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*Editorial*

# Development Trends in Vehicle Propulsion Sources—A Short Review

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Today's vehicle powertrains, especially in cars and vans, have to meet increasingly stringent type approval standards. Global measures presented as GHGs [1] or CARB-CAR [2] ultimately aim to reduce $CO_2$ emissions despite the differing opinions in this regard [3]. Recent legislation adopted by the European Commission aims to limit $CO_2$ emissions to 0 g/km in a driving test by 2035 [4]. In contrast, the 'Fit for 55' plan requires a 55% reduction in $CO_2$ emissions by 2030 for newly manufactured passenger cars [5]. These measures force manufacturers to supplement classic powertrains with an additional (green) source of propulsion or to use only non-emitting sources of propulsion. The NEDC type approval test [6] approached emission testing in a laboratory/simplified manner. The type approval transition to WLTC [7] and RDE [8] tests brought the test conditions more in line with normal operating conditions. In the case of passenger cars, for which emission requirements are the most stringent, a supplementation of at least 50% of the ICE with an additional propulsion source is required today. Another obstacle to the exclusive use of ICE in vehicle propulsion is the Euro 7 legislation that is scheduled to be introduced in Europe in the near future [9].

When looking at the global development and contemporary requirements for the propulsion sources of various vehicles, the following trends are evident: a change in the organisation of the combustion process to systems such as ATAC [10], CAI/HCCI [11,12], HPDI or RCCI [13]; the use of dual fuel [14,15]; the use of exhaust gas cleaning components, such as EC, DOC, FAP, DPF, GPF and SCR [16–19]; the use of lower carbon fuels [20]; the use of alternative fuels, such as LPG [21–24], CNG [25–27], LNG [21,28,29], HVO [30,31], PVO [32] and FAME [33]; the use of refuse-derived fuels, such as biogas [34], syngas [35], a biomass gasifier [36], POMDME [37], TPO [38] and NH3 [39]; the use of carbon-free fuels, such as H2 [35,40,41]; and eco-driving [42].

Currently, hybrid powertrains are being built with ICE configurations in MHEV, PHEV, FCV or BEV [43–45]. A number of research studies indicate that using an electric motor as a supplementary propulsion source in addition to the ICE is the most optimal solution before switching to battery-only propulsion [46]. However, as shown in [47], long-range BEVs and fuel cell plug-in hybrid electric vehicles (FCPHEVs) have similar life cycle emissions as PHEV-CNG. Charging and energy storage systems are important [48]. The target fuel of future vehicles is hydrogen, which would either be used as the sole fuel [49,50] or as an additive to other fuels [51,52]. Energy management now plays an important role in hybrid or battery systems in the same way as with ICE [53–55]. Determining the characteristic ratios of different propulsion sources and whether their shape/path matches with the approximating functions is important for computing and modelling the performance of different vehicle powertrains [56,57].



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Besides cars, hybrid and battery drives are being tested in aviation [58–60] or marine ships [61]. Decarbonisation in densely populated areas like cities, where fuel cell buses with a supercapacitor are being used successfully [62], is very important. There is some hope behind the use of air motors as propulsion sources or as supplements in hybrid systems [63–65]. The important features of modern propulsion systems are that they are safe during operation and meet the demands of road infrastructure or road rescue equipment [66,67]. The market analyses presented in [68] show that in the future, younger potential buyers will prefer hydrogen and electric vehicles, which is currently taking place with the support of policy and strategic instruments and is extending to other age groups.

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## Abbreviations and Acronyms

The following abbreviations and acronyms are used in this manuscript. Greenhouse Gases, GHGs; California Air Resources Board and validated by the Climate Action Reserve, CARB-CAR; Carbon Dioxide, $CO_2$; New European Driving Cycle, NEDC; Worldwide Harmonized Light vehicles Test Cycle, WLTC; Real Driving Emissions, RDE; Internal Combustion Engine, ICE; European Vehicle Emissions Standards, Euro 7; Active Thermo-Atmosphere Combustion, ATAC; Controlled Auto-Ignition, CAI; Homogeneous Charge Compression Ignition, HCCI; High-Pressure Direct Injection, HPDI; Reactivity Controlled Compression Ignition, RCCI; Exhaust Catalyst, EC; Diesel Oxidation Catalyst, DOC; Filter a Particular, FAP; Diesel Particulate Filter, DPF; Gasoline Particulate Filter, GPF; Selective Catalytic Reduction, SCR; Liquefied Petroleum Gas, LPG; Compressed Natural Gas, CNG; Liquefied Natural Gas, LNG; Hydrotreated Vegetable Oil, HVO; Pure Vegetable Oil, PVO; Fatty Acid Methyl Ester, FAME; Polyoxymethylene Dimethyl Ether, POMDME; Tire Pyrolytic Oil, TPO; Ammonia, $NH_3$; Hydrogen, $H_2$; Mild Hybrid Electric Vehicle, MHEV; Plug-in Hybrid Electric Vehicle, PHEV; Fuel Cell Electric Hybrid Vehicle, FCV; Battery Electric Vehicle, BEV; Fuel Cell Plug-in Hybrid Electric Vehicle, FCPHEV.

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