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Life Cycle Assessment of Vehicles

Comparison of Fuel Cell Vehicle and Conventional Diesel and Gasoline Vehicles

The target of this study is a well-to-wheel analysis of a fuel cell vehicle and subsequently a comparison of the fuel cell vehicle to a vehicle with an internal combustion engine.

To assess the whole life cycle of the vehicles, the production stage, use stage and the end of life stage are taken into account. The assessment includes all system components and precursor materials as well as energy or auxiliaries needed for manufacturing.

In the course of the life cycle assessment, the key factors that influence the environmental performance are identified. On that basis, possibilities to ecologically improve all three stages of the life cycle can be deduced.

In a second step, scenarios for those key factors are calculated to predict potential future improvements for the production of the fuel cell vehicle. Since the technology is not yet fully established, there is still room for improvement. Scientific papers and documents from the DoE and other sources have been used to reflect the current state of the art and status of research.

In the scope of the well-to-wheel analysis, several indicators such as CO2, NOx, SOx, PM 2.5 and PM 10 as well as the primary energy demand from renewable and non-renewable resources are evaluated.

To be able to compare the different types of vehicles, generic vehicle models with the same power output are built for both the fuel cell vehicle and the ICE vehicle, one fuelled with gasoline and one fuelled with diesel. The models created with the GaBi software can be adjusted to individual specifications by changing parameters. These parameters are for example the type of battery in the FCV or the weight of the motor in the ICEV.

The life cycle assessment shows the crucial parts and materials of the fuel cell vehicle. These are mainly platinum, carbon fiber and hydrogen.

The hydrogen production plays a vital role in the assessment of the emissions of the fuel cell vehicle. If the hydrogen is produced from electrolysis from renewable energy sources, the emissions are a lot lower than if the hydrogen is produced from steam reforming from natural gas.

The production and processing of platinum generate a lot of emissions. That is why the relatively small amount of platinum in the fuel cell vehicle accounts for 17% of the total CO_2 emissions of the vehicle. The same is true for carbon fiber which is responsible for 12% of the total CO_2 emissions of the fuel cell vehicle.

Compared to the ICE vehicles, the different types of emissions from the production of the fuel cell vehicle are always at least twice as high. However, the future scenarios that have been modelled show a lot of potential to lower these emissions. The scenarios show that relatively small improvements and changes affect the level of emissions significantly. Currently there is a lot of research to lower the platinum load in the fuel cells and the rate of recycled platinum is likely to increase as well. The reduction of the weight of the hydrogen tank is another likely objective to lower the amount of carbon fiber used.

Considering the whole life cycle of the three vehicle types, the results are different and depending on the indicators. For example SO_x emissions and the primary energy demand are higher for the fuel cell vehicle than for the gasoline and diesel vehicle. For most of the other indicators however the emissions are almost the same as for the ICE vehicles, the CO_2 emissions are even a lot lower for the fuel cell vehicle if the hydrogen is produced from electrolysis from renewable energy.

An advantage of the fuel cell vehicle over the ICE vehicles is that there are no driving emissions. This is especially important considering that the driving emissions of ICE vehicles mainly pollute the air in the cities and reduce the air quality for the people living there.

The emissions in the use stage of the fuel cell vehicle result only from the hydrogen production. This is why the hydrogen production from renewable energy is identified as one of the most important factors to improve fuel cell vehicles in terms of environmental aspects.