Transforming Europe:
Germany's Electricity Mix and Welfare in Light of EU ETS Certificate Prices

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Overview

The European Union Emission Trading System (EU ETS) was enacted in 2003 in the wake of the Kyoto Protocol. Based on a cap and trade system, EU member states establish national limits on greenhouse gas (GHG) emissions via what is being referred to as National Allocation Plans (NAPs). Subsequently, CO2 certificates (i.e. emission allowances (EUAs)) are being auctioned off (or allocated for free) and factories, power plants as well as other installations subject to these NAPs may either reduce their emissions or buy EUAs at the market to ensure their right to continue emitting GHGs. Hence, climate policy may have an increasing effect on the electricity production sector and thus, this paper is examining the possible influences of carbon emission pricing on the electricity production mix as well as electricity prices by means of a simulation model. We focus our analysis on the German electricity market and calibrate our simulation model with respect to the regulation in the electricity production sector but also with respect to the national allocation plans and Germany's CO2 reduction targets. In particular we analyze the impact of varying CO2 certificate prices on the electricity production mix, electricity prices and welfare. We find that CO2 certificate price gains result in a decline of carbon-emitting primary energy sources and an increase of the share of renewable energy sources. Consequently, the most important policy implication of our findings is that the establishment of CO2 as scarce resource (i.e. by introduction the EU ETS) really does enable regulators and policymakers to positively influence the electricity production mix.

Methods

Our simulation model focuses on the impact of carbon prices on the wholesale prices resulting in the German electricity market. We take a similar simulation approach as Bremberger et al. (2012) and thus, take the numerical and static short–term model developed by Andersson and Bergman (1995) as a starting point. Herein, we introduce carbon prices in order to analyze their impact on the generation market and the electricity price in Germany. All major German electricity producers are included in the model and we assume a Cournot competition following the first order condition:

$$P_E + \frac{1}{\epsilon} \cdot \frac{X(f)}{S_E} \cdot P_E = \frac{\partial C(f)}{\partial X(f)} + P_{net}; \qquad for\ f = 1,2,\dots,F$$

P_E stands for the current market price of electricity, P_{net} represents the transportation costs for each unit supplied, X_f is the individual firms' produced amount of electricity, ϵ the price elasticity of demand and $C(f)$ stands for the individual firms' cost function. F gives the total number of firms. The installed capacities per firm and primary energy source correspond to real market data. We distinguish eight different types of primary energy sources, and we also specify eight different types of marginal cost functions. The demand for electricity is depicted by a linear demand function, which allows us to compute varying market equilibria as well as resulting welfare effects. We implement our simulation model as MCP (Mixed Complementary Problem) and solve it in GAMS (General Algebraic Modeling System). We use German market data from 2011 for the model calibration and we run the simulation for three scenarios: 2011, 2020 and 2030 (in line with scenario data from the EWI study (2012)).

Preliminary Results

Our results indicate that rising CO2 certificate prices lead to changes in the electricity mix, i.e. a decline in the use of carbon-emitting fossil fuels and an increase of the share of renewable energy sources (Figure 1).

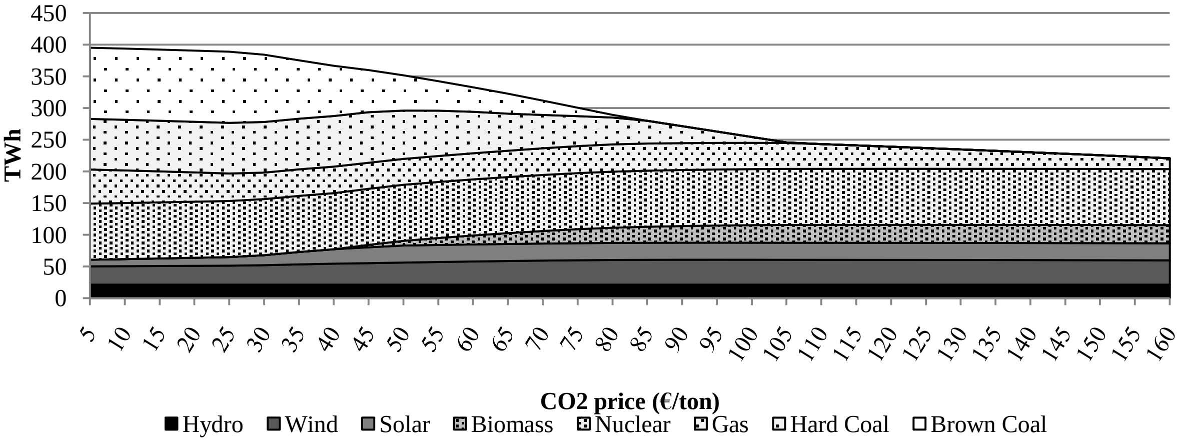

Figure 1: 2011 Fossil Fuel VS Renewable Share

In addition to these changes in the electricity mix, rising CO2 certificate prices also induce electricity prices increases as well as total welfare and consumer surplus decreases (Figure 2).

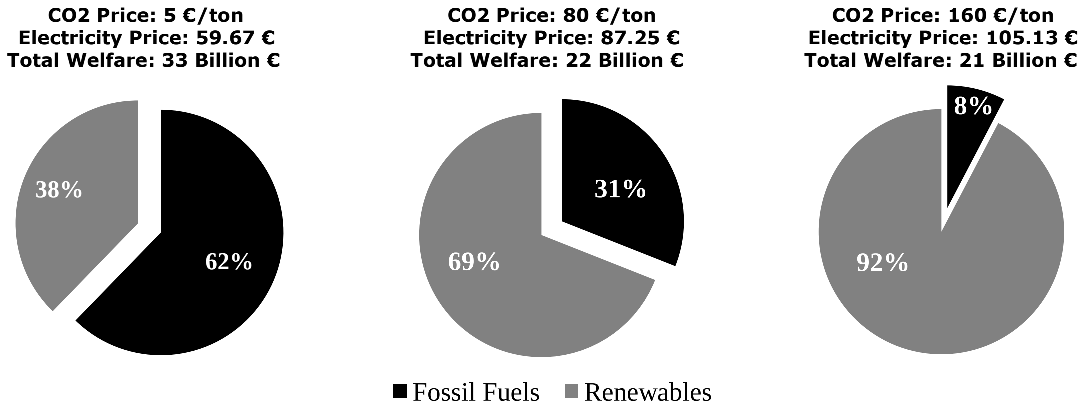

Figure 2: 2011 Fossil Fuel VS Renewable Share

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