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Status and trends for electrified transport logistic vehicles

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Abstract

Due to the current dominance of conventional transport logistic vehicles, recent efforts primarily focus on technologies reducing fuel consumption of these vehicles. Another way to reduce the GHG emissions of road vehicles is the electrification of the vehicle. The electrification of road vehicles has accelerated in the recent years. However, the electrification of passenger cars seems to be prioritized over transport logistic vehicles as the first step, mainly due to the current limitation of CO_2-emission primarily for passenger cars. As a consequence, the number of electrified passenger cars is significantly more than number of electrified transport logistic vehicles (as prototype, close to series production and e-conversion). Furthermore, vehicle manufacturers are not keen on producing electrified transport vehicles due to the limited demand from the market. One of the possible ways to overcome this hurdle is to establish city alliances in order to increase the number of vehicles ordered. However, during our discussions with local authorities and city municipalities, a lack of information about the status of existing electrified transport logistic vehicles and their technical specifications, as basis for decisions regarding the fleet implementation, was identified. This paper aims to close the mentioned knowledge gap by showing the recent trends in the electrified transport logistic vehicles with their detailed technical specifications.

This study identified about 80 electrified transport logistic vehicles as prototype, e-conversion or close to series production in the investigated markets (Austria, Canada, France, Germany, Turkey, Italy, the Netherlands, Portugal, USA, Sweden and the UK). Most of the electrified vehicles (more than 50%) belong to the vehicle category N1, most of which (>90%) are battery electric vehicles (BEV). Electric range of transport logistic vehicles vary for N1, N2 and N3 vehicles between 35-200 km, 50-200 km and 120-325 km, respectively. Furthermore, Li-Ion or Li-Iron phosphate batteries dominate the electrified transport logistic vehicles with about 75% of market share.

The results suggests that currently, the offered electrified transport logistic vehicles are designed mainly for (inner-) urban transportation tasks, matching requirements of low payload and volume, low distances and vehicle speed. Besides technical advancements in the battery sector, a larger uptake of these vehicles also requires an EU policy strategy that provides clear signals to the trucking industry on climate and air quality targets.

Keywords: Market, Truck, Powertrain, Range, Battery

1 Introduction

Road movements comprise an important role in freight distribution (collection and delivery) and passenger transportation in both urban and rural areas and have significant economic and societal impacts. In addition, they have hazardous and threatening effects on the environment and society such as resource consumption, land use, toxic effects on ecosystems and humans, noise, and the effect induced by accidents and Greenhouse Gas (GHG) emissions.

Transportation accounts for about 20-25% of global energy consumption and CO_2 emissions. Road transport is a major source with 75% share [1]. 95% of the world's transportation energy comes from fossil fuels, mainly gasoline and diesel. In the EU, 63% of fuel consumption and 29% of all CO_2 emissions are transport related. Moreover, freight transport activity is predicted to grow by around 80% in 2050 compared to 2005 [2]. The trends reveal that road freight transport will continue to be one of the fastest growing modes of transport and contributes significantly to the increase of greenhouse gas (GHG) emissions within the transport sector [3]. Hence, governments are considering new environmental measures and targets for reducing emissions and fossil fuel consumptions. The EU targets 80–95% reduction of GHGs below 1990 levels by 2050, where a reduction of at least 60% is expected from the transport sector. The European Commission aims at reducing the transport-related GHG emissions to around 20% below their 2008 level by 2030. The use of conventionally fuelled cars will be reduced by 50% in urban transport by 2030 and phased out by 2050. City logistics in major European urban centers will be CO_2-free by 2030 [1].

In order to achieve these targets, it is important to elaborate ways to reduce the GHG emissions from road freight transport effectively. Due to the current dominance of conventional transport logistic vehicles, recent efforts primarily focus on technologies reducing fuel consumption of these vehicles [4], [5]. Another way to break the vehicles' dependence on fossil fuels and reduce the GHG emissions is the electrification of the vehicles. The use of electric vehicles would also reduce noise, which would allow shifting a considerable amount of freight transport to night time. In return, this would help reducing the road congestion in the urban areas during the day time peak hours, hence decreasing the emissions indirectly.

The electrification of road vehicles has accelerated in the recent years [6]. However, the electrification of passenger cars seems to be prioritized over transport logistic vehicles as the first step [7], mainly due to the current limitation of CO_2-emission primarily for passenger cars. As a consequence, the number of electrified passenger cars is significantly more than the number of electrified transport logistic vehicles (as prototype, close to series production and e-conversion).

Furthermore, vehicle manufacturers are not keen on producing electrified transport vehicles due to the limited demand from the market [8]. One of the possible ways to overcome this hurdle is to establish city alliances in order to increase the number of vehicles ordered. However, during our discussions with local authorities and city municipalities, a lack of information about the status of existing electrified transport logistic vehicles and their technical specifications, as basis for decisions regarding the fleet implementation, was identified [8] and [9].

This paper aims to close the mentioned knowledge gap by showing the recent trends in the electrified transport logistic vehicles with their detailed technical specifications.

2 Method and data

In this paper, methods from descriptive data analysis (e.g. through classification and declaration of occurrence) are used in order to discover the nature and interdependencies of the available data [10]. Furthermore, the use of descriptive data analysis allows for a clear illustration of relevant data characteristics. Therefore, either the distribution of parameter values of individual characteristics (univariate statistic) or the combination of parameter values of multiple characteristics (multivariate statistic) are of high interest and, therefore, methodically used in order to achieve the aims of the paper.

For the purpose of data collection of electrified transport logistic vehicles, a vehicle database was created based on market inputs from Austria, Canada, France, Germany, Turkey, Italy, the Netherlands, Portugal, USA, Sweden and the UK. The inputs are mainly based on information from vehicle data sheets. Currently, the database includes about 80 electrified vehicles. Relevant vehicle characteristics are classified into general and specific data.

General data characteristics of interest are:

- *Market:*
  Name of the country where the vehicle was presented or is commercially available
- *Producer:*
  Name of the company producing or converting the vehicle
- *Name:*
  Name of the vehicle
- *Powertrain technology:*
  - HEV (hybrid electric vehicle),
  - PHEV (plug-in hybrid electric vehicle),
  - BEV (battery electric vehicle),
  - FCEV (fuel cell electric vehicle)
- *Type of powertrain:*
  - parallel hybrid,
  - serial hybrid,
  - pure electric,
  - fuel cell electric
- *Functionality:*
  - micro hybrid
  - mild hybrid
  - full hybrid,
  - plug-in,
  - range extended
- *Production status:*
  - Prototype (vehicle used for research purpose),
  - e-conversion (conversion of conventional commercially available vehicle or electrification of conventional chassis),
  - close to series production (more than one vehicle has been produced and/ or as per producer announced commercially available)
- *European vehicle category:*
  - N1 (≤ 3.5t GVW),
  - N2 (> 3.5t - ≤ 12t GVW),
  - N3 (>12t GVW and TT)
- *Year:*
  Year of vehicle presentation to public or date of press release

Vehicle specific data of interest comprises the vehicles technical specification in terms of:

- *Engine displacement in cm³*
- *Nominal performance in kW*
- *Max. Torque in Nm*
- *Gearbox type*
- *Type of EM*
- *Battery type*
- *Battery capacity in kWh*
- *Gross vehicle weight in tons*
- *Payload in tons*
- *Driving range in km*
- *Top speed in km/h*

The analysis for the electric transport logistic vehicles is compared with the trends of electrified passenger cars reported in [6].

3 Results

The results show that most electrification efforts are expended for the vehicles within the smaller vehicle classes (see **Figure 1**). Among 78 electrified transport logistic vehicles in the database, more than 45 vehicles belong to the N1 vehicle category with gross vehicle weight smaller than 3.5 tons. However, electric transport logistic vehicles are commercially available for customers across all the vehicle categories (either as close to series production or through e-conversion).

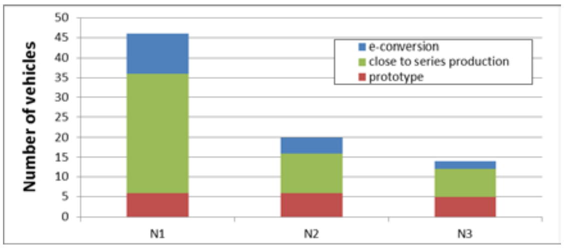

Figure 1: Number of transport logistic vehicles identified (prototype, close to series production or e-conversion) with electrified powertrain (Total number of vehicles is 78)

Most of the electrified vehicles (more than 50%) belong to the vehicle category N1, most of which (>90%) are BEVs. As the gross vehicle weight increases, the number of vehicles and the share of BEVs decrease (see **Figure 2**).

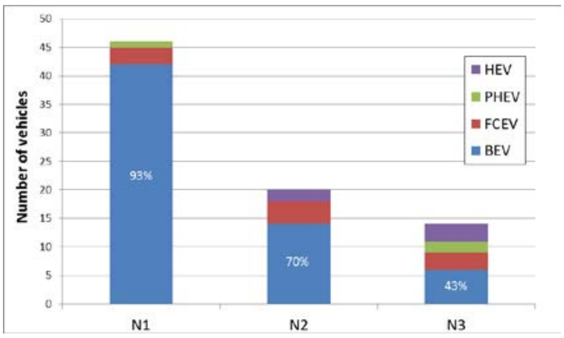

Figure 2: Number of transport logistic vehicles identified with electrified powertrain (Total number of vehicles is 78)

The comparison of the electrified vehicles for transport logistics and passenger cars according to the nominal power of the electric motor and powertrain concept verifies that the number of vehicles is significantly higher for passenger car sector (see **Figure 3** and **Figure 4**). Furthermore, most of the electrified passenger cars have an electric motor power between 101 and 300 kW whereas the number of electrified logistic vehicles decreases with the increasing motor power.

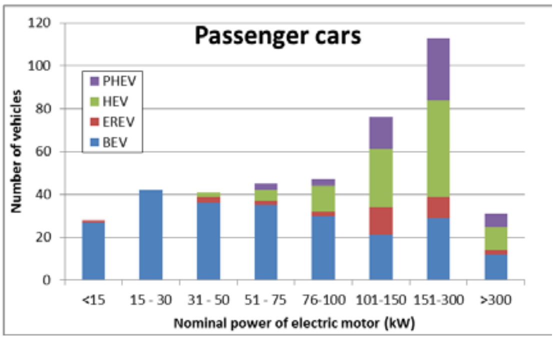

Figure 3: Number of passenger cars from [6] according to the nominal power of electric motor and the powertrain concept (total number of vehicles is 423)

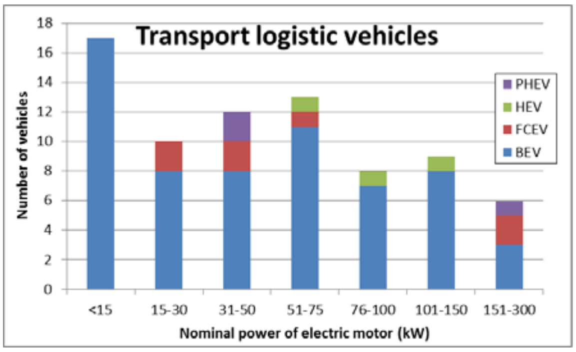

Figure 4: Number of transport logistic vehicles according to the nominal power of electric motor and the powertrain concept (vehicle database, total number of vehicles is 75)

However, a similarity between the two vehicle types is that vehicles with an electric motor power less than 51 kW are mainly dominated by the BEV concept. As the motor power increases, the importance of BEV concept decreases for passenger cars, which is not the case for transport logistic vehicles.

Electric driving range and payload are very important technical specifications for a logistic vehicle fleet operator. These specifications are presented for the existing vehicles on the market depending on their battery type (see **Figure 5**). Among the 64 data points (where payload and electric range information are available), only 3 vehicles are FCEV, and the others (61) are BEV. We observe that for most of the vehicles (with only a few exceptions), the electric range is shorter than 250 km, independent from the payload. In addition, only low electric range and low payload vehicles are powered by a lead acid or lead acid gel battery. Although many battery type possibilities for N1 and small N2 vehicles exist, the vehicles with longer electric range and especially larger pay load are equipped with either Li-Ion or Li-Iron phosphate batteries. N3 segment vehicles are powered exclusively by the latter battery type. These two battery types dominate also the overall group of electrified transport logistic vehicles. 40 vehicles among 54 vehicles, where the type of the battery is known, are equipped either with Li-Ion or Li-Iron phosphate batteries.

For N1 vehicles (number of vehicles is 43), bandwidth of range varies from 35 km up to 200 km with an arithmetic average of 122 km (median 130 km) and for payload from 0.23 tons up to 2.30 tons with an arithmetic average of 0.76 tons (median 0.65 tons), respectively. For N2 vehicles (number of vehicles is 13), bandwidth of range varies from 50 km up to 200 km with an arithmetic average of 170 km (median 150 km) and for payload from 1.0 tons up to 7.4 tons with an arithmetic average of 4.1 tons (median 3.5 tons), respectively. For N3 vehicles (number of vehicles is 8), bandwidth of range varies from 120 km up to 325 km with an arithmetic average of 190 km (median 180 km) and for payload from 6.0 tons up to 11.0 tons with an arithmetic average of 9.5 tons (median 9.9 tons), respectively.

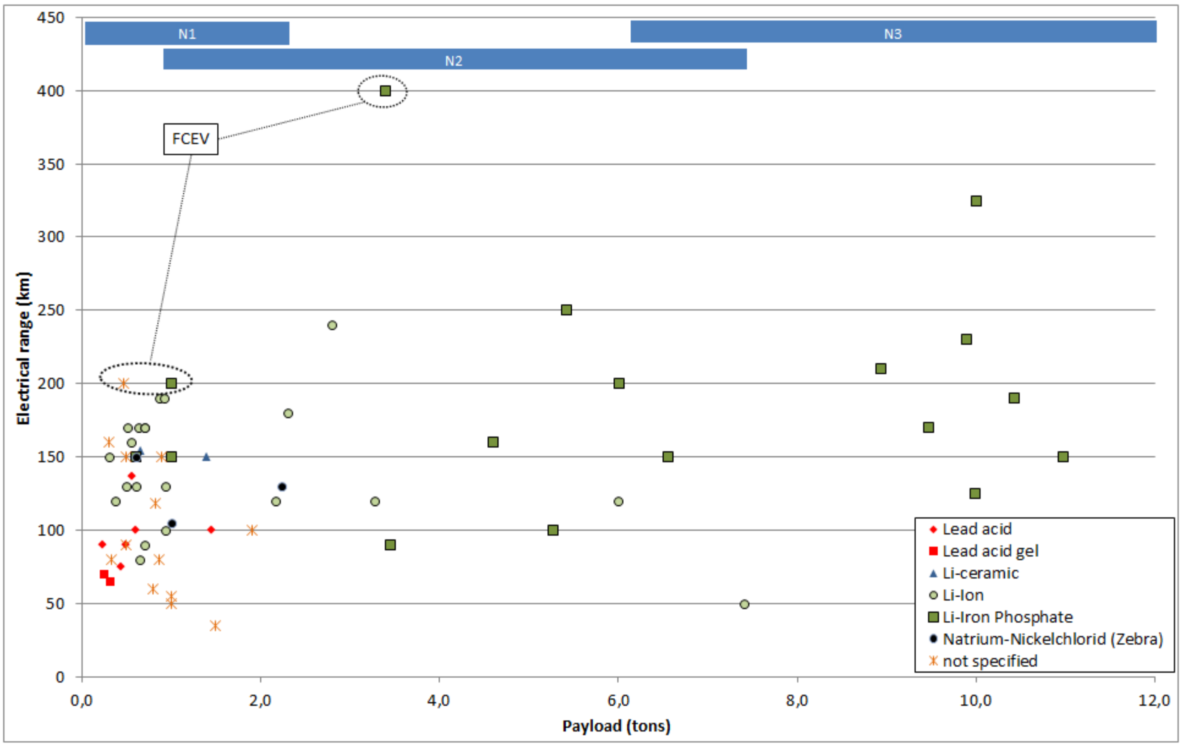

Figure 5: Comparison of electric range and payload of electrified logistic vehicles according to their battery type (3 FCEVs and 61 BEVs in total)

4 Discussion and Conclusion

This study identified about 80 electrified transport logistic vehicles as prototype, e-conversion or close to series production in the investigated markets (Austria, Canada, France, Germany, Turkey, Italy, the Netherlands, Portugal, USA, Sweden and the UK). This information is especially interesting for the local authorities and city municipalities [8].

However, at a closer look to the vehicle specifications, the diversity of logistic transportation tasks and transport logistic vehicle requirements is not yet fully reflected by a correspondent distribution of commercially available vehicle models in the different vehicle classes. The majority of identified vehicle models belong to class N1, offering relatively small payloads, in most cases around or below 1 ton, and volumes. Within class N1, “light vehicles” make up another larger subgroup, with payloads of less than 0.5 ton, ranges less than 100 km and engine power of less than 50 kW.

This suggests that currently, the offered electrified transport logistic vehicles are designed mainly for (inner-) urban transportation tasks, matching requirements of low payload and volume, low distances and vehicle speed. This is encouraging since the strategic focus of electrifying road transport is at first on urban areas. Still, it needs to be seen that also (sub-) urban logistics and its diversity of transportation tasks requires the whole range of vehicle classes, including heavy duty vehicles. Opposed to current technical and economic barriers for electrifying heavy duty transport vehicles, mainly related to the large, heavy and expensive batteries required, it is promising that first N2 and N3 electrified vehicles, even BEVs, become available. Besides technical advancements in the battery sector, a larger uptake of these vehicles also requires an EU policy strategy that provides clear signals to the trucking industry on climate and air quality targets.

The presented work demonstrates the state of the art and trends for electrified transport logistic vehicles and provides fleet managers and municipalities with necessary information regarding vehicle specifications. This database will be updated continually in the future and will include data from other countries as well. Furthermore, pilot projects and case studies for electrified transport logistic vehicles will be analyzed in the future in order to match technical specifications and economic performances of vehicles presented in this paper with the concrete use case.

Acknowledgments

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