SCENARIOS FOR ACLIMATE NEUTRAL VEHICLE FLEET IN AUSTRIA USING DYNAMIC LCA

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1) Modelle, Szenarien und Innovationen für ein klimaneutrales Energiesystem

Introduction

The environmental effect of electric vehicles can only be assessed based on life cycle assessment (LCA) covering production, operation and end of life treatment. Since 2011 in the Technical Collaboration Program (TCP) on "Hybrid & Electric Vehicles" (HEV) of the International Energy Agency (IEA) with 20 participating countries an expert group develops and applies LCA methodology to estimate the environmental effects of the increasing electric vehicle (EV) fleet globally [1, 2, 5]. Since 2014, IEA HEV Task 30 estimates the LCA based environmental effects of the worldwide EV fleet in 40 countries. In the LCA of these vehicles using the different national framework conditions, the environmental effects are estimated by assessing the possible ranges of GHG emissions, acidification, ozone formation, PM emissions and primary energy consumption in comparison to conventional ICE vehicles [3, 4, 6, 7]. Now this approach was further developed to a dynamic LCA by taking the time depending effects of the BEV fleet introduction and the parallel increasing supply of renewable electricity into consideration

Aim

The TCP HEV Task 30 developed the methodology of dynamic LCA to analyse and assess the environmental effects of electric vehicle and the necessary additional generation of renewable electricity. A dynamic approach is necessary to address also the future possibility of a "climate neutral mobility service" provided by electric vehicles using additional renewable electricity. The aim of this analysis is to apply this methodology to calculate the environmental effects over time for the Austrian situation. The analysis is split in three parts to show the stepwise application and results of this methodology. The application focuses on GHG emissions and the cumulated primary energy demand taking the development of the increasing BEV fleet into account. In the 1st step the GHG emissions of the supply of additional renewable electricity are calculated in the dynamic LCA. In the 2nd step a scenario for a climate neutral mobility service by the Austrian passenger vehicle fleet in 2050 is developed. In the dynamic LCA the greenhouse gas emissions (CO_2, CH_4, N_2O) in CO_2-eq, and the primary energy consumption (total, fossil, nuclear, renewable) are assessed.

Results for passenger vehicles

The dynamic LCA is used for the future development of the Austrian passenger vehicle fleet for reaching climate neutrality in 2050. Based on the historic development and the current stock of passenger vehicles scenarios are developed to reach the following goals:

- 2030: 55% GHG reduction compared to 1990
- 2040: climate neutrality for the transport sector
- 2050: climate neutrality for all global GHG emissions in dynamic LCA

In Figure 1 (left) the development of the passenger vehicle fleet in Austria is shown, with a strong increasing share of new registered BEV and a limitation of the total passenger stock (5.2 Mio vehicles) based on 2020. On the right hand side, the final energy demand is shown with a strong increase in electricity and a constant amount of biofuels based on 2020. To reach the 2030 target of 55% GHG reduction in transportation sector the amount of fossil fuels is limited to about 16 TWh and climate neutrality in 2050 to 0 TWh.

In Figure 2 the GHG emissions (left) and primary energy demand (right) of Austrian Passenger Vehicle

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Fleet are shown based on dynamic LCA. The GHG emissions of vehicle fleet operation in 2030 is 55% less than in 1990 and 0 in 2040. The remaining GHG emissions e.g. electricity supply, in the dynamic LCA are reduced until 2050. The GHG emission from "end of life" and "vehicle export" are negative as GHG credits for secondary material and 2nd use of vehicles are given. The GHG emission from the production of the "newly registered vehicles" increases between 2020 and 2030 as the production of BEV have significant higher GHG emissions than conventional ICEs. The total GHG emission decrease significantly after 2025 due to the strong increasing amount of BEV in the vehicle fleet. The cumulated primary energy demand also significantly decreases due to the higher energy efficiency of BEV using renewable electricity.

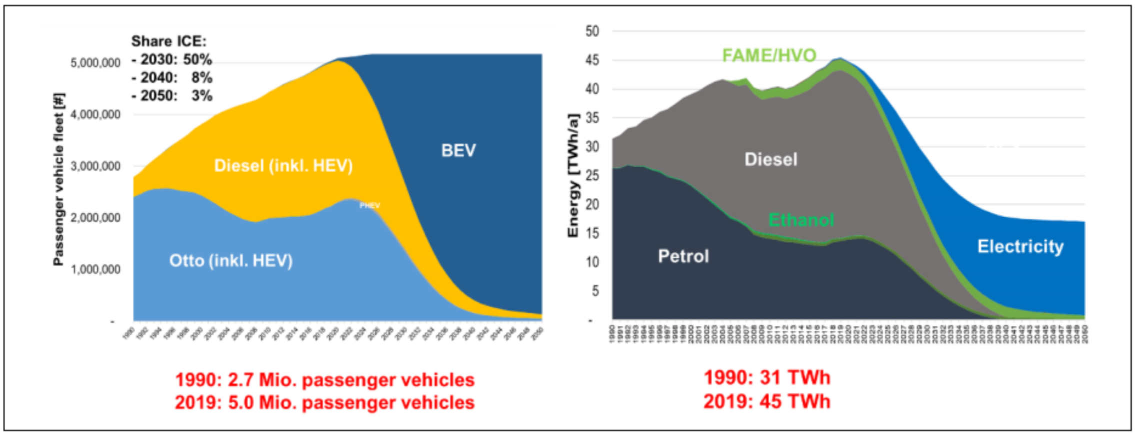

Figure 1: Characteristics and final energy demand of Austrian passenger vehicle fleet

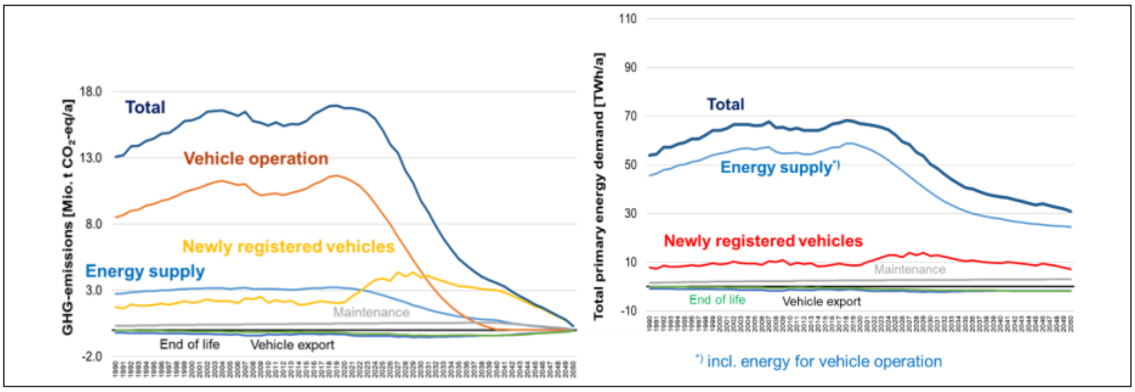

Figure 2:GHG emissions and primary energy demand of Austrian passenger vehicle fleet based on

Conclusions

Timing of environmental effects in LCA of EVs covering production, operation and end-of-life phases becomes relevant in the transition time of strong BEV introduction in combination with a strong increase of additional renewable electricity generation and improvement of battery production technologies. Within the framework of LCA a methodology is developed and applied to the annual environmental effects of an increasing BEV fleet and substitution of ICE vehicles by considering the environmental effects of

- new vehicle production
- supply of renewable electricity from existing and new power plant
- substituted operation of ICE vehicles and
- end of life or export of vehicles.

The scenarios for Austria up to 2050 show that Climate Neutrality in Austria passenger vehicle fleet is possible with BEV. The main influences to reach climate goals in passenger vehicle fleet are:

- increasing high number of newly registered BEV
- development of total vehicle stock

- development of annual driven mileage of vehicle fleet
- generation of additional renewable electricity for BEV

References

[1] Jungmeier Gerfried, Dunn Jennifer B, Elgowainy Amgad, Gaines Linda, Ehrenberger Simone, Doruk Enver Özdemir, Widmer Rolf: Key Issues in Life Cycle Assessment of Electric Vehicles - Findings in the InternationalEnergy Agency (IEA) on Hybrid and Electric Vehicles (HEV) (EVS27, 2013)

[2] Jungmeier Gerfried, Dunn Jennifer B, Elgowainy Amgad, Gaines Linda, Ehrenberger Simone, Doruk Enver Özdemir, Widmer Rolf: Life cycle assessment of electric vehicles – Key issues of Task 19 of the International Energy Agency (IEA) on Hybrid and Electric Vehicles (HEV), TRA 2014

[3] Gerfried Jungmeier, Jenifer Dunn, Amgad Elgowainy, Simone Ehrenberger, Rolf Widmer: Estimated Environmental Effects of the Worldwide Electric Vehicle Fleet – A Life Cycle Assessment in Task 19 of the International Energy Agency (IEA) on Hybrid and Electric Vehicles (HEV), , Conference Proceedings, EEVC 2015- European Battery, Hybrid and Fuel Cell Electric Vehicle Congress, Brussels, Belgium, 2 – 4. December 2015

[4] Gerfried Jungmeier, Jennifer B. Dunn, Amgad Elgowainy, Linda Gaines, Martin Beermann, Simone Ehrenberger, Rolf Widmer: Life-cycle Based Environmental Effects of 1.5 Mio. Electric Vehicles on the Road in 35 Countries – Facts & Figures from the IEA Technical Cooperation Program on Hybrid & Electric Vehicles (EVS 30, 2017)

[5] Gerfried Jungmeier, Amgad A. Elgowainy, Simone Ehrenberger, Gabriela Benveniste Pérez, Pierre-Olivier Roye, Lim Ocktaeck: Water Issues and Electric Vehicles - Key Aspects and Examples in Life Cycle Assessment (EVS 31, 2018)

[6] Gerfried Jungmeier, Amgad A. Elgowainy, Simone Ehrenberger, Gabriela Benveniste Pérez, Pierre-Olivier Roye, Lim Ocktaeck: LCA Based Estimation of Environmental Effects of the Global Electric Vehicles Fleet – Facts & Figures from the IEA Technology Collaboration Program on Hybrid & Electric Vehicles, Transport Research Arena TRA 2018 in Wien, 16-19 April 2018

[7] Gerfried Jungmeier, Lorenza Canella, Jarod C. Kelly, Amgad A. Elgowainy, Simone Ehrenberger, Deidre Wolff: Evaluation of the Environmental Bene-fits of the Global EV-Fleet in 38 Countries – A LCA Based Estimation in IEA HEV (EVS 32, 2019)

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