MODELLING THE TRANSPORT SECTOR IN THE CONTEXT OF A DYNAMIC ENERGY SYSTEM

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Overview

As part of the project *Dynamis* the *Forschungsstelle für Energiewirtschaft* develops a model of the German energy system which couples its energy supply optimisation models *ISAaR* and *MInGa* with four energy application submodels for the industry sector, the commerce, trade and service sector, private households and the transport sector. In this course the target is not to simply analyze scenarios but to evaluate measures to reduce CO_2 emissions in the context of the dynamic changing system.

In this paper the methodology of modelling an energy application sector and its measures is shown for the example of the transport sector. Therefore the detailed implementation of the sector and its functional relations in the context of the whole dynamic energy system is explained. Furthermore analogies to other application sectors will be pointed out. Finally the results for the application of a significant example measure will be presented and discussed taking similar studies into account.

Methods

In order to model the whole energy system in a dynamic way which is not dependent on scenarios, one has to exactly define the program sequences as well as the interfaces between the submodels. The main output of the energy application submodels is the time-resolved energy demand for each energy source as well as the emissions and measure related costs within the sector. This information will be passed to the optimisation models which simulate the supply and therefore the energy source related emissions and costs.

In terms of the energy application sectors and especially the transport sector there are three main issues to address in order to correctly depict the functional relations and the impact of applied CO2 reduction measures: the translation of the measure input, the displacement effect resulting from it and the arising costs and emissions. Applied reduction measures can either impact the development of the composition, the usage and therefore the energy demand as well as the time of the energy demand of the fleet. The implementation of a measure has a direct relation to the displacement effects which represent the change in comparison to the natural replacement like e.g. the purchase of a new car to exchange an old one. The natural replacement is defined by a reference. The costs and the emissions in one sector are also compared to the reference.

Results

The method allows to analyse different measures in different scales and for different years very easily. For the results in this paper the measure of a 30 billion Euros investment on electrical vehicles in individual road transport is taken. The measure is applied on a linear basis between 2020 and 2030 and the direct impact on the car fleet composition is shown in Figure 1. The result shows an accelerated expansion of the penetration of electrical vehicles starting at the year of the application. It also shows the replacement of conventional cars, eventhough the percentage change is quite low because of the large share of these technologies in the fleet.

Figure 2 presents the change of CO_2 emissions arising through the use of each energy carrier with the application of the measure. The emissions of the electricity mix are following Regett et al. [1]. Starting at 2021 there is a increased amount of CO_2 emissions per year due to electrical vehicles. However the emissions of conventional cars are reduced in a larger scale and hence it would result in a ecologic advantage. The resulting cumulative CO_2 reduction is also shown in Figure 2.

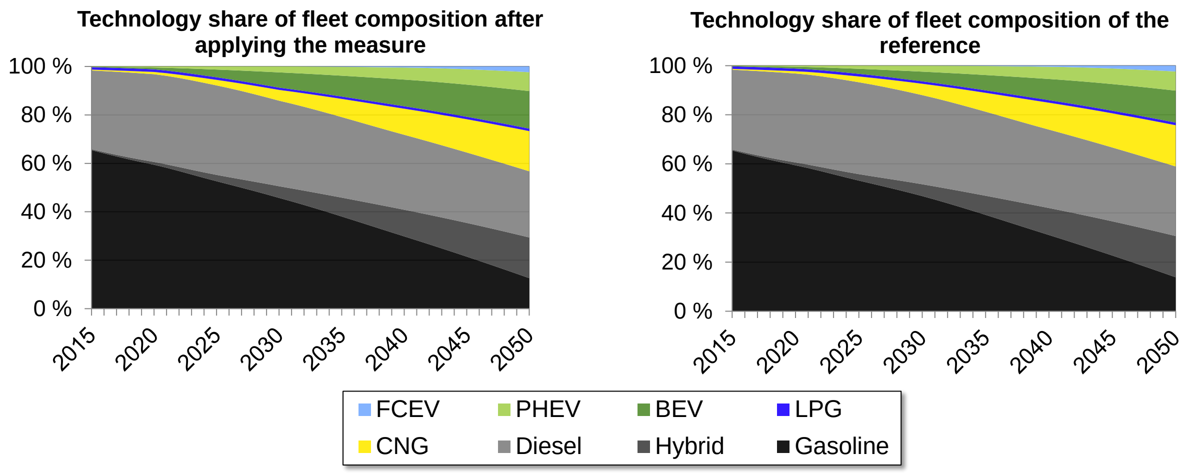

Fig. 1: Development of the composition of the car flee until 2050 for the reference (left) and after applying the measure of 30 billion Euros investment for electrical vehicles between 2020 and 2030 (right)

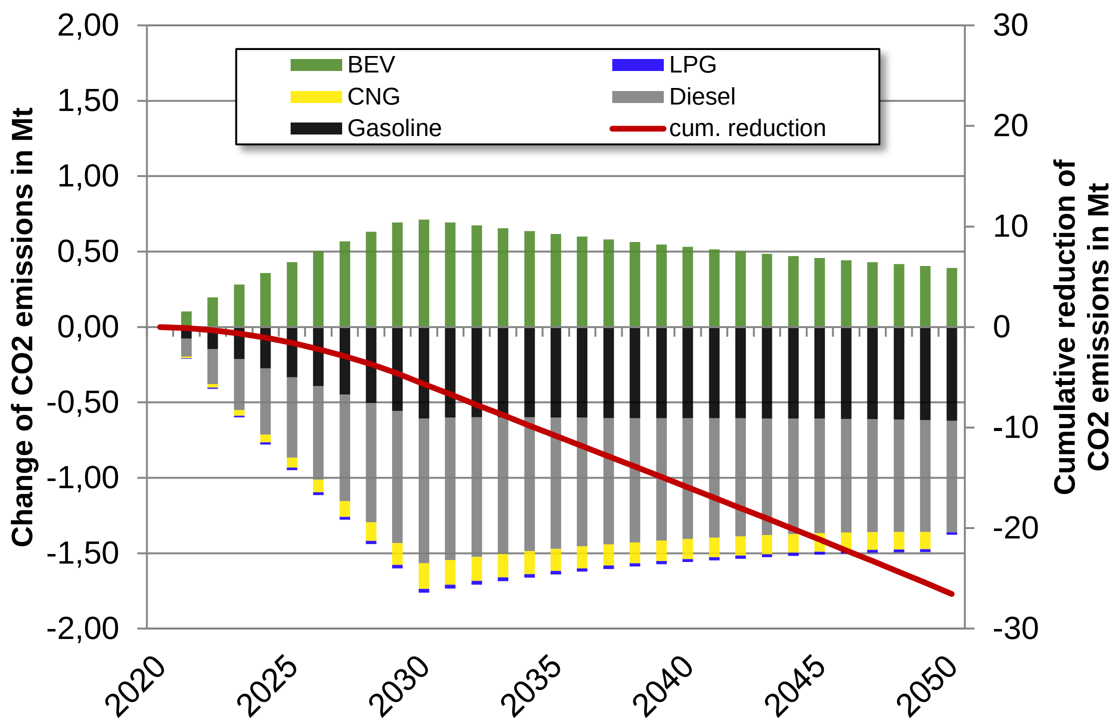

Fig. 2: Change of CO_2 emissions by energy source of cars and cumulative CO_2 reduction after applying the measure of 30 billion Euros for electrical cars

A more detailed set of results including consequential effects that are caused by the measure but become effective in the years after 2030 will be presented in the paper. Besides changes of the car fleet composition itself, also differences in the fleet specific values such as the average fuel consumption of conventional cars are evaluated. In this context the paper presents results concerning the effects of applied measures on the fleet's age structure.

Conclusions

In order to image a energy application sector such as the transport sector one in order to apply measure to reduce CO_2 emissions one has to develop a detailed modelling of the functional relations of a sector. Combined with a substantiated model of the displacement effects of measure it is possible to make an informed statement of a measure's impact. Furthermore parts of the implementation of the transport sector can be transferred to other sector such as private household by analogy.

References

[1] Regett, Anika; Zeiselmair, Andreas; Wachinger, Kristin; Heller, Christoph: Merit Order Netz-Ausbau 2030 - Teilbericht 1: Szenario-Analyse. München: Forschungsstelle für Energiewirtschaft e.V., 2017