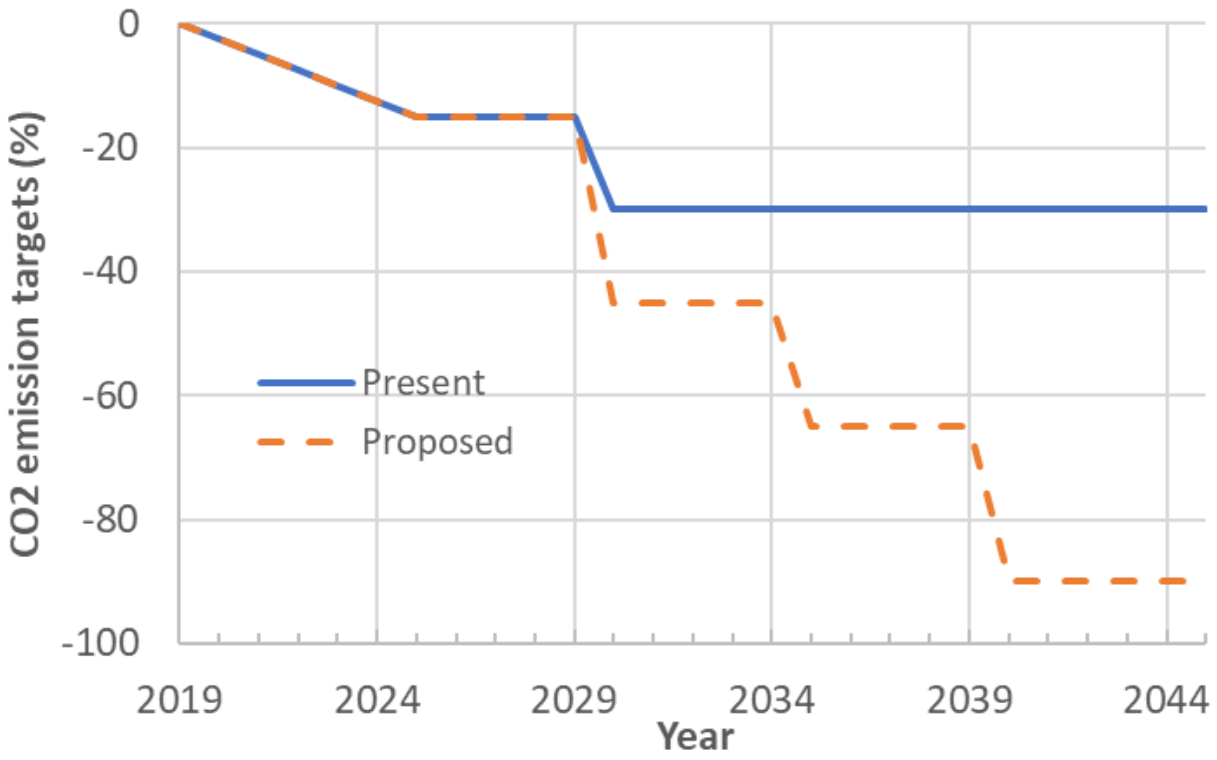
Vety ja muut kuljetusten nollapäästöiset käyttövoimat

SKAL Forum 2023, 28.10.2023
Mikko Pihlatie

CO_2 emission targets for heavy-duty vehicles

- Emission reduction in new registrations compared with 2019/2020
- Increased scope
  - Present: about 40% of vehicles exempted
  - Proposed: about 10-20% of vehicles exempted
- Zero-emission technologies
  - Battery electric
  - Fuel cell & hydrogen
  - Hydrogen ICE
  - Question on electrofuels



Zero-Emission Trucks: Trends & Barriers

Top Transformational Shifts Shaping the Future of Electric Trucks

Low Emission Zones (LEZs)
Regulation of air quality in urban areas by the levying of a fee on vehicles causing pollution

Fuel Price Volatility
Driving fleet owners toward alternate powertrains

Energy Storage Research
Rapid technological advancements

Regulatory Environment
Legislation making green transport solutions mandatory

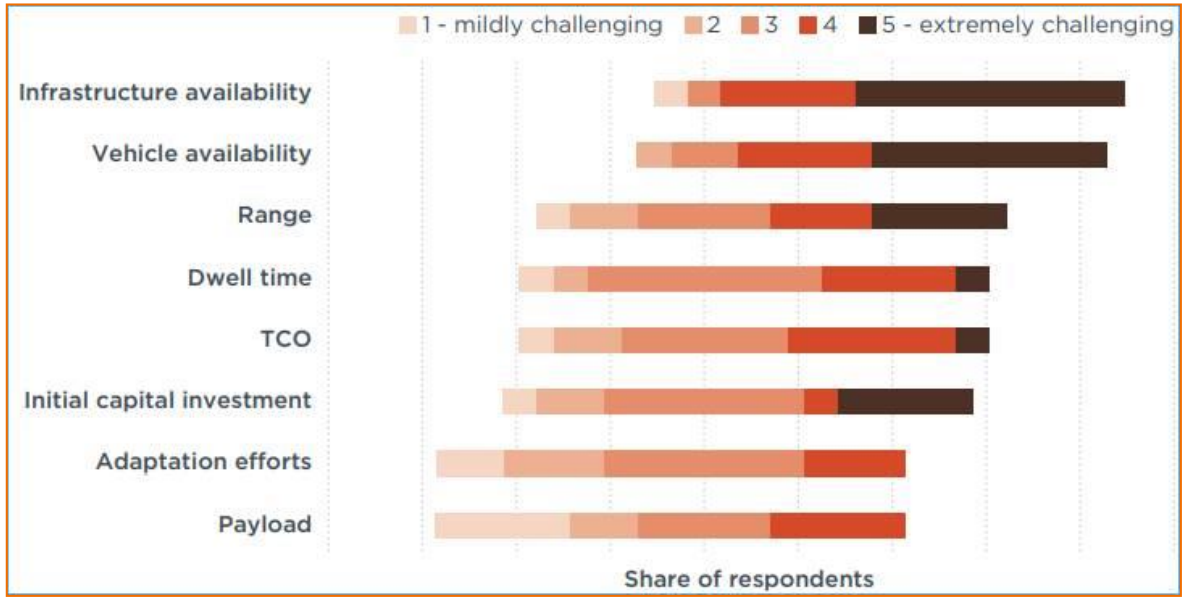
Energy Security
Reducing energy import through the adoption of renewable energy

Infrastructure Barriers
The least pressure on the existing energy infrastructure

Global Supply Chain
Technology licensing and economies of scale because of the increasing adoption of EVs

Government Support
Incentives for new vehicle purchases and subsidies for hybrid electric R&D

Importance of Key Barriers to the Transition to Zero-Emission Freight Vehicles



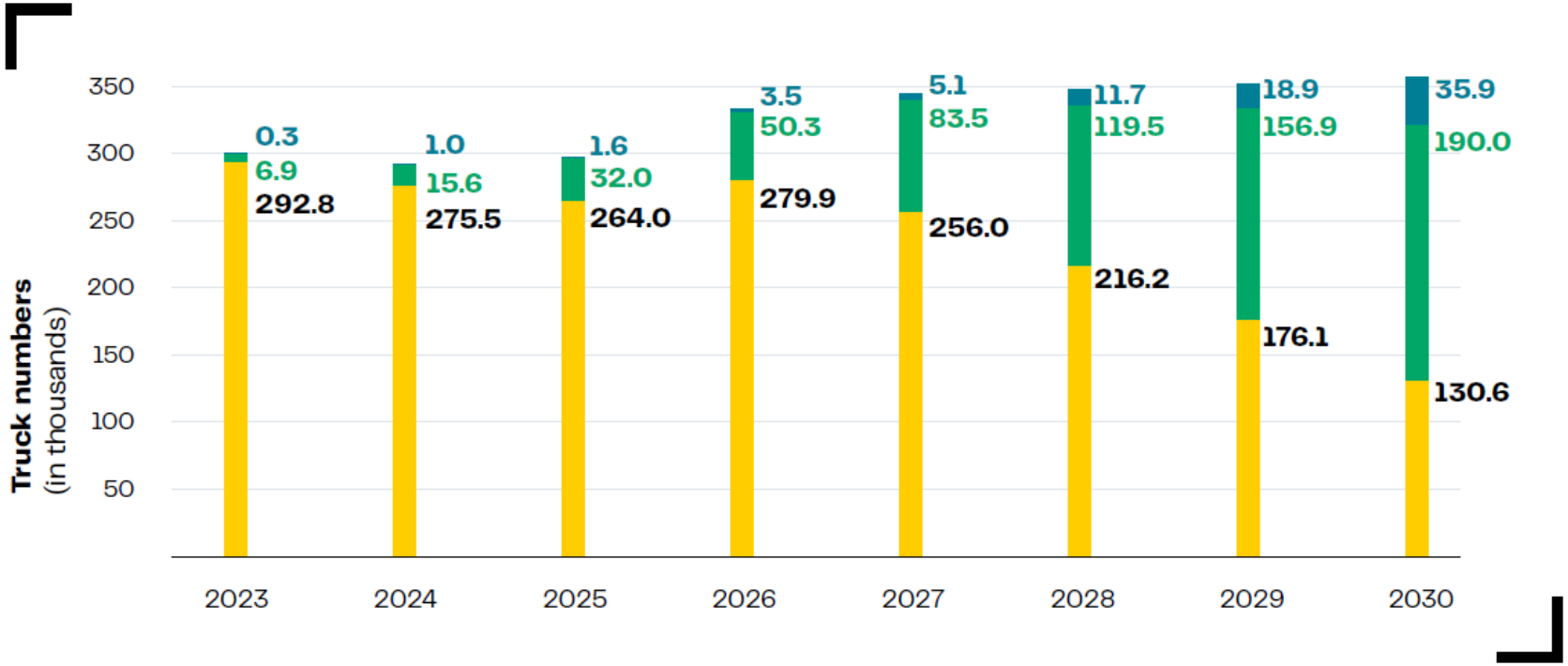
There is little publicly accessible electric charging and hydrogen refueling infrastructure dedicated to heavy-duty vehicles in Europe, which is perceived by ECTA (European Clean Trucking Alliance) members as the most important barrier hindering the transition to zero-emission trucking

SOURCES: Frost & Sullivan (Dec 2021): European Medium-duty and Heavy-duty Electric Trucks Growth Opportunities ; ICCT (Sep 2022): Road freight decarbonization in Europe - readiness of the European fleets for zero-emission trucking

Forecast manufacturer data sales figures in Europe for heavy-duty vehicles (> 12 t)

Three key drivers towards reaching toal cost parity

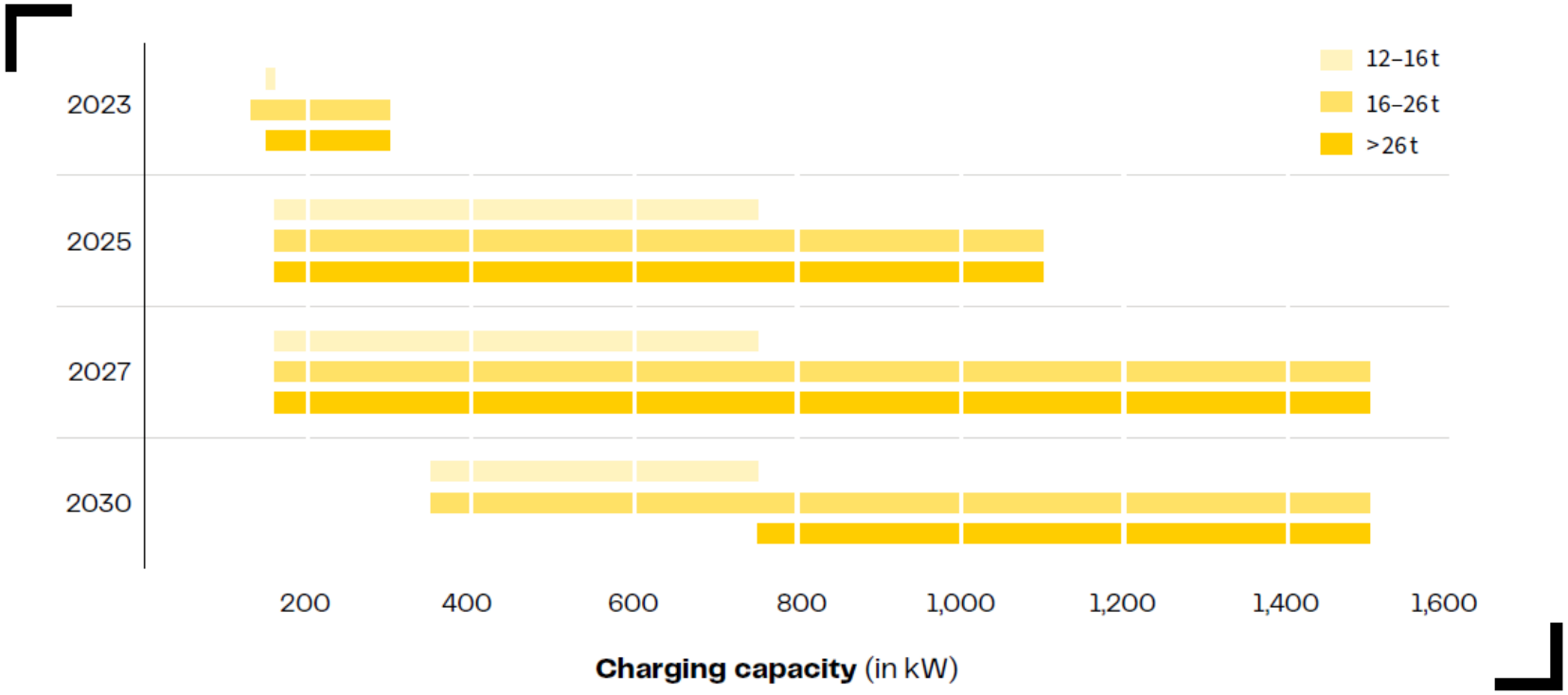
- Early incentives for vehicles and infrastructure (can also be e.g. CO2 dependent road tolls)
- Regulatory framework e.g. CO2 limits for manufacturers
- Energy costs: electricity and hydrogen vs diesel



Source: Market development of climate-friendly technologies in heavy-duty road freight transport in Germany and Europe, NOW GmbH, May 2023

Anticipated development of the charging capacity of battery trucks (> 12 t) by GVW

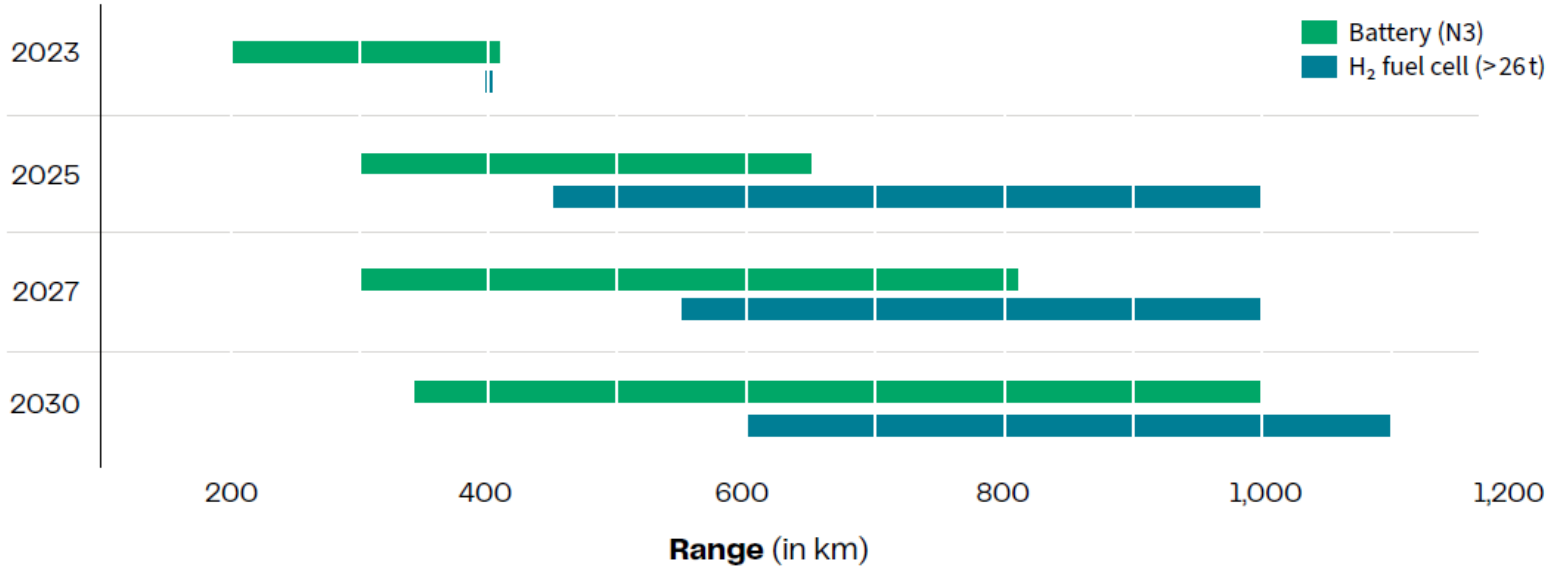
- Suitable alternative fuel infrastructures is imperative for ZE-HDV
- AFIR regulation will require deployment of both charging and H_2 refilling
- Both charger capacity and battery charge acceptance will be increasing
- Megawatt charging is a key requirement for battery electric trucks



Source: Market development of climate-friendly technologies in heavy-duty road freight transport in Germany and Europe, NOW GmbH, May 2023

Anticipated development of the range of battery and fuel cell trucks

- Fuel cell trucks are currently behind battery electric trucks in market development
- Availability and price of green hydrogen for transportation not yet solved
- Hydrogen refilling infrastructure only in planning
- Increase in battery size and range in electric trucks expected



Source: Market development of climate-friendly technologies in heavy-duty road freight transport in Germany and Europe, NOW GmbH, May 2023

Jointly-funded projects on electrification

VTT

steve
2017–2021 | H2020

ESTV
2020–2024 | AoF

SOMA
2021–2024 | EIT RM

HiECSs
2023–2029 | AoF

NO DAMAGE
2022–2024 | BF

DECARBO
2023–2025 | BF

ASSURED
2017–2022 | H2020

ADDMAG
2020–2024 | AoF

EU AFRICA DIGILOGIC
2021–2023 | HEU

VOLTCAR
2023–2026 | HEU

eBRT 2030
2023–2026 | HEU

DRIVEMODE
2017–2021 | H2020

ARROWHEAD TOOLS
2019–2022 | H2020

REFLECTIVE
2021–2024 | HEU

MultiMag
2022–2025 | HEU

ESCALATE
2023–2026 | HEU

2019 2021 2023 2025

FEMMa
2021–2024 | BF

SIX HOVE
2023–2025 | Traficom

B4B
2017–2019 | BF

INVADE
2017–2019 | H2020

HIDDEN
2020–2023 | H2020

BATCircle
2021–2024 | BF

BATMAX
2023–2026 | HEU

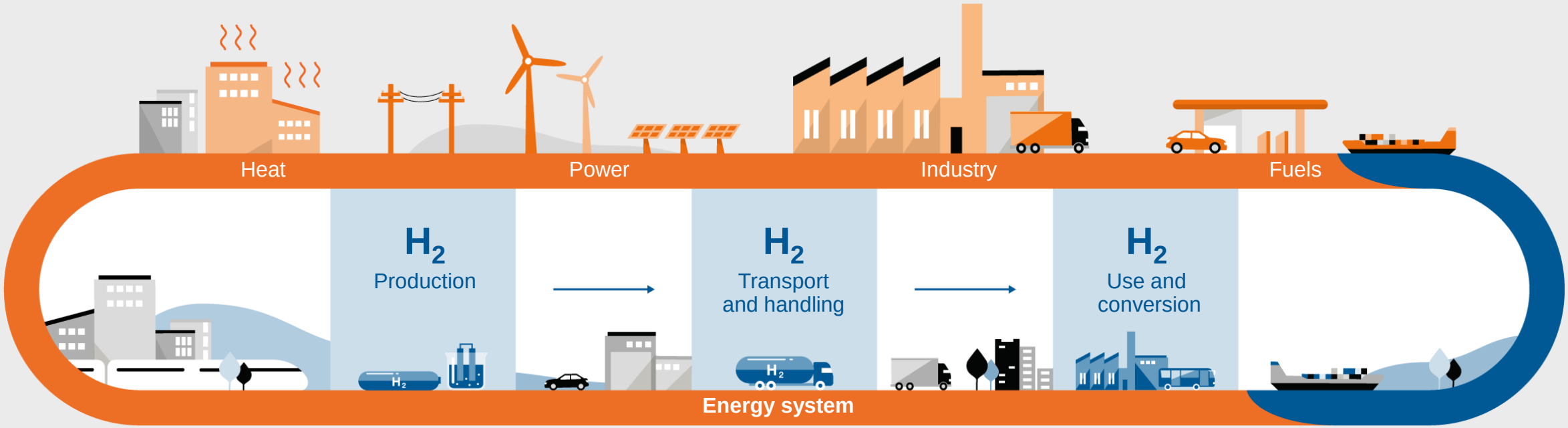
NEXTBAT
2023–2026 | HEU

StoRIES
2021–2025 | H2020

FASTEST
2023–2026 | HEU

BF	Business Finland (national)
AoF	Academy of Finland (national)
Traficom	Traficom (national)
EIT RM	EIT RawMaterials (EU)
H2020	Horizon 2020 (EU)
HEU	Horizon Europe (EU)

Hydrogen for society



VTT Key offering

Electrolyser and fuel cell systems development, design, manufacturing and operation

Hydrogen quality, storage regulations and safety

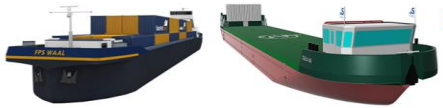
Hydrogen and power to x systems

Hydrogen fuelling stations, working machines and heavy duty vehicles

Piloting and demonstration activities of transport applications related to H_2

FLAGSHIPS

The FLAGSHIPS project will raise the readiness of zero-emission waterborne transport to an entirely new level by deploying two commercially operated hydrogen fuel cell vessels.



VTT · Compagnie Fluviale de Transport · FPS · ABB · Ballard · maritime cleantech · NORLED · SEAM · Clean Hydrogen Partnership · Co-funded by the European Union

SHIP-AH2OY project: 1 MW SOFC using LOHC on board wind-farm service vessel

Ill.: Demonstrator ship and LOHC bunkering station
Photo Credit: Breeze Ship Design

Goal: Develop and demonstrate a **scalable**, **safe** and **sustainable** technology for power and heat generation on board ships

Technology:

- Solid oxide fuel cells (SOFC)
- Liquid organic hydrogen carrier (LOHC)
- Efficient heat integration

A 1 MW power LOHC/SOFC unit will be installed on an offshore wind vessel (C/SOV) to enable **zero-emission operations**

RH2IWER

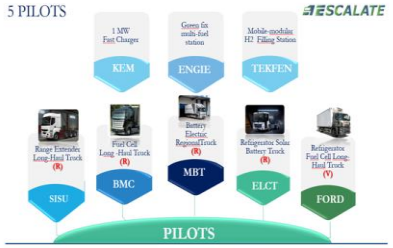
RH2IWER | Renewable Hydrogen² for Inland Waterway Emission Reduction

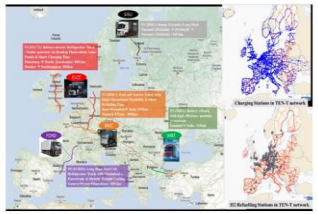
Clean Hydrogen Partnership · Co-funded by the European Union

The project is supported by the Clean Hydrogen Joint Undertaking and its members Hydrogen Europe and Hydrogen Europe Research. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Clean Hydrogen Joint Undertaking. Neither the European Union nor the granting authority can be held responsible for them.

ESCALATE zero emission trucks for regional and long haul

ESCALATE





ACCELERATING THE UPTAKE OF GREEN HYDROGEN FOR TRUCKING

The H2Accelerate Collaboration parties are working together to enable the use of hydrogen to decarbonise long-haul, heavy duty trucking across Europe

Coordination, research and dissemination partners

SINTEF · VTT · UNITRE · FIAP · elementenergy · RU · WKO

H2Accelerate

Everfuel · OMV · Shell · TotalEnergies · Daimler Truck · Iveco · Volvo

HyCoRA

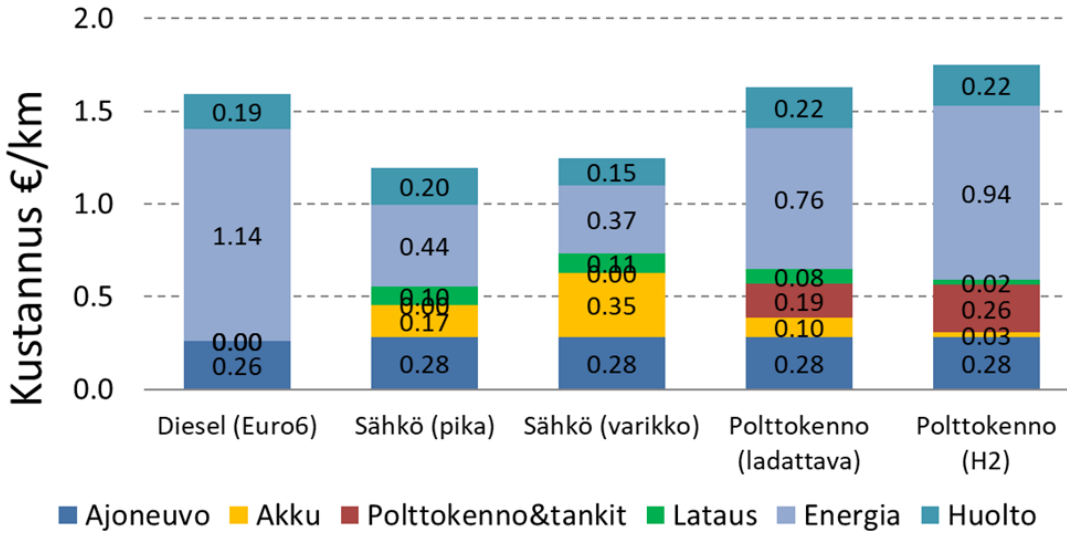
Hydrogen Contaminant Risk Assessment

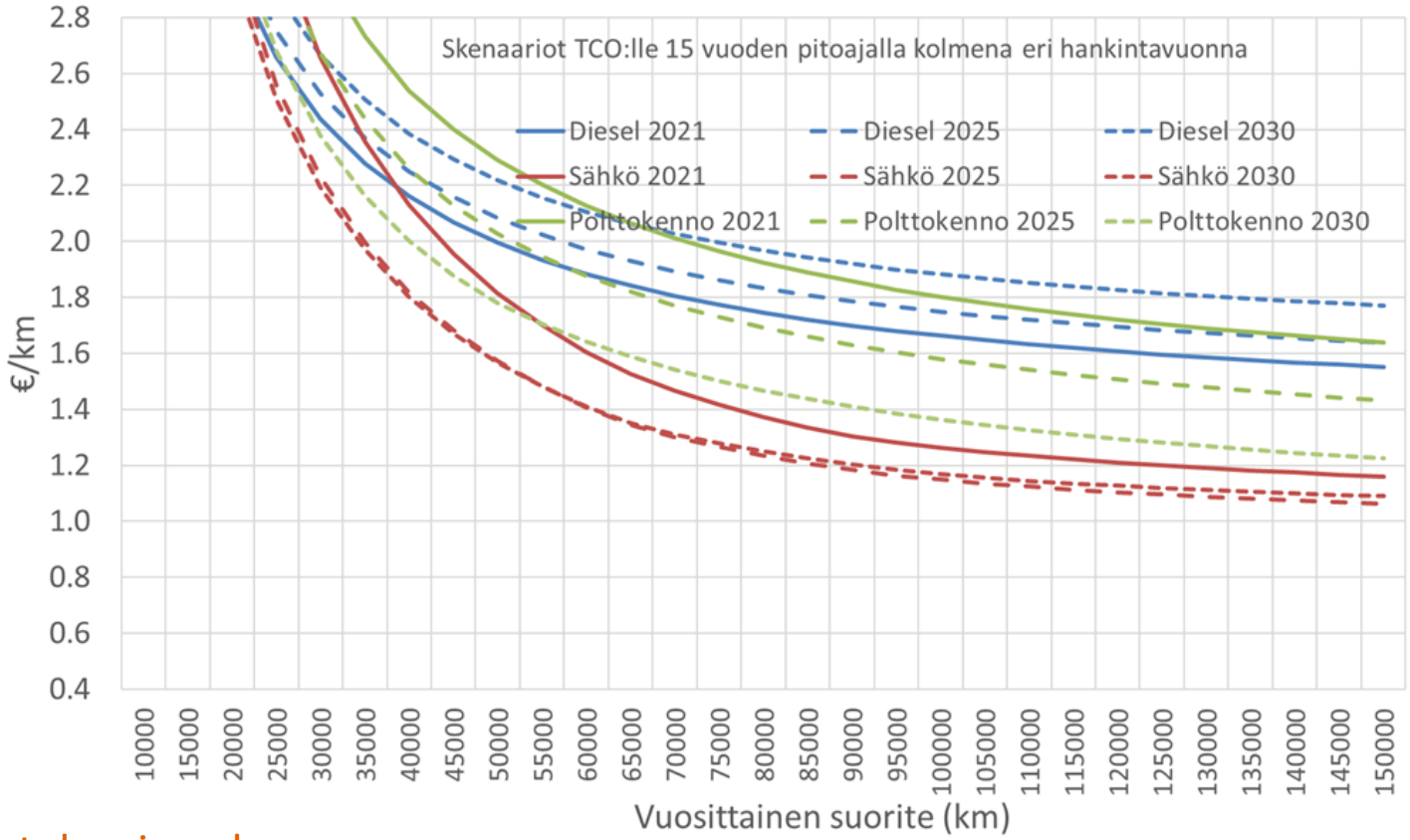
HYDRAITE

METROLOGY for HYDROGEN VEHICLES 2

MARANDA

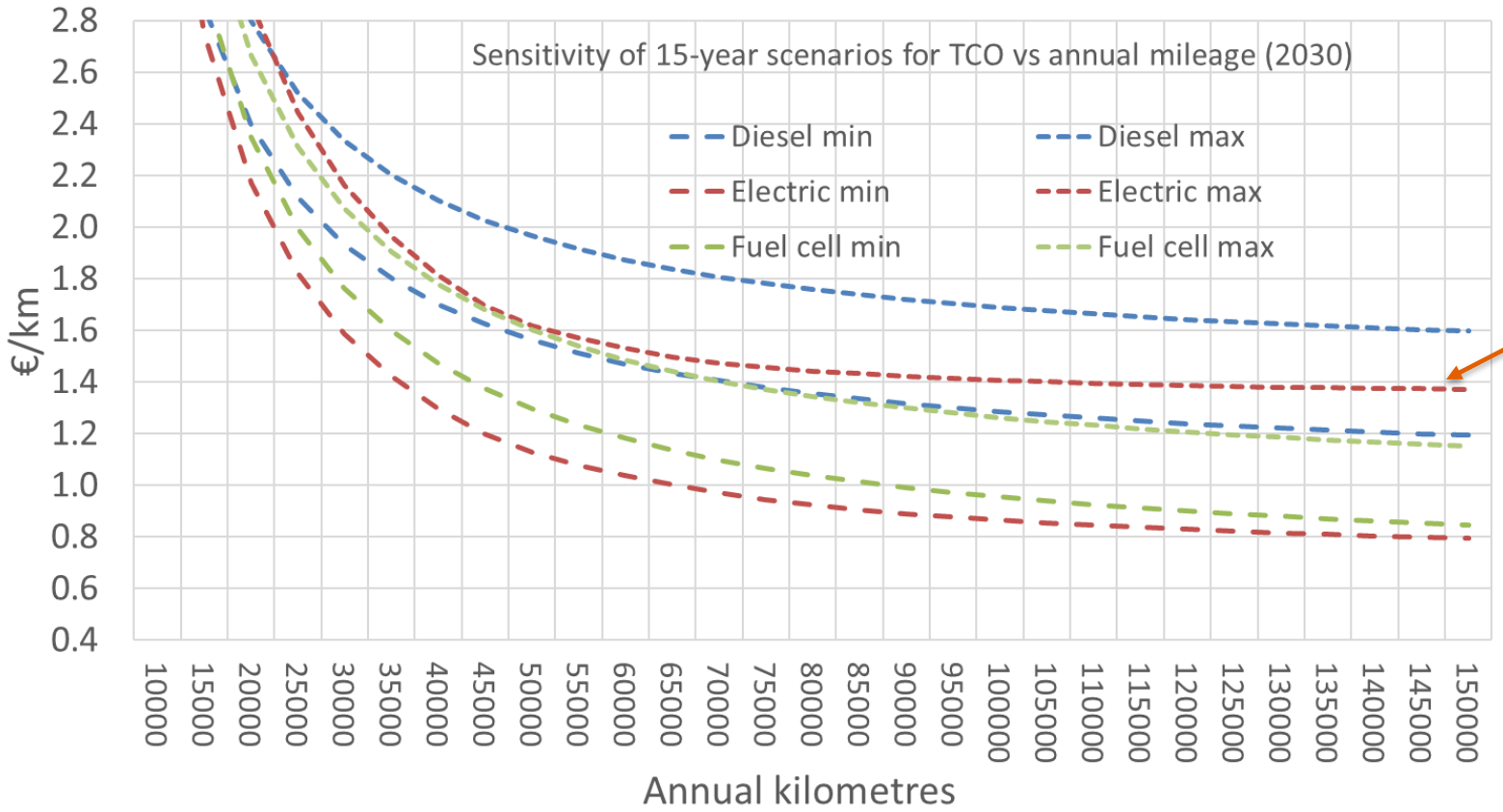
Total cost of ownership scenarios: urban bus trunk line (126000 km/a nominal)





VTT: Paikallisliikenteen puhtaat käyttövoimat nyt ja tulevaisuudessa:
https://cris.vtt.fi/en/publications/paikallisliikenteen-puhtaat-käyttövoimat-nyt-ja-tulevaisuudessa?utm_source=email

Example: Sensitivity analysis TCO vs km: urban bus year 2030 diesel vs electric vs H2

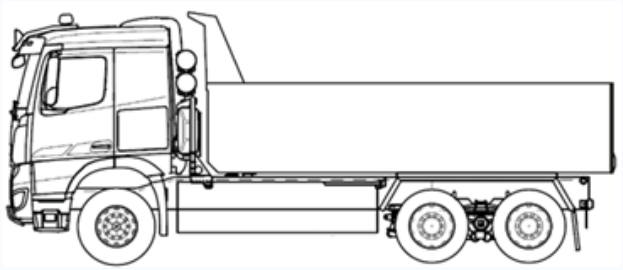


Huom: Sähköbussille oletettu 50% korkeampi energiankulutus matkustamon lämmityksen vuoksi

VTT: Paikallisliikenteen puhtaat käyttövoimat nyt ja tulevaisuudessa:
https://cris.vtt.fi/en/publications/paikallisliikenteen-puhtaat-käyttövoimat-nyt-ja-tulevaisuudessa?utm_source=email

ESCALATE Finland pilot: Key innovations

- Modular and scalable HD powertrain with battery, FC and H2 tanks
- Nominal use case: GVW 40 t but piloting up to GVW 76 t
- Hybrid power source flexible design through modularity and scalability: battery-FC-H2 tanks
- Prototype: Pure BEV with hydrogen FC range extended for long haul use case
- Flexible vehicle platform based on 3-axle tractor
- Modularity of hybrid powertrain battery/FC power and capacity combinations and hybridisation degrees
- Hybrid BE-FC powertrain control, energy management and operation optimisation
- Fast charging up to 1 MW and H2 refilling with user-friendly interfaces

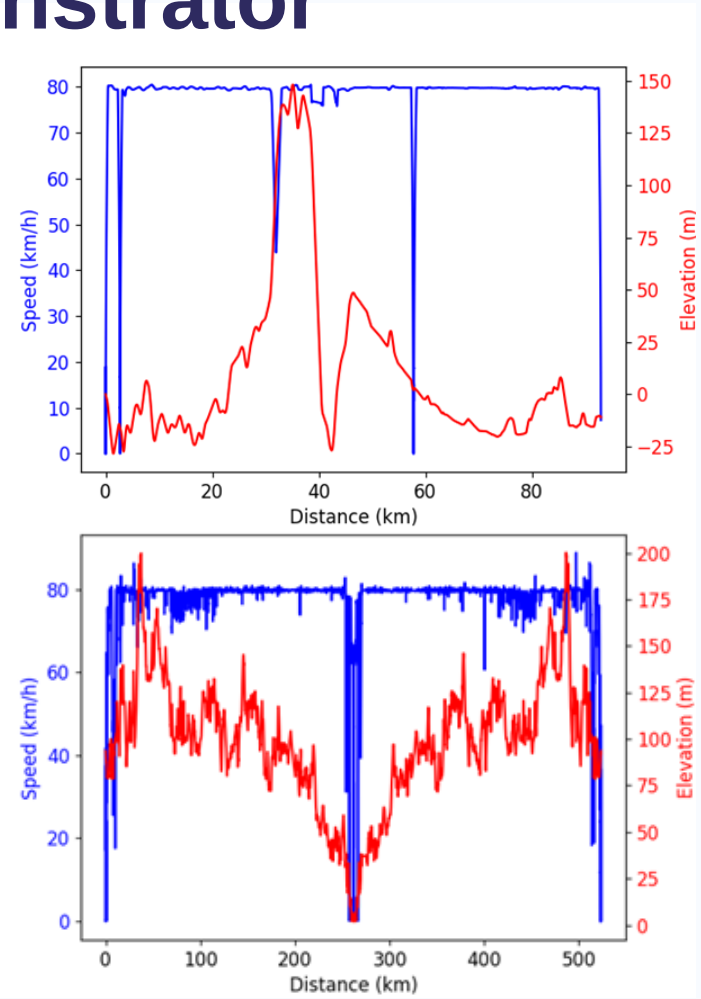


Source: M. Pihlatie et al, Zero-Emission Truck Powertrains for Regional and Long-Haul Missions World Electr. Veh. J. 2023, 14(9), 253; https://doi.org/10.3390/wevj14090253

Design criteria for the GVW 40 t demonstrator

1. VECTO long haul 750 km continuous operation
2. Real-life long haul mission in Finland
   - Vuosaari – Jyväskylä oneway without recharging (262 km)
   - Vuosaari – Jyväskylä roundtrip + refuelling (523 km)

- VECTO long haul most demanding, both in terms of energy consumption and distance
- Real operation scenario gives requirements to charging, H2 refill and powertrain performance



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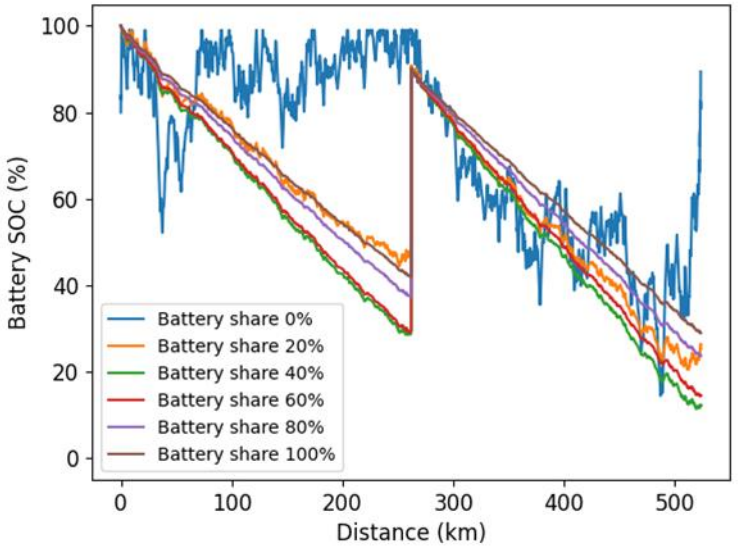
Results of the real operation long haul use case

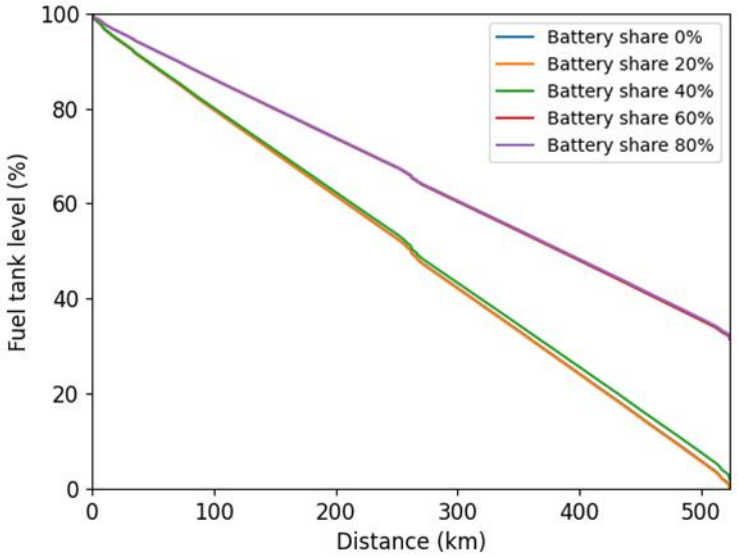
Share of battery electric operation	GVW 40t nominal case				GVW 76t HCT case			
	Jyväskylä – Vuosaari		Vuosaari – Jyväskylä		Jyväskylä – Vuosaari		Vuosaari – Jyväskylä	
	Battery electric energy (kWh/km)	Hydrogen energy (kWh/km)	Battery electric energy (kWh/km)	Hydrogen energy (kWh/km)	Battery electric energy (kWh/km)	Hydrogen energy (kWh/km)	Battery electric energy (kWh/km)	Hydrogen energy (kWh/km)
0%	-0.04	3.72	0.05	3.70	-0.04	7.59	0.02	7.52
20%	0.30	3.10	0.35	3.09	0.47	5.94	0.67	5.89
40%	0.62	2.52	0.67	2.51	1.42	3.63	1.63	3.60
60%	1.02	1.84	1.08	1.83	2.20	1.88	2.38	1.86
80%	1.39	0.94	1.46	0.93	2.60	0.96	2.78	0.95
100%	1.78	0.00	1.85	0.00	2.99	0.00	3.21	0.00

Source: M. Pihlatie et al, Zero-Emission Truck Powertrains for Regional and Long-Haul Missions World Electr. Veh. J. 2023, 14(9), 253; https://doi.org/10.3390/wevj14090253

Summary and conclusions

- Battery electric and fuel cell trucks are the primary zero-emission alternatives for the future requirements
  - Hydrogen ICE and electrofuels additional options
- Battery electric is currently leading the development (both technology and market)
- Viability needs to be proven at system level
- BET need improved batteries and fast (MW) charging, infrastructure and grid power
  - Likely to be unbeatable at shorter distances and volume-constrained transportation
- FCT need competitive fuel cells, H2 at a competitive price and infrastructure
  - A Viable alternative/complement at long haul and weight-constrained transportation
- Metrics for assessment: TCO





VTT

beyond

the obvious

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