The early adoption of battery electric trucks

Results from the MoZEES case study on electrification and hydrogen solutions for trucks in Norway

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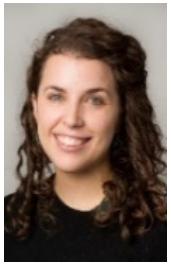

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EVS32 Symposium
Lyon, France, May 19-22, 2019

Experiences from battery-electric truck users in Norway

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Executive Summary

This paper presents experiences from pilot-projects with battery-electric trucks in Norway, focusing on purchasing processes, technology, vehicle choices, use and different performance aspects. Further, we discuss the electrification potential for light distribution trucks given typical user patterns, and compare ownership costs vs. trucks with internal combustion engine (ICE) for different technological maturity stages. Results show that experiences have generally been positive, but often require tailoring. Further, current battery-electric technology could to some extent cover typical use of ICE-trucks, but is situation-dependent. In terms of costs, battery-electric light distribution trucks first become competitive vs. ICE when technology reaches mass production.

Keywords: BEV (battery-electric vehicle), case study, truck, cost, ZEV (zero-emission vehicle)

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Contents

- User experiences
- Electrification potential
- Cost competitiveness versus ICE

Since 2016:

+4 H_2 trucks from 2019

Since 2018:

31.12.2018: +5

∑ = 13

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Assess of user experiences

- **Case study** based on semi-structured interviews of
  - Enterprises with **experience in operating battery-electric trucks** in Norway
  - Sample based on the **project list of ENOVA** (the Norwegian Government Agency for the transition towards a low-emission society), and the **Norwegian Public Road Administration's vehicle registry Autosys, as of April 2018**
  - In addition a number of relevant government/public policy bodies and manufacturers were interviewed
- Interviews conducted as **Skype meetings** with people **closely involved in investment or policy decisions** of each organization
- **Interview questions** were related to **vehicle purchase process**, **technology, performance**, service/maintenance, charging infrastructure, use of the existing fleet, **investment and operation costs**, **public frameworks** and incentives for enforced in-phasing of zero-emission vehicles

The BE truck pilots in few words

- The trucks
  - **Rebuilt** from ICE
  - Vary in power, range and max total weight
  - Intended to operate 5 (or even 7) days a week; 1 to 3 shifts per day
  - **Expected mileages** vary from 18 000 to around 120 000 km annually
- Used in **food distribution, refuse collection and recycling**
- Fewer battery-electric trucks in operation than is the case for electric buses
  - Higher technological and capacity demands set by freight vehicles
  - Bus market is more steered by public tenders
- Main **incentives for purchasing** electric trucks
  - **ENOVA-subsidies**
  - **Exemptions from road toll and ferry charges**
  - Bus lane access
- Charging based on **industrial plug** at depot

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Technical information about the vehicles

	Operator 1	Operator 2	Operator 3	Operator 4	Operator 5
Vehicle type	Distribution truck	Distribution truck	Refuse collection truck	Refuse collection truck (Tractor)	Tractor
Manufacturer	MAN/Emoss	Iveco	Dennis Eagle/ PVI (Renault)	MAN/Emoss (/Allison)	MAN/Emoss/ Allison
Expected range (km/y)	50 000		18 000	80 000	120 000-130 000
Stated range/charge (km)	180	200	140	200	178
# of vehicles	1	1	2	1 (+1)	2
Registration year	2016	2018	2018	2018 (2019)	2018
Total weight (t)	18.6	5.6	27.0	28.0 (50.0)	50.0
Length (m)	9.0		9.5		
Battery technology	Lithium-ion		Lithium-ion	Lithium-ion	Lithium-ion
Battery power (kW)	240	60	240	200 (300)	300
Depot charging	2x43 kW chargers, industry plug	32A (22 kW) charger, industry plug	64A (44 kW) charger, industry plug	44 kW charger, industry plug	44 kW charger, industry plug
Opportunity charging				150 kW fast charger planned	2x150 kW fast chargers
Charging time (hrs)	5	2	8 (overnight)	4.5 (lunch break/ overnight)	4-6/0.3

Main challenges

- **Long time** from purchase to vehicles are in traffic
- **Decrease in gross weight** compared to similar trucks with ICE
- **Lower range** than expected gives **less flexibility** and more needs for route optimisation
- **Follow-up and problem solving**
- (Establishing) **Fast charging** infrastructure
- Power to **refrigeration and compression units**

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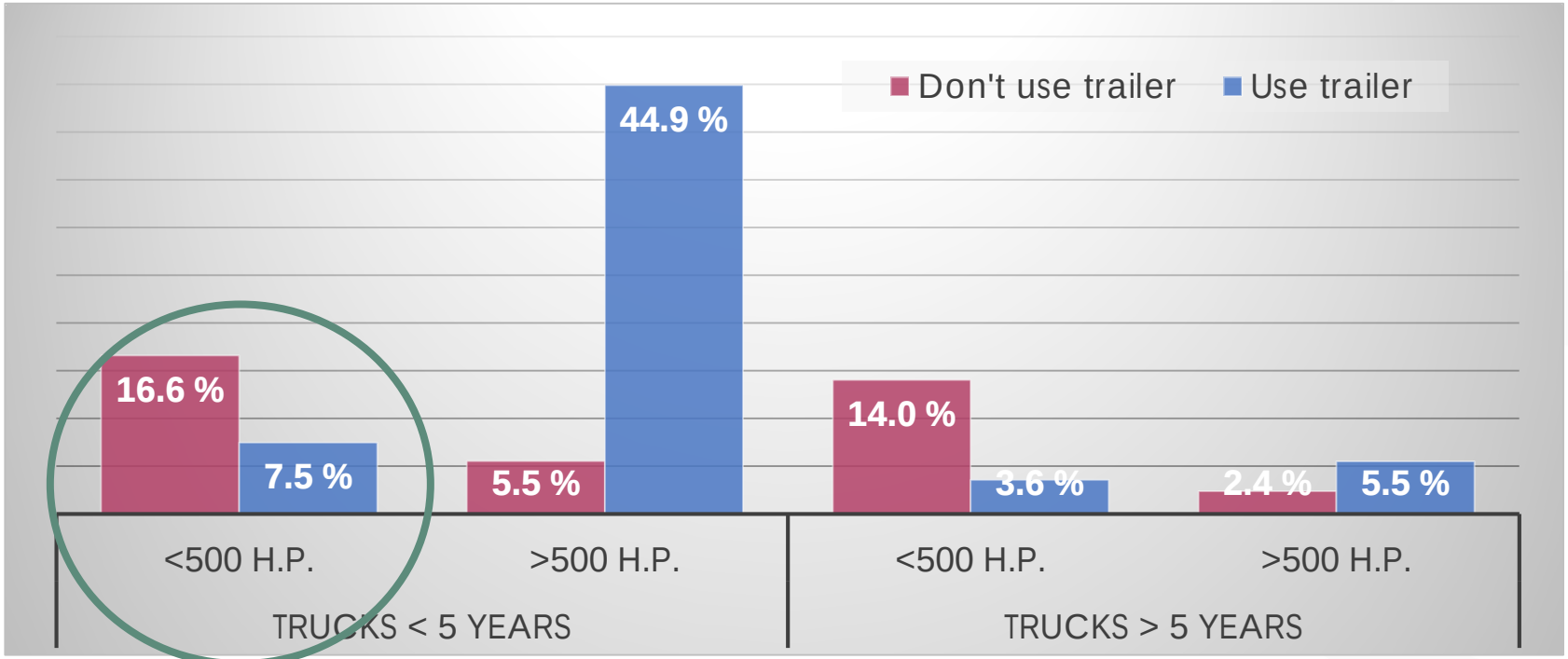
Truck segments with electrification potential

- Trucks that have:
  - An engine with less than 500 h.p. (horsepowers)
  - A maximum daily mileage shorter than the range of a fully charged battery
  - Do not use trailer (except citytrailer)
- Access to charging facilities increase potentially maximum daily milage
- Transport patterns studied for:
  - Trucks up to 5 years old (6 150 trucks)
  - Main categories of trucks
    - Trucks with platform
    - Trucks with closed chapel (e.g. distribution trucks)
    - Tank trucks
    - Tractors with semitrailer
    - Special trucks (e.g. refuse collection vehicle, rescue vehicles, etc.)

Data and methodology

- Statistics Norway's **lorry survey for 2016 and 2017**
  - Includes information about among others; Daily transport pattern, place of origin and destination at post code level for approximately **8200 trucks and 75000 trips**
  - Each truck owner reports transport performance for one week
  - 52 counting weeks each year
- Norwegian Public Road Administration's Autosys register
  - Includes **technical information** about each vehicle
  - **Combined with basic data from the lorry survey**
- Data segmented based on the trucks' age (>< 5 years), engine power, main truck categories, use of trailer (during the reporting week) and daily driving distances
- Maximum daily mileage is modified for charging possibilities if the truck has 2+ daily trips starting from the same postal code

Illustration of vehicle segments with potential for electrification



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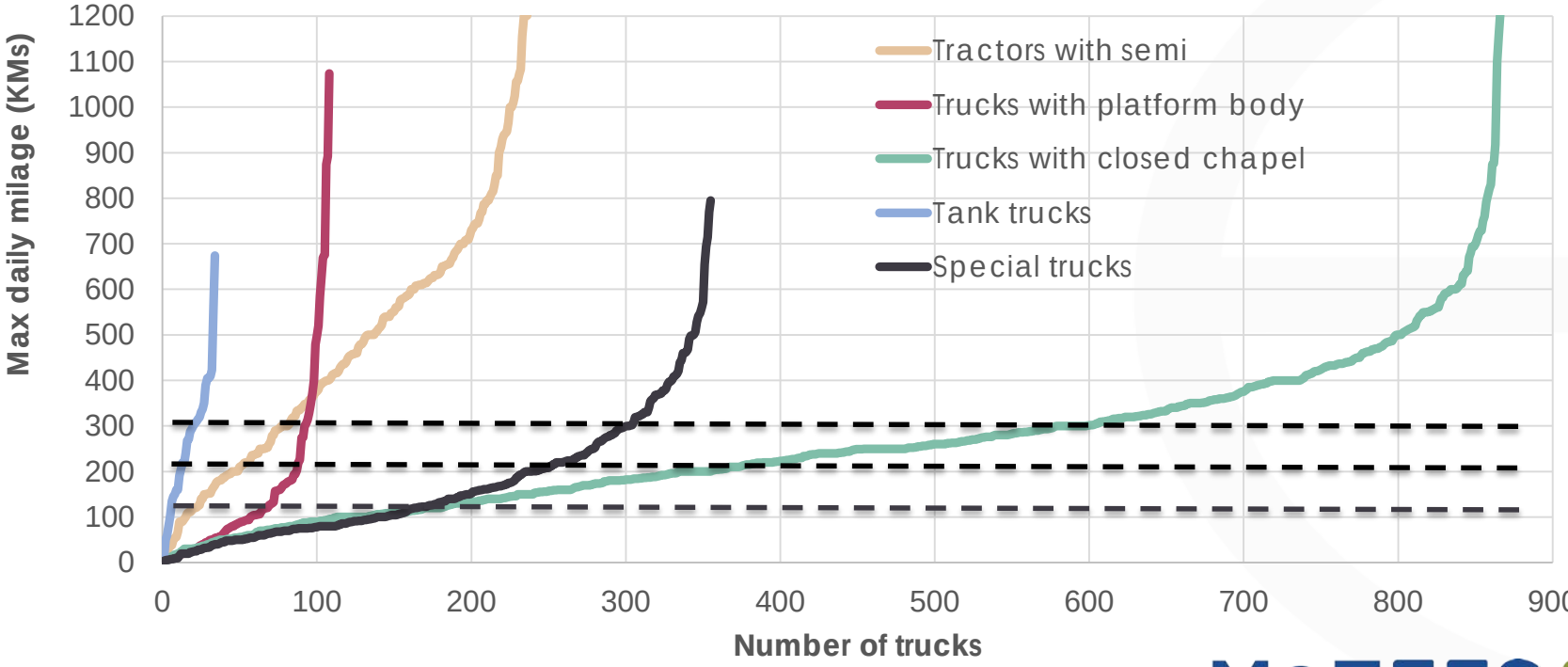
Special trucks and distribution trucks have most trucks in the potential electrification segment



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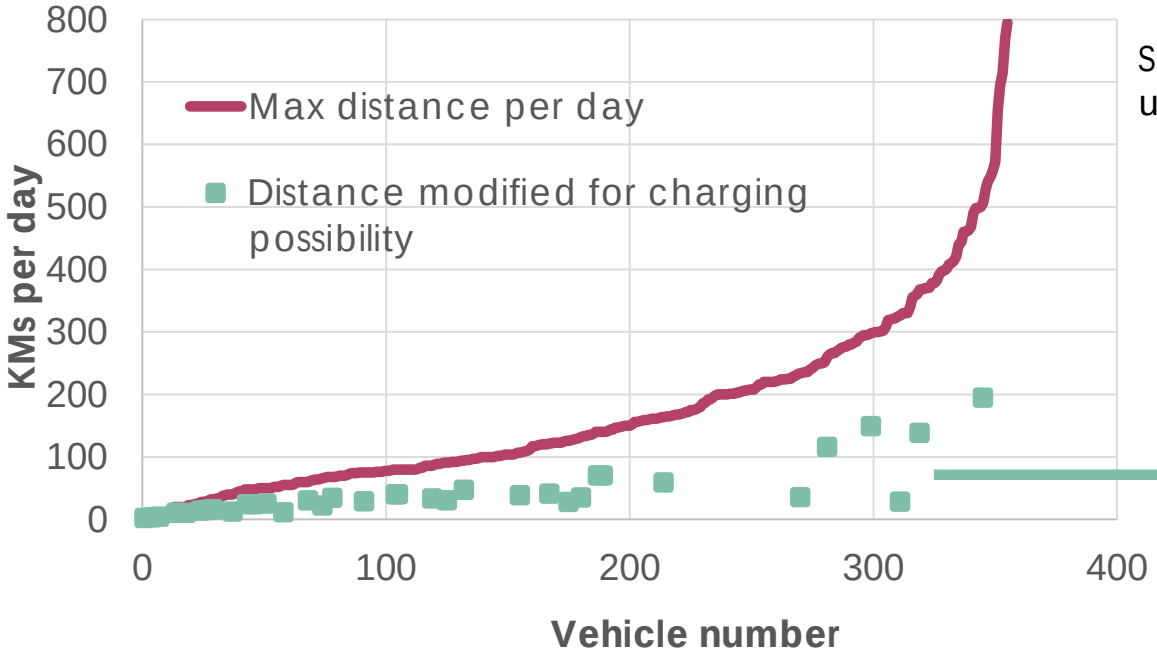
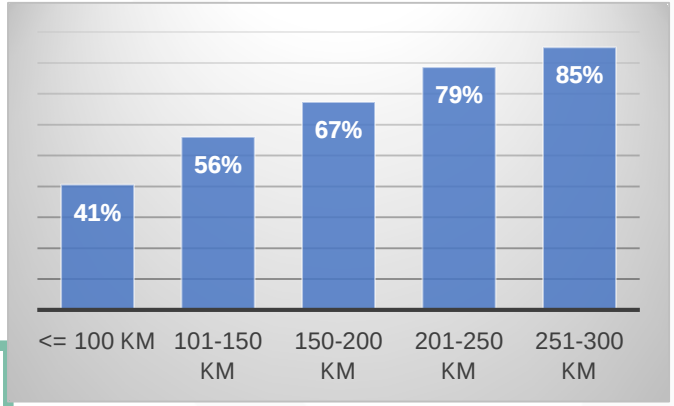
Maximum daily mileage for **special trucks** (e.g. refuse collection trucks)

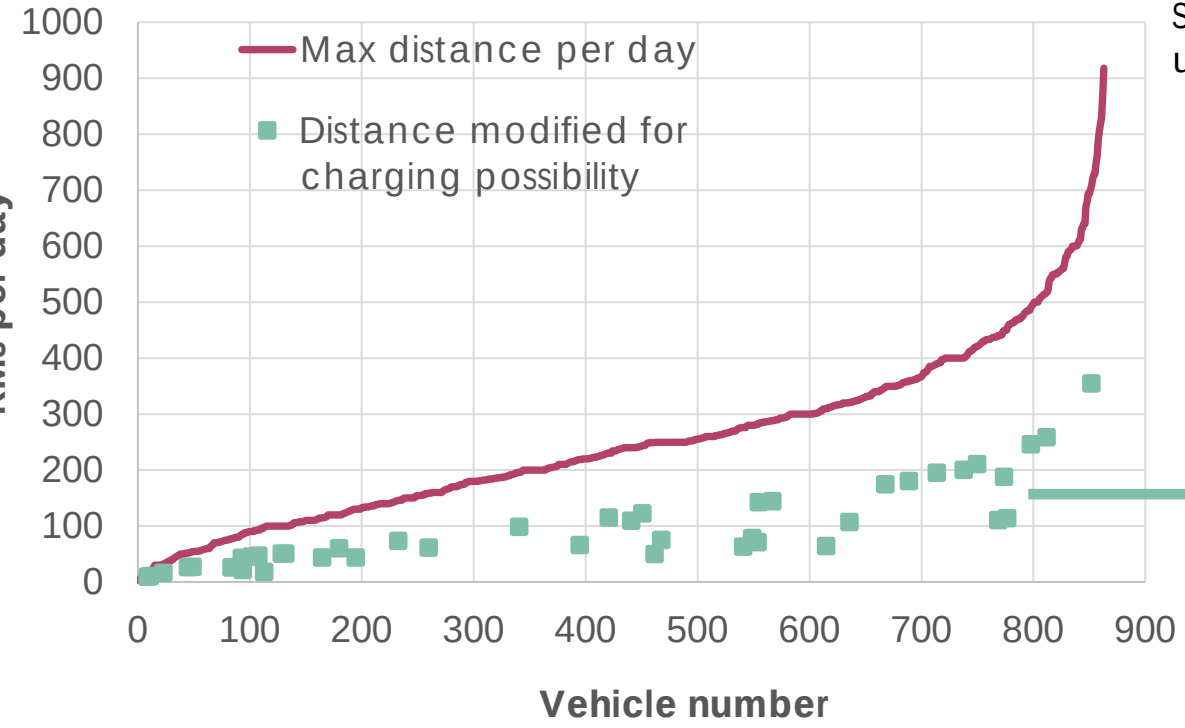


Share of vehicles with max daily mileage up to:

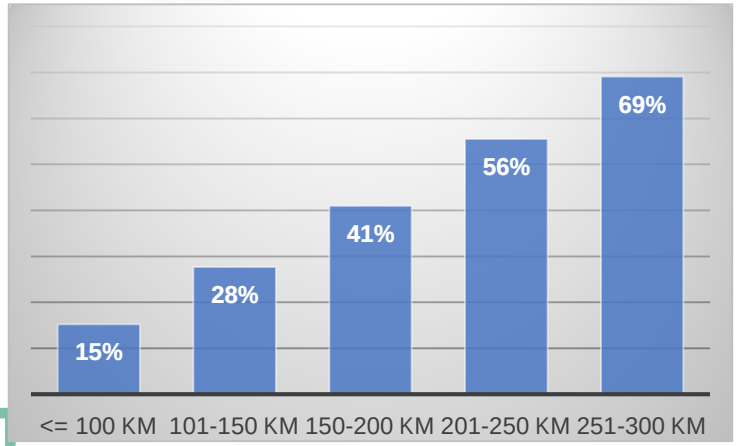


10 % have charging possibility

Maximum daily mileage for **trucks with closed chapel** (e.g. distribution trucks)

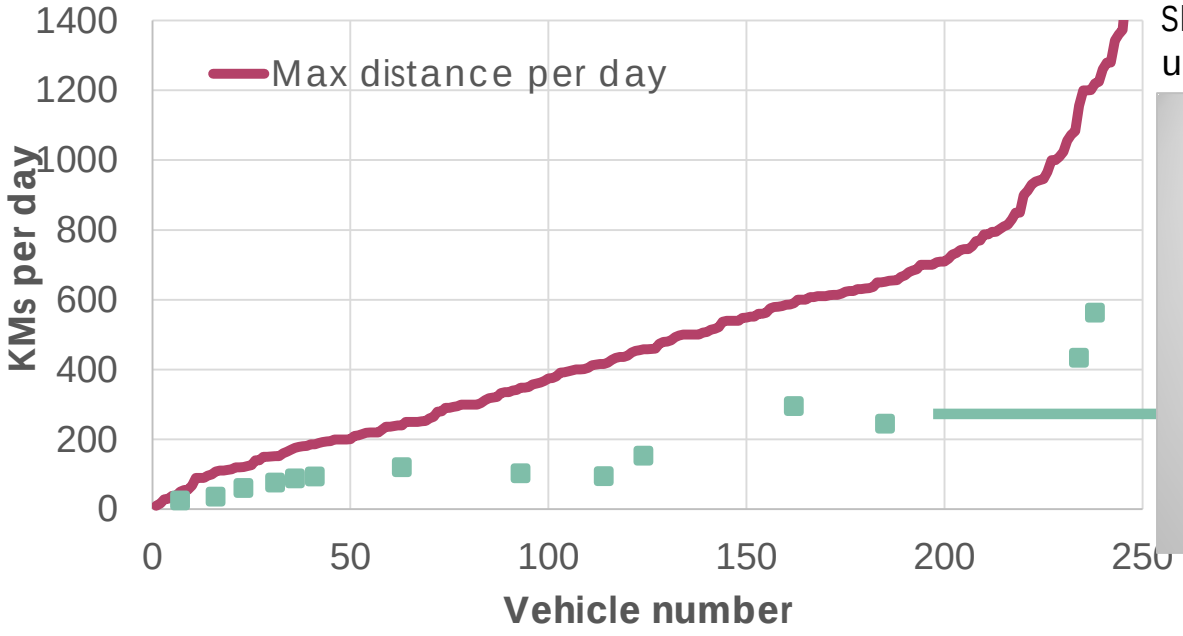


Share of vehicles with max daily mileage up to:

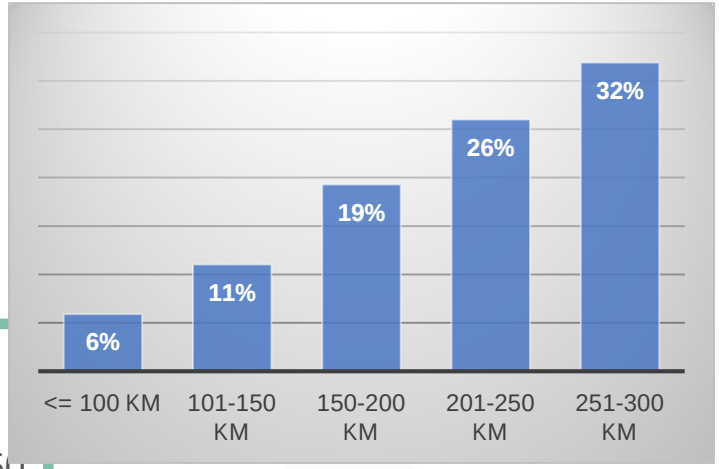


5 % have charging possibility

Maximum daily mileage for **tractor with semitrailer** (per ex. citytrailer)



Share of vehicles with max daily mileage up to:



6 % have charging possibility

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Cost competitiveness of electric vs. ICE operation

Cost category	Main aspects taken into account		
Time dependent	Investment/capital costs excl. subsidies	Depreciation, residual values and discount rate	
Distance dependent	Energy consumption & cost (base price + any levies)	Road toll charges and exemptions for zero-emission	Driving distances & mileages
Maintenance & repair	General maintenance	Tyres	Wash, etc.
Technology-independent	Wage expenses	Admin & Insurance	Annual weight fee

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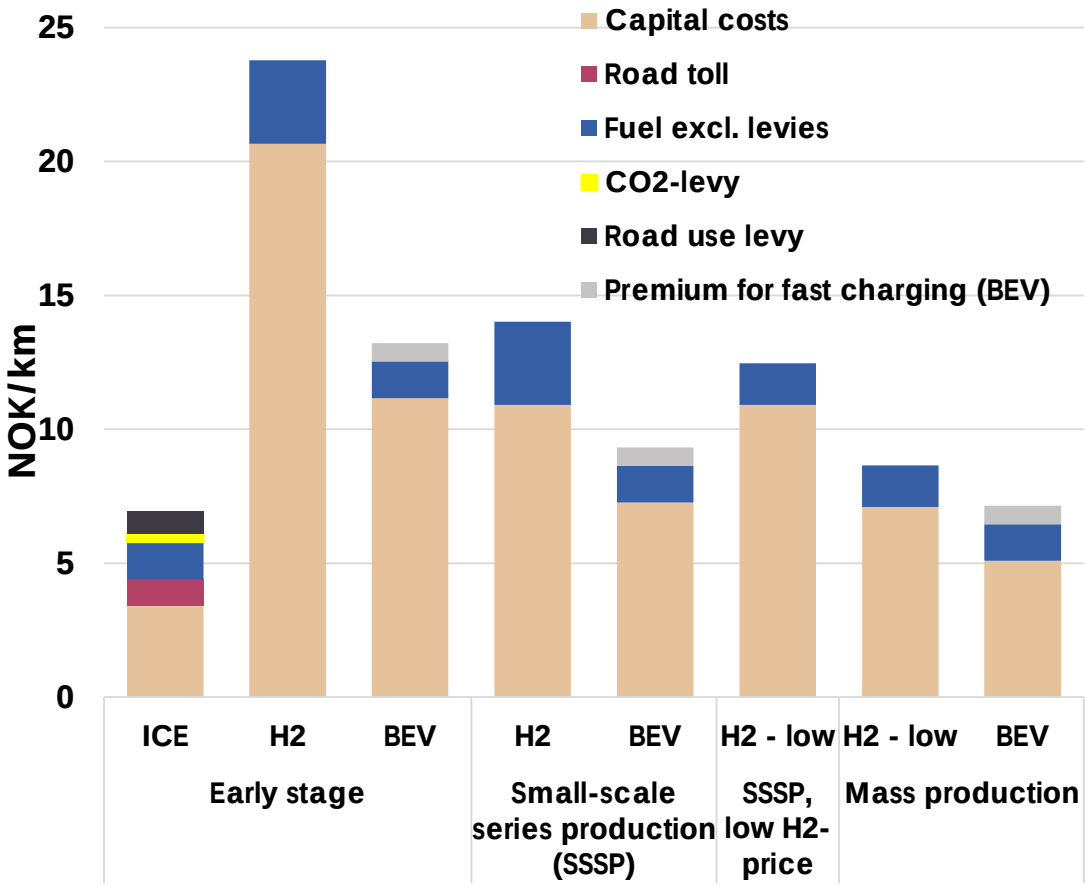
Ownership cost decomposition

Light distribution trucks (ICE, BEV and H2)

Four technological maturity scenarios.

Figures in NOK/km



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Annual mileages (km) required for battery-electric and hydrogen-electric light distribution trucks, respectively, to achieve costs of ownership lower than for ICE

	Early stage	Small-scale serial production (SSSP)	SSSP with low H2-prices	Mass production
Battery-electric	>180 000	>86 000 (regular charging) > 160 000 (given fast charging)		>20 000 (reg. charging) > 38 000 (fast charging)
Hydrogen-electric	Not competitive		>225 000	>93 000

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Summing up

- Few pilots with experience from BE truck operations, but increasing numbers
- Most challenges with the first BE truck, most users are satisfied
- Range needs to be more than 200 kms if electrification should have a significant market share for HDVs:
  - Vehicles <500 h.p., daily mileage up to 200 kms and never using trailer, make up only 5% of total mileage conducted with trucks newer than 5 years
  - Vehicles <500 h.p., daily mileage up to 200 kms and using trailer, make up only 1% of total mileage conducted with trucks newer than 5 years
- There are also needs for more powerful engines than in today's pilots
  - About 70% of total mileage for trucks newer than 5 years are with trucks with > 500 h.p.
  - This segment have very few alternatives to diesel
- Special trucks (e.g. refuse collection trucks) and distribution trucks are the most suitable vehicle segment: 85 % and 69 % of the vehicles have a max. daily mileage of less than 300 kms