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Extended Abstract

Opportunities and Barriers of Hydrogen–Electric Hybrid Powertrain Vans: A Systematic Literature Review

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Abstract

The environmental impact of the road transport sector, together with urban freight transport growth, has a notable repercussions in global warming, health and economy. The need to reduce emissions caused by fossil fuel dependence and to foster the use of renewable energy sources has driven the development of zero-emissions powertrains. These clean transportation technologies are not only necessary to move people but to transport the increasing demand for goods and services that is currently taking place in the larger cities. Full electric battery-powered vans seem to be the best-placed solution to the problem. However, despite the progress in driving range and recharge options, those and other market barriers remain unsolved and the current market share of battery electric vehicles (BEVs) is not significant. Based on the development of hydrogen fuel cell stacks, this work explains an emerging powertrain architecture concept for N1 class type vans, that combines a battery-electric configuration with a fuel cell stack powered by hydrogen that works as a range extender (FC-EREV). A literature review is conducted, with the aim to shed light on the possibilities of this hybrid light-duty commercial van for metropolitan delivery tasks, providing insights into the key factors and issues for sizing the powertrain components and fuel management strategies to meet metropolitan freight fleet needs. Nowadays, energy efficiency and sustainability are critical objectives in the value chain of business activities. Manufacturing and logistics are key links in this chain. According to International Energy Agency (IEA) and European Environment Agency (EEA) data, at the end of the year 2017, the world-level energy consumption for the industry and transport sectors were almost the same, around 12.6 ZJ, nevertheless, CO2 emissions for industry and transport were around 6.2 Mt of CO2 and 8 Mt of CO2 respectively. However, what is more interesting, observe the trend curves of energy consumption and CO2 emissions, which, for industry, has been similar since 2011, however, in the transport sector, it is continuously growing. In particular, if we focus on road transport share of greenhouse gas emissions in the EU28 zone, according to EEA data, is observed that this means of transport has the most important impact with 71.7%.The environmental impact of road transport takes on special relevance in metropolitan areas, mainly due to the high rate of economic activities and population concentrated in these areas. The segment of road freight transport whose activities are focused on pick-up and delivery activities in metropolitan areas is known as Urban Freight Transport (UFT). The key objective of UFT is to carry goods to the end of the supply chain throughout commercial vehicle fleets. UFT is considered a complex task because the delivery acts performed are in most cases composed of heterogeneous loads (different types and amount of objects, different sizes and weights), multiple delivery points and a great mileage to be covered. From the authors' point of view, an increasing and uncontrolled volume of UFT services may cause environmental, health and economic consequences, such as traffic congestion, pollutant emissions (both emissions and noises), energy inefficiencies, road accidents, infrastructure degradation and parking and land space for transport facilities instead of other purposes. On the other hand, greenhouse gas emissions linked to road transport in light commercial vehicles are continuously rising. As an illustrative example, the EU27 greenhouse gas emissions (GHG) caused by road transport in 2018 were 26.8% higher than the 1990s and, particularly, taking as a reference the latest EEA data in light-duty trucks, the growth reached 56.5% This worrying situation has spurred EU governments to engage with road transport environmental policies, such as forecasting low emissions areas and emission tolls, among others, aiming to reduce carbon dioxide emissions by 60% relative to 1990 levels by 2050. All these reasons lead to a transition towards lower emission vehicle technologies, aiming to reach a sustainable urban freight transport model with efficient energy consumption and at the same time achieving low environmental impacts.

Environmental policies combined with the permanent and unwavering objective of reduction in costs, because of the

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high cost shareof last-mile delivery in the transport process, are pushing the logistic companies to search for solutions for improving their overall efficiency and, at the same time, to minimize the environmental impact caused as a consequence of these activities. Currently, delivery management software (DMS) is widely used to enhance the logistic activities through tracking deliveries, delivery task management, route optimization and collecting data for the evaluation of delivery activity performances. The other face of the solution to address these challenges is based on the progressive substitution of internal combustion vehicles (ICVs) by electric vehicles (EVs) when replacing units of their urban freight delivery fleets. Electric vans could be a good option for a van fleet with a large number of vehicles, high annual mileage per vehicle, route planning and low speed profiles. These working conditions would lead to low running costs and facilitate the introduction of electric powertrains. Despite the advantageous conditions for using EVs in UFT and several governmental actions boosting their market spread, such as subsidies for the purchase of these vehicles, tax exemptions and other non-financial policies (as preferential parking zones, free access to low emissions restricted urban areas, among others), market sale evolution of electric light commercial vehicles has not been fast enough. In accordance with 2019 European Automobile Manufacturers Association (ACEA) data statistics, almost 93% of new registrations in light commercial vehicles across the European Community have a diesel powertrain and the future outlook is not very encouraging. However, there is significant literature and demonstrative projects that further explore and analyze the feasibility of employing different EV technologies in passengers and commercial vehicles. In light-duty vehicle class, battery electric vehicles (BEVs) attract all the attention, nevertheless, little attention has been paid to other available electric powertrain configurations that would be of possible interest for UFT activities. This is the case of electricity/hydrogen hybridization and specifically the use of hydrogen, in combination with electricity, in a range extender powertrain (FC-EREV) with an energy-managing strategy designed to overcome the main operational limitations: the range and the recharging time in the case of battery electric vehicles, and the lack of refueling infrastructure in the case of hydrogen. Taking into account European Alternative Fuels Observatory (EAFO) data, there are near 195,000 public charging stations across EU-33 countries, mostly concentrated in five countries, and approximately 90% are power chargers with less than 22 kW of output power. The case of hydrogen filling stations are even worse, there are only 124 filling stations in EU-33, most of them concentrated in Germany. There are other particular barriers related to technological, economic and environmental issues affecting BEV and FCEV technologies to a greater or lesser extent that affect their market success and could be solved with a fuel cell range extender powertrain (FC-EREV).

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