Comparison of Environmental Effects of Different Fuels in Vehicles

Bachelorarbeit

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Table of Contents

1 Introduction

1.1 Motivation and Relevance

As a key component of economic development the transport sector is accountable for about 19% of global energy use (IEA 2009). The transport activities are likely to grow in the future. Currently the majority of the world's population has no access to motorized transport, but this situation is rapidly changing (Kahn Ribeiro et al. 2007). Following the current trends transport energy use will increase by nearly 50% by 2030 and to more than 80% in 2050 (IEA 2009). The major sources for climate change are anthropogenic caused emissions (Allgeier & Ullmann 2010).
Practically the transport sector relies on fossil resources for all its fuels (Kahn Ribeiro et al. 2007).
Because vehicles are the source of several environmental problems, especially through the atmospheric pollution caused by the combustion of fossil fuels (Viñoles-Cebolla et al. 2015) one of Europe's car industry main goals is the reduction of CO_2 emissions to reduce the effects of global warming (Nieuwenhus & Wells 2003). About 80% of the CO_2 emissions of an internal combustion vehicle arise during its utilization phase. Using battery electrical vehicles the emissions during the vehicle usage are far less (Daimler 2014). Therefore the Volkswagen concern developed the "Think Blue" strategy. This strategy includes the technological development of vehicles and factories in order to reduce emissions (Volkswagen 2014b). With the "BlueEFFICIENCY"-program Daimler is trying to reduce its emissions in various phases of their product life cycle and the average CO_2 emissions of its new car fleet (Daimler 2014). Not only is the fuel usage contributing to the greenhouse effect, but also the complete life cycle of the fuel.

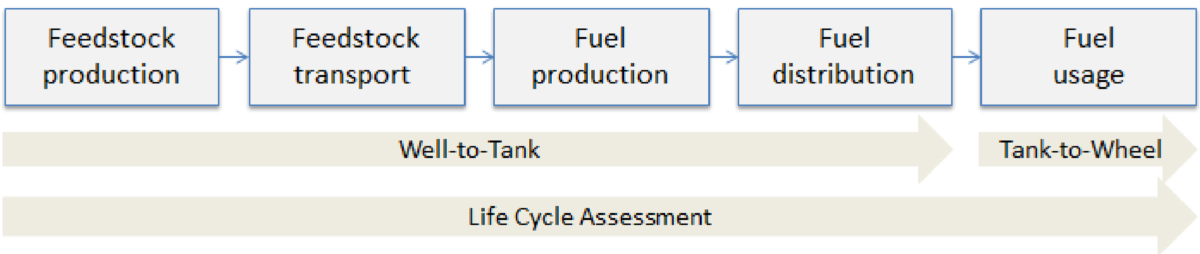

Figure 1: Fuel life cycle following Lane 2006

The motivation to use alternative fuels is not only to reduce the environmental impact due to the usage of fossil resources but also the need for security of supply. The goal for 2020 is to replace 20% of conventional fuels with alternative ones stated by the European Commission, as well as to reduce the tailpipe emissions of the new passenger car fleet to $95 g_{CO2}$ per km (Allgeier & Ullmann 2010, BMWI 2012).

One approach is the usage of battery electric vehicles (BEV) powered by electricity. BEVs are likely to grow in numbers in the future due to their zero emission utilization phase (Nieuwenhus & Wells 2003).

Using alternative fuels, such as electricity, instead of gasoline or other fossil based fuels has definitely an impact on the environmental effects in the transport sector. The chance to be completely independent on fossil sources and therefore be CO_2 emission neutral is one of the bigger action fields for us and future generations.

1.2 Aim and Structure of the Thesis

The aim of this thesis is to evaluate the CO_2-equivalent emissions and environmental impacts of different fuels during their life cycle. In later scenarios the main focus is the difference in emissions of gasoline and electricity used as fuels in vehicles.

After the relevance and motivation of this thesis are mentioned in **chapter 1**, **chapter 2** deals with the effects of global warming related to the greenhouse gas effect, the main difference of internal combustion engines and electrical engines, as well as the fundamentals of the considered fuels. In **chapter 3** the greenhouse gas (GHG) emissions of the respective fuels are researched by means of the life cycle assessment approach, as well as the life cycle GHG emissions of different vehicles. Furthermore other environmental impacts, like noise emissions and particular matter emissions are considered for internal combustion vehicles and battery electric vehicles. **Chapter 4** deals with different scenarios regarding the energy mixture in Germany for electricity production. Based on these values the CO_2-equivalent emissions of gasoline and electricity as fuels are compared by the life cycle of selected vehicles. The conclusion in **chapter 5** summarizes the results and gives a brief outlook.

5 Conclusion and Outlook

The aim of this thesis was to reveal the environmental impacts of different fuels. By means of the life cycle approach and various scenarios the fuels and respective vehicles were compared.

The occurring emissions are expressed as CO_2-equivalents due to the various types of different greenhouse gases, particular matters and other substances emitted in the upstream chains of fuels and vehicles. Gasoline and diesel as common fossil fuels achieve the lowest GHG emissions in the WTT approach, followed by natural gas from the selected sources. One of the biggest emissions factor of CNG is the distance of the transported gas via pipeline. The longer the distance, the higher the emissions are. That’s why natural gas from Russia emits nearly twice as much GHG in its WTT cycle as natural gas from the European mix. Considering the values for the Well-to-Tank cycle in figure 18 it is noticeable that hydrogen and electricity both known as alternatives for fossil fuels emit a significant higher amount of CO_2-equivalent emissions per produced fuel as the fossil ones. Taking the lifetime emissions into account electricity contributes overall exceedingly few GHG emissions. However Hydrogen in this thesis relies on the one hand on natural gas as feedstock; on the other hand during the reforming process of natural gas a great amount of GHGs is emitted, due to the release of the bound CO_2. Compared to the Golf and e-Golf the Hyundai ix35 cannot keep up. This is due to the significant higher weight and to the made assumptions of emissions during the fuel cell production and in the end-of-life stage. This is leading to the question:

How “green” is e-mobility really?

Compared to the other vehicles the e-Golf has the lowest emission values during its usage phase. But emissions in other stages of the life cycle compared to the ICEVs, NGVs are higher. This is due to the additionally battery. The battery production and end-of-life stage is a heavy contributor to the overall GHG emissions of BEV.

The overall emissions of the BEV rely heavily on the used energy mix. While using more renewable sources the emitted GHG are reduced. Approaching the fuels and vehicles life cycle BEV achieving better values as the conventional ICEV. The different scenarios show that even with an electricity production relying on 100% on fossil fuels BEV lifetime emissions are lower than ICEVs using current tailpipe emission values.

When considering particular matter emissions ICEV provide overall better results. Although BEVs have no tailpipe emissions the PM emissions are mostly from the lignite, hard coal and other fossil feedstocks during the electricity production. But

BEVs achieve better results at noise emission compared to ICEVs in the lower speed range because of the quieter engine. Especially in metropolitan areas is this advantageous.

Coming to the conclusion that considering the limitations made in this thesis, e-mobility is highly promising for todays and futures road transport. However fields of action are manly located in the battery life cycle and in the used sources for electricity production to achieve even better emission results.