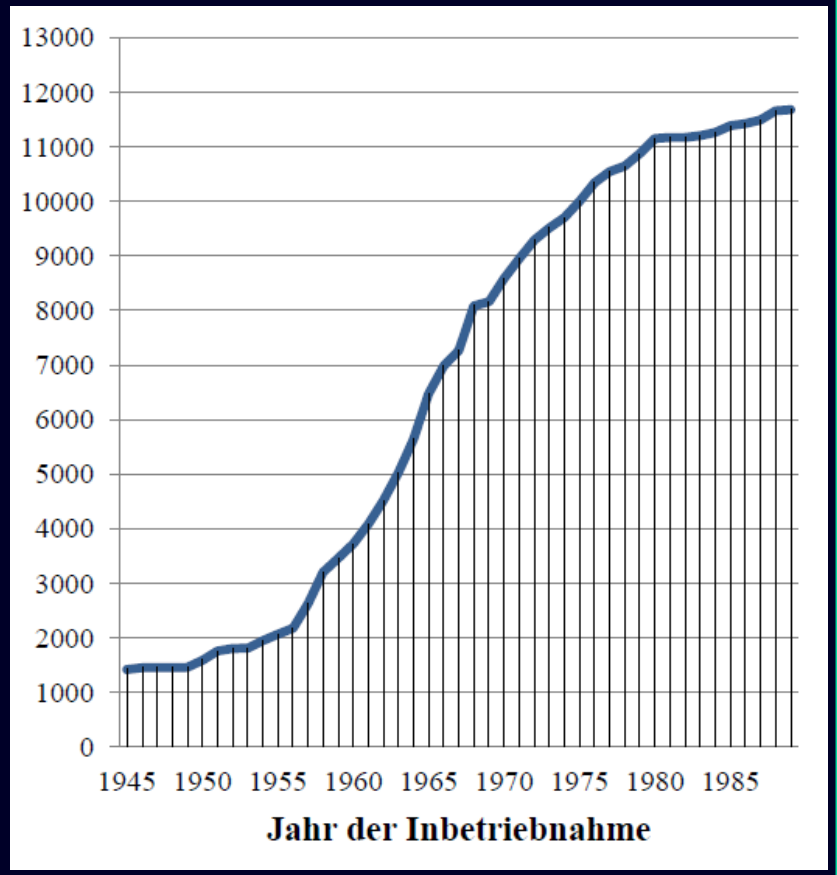
Build-out speed: Germany has already showed itself capable of building 5,000 km of overhead contact lines in just 10 years

Electrified rail km



Enabling framework

- Systemic planning – not case by case solutions
- Legislation to accelerate approval process, while maintaining due process

Industry confirmation

- Major installation actor confirms that similar build–out rates (ca. 400 double-track km per year) is realistic

International example

- India has electrified 26,000 km of railways in the past 5 years

→ Supply-chains available for the necessary materials

→ Know-how of OCL is spread across the globe

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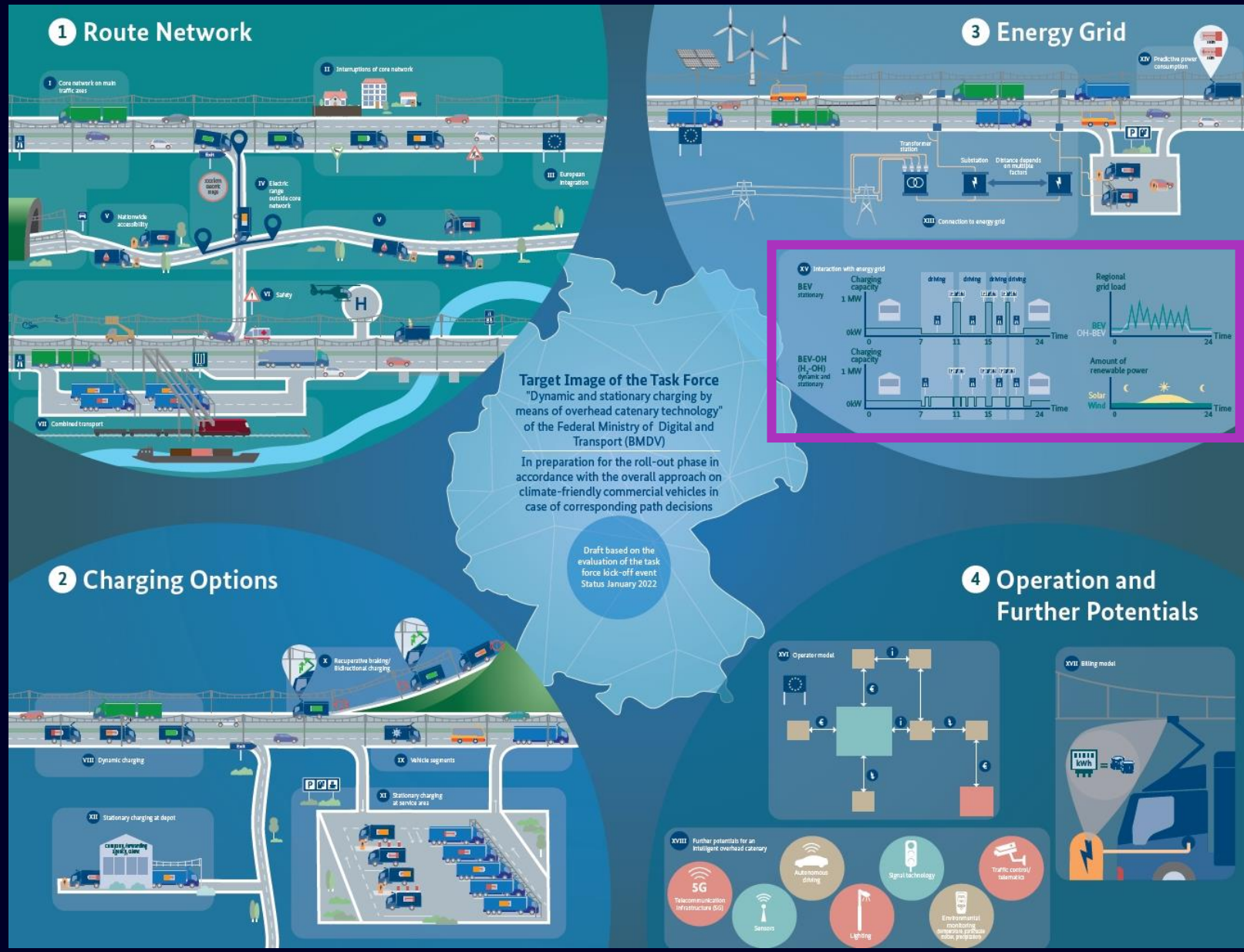
Ministry task force on dynamic charging

Available online

Including links to many supporting studies for each of the four fields:

- Route network
- Charging options
- Energy grid
- Operation and further potentials



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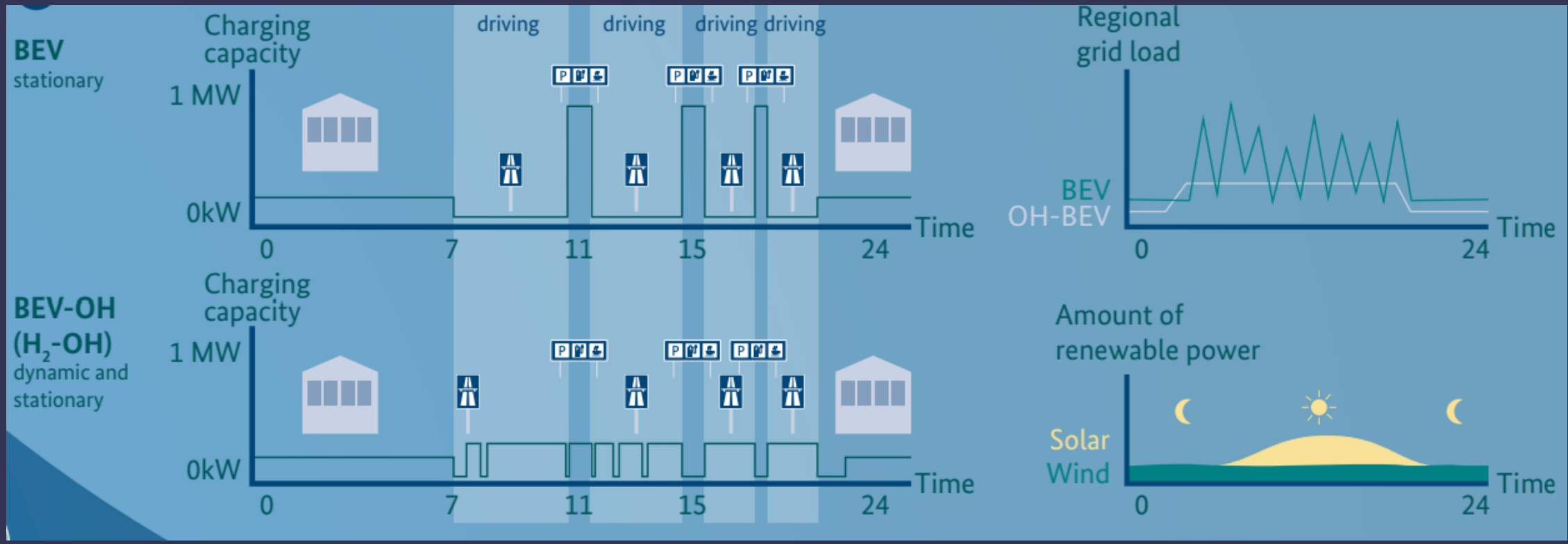
Dynamic charging
Beneficial interaction with the energy grid

Reduces demand charges

Matches Time-of-Use (TOU) rates



- Study showing significant influence of demand charges on cost of electricity: US DOE (2017) pages 70-83
- Study showing why policy makers should encourage daytime charing: https://www.nature.com/articles/s41560-022-01105-7
- Study showing the challenge power demand from large truck stops: https://www.nationalgrid.com/us/EVhighway

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Dynamic charging is an essential solution for climate protection in heavy road freight transport – Overhead catenary line advantages

… combines the benefits of electric railways with the flexibility of trucks
Proven in daily operations

… makes it possible to reach the climate protection goals
Highest efficiency

… can quickly be rolled out
€10 bn supply chain

… can be realized in an international context
Open standards

… highway landscape change
Unchanged roadway

… is flexibly compatible with other technologies and fuels
Up to 500kW at full speed

… is the most economical solution
Cheapest solution

- Cars & LDVs are going BEV w/o ERS
- Cars & LDVs tend to avoid truck lanes

More details in LinkedIn-Article

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