Global Alliance Powerfuels

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Powerfuels in Public Road Transport

Powerfuels can be a complement to direct electrification of buses, and hence play a major role to decarbonise public transport.

In highly populated urban areas, public transport contributes to CO_2 emissions as well as local air pollutants. The most widely used means of public transport are diesel buses, thus the introduction of alternative propellants for buses becomes an important issue in terms of reducing greenhouse gases (GHG) and improving local air quality. Alternative propulsion systems and renewable fuels that could lead to a decrease in GHG emissions for buses include natural gas, hybrid-systems, battery electric vehicles, trolleybuses and the usage of powerfuels.

The use of powerfuels is necessary for routes with high capacity utilisation and compliment the mobility sector's shift towards direct electrification. The advantages of powerfuels compared to battery electric vehicles is the longer range and the significantly lower time for refuelling. This makes powerfuels an interesting application for public fleets in transport as well as in other crucial public services (e.g. fire department, police, etc.). Due to a centralised procurement strategy of public fleets, a faster market ramp-up of powerfuels driven vehicles as well as powerfuels production infrastructure could be achieved. The central refuelling characteristics of public fleets and transportation in general makes it possible to build up the refuelling-infrastructure for hydrogen or gas before they are covering a wide public scope. This leads to lower infrastructural costs compared to private vehicles running on hydrogen or synthetic gas.

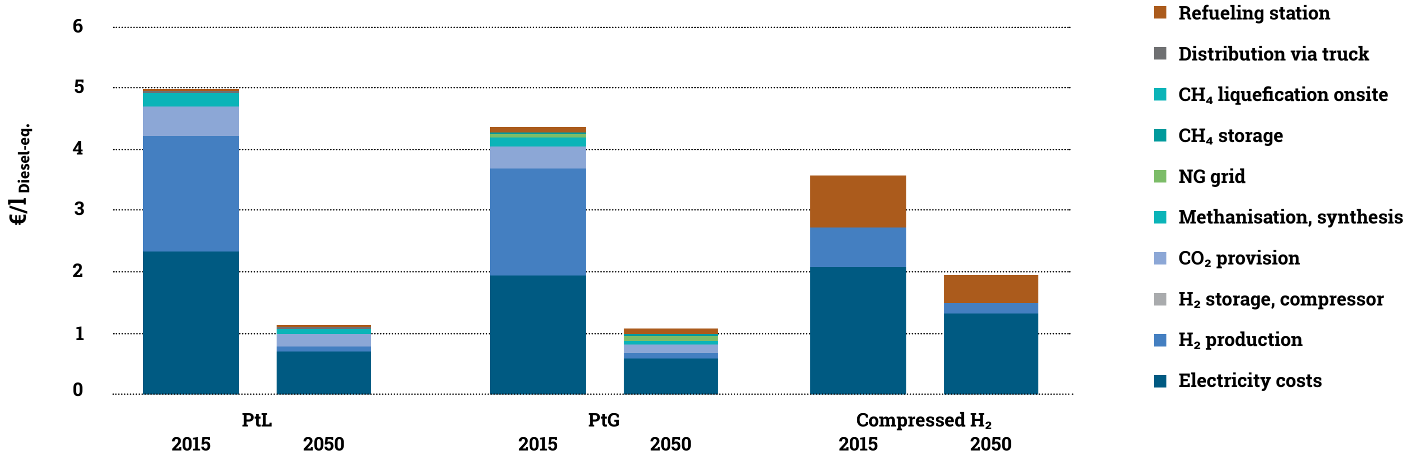
50 – 60 % of total public transportation in Europe is satisfied by buses[1]

95 % of buses run on Diesel[1]

H_2 **Hydrogen**	No local CO_2 and pollutant emissions; less noise pollution compared to conventional combustion engines	Higher range than BEV-buses; possibility for centralised refuelling infrastructure; short refuelling cycle	
Synthetic Methane	Significantly lower CO_2 and local pollutant emissions compared to diesel driven buses	Higher range than BEV-buses; possible usage of existing centralised refuelling infrastructure; short refuelling cycle	
Synthetic Diesel	Possible usage of existing refuelling infrastructure and vehicles; short refuelling cycle	Higher range than BEV-buses; “drop-in” character allows it to gradually substitute conventional diesel	No broad incentives yet to implement powerfuels into public transport sector

Actual and projected cost structure of relevant powerfuels for public transport

Actual (2015) and predicted (2050) prices for different powerfuels in €/l $_{\text{Diesel-eq.}}$



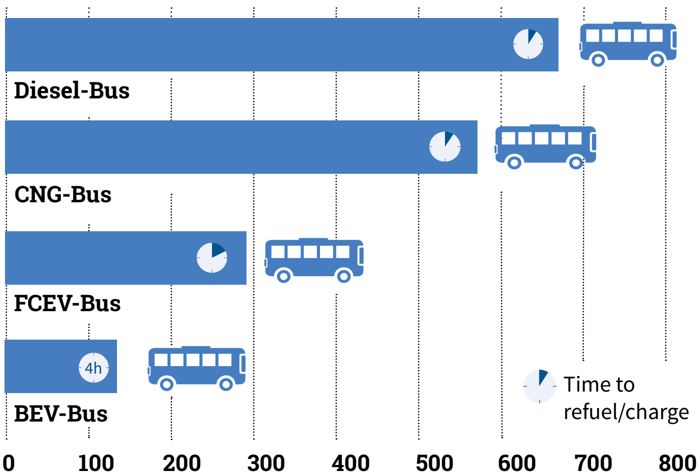
Hydrogen is provided by high temperature electrolysis for PtG and PtL, Hydrogen for compressed hydrogen is provided by low temperature electrolysis, Powerfuels are produced with EU domestic energy in 2015 and are imported for the year 2050, Carbon-dioxide is provided by direct air capture technology Source: “e-fuels” study (LBST and dena)[2]

From today’s perspective, **hydrogen** is the energy carrier, which has comparatively lowest production costs in the range of powerfuels. On the other hand, hydrogen triggers high investments in vehicle technology and infrastructure. A significant decline of the costs is expected with ramp-up of global electrolyses capacities.

The production of **synthetic methane** is associated with slightly higher energy demands compared to the hydrogen production. Synthetic methane has “drop-in” character and can thus immediately substitute natural gas. This establishes significant financial benefits.

The production of **synthetic diesel** is associated with slightly higher conversion losses than the production of synthetic methane. Its major advantage is, that the usage of existing infrastructure and combustible ready vehicles is possible. This can establish significant financial benefits.

Range of typical public buses depending on different powertrains*



*Example calculation for public buses of the model series Mercedes-Benz Citaro. Used parameters (Energy storage, consumption) – BEV-bus: Range according to manufacturer; FCEV-bus: 35 kg, 12 kg/100 km; CNG-bus: 209,2 kg (1360 l), 38,25 kg/100 km; Diesel-bus: 260 l, 38,7 l/100 km.

All powerfuels-driven vehicles have a significantly longer range compared to battery electric buses, whilst having shorter refuelling durations.

Synthetic diesel has highest fuel costs compared to other powerfuels, but its “drop-in”-character allows the immediate use of this decarbonized fuel in any existing diesel vehicle today without the need for any modification in infrastructures or vehicles. Synthetic diesel thus allows immediate GHG reduction in existing vehicle fleets.

Gas-driven buses have significantly reduced local pollutant emissions compared to diesel buses. Production process for synthetic methane needs less energy and has therefore lower fuel costs than synthetic Diesel.

Fuel-cell electric buses (FCEV-buses) have a significantly higher well-to-wheel energy efficiency compared to combustion engine vehicles. In addition, FCEV-buses have the advantage of no tailpipe emissions, which is especially interesting for highly populated urban areas with a high exposure of air pollutants (e.g. NOx).

Public transport as ideal early adopter for powerfuels

Public transport usually uses centralised infrastructures for maintenance and refuelling. Public transport can forecast its specific transport demand, leading to a continuous and predictable fuels demand. Therefore, long-term planning stability is given, making power-to-X production investments feasible and thus favours the use of powerfuels. In addition, public transport operation has to undergo a competitive tendering process, in which public policy makers can include GHG emission targets to the tender conditions. These make such public fleets perfect for early market ramp-up of powerfuels.

1 Decarbonisation: the public transport contribution, International Association of Public Transport.
2 The potential of electricity-based fuels for low-emission transport in the EU, dena and Ludwig Bölkow Systemtechnik.

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