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Including road transport in the EU ETS (European Emissions Trading System): A model-based analysis of the German electricity and transport sector

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ABSTRACT

The EU ETS (European Emissions Trading System) is being enlarged stepwise to cover an increasing amount of overall European CO_2 emissions. However, one of the largest and still growing CO_2-emitting sector, the transport sector, and particularly road transport, has not yet been included in the EU ETS. Against this background, the question arises whether integrating the road transport sector in the EU ETS represents a cost-efficient CO_2 reduction strategy. For this reason, the consequences of this integration are analysed with a focus on Germany. To do so we utilise a model-based approach. In order to account for both sectors simultaneously, we couple an electricity system model, *PERSEUS-EU* (Package for Emission Reduction Strategies in Energy Use and Supply in Europe), with a road transport model, *COMIT* (CO_2 emission Mitigation in the Transport sector). The time horizon we consider ranges from 2010 to 2030. In our analysis, we differentiate our scenarios according to commodity prices, share of renewable energies in electricity generation and share of electric vehicles. The results show that the enlargement of the EU ETS to include road transport leads to a reduction of overall CO_2 emissions, but equally reduces the mitigation efforts in the road transport sector. Simultaneously, the German electricity sector is mainly influenced according to the certificate demand or supply of the road transport sector.

1. Introduction

In order to reach the Kyoto targets, the EU ETS (European Emission Trading System) was established in 2005 according to EU directive 2003/87/EC and already covers 30 countries (the 27 EU Member States in 2010 plus Norway, Iceland, and Liechtenstein) [1]. Until now it has been structured into four periods up to 2028 with varying restrictions. Whereas so far national caps have been allocated, in the third phase of the EU ETS (2013–2020) only one single Europe-wide cap is applied. Furthermore, the European Union has standardised the installations affected by the EU ETS as well as the allocation and auctioning of CO_2 allowances. In this way, CO_2 emissions are to be reduced where it is most cost-efficient.

Two major CO_2-emitting sectors are excluded from the EU ETS. These are the residential sector with a share of 9.9% of overall CO_2 emissions in the European Union (EU27) in 2007 and transport, which is the only sector without emission reductions so far. In 2007, CO_2 emissions from transport increased by 25% compared to 1990 and had a share of 23.1% in the EU27 CO_2 emissions [2]. More than 71% of these emissions in 2007 originated from road transport [3].

From an economic point of view, these framework conditions are inefficient: some sectors in the EU ETS struggle to reduce their emissions, while others are not affected by the limitations (i.e. transport sector). The latter increases the pressure on those already "suffering" from the EU ETS. These inefficiencies are most apparent in the transport sector, as its emissions are still growing and will continue to increase on a European scale and are going to double on the global scale up to 2050 [4]. This development strongly conflicts with the long-term CO_2 emission targets of industrialised nations, such as Germany, which is striving to reduce CO_2 emissions by 30–40% by 2030 compared to 1990 and by about 80% by 2050 [5,6]. Another policy instrument in this issue is the European Directive 443/2009, which forces vehicle manufacturers to meet the vehicle-specific CO_2 emissions of 95 g per km by 2020 for new passenger

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Abbreviations

BEV	battery electric vehicle
CDM	Clean Development Mechanisms
CO_2	carbon dioxide
COMIT	**CO_2** emission **Mi**tigation in the **T**ransport sector (multi-agent based model)
EU	European Union
EU27	the 27 countries of the EU in 2010
EU ETS	European Emissions Trading System
EV	electric vehicles
GMP	German Mobility Panel
ILUTE	integrated land use, transportation, environment
JI	Joint Implementations
MAS	multi-agent (based) simulation
MATSim	Multi-Agent Transport Simulation
N_2O	nitrous oxide
NREAP	National Renewable Energy Action Plans
PFC	perfluorocarbon
PERSEUS-EU	Program **P**ackage for **E**mission **R**eduction **S**trategies in **E**nergy **U**se and **S**upply in **Eu**rope (energy system model)
RES	renewable energy sources
VMT	vehicle miles travelled

cars. Unfortunately, this instrument focuses on the efficiency of the vehicles and therefore neglects the rebound effect. This means that more efficient cars lead to lower operating costs and therefore stimulate a higher mileage [7]. Even though the German transport sector is one of the few worldwide with decreasing CO_2 emissions, most experts agree that technical measures of conventional passenger cars alone will not enable vehicle manufacturers to meet the European reduction target [8,9]. This is mainly determined by the high technical CO_2 emission abatement costs. On the other hand, these high costs could also be interpreted as a great willingness to pay for luxury passenger cars.

A first step towards including the transport sector in the EU ETS was taken in 2012, with all flights arriving at and/or departing from EU airports being included (European Directive 2008/101). The idea of integrating road transport in cap and trade and other approaches has been discussed extensively for several years (e.g. Refs. [10,11]). Due to the low price elasticity for fuel in road transport (e.g. Refs. [12,13]) and comparatively low marginal CO_2 abatement costs in the energy sector, such an integration into the EU ETS leads to monetary flows from the transport sector to the other EU ETS sectors rather than to real emission reductions within the road transport sector. An efficient reduction of overall emission is, however, assured [14].

Today, significant emissions reductions within the European transport sector without the EU ETS seem to be unlikely. The historic CO_2 emissions development in the European transport sector shows that a reduction is impossible without a substantial change in the traffic participant's attitude, a technical breakthrough or a faster increase of transport cost in comparison to income gains. On the one hand, inclusion in the EU ETS would lead to a marginal increase in transport costs in road transport (which might be higher if stronger emission targets are imposed) and on the other hand it leads to an increased allowance demand in the EU ETS market, where the energy industries have a major market share. Hence, the main impacts of such an implementation could be a change in the price of allowances in the EU ETS and due to this in electricity generation as well as in mileage performance and vehicle fleet composition. Therefore, these impacts will be analysed in considering feedback to road transport itself and the mitigation potentials from energy industries. The interactions between these two sectors actually increase through the market penetration of EV (electric vehicles) – which seems to be relevant for the coming decades [15,16]. Hence, a model-based approach is chosen for this analysis to cope with the high system complexity in a systematic way. This model approach has to adequately cover both sectors.

In the energy industry, mainly investment and production planning are affected by the EU ETS. Optimising energy system models enables an adequate analysis of the long-term energy system developments to be made for investment planning for power plants [17–26]. In the EU ETS, the development of the CO_2 allowance price depends mainly on the marginal CO_2 abatement costs of European power plants and the CO_2 reduction target. We therefore use an optimising energy system model (*PERSEUS-EU* (Package for Emission Reduction Strategies in Energy Use and Supply in Europe)[1]), which includes emissions trading and assumes optimising agents in the energy industry [27,28]. The road transport sector, by contrast, is characterised by individual purchase decisions (especially in passenger transport) of multiple actors with heterogeneous preferences and decision patterns. Here we apply the *COMIT* (CO_2 emission Mitigation in the Transport sector)[2] model, which is a MAS (multi-agent-based simulation) model, which is widely accepted as being able to cope with these (sometimes irrational) inhomogeneities [14]. As already stated, this combination of sophisticated models of both sectors is necessary in order to achieve sound results for our research question.

So far the two models have only been used separately and therefore contain only a reduced representation of the other sector. The corresponding results have thus never considered all the necessary aspects of the impact of road transport being included in the EU ETS. In the following, the results are harmonised and allow for the first time a consistent interpretation, insofar as both models use the same relevant parameter values (e.g. oil prices) and exchange their values for the demand and price of CO_2 emission allowances.

The paper is structured as follows: After an outline of the two models applied, *COMIT* and *PERSEUS-EU*, their data exchange and underlying scenarios are described. Subsequently, the model results are presented and their sectoral impacts are discussed. The paper concludes with a discussion of the impacts of an extended EU ETS on the German road transport and (European) electricity sectors.

2. Modelling the German road transport sector by the *COMIT* model

Multi-agent simulation is a fairly new modelling approach in transport economics. The first MAS models focused more on network-based approaches (e.g. MATSim (Multi-Agent Transport Simulation) [29] and ILUTE (integrated land use, transportation, environment) [30]). As CO_2 emission reductions of optimised routing and navigation seem lower than reductions from car fleet technology and mileage, we neglect the underlying road network for the following analysis [14]. The *COMIT* model used here focuses on mode shift, mileage reduction, and vehicle purchase decision for private households and freight forwarders.

2.1. Model structure

The *COMIT* model includes 700 different households and more than 600 different road freight transport actors, which represent

[1] Program **P**ackage for **E**mission **R**eduction **S**trategies in **E**nergy **U**se and **S**upply in **EU**rope.

[2] **CO_2** emission **Mi**tigation in the **T**ransport sector.

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