International Energy Agency
Technology Collaboration Programme – Hybrid and Electric Vehicles

Final Report of Taskforce 41 "Electric Freight Vehicles"

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Introduction

Road freight transport is one of the fastest growing modes of transport and has an increasing share in the total GHG emissions of transport. Furthermore, higher gradients are observed for freight emissions compared to passenger travel emissions for most of the IEA countries [1]. Hence in order to meet the Paris Climate Agreement targets, the global road freight sector will need to cut its CO2 emissions by 60% until 2050 [2]. Various technical and non-technical options exist for reducing the emissions of road freight transport, such as improving the efficiency of freight logistics, reducing the fuel consumption performance of conventional vehicles and introducing (near) zero tailpipe emission vehicles such as battery-electric vehicles (BEV) into the market that could result in the large-scale emission reduction. However, current emphasis is on incremental technology developments to reduce fuel consumption of conventional vehicles. Although electrifying the fleet is the ideal option for the future and has been the subject of significant discussion, there is still a high degree of uncertainty regarding technology developments of electric powertrain options. Specifically, the challenge has been to introduce electrification whilst continuing to meet the user requirements. This has given rise to numerous activities in the different vehicle segments of the freight sector with some uncertainty as to which solutions will be adopted in the longer term.

Task objective and working method

The Taskforce 41 “Electric Freight Vehicles” (EFV) of the IEA Technology Collaboration Program “Hybrid and Electric Vehicles” aimed to monitor progress and review relevant aspects for a successful introduction of electric freight vehicles (EFV) into the market. Four focus areas were included for this purpose.

EFV market structure

The first area "EFV market structure" looked at the current market developments of EFVs. This includes key characteristics of the truck market in Europe as well as the current EFV portfolio.

Technology development

The next area „technology development of EFV" addressed the technical viability of EFV. Based on available EFVs on the market, their performance were described to monitor the technical progress of EFVs.

Best practice & suitability

The third area of interest dealt with "best practices and suitability aspects of EFV" to identify potential application areas of EFV. Successful examples of EFV applications based on best practice pilot project were described and their opportunities and barriers for a broad market introduction were discussed.

Evaluation & policy framework

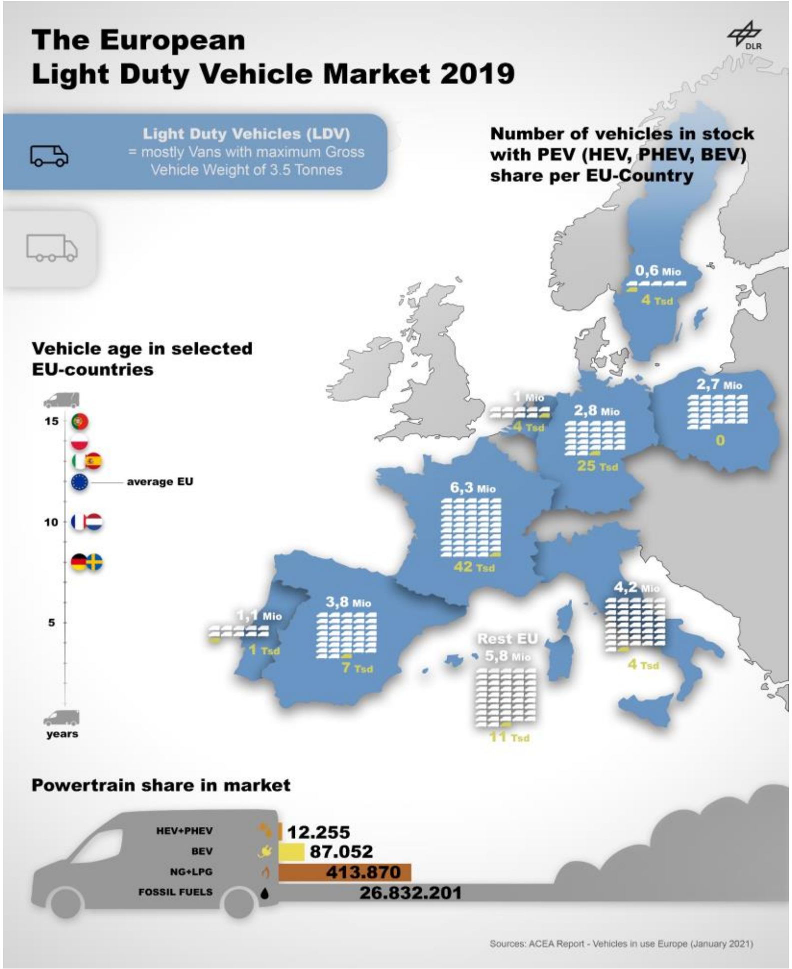
The last area looks at demand-side issues and was linked both to end costumers and to policies. Given the different suitability of EFV technologies for replacing conventional diesel engines, economic and ecological aspects of EFV were evaluated.

Topics of each focus area were linked in a series of stakeholder workshops and presented in form of fact sheets (see following pages) which provided the base to review the aspects for a successful introduction of EFV into the market (last page). The scope of Task 41 included vehicles of the size classes N1, N2 and N3 and all types of electrified or electric powertrains like hybrid, plugin-hybrid, battery-electric, fuel cell electric and electric road powertrain.

EFV market structure

The European Light and Heavy Duty Vehicle Market

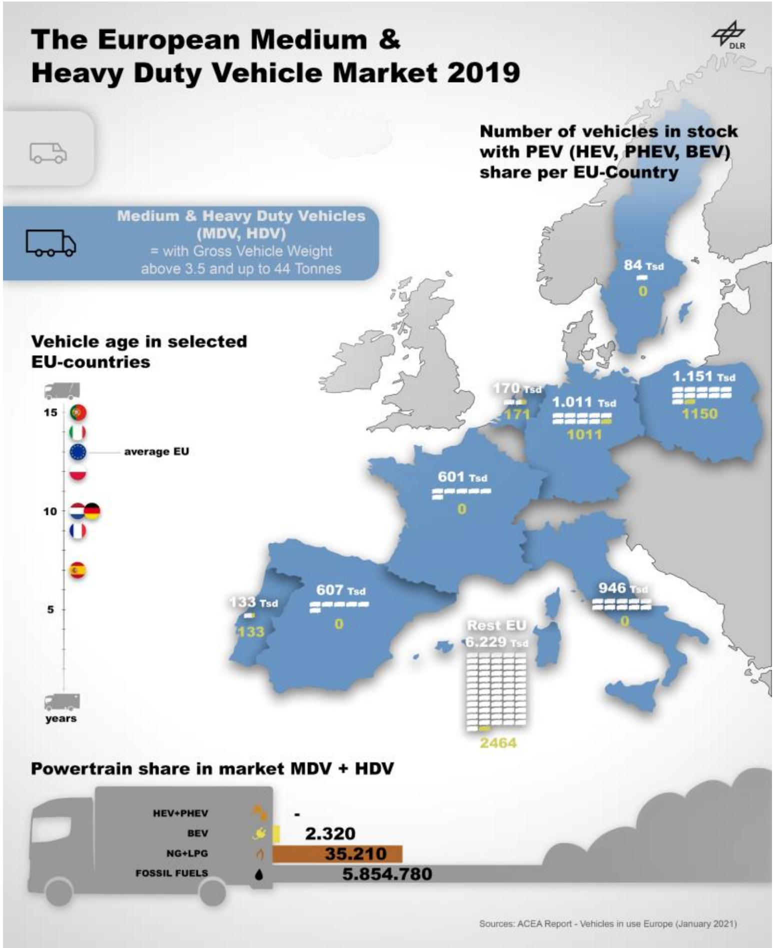
In 2019, 2.48 million Light and Heavy-Duty Vehicles were newly registered in Europe, 85% of which were Light-Duty Vehicles (LDV) under 3.5 tons gross vehicle weight (GVW). The following figures illustrate the European light and heavy-duty vehicle market in 2019. Eight selected countries are shown, representing about 75% of each of the European light and heavy-duty vehicle stock.



Most of the vehicles are powered by a diesel engine (92.8% LDV, 97.9% HDV). Alternative fuels, like CNG, LPG, biofuels and ethanol, had a share of approximately 1.4% in the overall commercial vehicle registration in 2019. The market niche is made up of Hybrid Electric Vehicles (HEV) with 0.2% of new registrations. However, the market share in the LDV has risen to almost 160% compared to the previous year (4,577 hybrid-electric vans in 2019). Another high increase was recorded by plug-in electric commercial vehicles (BEV, FCEV, REEV, PHEV) with 26,107 plug-in electric LDV and 747 plug-in electric HDV newly registered in 2019.

The year-on-year increase was stronger in the HDV segment (+109%) than in the LDV segment. The main markets for these vehicles are primarily Germany, followed by the Netherlands and France. [3, 4]

The diesel engine is by far the main drive train in the commercial vehicle segment. It is an efficient internal combustion engine and since the introduction of the Euro standards (1988), Euro 6 and exhaust after-treatment pollutant emissions from heavy-duty vehicles dropped significantly [5]. Never-theless, to achieve the CO2 fleet targets, not only technological progress of the diesel engine itself is necessary, but also low- and zero-emission vehicles need to be promoted more in the market.



EFV market structure

Current market status for electric freight vehicles

The IAA Commercial Vehicle Fairs in 2018 and 2020 characterized an increasing electrification strategy for commercial vehicles. Different manufactures showcased their first battery-electric vehicle models. Especially in the LDV segment, vans from Volkswagen, Daimler, MAN, IVECO, Nissan and Renault are already in series production. Prototypical BEVs in the medium and heavy-duty segments are currently being tested in the last phase of various pilot projects with customers. The start of production (SOP) of these medium and heavy duty vehicles are set for 2022 or early 2023. Electric heavy articulated tractors and semitrailer trucks are currently also manufactured and sold by small suppliers such as the Swiss E-Force One AG and the German Framo GmbH [6, 7]. These are so-called electric vehicle converters, which replace the combustion engine of trucks from MAN, Daimler and Co. with their electric powertrain. The following figure shows the market readiness level of electric freight vehicle examples in different vehicle segment.

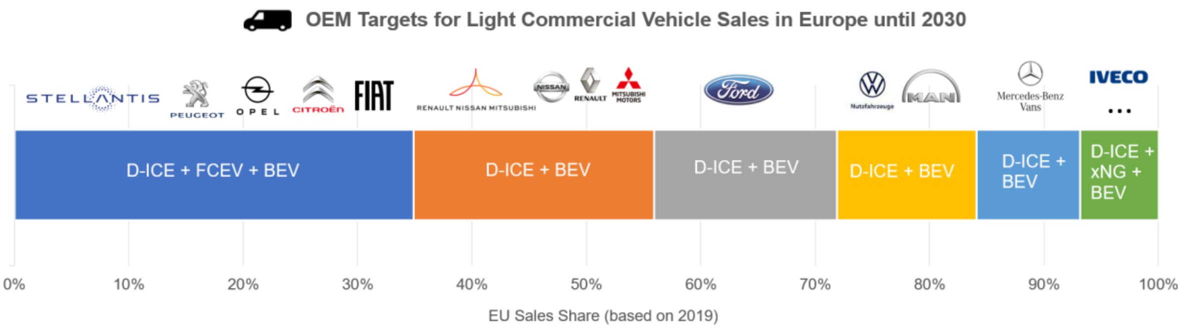
Electric Freight Vehicle Market Overview 2022

Most manufacturers already have battery-electric series vehicles for the light vehicle segment in their portfolio. With increasing gross vehicle weight, the transport applications of the vehicles are shifting toward long-distance operation and thus also higher range requirements. Pure battery solutions for the heavy vehicle segment (up to 26 tons) in distribution transport have been tested in recent years and have been in small series production since 2022. In the heavy-duty long-distance transport, FCEVs, BEVs and electric vehicles with dynamic charging options are still being tested with customer participation.

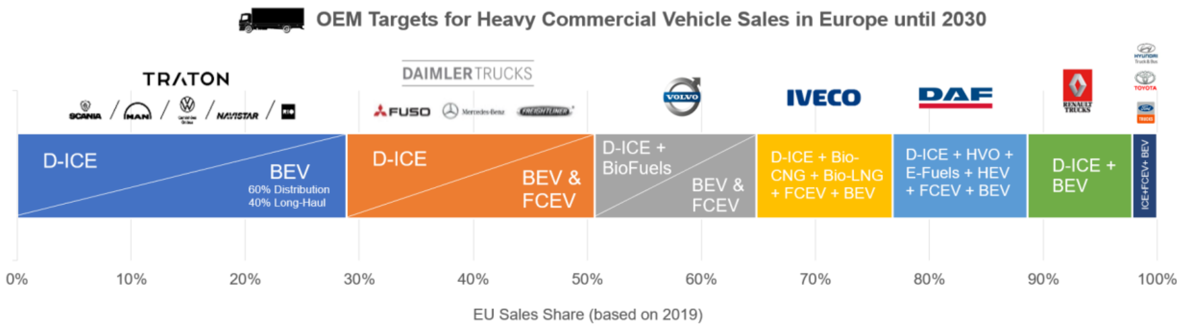
EFV market structure

Prospects for electric freight vehicles from the manufacturers' point of view

In the media, the first long-term strategies of the manufacturers have appeared with information on the planned investments. For example, Daimler, the world's largest commercial vehicle manufacturer, plans to phase out all diesel engines in its trucks and buses (in addition to passenger cars) in their biggest market regions in the world (primarily Europe, Japan and North America) by 2039. In the future, trucks will be powered either by a traction battery system (BEV) or fuel cell systems (FCEV). The VW Group subsidiary TRATON, which is the largest producer of commercial vehicles in Europe and to which the commercial vehicle brands MAN and Scania belong, wants to invest one billion Euros in the development of electric mobility (primarily as BEVs) by 2025 and expects that by 2030 a third of its commercial vehicles could be driven with electric motors. [8]
The market developments show that electrification efforts are beginning to take hold in the entire commercial vehicle segment. However, compared to the passenger car market, the manufacturers' strategies differ in some respects. The following figures show the largest manufacturers in Europe in terms of sales in 2019 respectively for the light and heavy goods vehicle segments. Based on the public announcements of the manufacturers, the long-term powertrain strategies are noted in the figures. In the van market, a strong preference for the BEV option is seen.



In the heavy truck segment, manufacturers are pursuing different strategies. The TRATON Group is currently following almost a single BEV strategy like in the VW Passenger Cars Group. Daimler Trucks and Volvo Group are focusing more on a dual strategy with BEV and FCEV. In common, these three largest truck manufacturer groups aim to provide at least every second vehicle with an electric drive by 2030. Other manufacturers in the heavy-duty segment also see potential in CNG and LNG as well as renewable fuels such as biofuels and synthetic fuels. [9]



From a vehicle design perspective, fuel cell makes particular sense in heavy-duty traffic, where longer distances are covered and more demanding payload profiles are required compared to light-duty traffic. The higher gravimetric energy density of the fuel cell compared to the battery offers systemic advantages for the vehicle design.

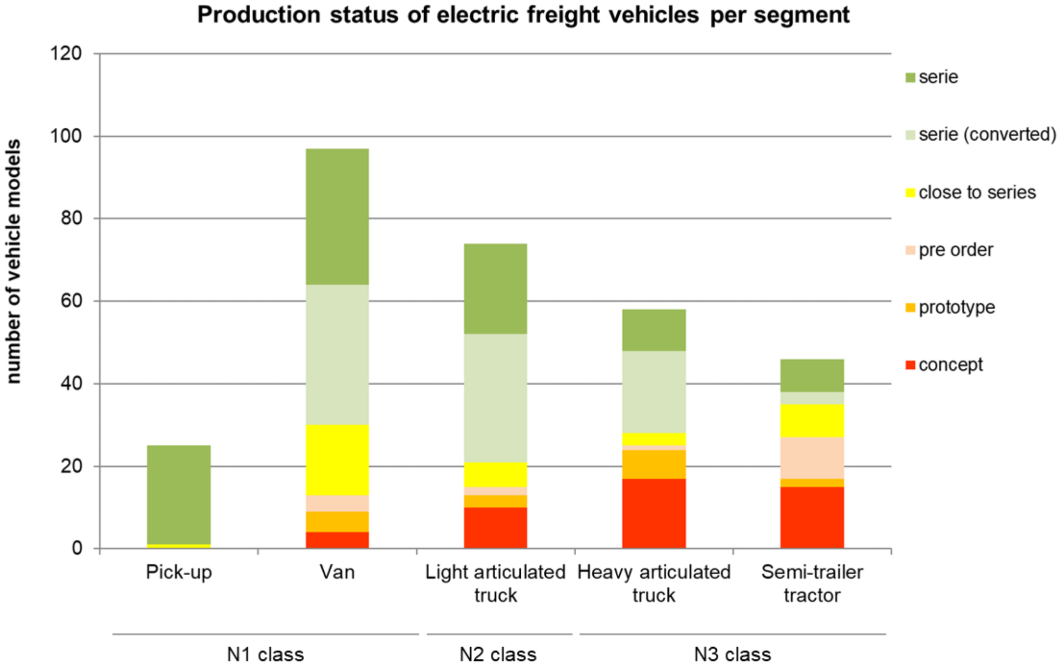
Technology development

The State of the Art of Electric Freight Vehicles

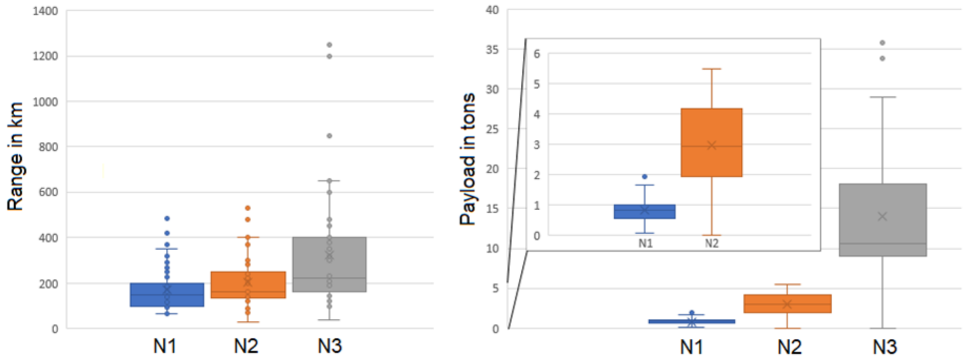
Technical Performance – Range and Payload

The main challenges in the technical performance of Electric Freight Vehicles (EFV) are the available range, payload and charging time today. The traction battery has a major influence on the indicators. In addition, the limited availability of EFV models and the rapid technological development plays a major role in the attractiveness of EFV in the market [10]. However, the market is developing rapidly. The question therefore arises whether the current state of performance of EFV is competitive with a conventional freight vehicle today.

A benchmark analysis of EFV was carried out using technical information on all available vehicle models and concepts that are publicly known. This includes Hybrid Electric Vehicles (HEV), Range Extended Electric Vehicles (REEV), Fuel Cell Electric Vehicles (FCEV) and Battery Electric Vehicles (BEV). The collected information was compiled over a time period from April 2018 to April 2022 and has been consolidated in a vehicle database. The data contains the standard specifications of the vehicles with technical data such as power, battery capacity, range etc. From the research, 265 vehicles were collected.
The following figure shows the collected numbers of electric vehicle models regarding their market readiness level and the segment. In principle, a lower market readiness level can be identified with increasing gross vehicle weight. This is mainly due to the technical requirements for heavy-duty vehicles in long haul transport that cover longer distances and have more demanding payload profiles.



On average, the range of the battery-electric vans available on the market is 150 km. The ranges go from 64 km to 500 km – see figure below. In the upper section, REEV is more likely to be found than BEV. The increase of the electric range and thus the battery capacity goes hand in hand with an increase in the mass of the traction battery, which is in conflict with the available vehicle payload in the corresponding vehicle segment. This optimization problem is one of the challenges for the design of EFVs but has improved in recent years with developments in battery efficiency. The vehicle payload of electric vans ranges from 200 kg to 1,950 kg with 835 kg on average. Regarding the driving range of N2 category vehicles, the current performance varies from 30 km to 530 km with an average of 160 km. Vehicle payload ranges from 1,000 kg to 5,500 kg with 3,100 kg on average. For the N3 category vehicles, the driving range varies between 40 km to 1250 km with 220 km on average. Vehicle payload ranges from 4,400 kg to 36,000 kg with 11,100 kg on average.



Technology development

The State of the Art of Electric Freight Vehicles
Technical Performance – Battery and Infrastructure

Whether the range is a limiting factor for vehicle operation also depends on the availability of the charging points and the charging speed [11]. Charging time varies largely depending on the type of electric vehicle supply equipment and type of battery in the vehicle. Alternating Current (AC) and Direct Current (DC) charging systems are available. With the AC system, regular charging is possible via the household power grid (e.g. via wall-box). DC charging has the problem that the batteries in the vehicle can quickly become overheated. An example of series battery-electric freight vehicles with information about the battery capacity and the charging time according to AC and DC is shown in Table below.

Battery capacity and charging time of series battery-electric freight vehicles

Vehicle Class	Vehicle model	Battery capacity [kWh]	Charging time AC 0-100% [h]	Charging time DC 0-80% [min]	Max. range [km] (without payload)
N1	Nissan E-NV200 (3,5 t.)	40	5,5 (11 kW)	40 (50kW)	275 (NEFZ)
	Mercedes eVIto (3,5 t.)	41,4	10 (11 kW)	80 (50kW)	150 (WLTP)
N2	IVECO Daily Electric 50C (7,5 t.)	80	4,2 (22 kW)	40 (50 kW)	280 (NEFZ)
	FUSO eCanter (7,5 t.)	82,8	12 (22 kW)	105 (50 kW)	100 (WLTP)
N3	Volvo FL Electric (16 t.)	300	13 (22 kW)	60-120 (150 kW)	300 (NEFZ)
	Volvo FE Electric (27 t.)	300	10 (22 kW)	90 (150 kW)	200 (NEFZ)

Depot charging is most attractive for freight transport because it offers a high degree of flexibility in operation. For depot charging, fleet operators usually need their own charging points at the depot. The vehicles are then preferably charged overnight or during the day (opportunity charging), as in some transport tasks vehicles have to return to the depot during the day. For the heavy duty vehicle segment 150-kW DC-charger is appropriate but a minimal standard. For most sub-contractors or similar logisticians who do not have a private parking space for their vehicles it is more difficult to find suitable charging business cases. Their vehicles are usually parked overnight on public roads. For electric vans there is the possibility to charge them via the current public charging infrastructure. For this purpose common 50-kW DC-Chargers (standard CCS) are suitable.
Logisticians often complain about the long charging time of EFV. However, 90 percent of today's vans are parked overnight at a fixed depot [12]. Considering the average charging time via an 11kW/22kW AC-charger, electric vans could be conveniently recharged overnight. Public 50kW/150kW DC-Charger could be additionally used to recharge the vans between the daily tours. As mentioned, public charging is seen more as a supporting factor in the charging strategy of EFVs, and will not be able to replace the own charging station with fixed parking space in the depot [12]. However, the relatively long charging time compared to conventional diesel refueling can be regarded as no problem in some applications already today.
The way and frequency of charging and discharging determine the battery life. The charging time of the battery depends on the limited electrical intensity to avoid irreversible damage to the battery [11]. A health indicator of batteries is the capacity. Lithium-Ion (Li-Ion) batteries lose on average more than 20% of their capacity over lifetime [11]. For Li-Ion batteries in electric vehicles the lowest capacity loss is reached by charging the Li-Ion battery (at 20°C) between 25-75 percent state of charge (SOC). This would delivery around 3,000 cycles (to 90% capacity) [13]. In real operation these operational parameters (charging strategy (speed), depth of discharge, operating temperatures, tour profile etc.) vary strongly and make it therefore harder to estimate the average lifetime of the battery.

EFVs available on the market today demonstrate important technological progress in comparison to vehicles from 10 years ago. The technical indicators show that some EFV are potentially as efficient as conventional vehicles. With the rapid development in battery technology, further technological improvements can still be expected.

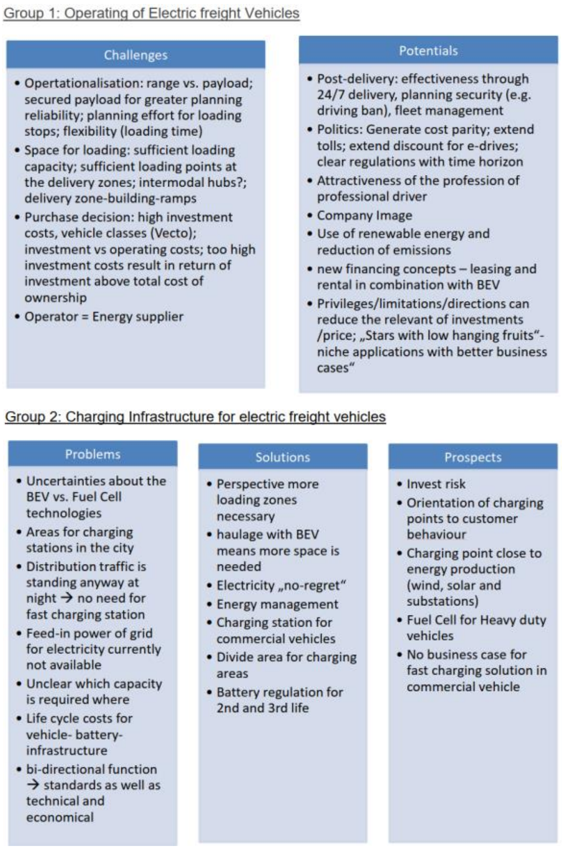
Best practice & suitability

Vehicle technologies and applications of battery-electric freight vehicles in city logistics

The first Task 41 workshop "battery-electric freight vehicles in urban logistics" were held in Stuttgart (Germany) on October 15th 2020. Dedicated topics of the workshop were: current technical characteristics of battery-electric freight vehicles, development of the charging infrastructure and practical experience and knowledge from pilot projects. The workshop was a joint activity by the ERA-NET project "Promoting Electric Mobility in Urban Europe" (proEME) and the task force 41.

Twenty-four local and international guests from logistics as well logistics associations, vehicle industry, charging infrastructure, city administration and research took part in the discussion on opportunities and hurdles for the successful implementation of battery-electric freight vehicles in urban logistics. The workshop was introduced with impulse presentations by companies from the vehicle, infrastructure and logistics sectors. The first session "current technical characteristics of battery-electric freight vehicle" was held by the vehicle manufacture Daimler with insights on their current electrification strategy. In the second session "development of the charging infrastructure: costs and availability" three key charging infrastructure suppliers in Germany: ABB, ChargeHere by EnBW and EBG compleo, have introduced dedicated AC and DC charging stations for commercial vehicle application with information on suitable power ranges and current available charging points in Germany. The third session "practical experience and knowledge from pilot projects and initial applications" was structured by impulse presentations from the logistic company Dachser in Stuttgart, Germany and Fier Automotive from Helmond, the Netherlands. Dachser share their experiences with the Fuso eCanter and Mercedes-Benz eActros in Stuttgart and Fier Automotive presented the results from the EU-Project ElectricGreenLastMile.

On the basis of the technical and experience reports, the guests of the workshop discussed the problems and solutions for the implementation of vehicles and suitable charging infrastructure in urban logistics in two interactive groups. The main topics of the group discussion were the still ongoing uncertainty in battery electric as well as fuel cell technologies, the lack of space for electric charging stations and loading stations in urban areas and the uncertainty about necessary charging capacities for different transport applications. Furthermore, the discussion with the participants showed that there is no urgent need for fast charging solutions in urban logistics. It could be useful for the logistic and fleet operators to learn more about current applications with battery-electric freight vehicles including information on their total cost of ownership. The discussions were noted on two flipcharts and illustrated in the following tables.



Group 1: Operating of Electric freight Vehicles

Challenges	Potentials
• Opertationalisation: range vs. payload; secured payload for greater planning reliability; planning effort for loading stops; flexibility (loading time) • Space for loading: sufficient loading capacity; sufficient loading points at the delivery zones; intermodal hubs?; delivery zone-building-ramps • Purchase decision: high investment costs, vehicle classes (Vecto); investment vs operating costs; too high investment costs result in return of investment above total cost of ownership • Operator = Energy supplier	• Post-delivery: effectiveness through 24/7 delivery, planning security (e.g. driving ban), fleet management • Politics: Generate cost parity; extend tolls; extend discount for e-drives; clear regulations with time horizon • Attractiveness of the profession of professional driver • Company Image • Use of renewable energy and reduction of emissions • new financing concepts – leasing and rental in combination with BEV • Privileges/limitations/directions can reduce the relevant of investments /price; „Stars with low hanging fruits"- niche applications with better business cases"

Group 2: Charging Infrastructure for electric freight vehicles

Problems	Solutions	Prospects
• Uncertainties about the BEV vs. Fuel Cell technologies • Areas for charging stations in the city • Distribution traffic is standing anyway at night → no need for fast charging station • Feed-in power of grid for electricity currently not available • Unclear which capacity is required where • Life cycle costs for vehicle- battery-infrastructure • bi-directional function → standards as well as technical and economical	• Perspective more loading zones necessary • haulage with BEV means more space is needed • Electricity „no-regret" • Energy management • Charging station for commercial vehicles • Divide area for charging areas • Battery regulation for 2nd and 3rd life	• Invest risk • Orientation of charging points to customer behaviour • Charging point close to energy production (wind, solar and substations) • Fuel Cell for Heavy duty vehicles • No business case for fast charging solution in commercial vehicle

Best practice & suitability

Electrification of Heavy-Duty Vehicles in Long Haul Transport

On September 29th 2020, the Task41 team hosted the 2nd online workshop on "Electrification of Heavy-Duty Vehicles in Long Haul Transport". In three sessions experts shared and discussed the present state of technologies, experiences and best practices – covering alternatives including fuel cell electric, battery-electric and catenary electric freight vehicles. In total, thirty-four attendants from industry, research, logistics and governmental organization joined the webinar.

Essential for the implementation of electric freight vehicles in long-haul transport are the new developments in battery and fuel cell technology. Akasol AG predicted that in between 2021 and 2025 the energy density of their high energy batteries for commercial vehicle applications would likely increase from 140 Wh/Kg today to 240 Wh/kg – a near 100% increase. For their high power batteries, which are especially suitable for fast charge and hybrid power applications, Akasol expect the charge capacity to increase from 500 W/kg today to 800 W/kg in 2024 – an increase of over 50%. The Speaker from the International Council on Clean Transportation (ICCT) noted that the battery prices for truck applications are dropping with two to three years delay to car applications – hence the reduction in price observed in the passenger car market can be expected to be seen in the freight sector. As an alternative, or as an adjunct to the battery for energy storage there is also the option of a fuel cell. This is viewed as attractive for the long haul freight sector. However, there is a cost issue to overcome. The Akasol speaker stated that 1 kWh of fuel cells today costs five to six times more than one kWh of battery. In addition to cost the issue around fuel cell and battery is wider than how to specified the vehicle. To be successful with deployment of any alterative it is essential for the vehicle operation that the infrastructure is aligned to the specific tour (profile use case) in order words the energy should be available where the vehicle is being used.
The MAN Truck and Bus SE, together with logisticians from the Council for Sustainable Logistics, has been testing nine electric MAN-CNL trucks on Austrian roads since 2018. The speaker from MAN highlighted that the charging process and communication needs to become as soon as possible standardized and mandatory across the different charging station operators around Europe (which would make cross-boarder freight movement easier). For long-haul transport, MAN expects that with the next battery generation the capacity will allow long-haul related ranges in tractor trucks.
Another best practice example for long-haul applications is the eHighways from the Siemens AG. The presenter from Siemens described that in general heavy-duty vehicles drive long distances and are often away from their base. Their transport tasks are highly concentrated on the highway network. Therefore, The presenter recommends using a dynamic charging approach, in this case catenary, on highways when this is possible and move to battery on the distributor routes (from the highway to the depot or delivery point). Other dynamic charging approaches, for example infrastructure embedded in the highway, may also be possible and are under consideration.

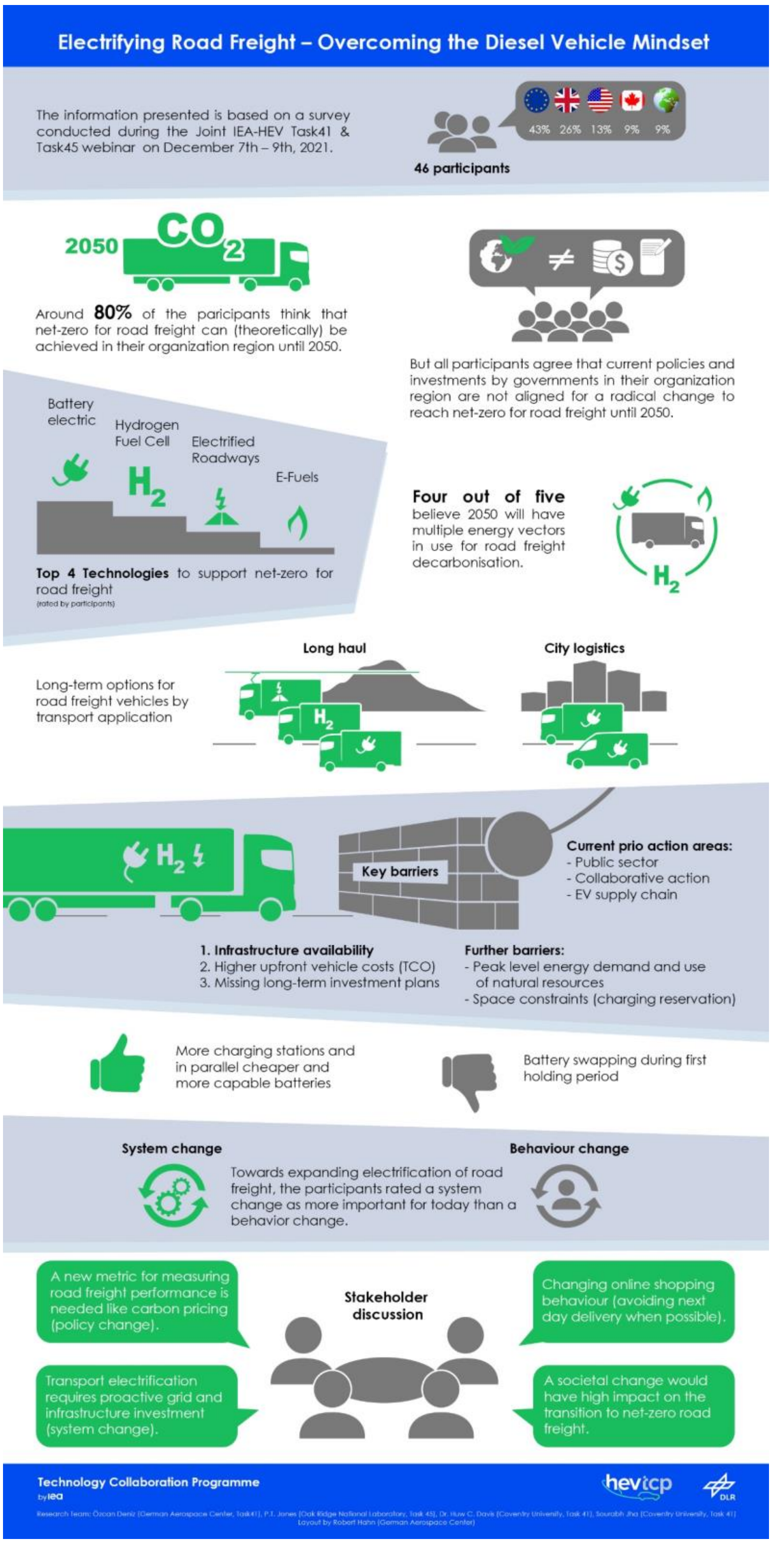
One of the topics in the panel discussion was on the total cost of ownership (TCO) parity of Electric Freight Vehicle and the speaker from Quantron AG answered that he does not expect that the purchase price of fuel cell electric vehicle (FCEV) will get below diesel trucks in the next ten years. However, there should be business cases for customers during this time depending on their specific transport task. The speaker from ICCT stated that access to capital is one of the key barriers they have seen in the past for fleets to invest in efficient technologies. Thus, it will require innovative financing solutions to ensure that the barrier of upfront cost and the access to capital can be overcome and depreciate over the vehicle operation time. The speaker from Transport Decarbonisation Alliance (TDA) shared that customers are also willing to pay for transportation and not only for the TCO. This requires new business models such as transport as services or leasing options. Nevertheless, there must be some frontrunners who are willing to pay a little extra for the TCO of electric freight vehicles. Besides, the workshop speakers are seeing cities as powerful ecosystems for this transition since they can push multiple local actors collaborations.

Best practice & suitability

Electrifying Road Freight
Overcoming the Diesel Vehicle Mindset

The third Task 41 workshop "Electrifying Road Freight – Overcoming the Diesel Vehicle Mindset on new performance evaluations for electrified road freight was a jointly hosted online event together with the Taskforce 45 of the HEV TCP. The workshop took place from December 7 to 9, 2021 with 46 participants in total from North America, Europe and Asia, in addition to stakeholders from the road freight sector, including energy providers, government actors, researchers and NGOs. The event was structured in the form of a webinar with expert-led presentations and panel discussions.

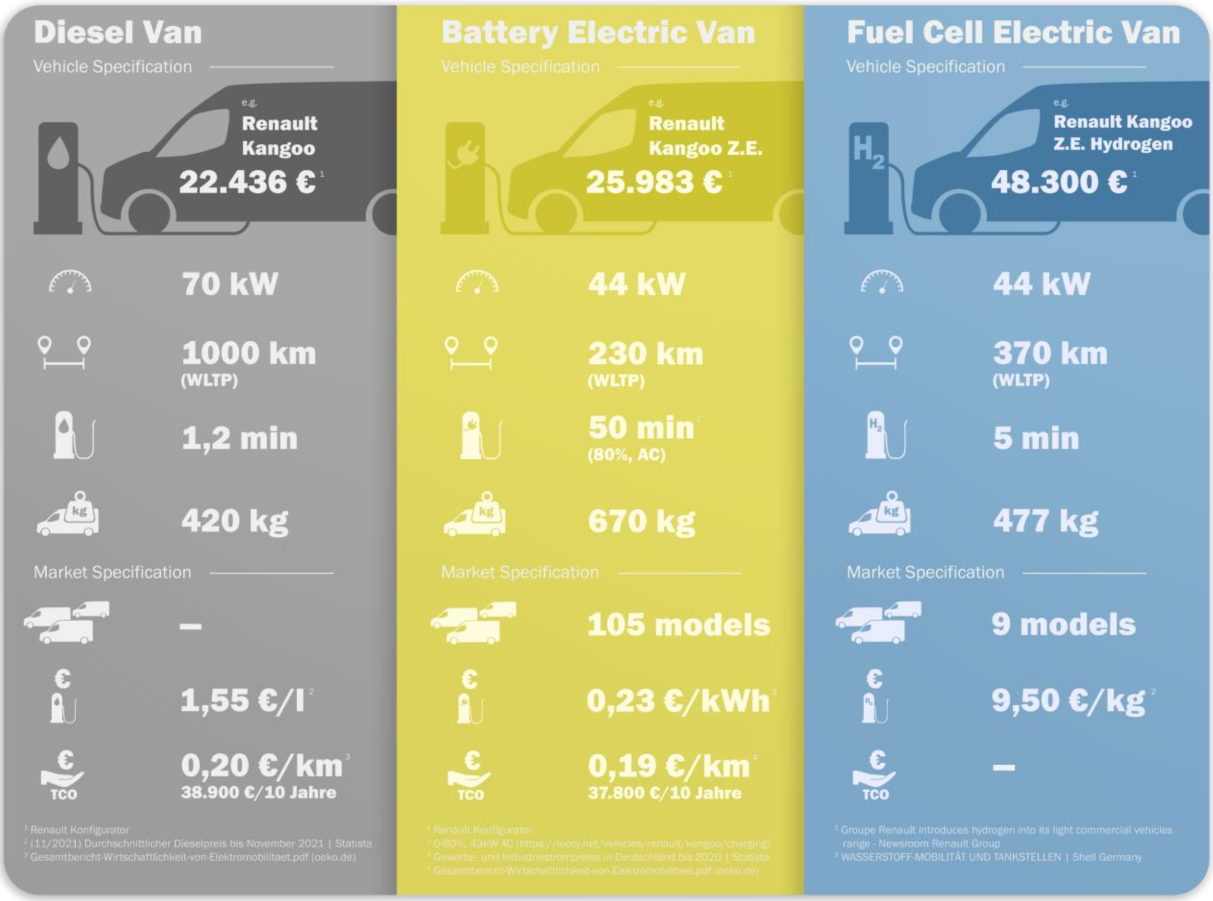
The introductory statement of the three-day workshop was that for the electrification of road freight systems the current existing diesel vehicle mindset needs to be overcome. This was in recognition that the system in which new technology is to be deployed needs to be adapted accordingly if that new technology is to be successful. Therefore, Day 1 of the webinar focused on identifying the system challenges. For this purpose, different stakeholders from political, environmental, societal, technical, economic and legal areas shared their views and discussed the question on system challenges. The next day was characterized by presentations on solutions for electric road freight innovation systems. The selection of presentations was based on covering the gamut of solutions - from technology to user-based. On day 3, participants were asked to evaluate the suitability of solutions (discussed day 2) in the context of the challenges identified (discussed day 1) and concluded with an open session on identifying how governments, logistics and industry can be mutually supportive in moving on from the present diesel mindset in freight. In parallel to the 3-day event, a survey was carried out. The figure here illustrates the main outcome of the surveys.



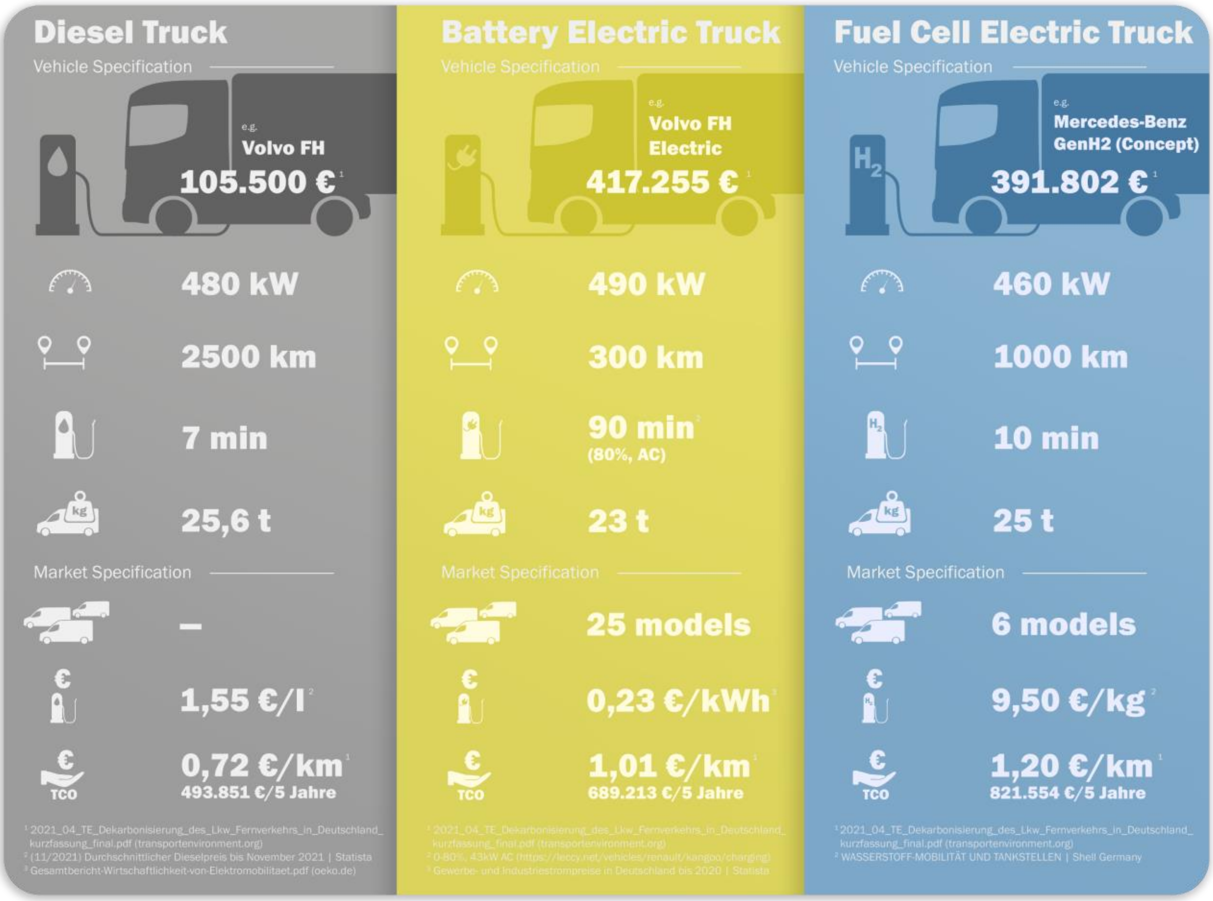
Evaluation & policy framework

Technical-economic comparison of electric alternatives for light and heavy freight vehicles

The following figures compare the vehicle and market specifications of diesel, battery-electric and fuel cell-electric vans and heavy-trucks in 2020. The information was obtained from the Task41 vehicle database and external studies.



The comparison shows among others that battery-electric vans for the considered use case (urban delivery) can have a lower TCO than diesel vans. In comparison, battery-electric and fuel cell-electric alternatives for heavy-duty trucks do not yet achieve economic advantages in the considered long-haul applications. Furthermore, the comparison shows that there are still significant differences in the vehicle ranges.

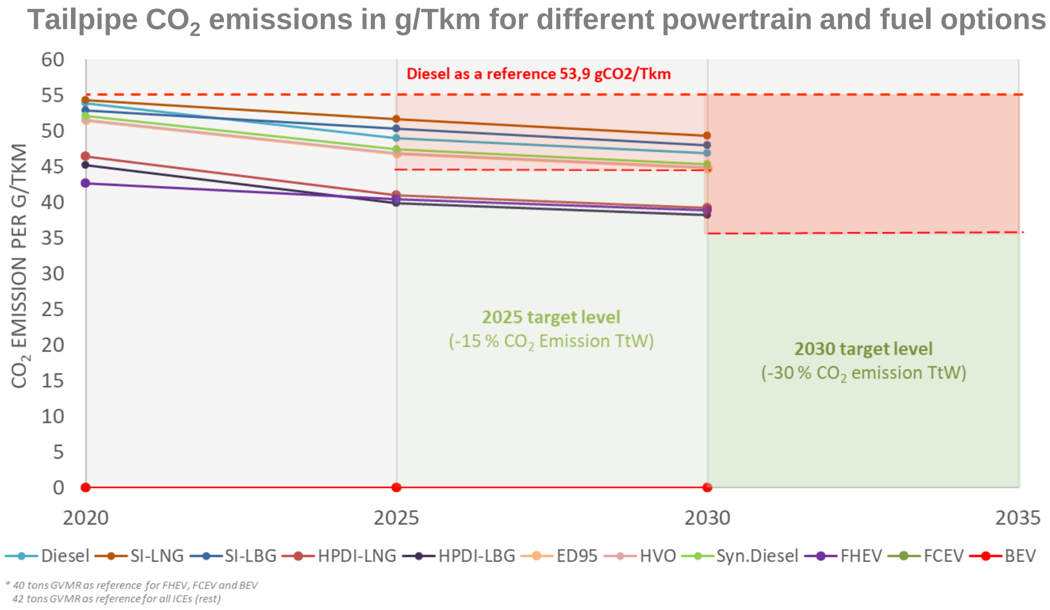


Evaluation & policy framework

Evaluation of powertrain and fuel options for HDV to meet the EU CO2 fleet targets

Technology Collaboration Programme on Advanced Motor Fuels

CO2 emissions from heavy-duty vehicle transport in Europe have increased by 25% since 1990 and are responsible for 27% of CO2 emissions in road transport today. Large lorries such as semi-trailer tractors on long-haul transport account for the largest share (65 to 70%) of the CO2 Emissions from HDV transport in Europe. [13] Hence, the first European CO2 standards are set and aim to reduce the Tank-to-Wheel (TtW) CO2 emissions of newly registered HDV by 15% in 2025 and 30% in 2030 compared to 2020. In this chapter, current and future energy and emission consumption of conventional and alternative powertrain systems in heavy-duty vehicle on long-haul transport are compared and weighed regarding the EU CO2 emission fleet targets. The analysis was developed in the framework of cooperation between the two IEA TCP [14] AMF Annex 57 and HEV Task41.
The basis for the investigation is the simulated energy consumption of different powertrain and fuel options in heavy-duty vehicles. The data on internal combustion engine (ICE) powered trucks were generated by AMF within the chassis dynamometer tests of a semi-trailer tractor with a 13 liter engine in Finland. The used simulation data on hybrid and electric trucks was generated within the Task 41. For the calculation of the Tank-to-Wheel (TtW) and Well-to-Wheel (WtW) CO2 emissions, fuel-specific CO2 emission factors in g CO2/MJ from the JEC Well-to-Tank report v5 [15] are used. The simulated CO2 emission of the different powertrain and fuel options are compared to the EU CO2 emission reduction targets, with -15% in 2025 and -30% in 2030 relative to 2020 [16]. The reference values for the comparison are the simulated WtT and TtW CO2 emissions of the diesel HDV in 2020. The simulated values are given for 2020, 2025 and 2030, describing anticipated progress.



The Figure shows the development of the calculated TtW CO2 emission per ton-kilometer for different powertrain and fuel options until 2030. TtW (tailpipe) CO2 emissions are used as the basis for all vehicle CO2 regulations today [17]. The main message derived from the figure is that ICE vehicles based on diesel, methane spark-ignition or ED95 engines, whether operated on fossil or renewable fuels, will not meet the 2025 TtW CO2 reduction targets with improvements to the engine only, even if relative efficiency improvements of 10% for diesel and 5% for SI engine are assumed. BEV, FCEV and only a few advanced ICE based powertrains (including FHEV) can meet this target. This would lead to a decreased supply of ICE vehicles and more hybrid and electric vehicles in the future. The results highlight the challenge in meeting the 2030 tailpipe CO2 emission reduction target with the conventional powertrains today.
When the CO_2 assessment is carried out on a WtW basis, both upstream (WtT) and end-use (TtW) emissions are considered, the picture is different. The analysis again assumes that reduction targets are -15% and -30%, relative to 2020 fossil diesel, but on a WtW basis. In the case of ICE powertrains, all renewable fuel options meeting the 2030 target with a wide margin. As a summary, it can be stated that going from a pure tailpipe CO2 based regulation system to a wider WtW type approach probably would increase flexibility for OEMs as well as truck operators. In the way CO2 regulations are set up currently, they are in principle mandates for certain technologies. The ideal situation would be that regulations define the targets in a technology neutral way, by letting the markets respond to the targets in the most functional and cost-effective ways.

Relevant aspects for a successful market-acceleration of electric freight vehicles

Given the numerous activities in the different vehicle segments and applications, practitioners are now urgently looking for information on how to navigate through the present, uncertain situation with the risk of stranded investments when envisaging extended operations. In response to the challenge as outlined the following key aspects are important from the taskforce point of view:

1 Increased focus on vehicle reliability

When comparing EFVs with today's applications, not only the total cost of ownership but also aspects relating to the reliability or practicability of EFVs are central purchase criteria for fleet operators. EFV must also be able to respond to a close-to-production oriented transport demand (such as just-in-time delivery). Thus higher vehicle ranges (above the daily range) are demanded and payload limitations are not accepted (in order to ensure high flexibility). However, the diesel mindset needs to be overcome to enable potential adoption of EFVs.

2 Longer delivery times constrain vehicle availability

Economic advantages for EFV are seen for selected operations today due current policy frameworks. Hence, the vehicle models and charging infrastructure need to be made available now. Currently, smaller manufacturers (such as e-converter vehicle manufacturers) are meeting the demand for EFVs. Following the announced pledges of the manufacturers, the number of EFV models will steadily increase in the next years. However, long delivery times (of one year) regardless of the current situation (supply chains and war) have to be taken into account.

3 Align the pace of infrastructure developments with EFV market transition

Current infrastructure developments are focusing on urban areas and the performances are only applicable to electric light freight vehicles. For long-distance transport, Megawatt Charging Systems (MCS) near (European) highways need to be developed rapidly. This requires the implementation of standards for MCS charging, the adaptation of international laws and the extension of fiscal incentives to include infrastructure. Incentives policies should not exclude infrastructure on private properties, as many logistics depots are already located close to highways. Charging on one's own depot avoids the risk/complexity associated with reservation of public charger. Currently, 800kW charger is considered as minimum for long distance transport (together with a 700kWh battery capacity in one-shift operation).

4 Battery Technology trends

The current technical trend (at least for the next 5 years) shows for most EFV applications that Lithium Ion batteries with NMC (Nickel Manganese Cobalt oxides) cathode will be the state of the art. In this context, the truck market benefits from cost degression potentials achieved in the passenger car volume market (since Li-NMC is predominantly used here as well). - Li-NMC batteries are particularly advantageous because of their high energy density and long service life. - For some "extreme" transport applications (e.g. in very hot or cold regions) also Li-LFP (Lithium iron phosphate battery) can have applications for EFVs.

5 Electric Road Systems out at scale

Electric Road Systems (ERS) include inductive and conductive as well as in road (or roadside) rail and overhead line power transfer technologies. ERS can minimise localised loading on grid - from higher power static charging - and spread energy demand - charge on the move over longer time period – and reduce size of onboard energy storage. Challenges are the multiplicity of options leading to dilution in investment – potential for different systems in different markets and not achieving critical mass in any one. ERS needs a role out at scale. As other solutions develop – lower cost and high capacity batteries – the role of ERS is marginalized leading to higher costs.

Relevant aspects for a successful market-acceleration of electric freight vehicles

6 Funding for pilots in city logistics

Cities are powerful ecosystems for the adoption of EFV, especially in last mile. More field trials are needed to identify further best cases – especially for more demanding driving profiles or niche applications – which can boost the acceptance for EFV among new operators. Through joint commitments and target action by all stakeholders the transition process can be accelerated. However, the limited space in urban area (e.g. for charging stations) is particularly problematic. New logistics concepts (like route consolidation) need to be incorporated for this purpose.

7 Technology-open guidance for long-haul transport

For Long haul transport, there is dichotomy regarding suitable technologies. The challenge is to innovate business models and products concurrently – Either business models are changed for existing technologies or technologies are adapted for existing business models. – Thus, we see that technology providers and users in the BEV sector are looking for higher ranges and faster charging solutions, which could shift the problem to other system actors. For example, energy providers, which will need to respond on the distribution side (grid). However, the ability of these system actors to respond is different across markets (due regulatory, economic etc. aspects).

8 Setting up a target regulatory framework that ensures competitiveness of EFV

Fiscal incentives today such as (80%) reduction of additional investment costs for EFV and charging infrastructure as well as toll and vehicle tax exemptions like in Germany, Austria and Switzerland are showing economic advantages for customers. These incentives are essential to reach TCO-parity. But they might come with authorities hurdles, which could slow down the conversion process. Furthermore, plannability is crucial for making investment decisions. Thus, long-term fixed incentives like road toll reductions are necessary to ensure investment security for the stakeholders. Especially road toll reductions are a very strong incentive to introduce EFV on long haul operations.

9 Updating CO2 emission standards

CO2 emission standards for light and heavy duty vehicles (such in EU regulation) are strong policies to push EFV into the market. An addition with energy efficiency standards could have a strong leverage for EFV.

10 Integrating new technologies into an overall system

Electrification of trucks require a holistic system approach. The overall ecosystem in which new technology is to be deployed needs to be adapted accordingly if that new technology is to be successful. For this, all stakeholders interacting with the commercial vehicle sector need to be identified and their awareness raised in order to promote collaborative activities. For example, the transformation of the energy market must take place beforehand and faster. But investors are hesitating of stranded investments. Collaborative approaches can break the barriers.

11 Vehicle Automation with EFV

Advancing driver automation will become increasingly prevalent for trucks. Particularly on long-distance (hub-to-hub) transport. Vehicle energy consumption could be reduced by efficient route management, but could also be increased by the additional equipment. With fossil diesel, this would have a bad impact on the environment.

From the essential user perspective, the alternatives in the cost-sensitive truck market must first achieve competitiveness. To achieve this, the total operating costs of the trucks must be reduced and a nationwide electricity charging network must be made available on European motorways. To this end, a targeted subsidy program for vehicles and infrastructure must be established and expanded.

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