INFLUENCE OF ENVIRONMENTAL POLICY AND MARKET FORCES ON COAL-FIRED POWER PLANTS: EVIDENCE ON THE DUTCH MARKET OVER 2006-2014

M. Mulder, University of Groningen, the Netherlands, +31 6 31035729, machiel.mulder@rug.nl

Overview

Many governments aim to reduce the dependence on coal-fired generation to decrease carbon emissions. At the same time power markets have been created leaving the actual decisions concerning electricity production to power firms. This paper analyzes the interaction between environmental policies and policies to foster energy markets. Using hourly plant-level data on the Dutch power market over 2006-2014, we find that the dispatch of fossil-fuel power plants is strongly influenced by relative fuel prices, despite the existence of several environmental policy measures. Coal-fired power plants have become more important in the Dutch market since 2006, not only in share of total production, but also as provider of flexibility. Examining the short-term dispatch decisions and the past volatility in relative fuel prices, a CO_2 price above approximately 40 euro/ton is required to provide robust incentives for power producers to dispatch a gas-fired plant instead of a coal-fired plant. We conclude that internalizing the external (CO2) costs by raising the CO_2 price is the appropriate measure to align the principles of a market-based power industry and the wish to implement effective climate-policy measures at relatively low costs.

Methods

To analyze the influence of markets forces and environmental policy on coal-fired power plants in the Netherlands over 2006-2014, we use a number of indicators. In order to quantify these indicators we use a unique data set containing hourly plant-level data regarding production levels and available capacity for each generation unit above 50 MW. First of all, we analyze aggregate numbers on the annual contribution of coal and gas-fired power plants to the Dutch market. Next, we analyze to what extent coal-fired power plants were dispatched compared to gas-fired power plants. Using hourly plant-level data, we examine how often coal and gas-fired power plants were yearly dispatched.

Furthermore, we investigate how coal-fired power plants are used in terms of providers of base load and flexibility. As a result of the increase of intermittent supply by renewable sources, more supply of flexibility is needed. We use duration curves of the annual production by coal and gas-fired power plants to analyze which role these two types of plants play and whether these respective roles have changed since 2006. Duration curves are generally used as indicators to measure the degree of flexibility of power supply. We test whether a change in the supply of flexibility can be observed between coal and gas-fired power plants in 2006, 2010 and 2014.

As the dispatch of power plants is strongly related to the marginal costs of production, we calculate these costs for all plants on a daily basis, using information on the technical characteristics per plant and daily data on gas, coal and CO2 prices.

In addition, we conduct a panel regression on the hourly dispatch of gas-fired and coal-fired power plants to explain the hourly dispatch levels. We hypothesize that the hourly dispatch of a power plant depends on the marginal generation costs as well as factors determining the total load. Regarding the former, we include the prices of gas, coal and CO2 in the regression model. As variables measuring the impact of changes in load, we include the hourly weather temperature and the supply of electricity by renewable sources. The latter is assumed to be related to environmental policy: the more effective this policy is, the higher the supply by renewable sources. We also include renewable supply in Germany since the Dutch market is closely connected to the German market, while the surge in the supply of renewable energy in this neighbouring country has strongly affected the German market. Note that the price of CO2 is also related to the impact of climate policies, as this price originates from the European ETS. We test whether the price of CO2 as well as the supply of renewable energy affects the production by coal and gas-fired power plants.

Next, we examine a scenario in which coal-fired power plants are non-existent and how this absence of coal-fired power plants may influence the electricity price. We use the actual merit-order in the Dutch market to examine the effect on system-marginal costs if coal-fired power plants would be excluded from supplying power as is currently subject to debate in the Netherlands as well as in several other countries.

Finally, we go more into depth in the role of the price of CO2. We calculate the break-even price of CO2, which is the price of CO2 where electricity producers are indifferent between dispatching a coal-fired or gas-fired plant. This

break-even price of CO2 is a short-term price which is predominantly influenced by relative gas and coal prices, given the current technical efficiencies of coal and gas-fired power plants. To determine the annual break-even price of CO2, the average marginal costs of coal-fired plants are set equal to the average marginal costs of gas-fired plants.

Results

we find that the decentralized decisions regarding the dispatch of power plants by electricity producers is strongly influenced by relative fuel prices of coal and gas, despite the existence of environmental policies. However, despite its low levels in the past, the price of CO2 in the ETS had a negative effect on the dispatch of coal-fired power plants and a positive effect on the dispatch of gas-fired power plants. Hence, the price of CO2 triggers the substitution of coal-fired plants by gas-fired plants. These results are in line with what was found by (McGuinness and Ellerman 2008) for the UK power market during the earlier years of the ETS.

We also find a small negative impact of the presence of renewable-electricity production in the Netherlands on the production by coal-fired plants. Contrary to what might be expected, we find that an increase in German renewable-electricity production raises production by the Dutch conventional power plants (both gas and coal). This phenomenon is related to the impact of renewable energy on cross-border loop flows which reduces the size of the available cross-border capacity between Germany and the Netherlands. Hence, we have the paradox that more renewable-energy production in one country stimulates fossil-fuel production in a neighbouring country, although both countries are closely connected. Apparently, the current magnitude of this connection is not sufficient to control for the cross-border loop-flow effect reducing the available capacity for traders.

In spite of the implementation of a number of environmental measures meant to foster the transition of the energy system, coal-fired power plants have become more important in the Dutch market since 2006. The increase in their contribution to total production could be expected given the changes in the relative fuel prices, but coal-fired power plants also became more important for providing flexibility. Although gas-fired plants are technically better equipped to offer flexibility, it is important to acknowledge that coal-fired plants also appear to be able to supply this service to a significant extent to the market.

Conclusions

From the Dutch experiences, we learn that an increase in CO2 price levels gives an incentive to electricity producers to use gas-fired power plants instead of coal-fired plants. Looking at the short-term dispatch decisions as well as the realized volatility in relative fuel prices since 2006, we conclude that a CO2 price above 40 euro/ton provides fairly robust incentives for power producers to dispatch a gas plant instead of a coal plant. Hence, internalizing the external (CO_2) costs by raising the CO_2 price, for instance by reducing the cap in the ETS, is the appropriate measure to align the principles of a market-based power industry and the wish to implement effective climate-policy measures at relatively low costs.

A measure to reduce the share of coal-fired generation which is currently considered in a number of countries is to force power firms to close these plants. Such a policy measure is at odds with the idea to have decentralized decision making in the power industry. Given the current constraints on cross-border capacity, such an intervention in the power market likely results in considerably higher prices for consumers as well as costs for societies compared to a market-based intervention directed at changing the incentives for power producers. Moreover, such a policy measure is not effective to reduce the overall level of CO_2 emissions because of the existence of the ETS, as any reduction in emissions will reduce the carbon price and, hence, raise emissions in other industries.

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