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Current status of the electrification of transport logistic vehicles - Early niche markets and commercialization opportunities

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Abstract

The transport sector heavily depends on fossil fuel to serve its energy needs. In the European Union transport accounts for 63 % of fuel consumption and 29 % of all CO_2 emissions. In order to reduce greenhouse gas emissions and pollutants in urban areas a transition to local zero emission alternative fuelled vehicles is deemed necessary. The transition for passenger cars is underway. However, the transition for light and heavy transport logistic vehicles transition is currently slow, caused by differences in political prioritization and a lack of fleet operator information about the status of existing electrified logistic vehicles and possible fields of applications. In order to counteract the knowledge gap, this paper aims to summarize the status of electrified transport logistic vehicle technology in terms of vehicle performance. For the purpose of this analysis, a transport logistic vehicle database was developed based on inputs from Austria, Germany, Korea, Turkey, the Netherlands and the United Kingdom. In order to identify early niche markets and commercialization opportunities for electrified transport logistic vehicles, country individual experiences of relevant pilot projects were collected and a summary for the countries Austria, Germany, Turkey and the Netherlands is given.

Keywords: market, truck, commercial vehicles, powertrain

1 Introduction

The transport sector heavily depends on fossil fuel to serve its energy needs. In the EU, transport accounts for 63 % of fuel consumption and 29 % of all CO_2 emissions [1]. Additionally, freight transport activity is predicted to grow by around 80 % in 2050 compared to 2005 [2]. Therefore, road transport contributes to local emissions and pollutants affecting the air quality and global warming [3]. In general, it is a challenge for most of the member countries within the European Union not to exceed the national emission ceilings for certain atmospheric pollutants given under the DIRECTIVE 2001/81/EC [4]. Therefore, standards and instruments to ensure good air quality were developed by the European Commission [5]. Member-country authorities have to initiate measures in order to tackle a wide range of pollution sources such as urban traffic, domestic heating, power plants and industrial activities. For this reason, the number of cities throughout the European Union with some form of driving restrictions e.g. implementation of low-emission zones, introduction of emission tolls, ban on driving based on vehicle size and weight, etc. increased by 87% compared to the year 2008 and results in 500 cities [6]. In order to reduce greenhouse gas emissions and pollutants without driving restrictions in urban areas, a transition to local zero emission alternative fuelled vehicles is deemed necessary which at the same time maintains or improves an efficient freight transport system. The transition for passenger cars is underway. However, the transition for light and heavy transport logistic vehicles transition is currently slow, caused by differences in political prioritization and a lack of information about the status of existing electrified logistic vehicles and possible fields of applications [7]. To counteract the current knowledge gap, this paper aims to summarize the current status of electrified transport logistic vehicle technology and country individual experiences gathered from different pilot projects.

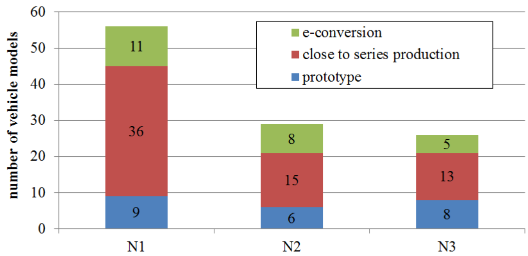
2 Status of electrified transport logistic vehicles

In order to summarize the status of electrified transport logistic vehicles a transport logistic vehicle database was developed based on inputs from Austria, Germany, Korea, Turkey, the Netherlands and the United Kingdom. Currently, the database includes about 120 electrified transport logistic vehicles. There is no claim for completeness. For further information regarding the data characteristics captured for each vehicle please see [7]. Only vehicles of the category N according to the European classification scheme are in the focus of interest. Category N vehicles are motor vehicles with at least four wheels designed and constructed for the carriage of goods and defined according to the following classification: [8]

- **Category N_1:** Vehicles designed and constructed for the carriage of goods and having a maximum mass not exceeding 3.5 tonnes
- **Category N_2:** Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 3.5 tonnes but not exceeding 12 tonnes
- **Category N_3:** Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 12 tonnes

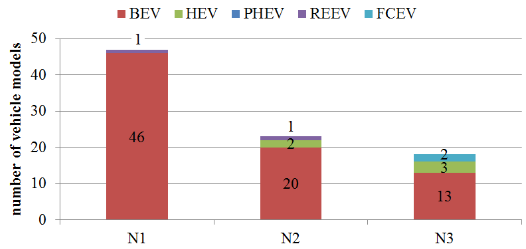
The number of vehicle models identified suggests that most research and development efforts are expended for vehicles related to the category N_1 (see Figure 1). However, research and development activities regarding vehicles category N_2 and N_3 are accelerating.

Figure 1: number of electrified transport logistic vehicles identified (total number of vehicles is 111)



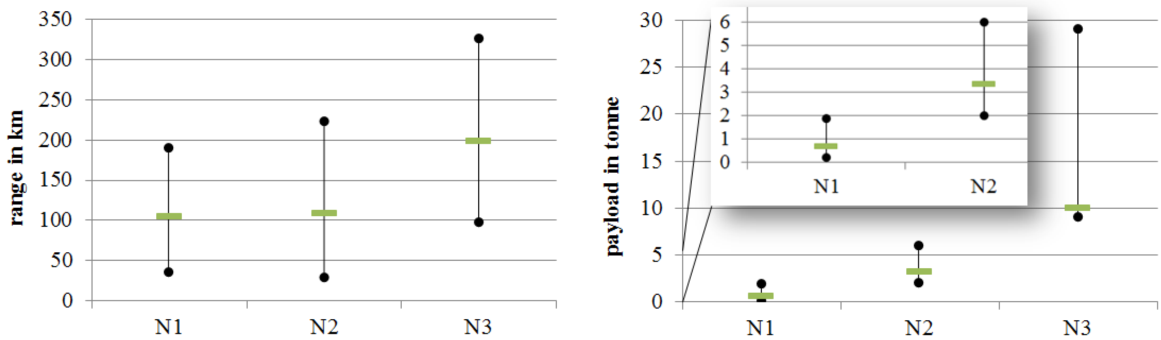
Taking only vehicle models categorised as e-conversion and closed to series production into account, battery electric vehicles (BEV) clearly dominate across all vehicle categories (see Figure 2). As the gross vehicle weight increases, the number of vehicles and the share of BEVs decrease, whereas the share of hybrid electric vehicles (HEVs) increases. Fuel cell electric vehicle models are only represented regarding the vehicle category N_3. However, fuel cell electric vehicles exist as prototypes or technology demonstrator in all vehicle categories. Generally, numbers of hybrid electric vehicles, range extended electric vehicles (REEV) and fuel cell electric vehicle compared to batter electric vehicles are low. Plug-in hybrid electric vehicles (PHEV) did not reach close to series production status so far. About 47 category N_1 vehicles models have been identified either with the production status of e-conversion (11) or close to series production (36). Nine out of 47 category N_1 vehicle models are from established manufacturers like Daimler, Volkswagen, Iveco, Peugeot, Ford Citroen, Renault and Nissan. Regarding category N_2 vehicle models, 23 vehicle models have been identified either with the production status of e-conversion (8) or close to series production (15). Four vehicle models are from established manufacturers. In terms of category N_3 vehicle models, 18 vehicle models have been identified either with the production status of e-conversion (5) or close to series production (13). One vehicle model is from an established manufacturer. However, the actual market availability of a particular vehicle should be requested individually from the manufacturer and vary according to the country. Mainly new suppliers offer alternative powertrains as well as complete electric vehicles.

Figure 2: number of transport logistic vehicles identified with electrified powertrains and production status e-conversion or close to series production (total number of vehicles is 88)



In terms of the driving range current vehicle performance of N_1 category vehicles range from 35 km to 190 km with 106 km on average. Vehicle payload ranges from 200 kg to 1,900 kg with 700 kg on average. Regarding the driving range of N_2 category vehicles the current performance varies from 30 km to 223 km with an average of 110 km. Vehicle payload ranges from 2,000 kg to 6,000 kg with 3,400 kg on average. Finally, for the N_3 category vehicles the driving range vary between 97 km to 325 km with 200 km on average. Vehicle payload ranges from 9,000 kg to 29,000 kg with 10,100 kg on average (see Figure 3).

Figure 3: bandwidth of current vehicle performance[1)] - regarding range[2)] (on the left) and payload[3)] (on the right)



[1)] based on manufacturer's data; [2)] total number of vehicles considered is 46 for N_1, 16 for N_2 and 7 for N_3. [3)] total number of vehicles considered is 40 for N_1, 14 for N_2 and 7 for N_3

3 Early niche markets and commercialization opportunities

In order to identify early niche markets and commercialization opportunities for electrified transport logistic vehicles, country individual experiences of relevant pilot projects were collected. A summary for the countries Austria, Germany, Turkey and the Netherlands is given within the following subsections.

3.1 Austria

In Austria five projects have been identified related to electric transport logistic vehicles. In three of these projects the objectives are the development of prototype vehicles and its testing in a real world logistic application. The developed battery electric vehicles are a category N_1 (converted Skoda Roomster) and a category N_2 (converted Mercedes Sprinter) vehicle. Both vehicle developments have not been completed yet, therefore no operation experiences could be reported so far. In addition, a category N_1 fuel cell hydrogen vehicle (converted Mercedes Vito) has been developed, which is currently only operated as technology demonstrator. The project E-LOG-Klagenfurt had the objective of operating three fuel cell hydrogen Citylog road-trains between the airport and the city centre. Due to technical problems and the high costs for the hydrogen fuelling infrastructure, these vehicles have recently been replaced by a battery electric category N_1 vehicle. The biggest electric logistic vehicle fleet is operated by the Austrian post service, with currently 420 electric category N_1 vehicles, including 20 Vito E-Cell. The following experiences have been reported:

- Low choice of vehicles available on the market
- The cargo volume of most vehicles on the market is too low
- Due to the limited range, electric vehicles can substitute conventional vehicles only in selected delivery areas with flat topography
- Low temperatures between 10°C and -10°C significantly reduce the range
- Always operate more than one electric vehicle in a distribution centre, to safe costs for the charging infrastructure and to enable exchange of experience between drivers
- Drivers can choose to drive an electric vehicle or not. Voluntariness is an important factor for acceptance
- 92% of the drivers are satisfied with driving an electric vehicle

3.2 Germany

In Germany about 20 projects were identified as relevant in terms of the electrification of transport logistic vehicles. These projects predominantly are supported by the German ministry. The fields of vehicle application are delivery of clothes, parcel delivery, air terminal operation, port terminal operation, waste collection, furniture transport and delivery of products for daily needs. The total number of vehicles test in field operation is about 225, whereof about 200 are category N_1 vehicles. About 15 vehicles are category N_2 and about 10 vehicles are category N_3 vehicles. Selected key results are:

- Development stage and extended charging duration limits operation
- Energy consumption varies significantly and is up to twice as high, depending on driving style and season. Significant differences between real driving distances and manufacturer information
- New technology is well accepted by the users
- A lack of comprehensive service infrastructure for BEV exists and leads to longer downtimes compared to conventional diesel driven vehicles
- Lack of experience along with technical issues generates "organizational range anxiety", which leads to overcautious route planning and dispatching
- General reliability highly volatile, yet single vehicles reach well over 90%
- If battery electric fleet growth, required power supply and possible mains fluctuations has to be taken into account regarding the charging infrastructure
- Potential users have to be involved in the development and implementation process in order to increase technology acceptance
- Due to transport capacity limitation of available BEV, organisations keep additional vehicles for being able to transport also bigger goods ad hoc over the required distances
- In case of quantity discounts for conventional diesel driven vehicles are not considered, N_1 category battery electric

transporter are profitable and an adequate alternative

In addition, the Deutsche Post DHL Group operates about 1,000 battery electric vehicles. The StreetScooter Work is a category N_1 battery electric vehicle model specifically developed for parcel and post deliveries. The experiences reported are that battery electric vehicles fulfil the requirements in terms of robustness and operability. Cost efficiency is almost achieved. However, challenges to be faced are related to the energy management of the grid and the charging infrastructure.

3.3 Turkey

In Turkey about four projects were identified as relevant in terms of the electrification of transport logistic vehicles. The fields of vehicle application are courier, parcel and grocery delivery. The total number of vehicles test in field operation is about 67 all of which are category N_1 vehicles. Selected key results are:

- Operable within particular districts due to range limitation
- Range anxiety concerns in Istanbul due to high traffic density and long travel distances
- No daytime charging due to lack of fast chargers and operational difficulties
- Three companies expanded their fleet, further expansion possible with extended driving range and availability of fast chargers
- One company will terminate at the end of their lease contract because of the incompatibility of the vehicles in terms of driving range, operational burden, and unsuitable business model

3.4 The Netherlands

In the Netherlands five projects were identified as relevant in terms of the electrification of transport logistic vehicles. The fields of vehicle application are waste collection, grocery and courier as well as parcel deliveries. The total number of vehicles test in field operation is about 26, whereof one vehicle is a category N_1 vehicle, 6 vehicles are category N_2 vehicles and 19 vehicles are category N_3 vehicles. Selected key results from the pilots are:

- Insufficient power of batteries did not allow for journeys on cold winter days
- Long downtime of the battery electric vehicles, due to a lack of experiences mechanics
- Long service time due to absence of a dealer network
- Marketing opportunities for participants are large. Companies are seen as innovative and environmentally aware when using electrified transport logistic vehicles
- Cost can be reduced by substituting conventional vehicles with battery electric vehicles, if daily demands of all vehicles are correctly assessed
- Still limited performance of battery electric vehicles
- Range of vehicles is highly influenced by the driving style of the driver
- Total Cost of Ownership exceeds the cost for conventional vehicles
- Reliability is an unknown quantity due it being a first generation vehicle on the market
- Only converted vehicles are deployed. This labour intensive and small scale conversion activity leads to an extremely high production cost, which comes on top of the vehicle price
- Converted vehicles are produced with limited quality experiences and hardly any established after sales network

4 Conclusion

The market for electrified transport logistic vehicles is still in an early stage. Most research and development efforts are expended for vehicles related to the category N_1. However, research and development efforts related to category N_2 and N_3 vehicles are accelerating. Battery electric vehicles clearly dominate across all vehicle categories. Current vehicle performance in terms of payload and range is limited compared to conventional diesel driven counterpart. About 47 category N_1 vehicles models have been identified as possibly available on the market. Regarding vehicle category N_2 23 vehicle models and in terms of vehicle category N_3 18 vehicle models have been identified as possibly available on the market. However, the actual market availability of a particular vehicle should be requested individually from the manufacturer and vary according to the country. Mainly new suppliers offer alternative powertrains as well as complete electric vehicles.

Urban logistic applications are generally seen as early niche markets for electric transport logistic vehicles from the operations point of view. Reasons for that are limited route lengths, low travel speed and frequent stop-and-go movements in urban areas. In addition, vehicles used within urban areas are going to be faced with tightened emission requirements. However, vehicle performance varies between specific vehicle types and depends on a number of factors related to cost, operational conditions, technology and infrastructure. Therefore, the operability and the business case highly depend on country specific conditions and the case of application. Most experience has been made with battery electric vehicles related to vehicle category N_1 used for parcel and post deliveries applications for which battery electric vehicles are well suited. Only a small number of vehicle category N_2 and N_3 vehicles have been tested so far in various applications. More experience is needed in order to identify suitable applications in urban goods distribution.

Common experiences across countries are:

- Current development stage of battery electric vehicles limits operation
- Availability and choice of electrified transport logistic vehicles is low
- Technology is well accepted by the drivers
- Business cases are hardly provided
- Business case highly depends on the local conditions

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