VOLVO GROUP'S TRANSITION TO FOSSIL FREE

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ABSTRACT

Volvo Group has an ambition to reach net-zero greenhouse gas emission-enabled products, solutions and services by 2040 and is investing heavily in technologies that will enable the transition to fossil-free solutions. The transition plan, visualized in figure 1, shows that net-zero solutions are already reached around 2040, which is necessary considering the 10-year lifetime of our rolling fleet at the customer so that usage of the Volvo products do not emit greenhouse gas emissions 2050. When it comes to propulsion technologies that will enable the transition, we will move from conventional diesel and other fossil fuels powered engines to a fleet consisting of battery electric vehicles (already in production), fuel-cell electric vehicles operated on green hydrogen, and internal combustion engines operated on decarbonized fuels such as hydrogen, biogas, e-fuels, biodiesel and HVO.

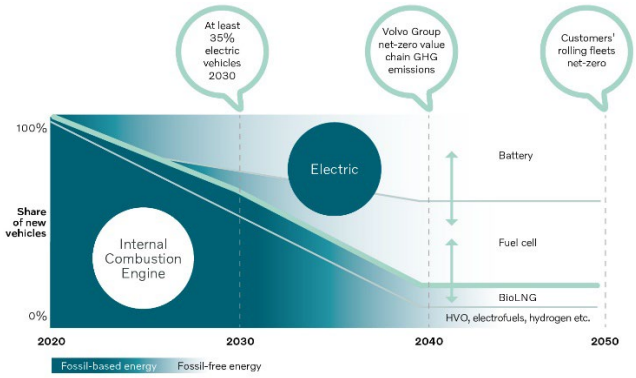

Figure 1, Volvo Group transition to a net-zero emissions fleet.

Volvo Group is convinced that there is a market for all three propulsion technologies due to their unique selling points and properties that can be utilized for different customer applications in different regions of the world depending on the availability of necessary energy and infrastructure. The two hydrogen energy conversion technologies are the hydrogen fuel cell electric vehicle and the hydrogen internal combustion engine where the latter has a lower product cost, but also a lower efficiency (hydrogen consumption, hence range) and could have additional emissions, beside water, such as particulate matter, NO_x and possibly CO_2, although at very low levels. The fuel cell electric vehicle requires significant system engineering efforts where the fuel-cell, battery system, electric motor, transmission, cooling system, and brake system need to be combined and optimized together for the best efficiency, performance and mission. The first generation of Volvo's fuel cell

electric truck will be equipped with a 2x 150kW fuel cell leading to an operational range up to 1,000 km, and up to 65t load. Summer and winter tests have been performed successfully and vehicles are being developed to participate in the European H2Accelerate project which is a large demonstration project involving actors from the complete hydrogen value chain. Already now, great efforts are being made by cellcentric (Volvo Group's fuel cell system joint venture together with Daimler Truck) to develop the second-generation fuel cell system with 20% better efficiency and a peak power above 350 kW. In 2026, Volvo Trucks will begin customer tests of hydrogen internal combustion engine powered trucks. These hydrogen engines use the high-pressure-direct-injection technology developed by Westport; a company Volvo Group now has a joint venture with. The HPDI technology itself is already in production using liquid natural gas as main fuel. Since this engine uses the diffusion combustion principle and high compression ratio, the fuel jets of the main, low cetane fuels are ignited by a compression ignited diesel pilot. For the decarbonized hydrogen HPDI version, the pilot fuel is renewable HVO diesel so that this engine is considered a zero-emission-vehicle (ZEV) according to the new EU standards for CO_2 emissions. Several other hydrogen combustion concepts are being investigated in parallel as depicted in figure 2. The low-pressure-direct-injection (LPDI) is based on a pre-mixed combustion system using spark-ignition and does not require a diesel pilot, hence operates solely on hydrogen.

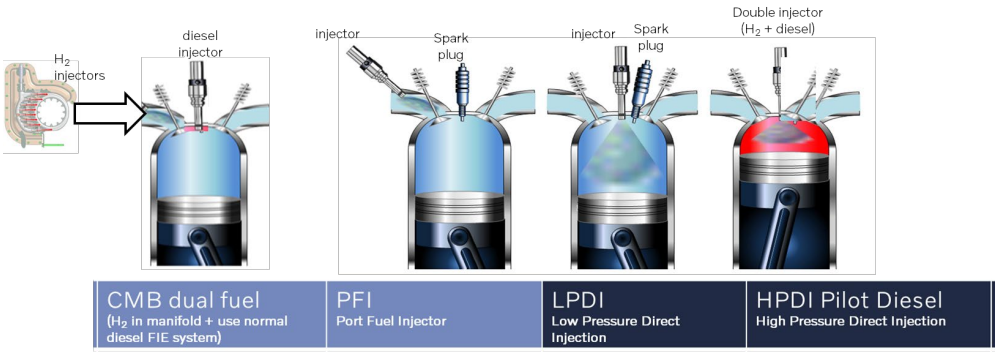

Figure 2, Hydrogen combustion concepts under evaluation

The biggest challenge with LPDI concepts is the mitigation of engine knock and pre-ignition while maintaining a high compression ratio for high efficiency. This is something that is very much dependent on air-fuel mixing where the objective is to create a homogeneous mixture at spark-timing. Vehicles with LPDI technology will be part of the European funded HyCET project. For hydrogen products, a hydrogen infrastructure is necessary at the right timing. Regardless, there will be applications, such as construction equipment, where it is challenging to have a fuel- or charging-station close enough. Therefore, Volvo Group is developing a mobile hydrogen refueling station, a project that is funded by the Swedish Energy Agency.

Conclusions

Volvo Group is on a transition path towards net-zero greenhouse gas emission-enabled products, solutions and services in 2040. For the powertrain, Volvo Group is developing three different technologies namely: battery electric vehicles, fuel cell electric vehicles and internal combustion engines operated on renewable fuels. R&D efforts are being made to demonstrate transition solutions, often as a common effort within public funded projects.