EVS 35 in Oslo, 2022

On the future contribution of fuel cell vehicles to low carbon heavy-duty road transport

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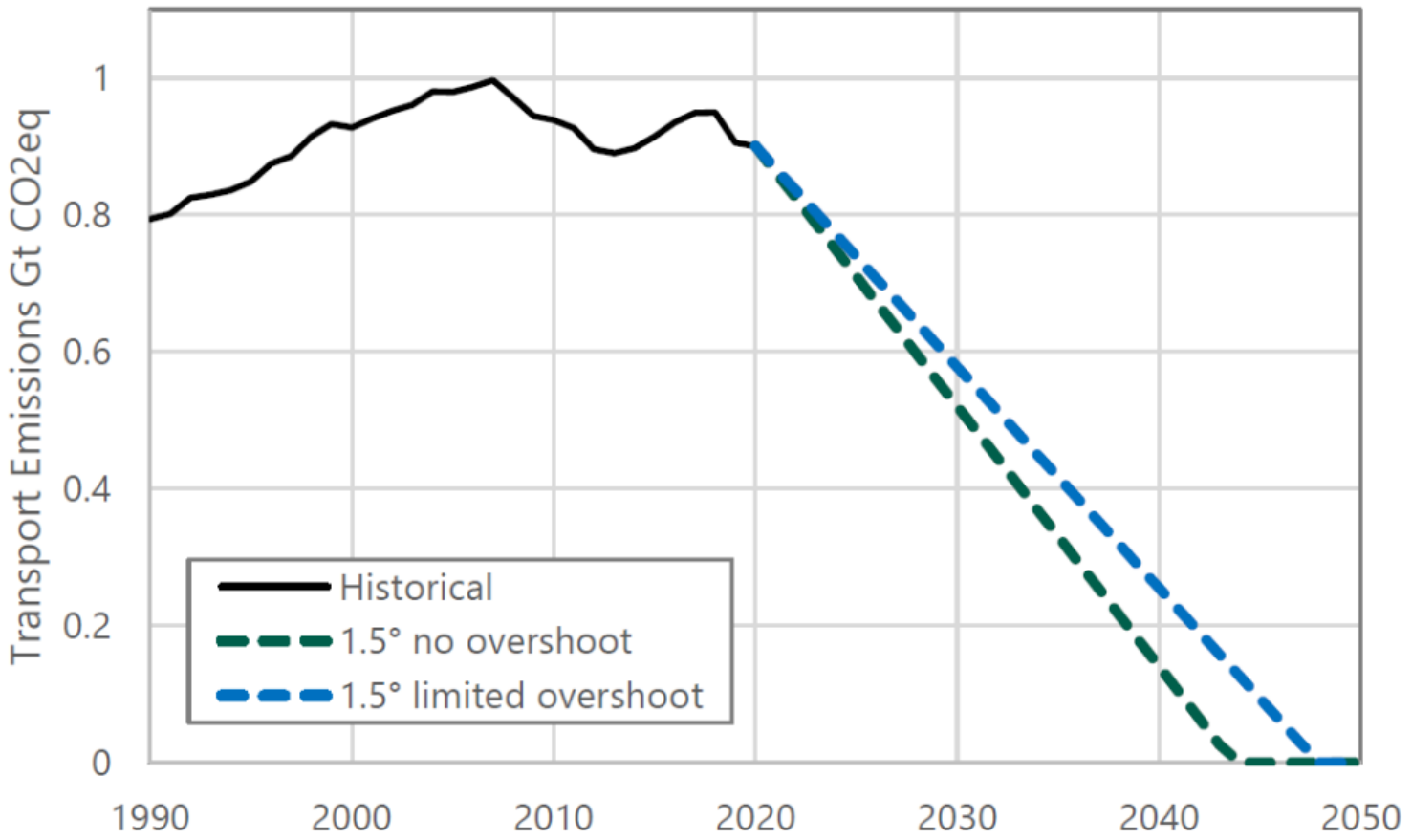
Transport emissions in Europe need to decrease dramatically

Otherwise we will not be able to limit global warming to 1.5 degrees

- Transport related emissions in Europe are about 0.9 Gt CO2 per year
- ca. 72% from road transport
- One third of emissions from heavy duty vehicles (> 3.5t GVW)
- Emission reduction required (compared to 1990):
  - – 35% until 2030
  - –100 % until 2045 / 2050
  - EU target: CO2 neutral until 2050



Plötz, P.; Wachsmuth, J.; Gnann, T.; Neuner, F.; Speth, D.; Link, S. (2021): Net-zero-carbon transport in Europe until 2050 – Targets, technologies and policies for a long-term EU strategy. Karlsruhe: Fraunhofer ISI

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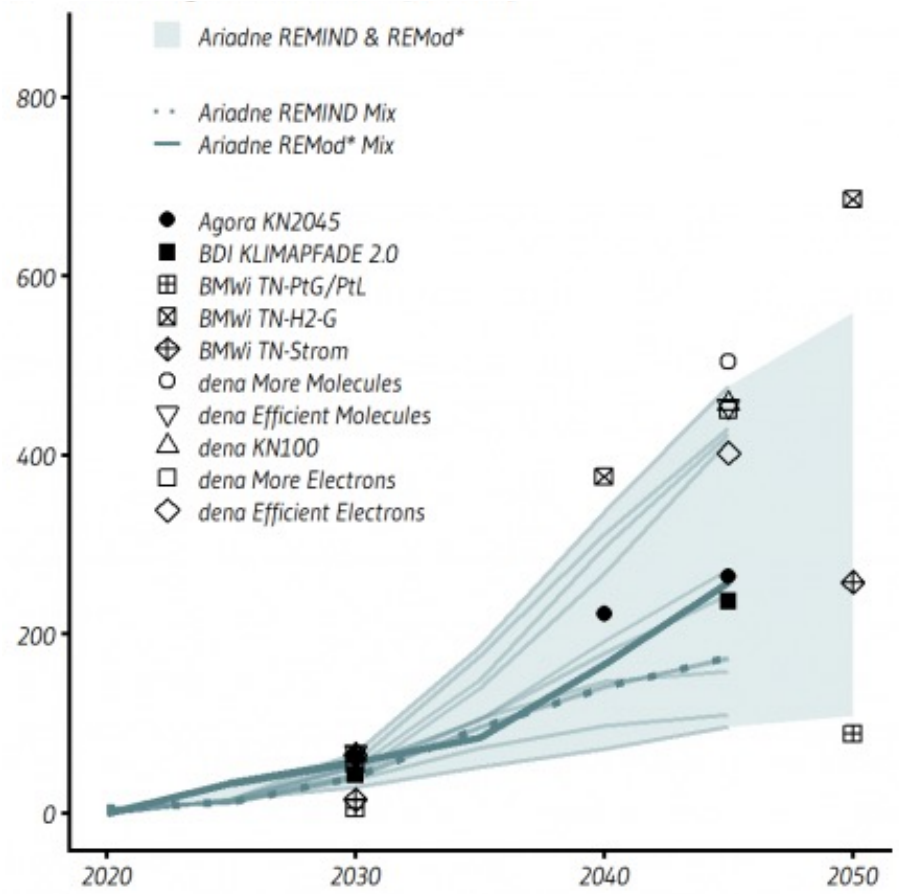
Hydrogen will play a huge role in future low carbon energy systems

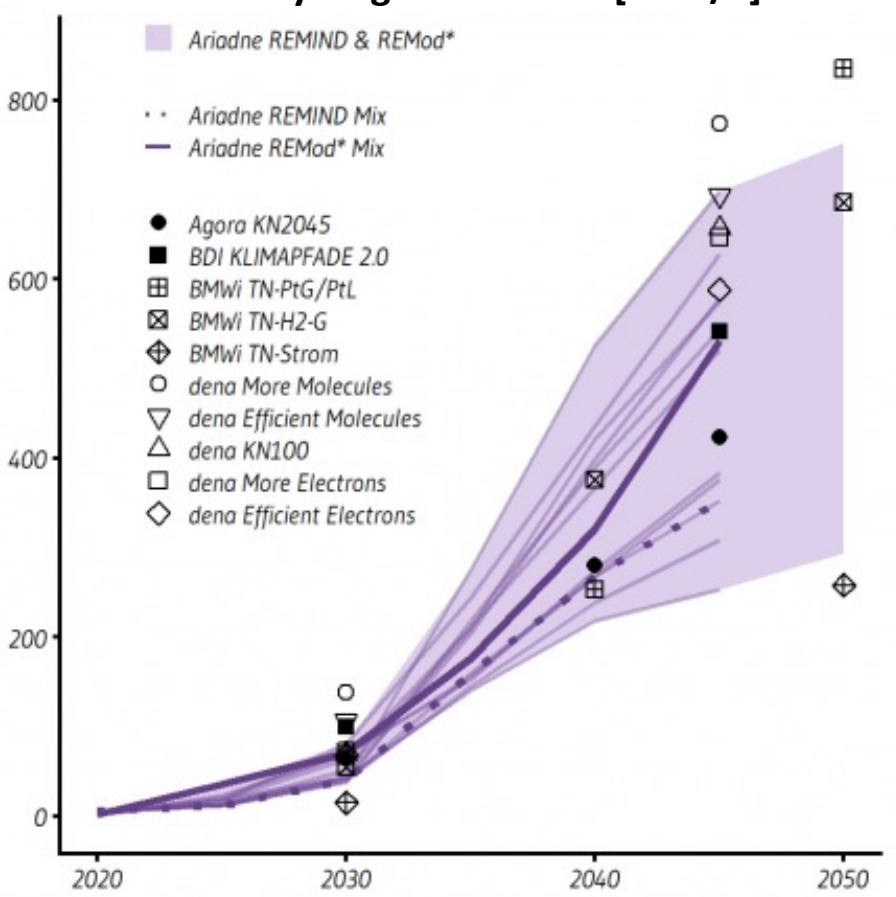
Hydrogen will play a major role in a low carbon energy system

But scenarios differ widely in total system costs and role of different energy carriers

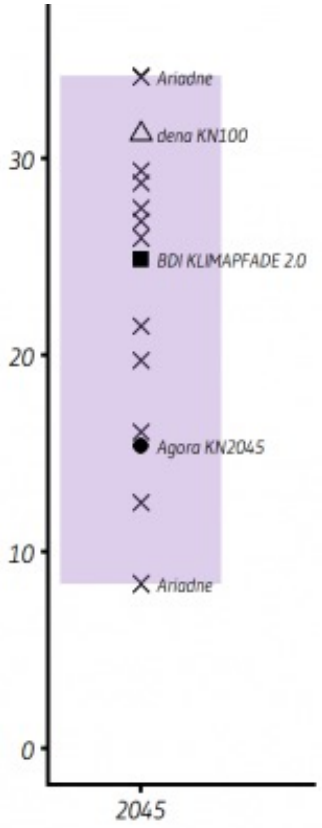
Demand for hydrogen [TWh/a]



Demand for hydrogen & e-fuels [TWh/a]



Share of final energy in %



Source: Ueckerdt et al. (2021): Kurzdossier: Durchstarten trotz Unsicherheiten – Eckpunkte einer anpassungsfähigen Wasserstoffstrategie https://ariadneprojekt.de/publikation/eckpunkte-einer-anpassungsfaehigen-wasserstoffstrategie/

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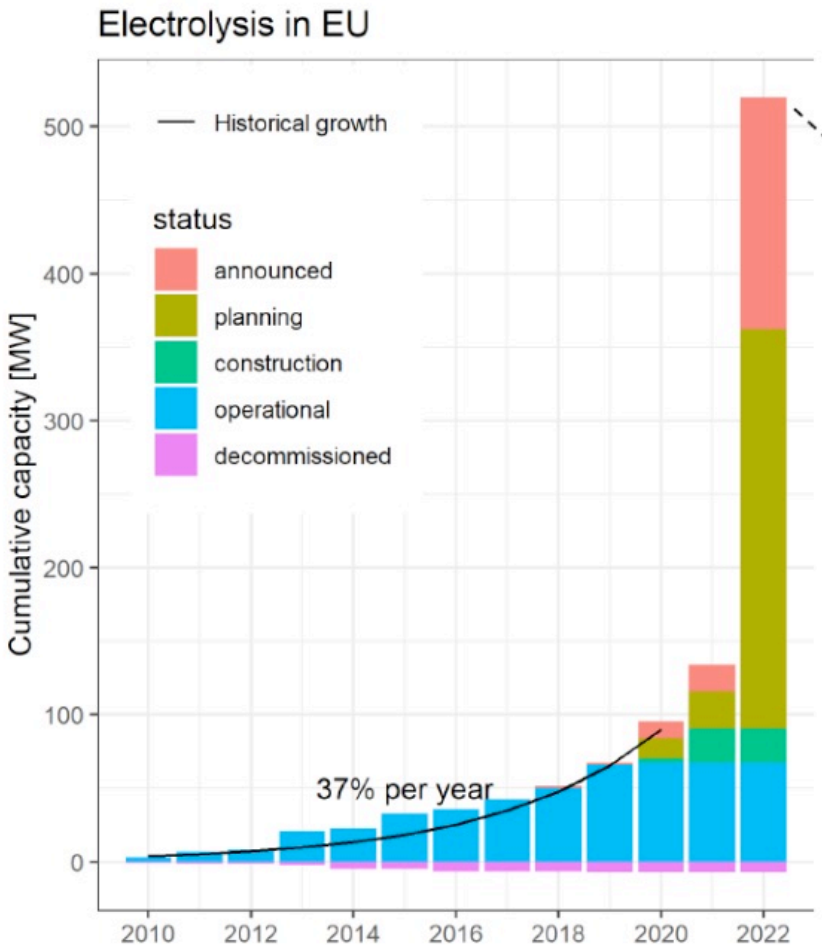
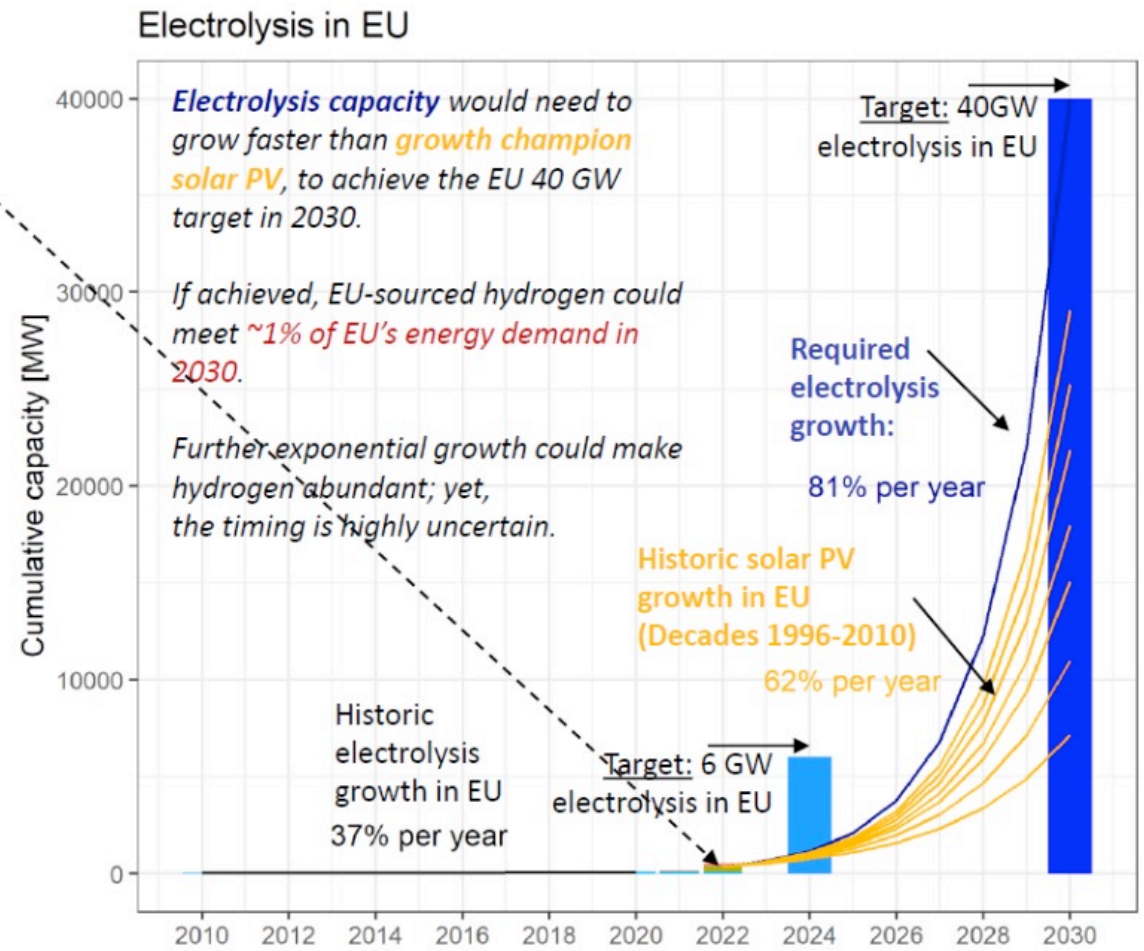
But hydrogen will be a scarce energy carrier until 2040

The market diffusion required would be a new record for energy technologies and import is uncertain





Source: Ueckerdt et al. (2021): Potential and risks of hydrogen-based e-fuels in climate change mitigation. Nature Climate Change
https://www.pik-potsdam.de/members/Ueckerdt/E-Fuel%20paper%20-%20presentation_slides_May2021_shared.pdf

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Possible applications for green hydrogen and e-fuels

We should focus on no-regret use cases

Green hydrogen needed?	Industry	Transport	Energy supply	Heating
No-regret	Steel making Material use (ammonia, chemistry)	Long-distance flights Long-distance shipping	Long-term storage and back-up capacity	District heating
Discussed	High temperature heat	Trucks & busses Short distance flights and shipping Rail	Market size as alternative are available	
Not recommended		Low temperature heat	Cars	Individual buildings

Source: Agora Energiewende 2021, similar in Wietschel et al. (2021)

Hydrogen in passenger cars: the window of opportunity is gone

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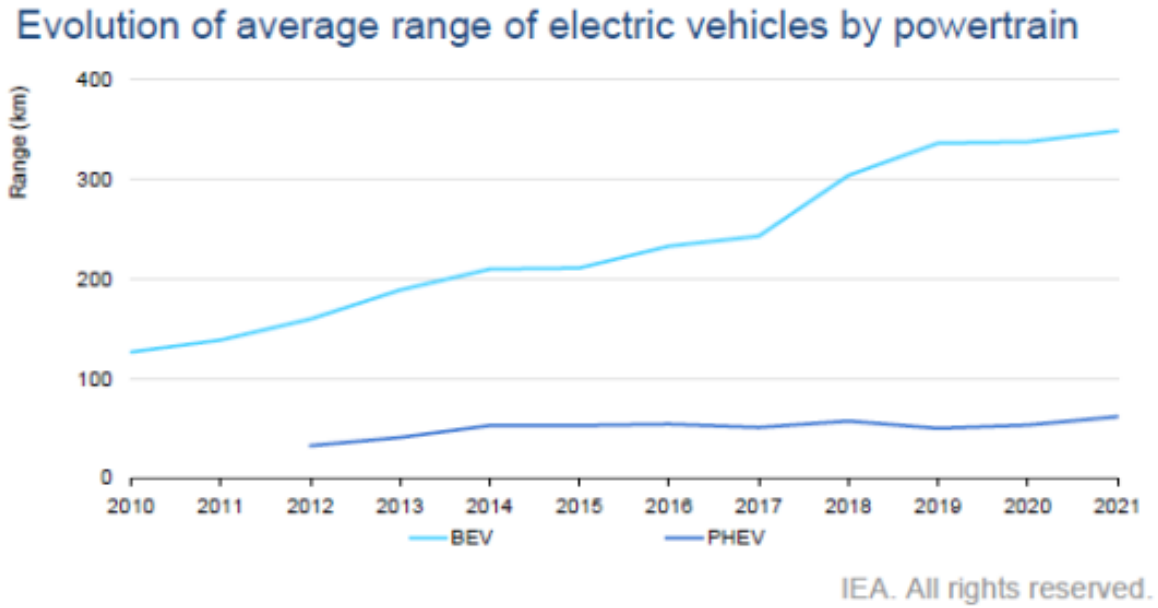
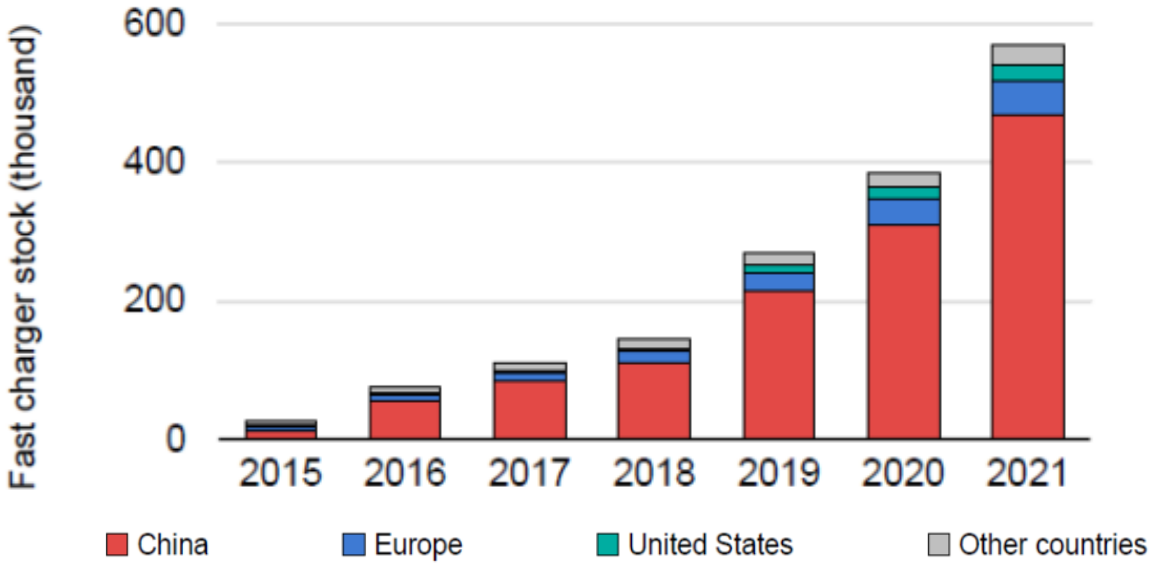
The main market for Fuel cell cars: Long-distance driving in large cars

Cheap batteries allow long-distance driving for BEV and fast charging has improved dramatically





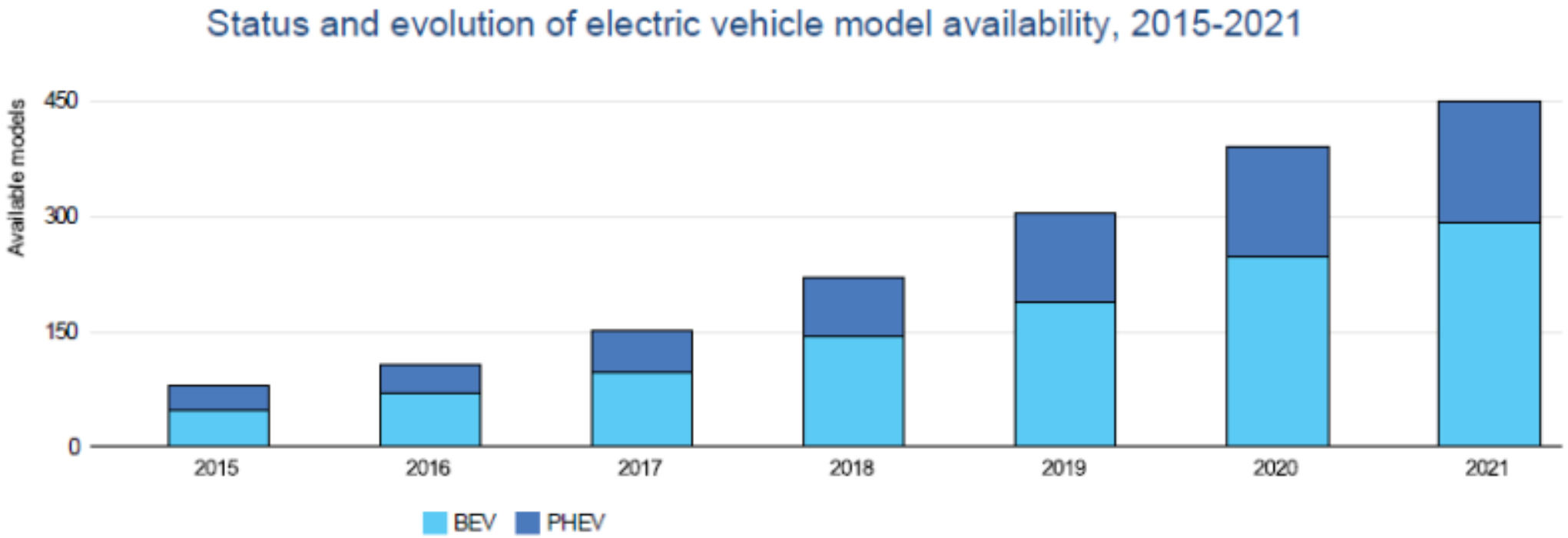
- Mean ranges of new BEV are over 300 km
- Many models with around 500 km range available

- New passengers cars charge with 200 kW and more
- 200 km additional range in under 20 min

Source: IEA (2022): Global EV Outlook 2022

Despite many years of research, FCEV models are hardly available

only two – three FCEV models compared to 300 BEV and 150 PHEV models globally



FCEV

Source: IEA (2022): Global EV Outlook 2022

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Hydrogen will be a niche in heavy-duty vehicles.

The size of the niche is uncertain.

Two factors are decisive for long term market shares: feasibilty & costs

The main argument for hydrogen used to be feasibility

Feasibility

Battery electric trucks (BET) seemed unfeasible until recently.

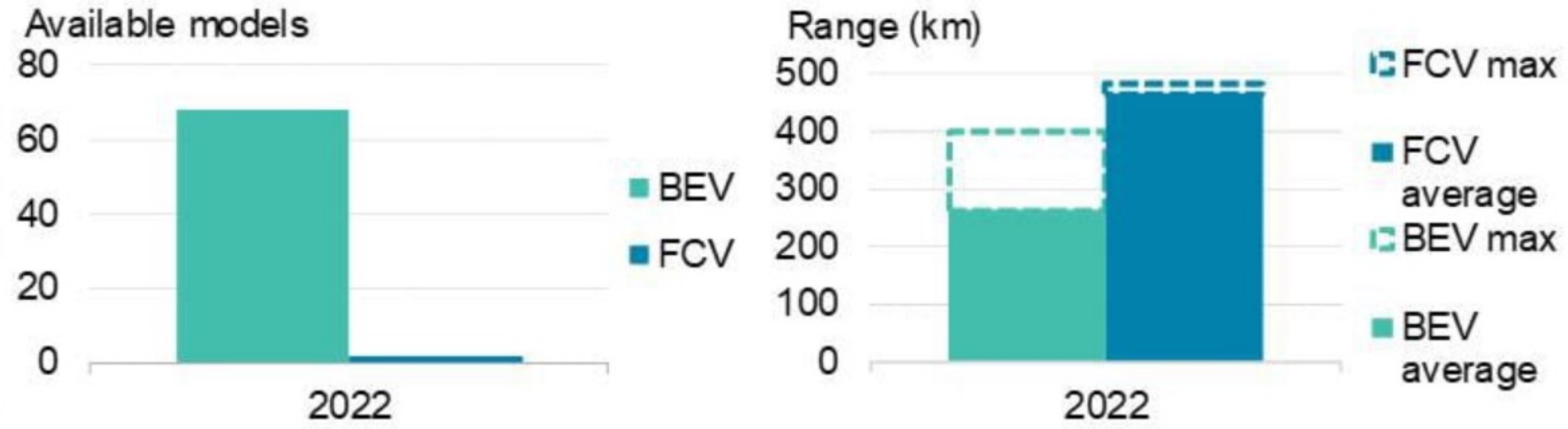
Costs

Costs are important for major market shares in the long run.

BEV Models dominate AFV truck market and max ranges are competitive

Announced fuel cell trucks have some but not too big range advantage

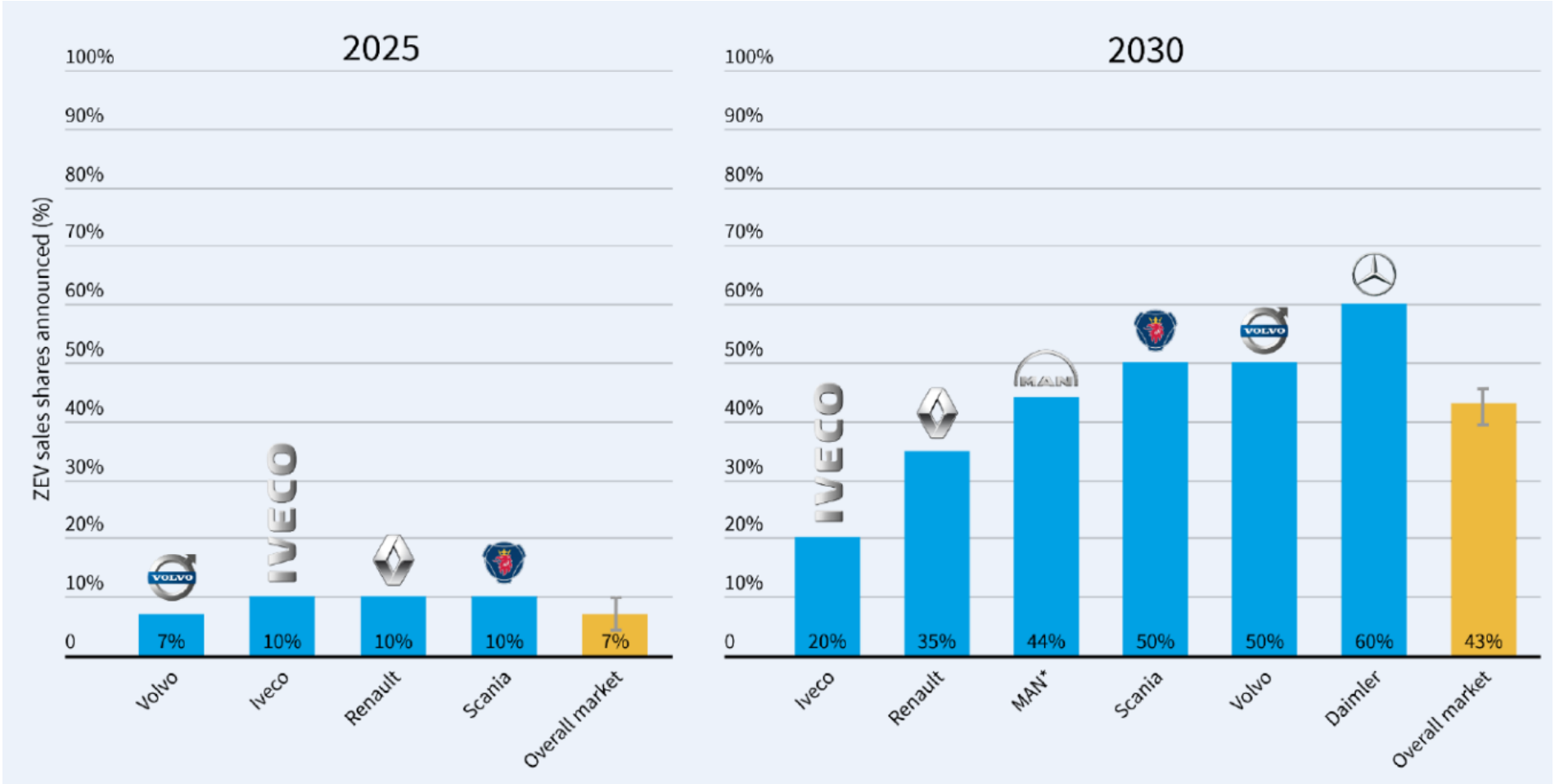
Model availability and range of battery electric and fuel cell trucks in 2022



Source: BloombergNEF, press releases, Calstart. Note: includes vehicles in Class 6, 7, and 8

Manufacturers: 20 – 60 % zero emission trucks in 2030

These will be mainly battery electric trucks as only few serial production fuel cell trucks are announced



Transport & Environment (2021). *Easy Ride: why the EU truck CO2 targets are unfit for the 2020s.* https://www.transportenvironment.org/wp-content/uploads/2021/10/202108_truck_CO2_report_final.pdf

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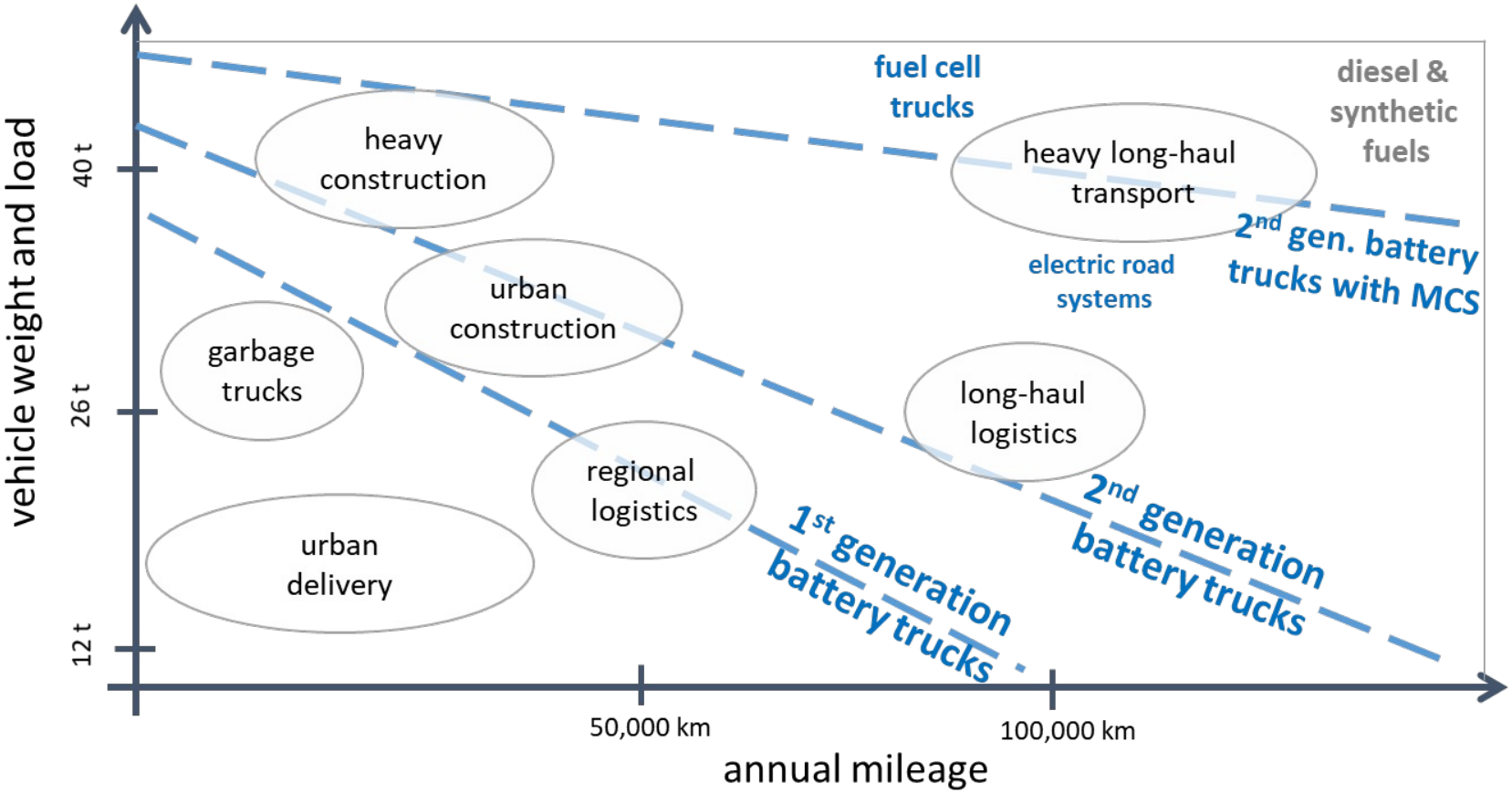
Larger batteries & megawatt charging make long-haul battery trucks feasible

Improvements in battery and charging technology kill the feasibility argument



Quelle: Plötz (2022): Hydrogen technology is unlikely to play a major role in sustainable road transport. Nature Electronics 5, 8–10. https://doi.org/10.1038/s41928-021-00706-6

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First megawatt charging projects are under way

HoLa

https://www.hochleistungsladen-lkw.de/hola-en/

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Most studies agree: Battery trucks have total cost of ownership advantage

Fuel cells compete only in few applications or at very low hydrogen prices (< 3 €/kg)

Table 2. Modeled new sales shares of battery-electric and fuel cell electric trucks from 2025 to 2050, based on the technology total cost of ownership

Truck use case	Technology	2025	2030	2040	2050
Long-haul	Battery-electric	99%	99%	96%	91%
	Fuel cell	1%	1 %	4%	9%
Regional delivery	Battery-electric	100%	100%	100%	100%
	Fuel cell	0%	0 %	0%	0%
Urban delivery	Battery-electric	100%	100%	100%	100%
	Fuel cell	0%	0 %	0%	0%

Ragon, Mulholland, Basma, & Rodríguez (2022): A REVIEW OF THE AFIR PROPOSAL: PUBLIC INFRASTRUCTURE NEEDS TO SUPPORT THE TRANSITION TO A ZERO-EMISSION TRUCK FLEET IN THE EUROPEAN UNION. ICCT 2022.

Conclusion:
Hydrogen technology is unlikely to play a major role in sustainable road transport

Discussion

Hydrogen will be part of the solution but wherever possible, direct usage of electricity will be cheaper

- Hydrogen seems the convenient option: Many practices remain as today and energy comes from distant desert
- I argue that hydrogen will have almost no market share in passenger cars and < 50% market share in trucks
- Battery electric trucks will further benefit from economies of scale in battery cars (nothing similar in scale for fuel cell trucks)
- The size of the fuel cell truck market share is uncertain
- Will the hydrogen niche be large enough for OEMs and infrastructure providers?
- Many studies focus on hydrogen generation costs, but we will pay hydrogen prices + other sectors (steel, shipping, aviation) have no alternatives and are likely to pay more for green hydrogen
- The quick availability of hydrogen is likely to be a bottleneck but MCS charging will also be challenging

Thank you for your attention!

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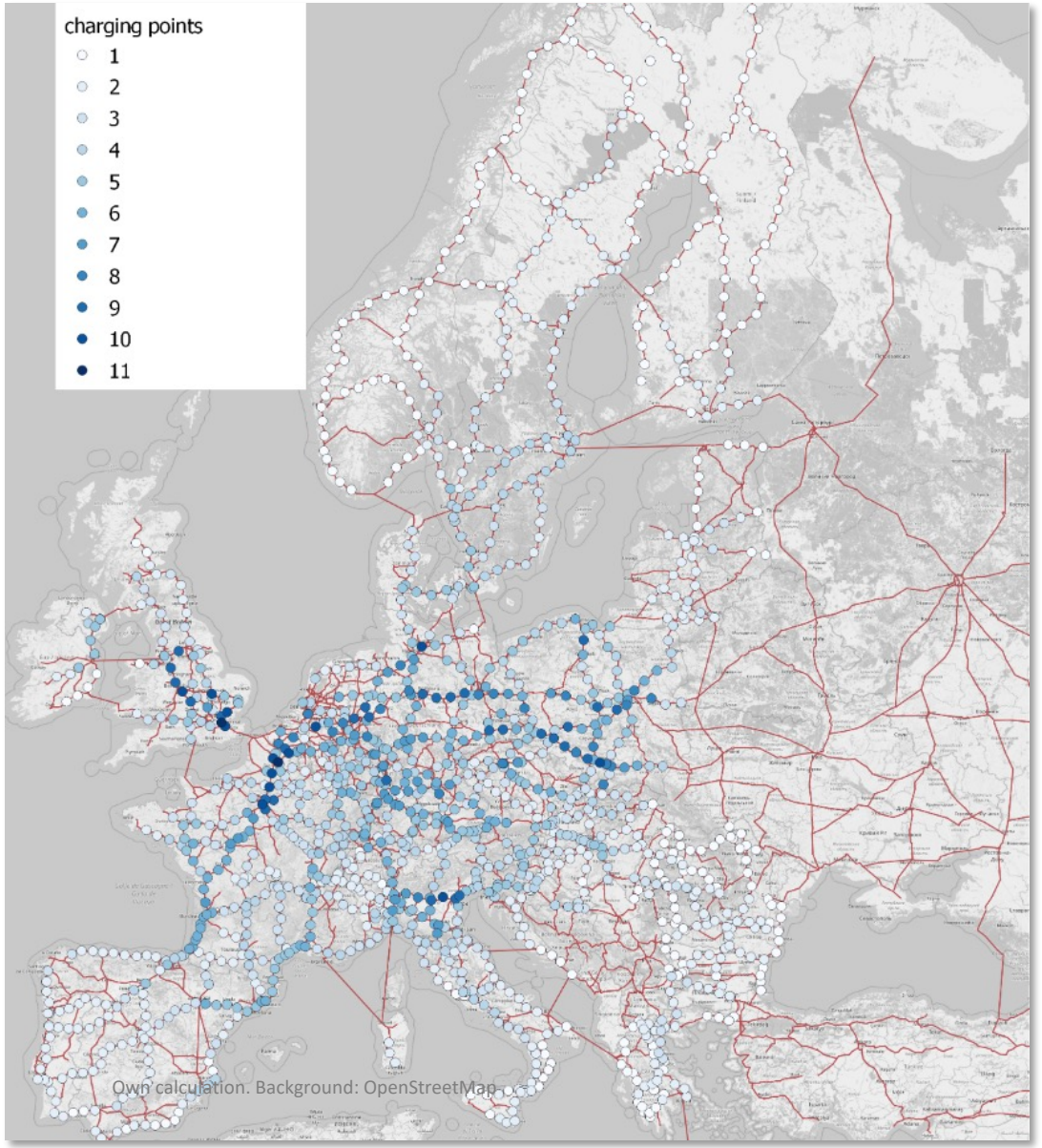
Truck charging in AFIR proposal

Many truck chargers in Europe proposed

	2025	2030	2035
TEN-T core network	1,400 kW every 60 km At least one ≥350 kW	3,500 kW every 60 km At least two ≥350 kW	
TEN-T compre-hensive network		1,400 kW every 100 km At least one ≥350 kW.	3,500 kW every 100 km At least two ≥350 kW.
88 Urban nodes	600 kW @ ≥ 150 kW	1200 kW @ ≥150 kW	

	CP by 2030
Core network	12,000
Comprehensive network	4,000
Safe & secure parking	700
Urban nodes	700
Total	Ca. 17,400



RESEARCH FOR TRAN COMMITTEE (Ed.) (2021): Alternative fuel infrastructures for heavy-duty vehicles. & Sauter, Speth, Plötz, & Signer (2021): A charging infrastructure network for battery electric trucks in Europe, Fraunhofer ISI Working Papers Sustainability and Innovation No. S 02/2021, Karlsruhe 2021

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