SO_2 EMISSIONS IN THE EU-28 COAL POWER SECTOR – AN LMDI DECOMOPOSITION ANALYSIS

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Overview

The primary source of anthropogenic SO_2 emissions is the combustion of sulphur-containing fossil fuels such as coal or oil in power stations and other large combustion plants. Although coal has remained the major fuel source of EU-28 energy generation (EUROSTAT, 2015), total EU-28 sulphur dioxide (SO_2) emissions have decreased by 87% between 1990 and 2013 (EEA, 2015a). This notable decoupling of SO_2 emissions from electricity and heat generation suggests that effective SO_2 abatement measures have been implemented in EU-28 coal-fired combustion plants.

This paper investigates the drivers of SO_2 emission reductions, focusing particularly on the impact of the politically encouraged installation of flue-gas desulphurisation (FGD) equipment in large coal-fired power plants. FGD is a post-combustion scrubber technology which absorbs up to 98% of SO_2 contained in flue gases, and has become the most applied SO_2 abatement measure in conventional combustion plants (Speight, 2012).

Applying a logarithmic-mean Divisia index (LMDI) decomposition analysis we decompose the SO_2 emissions of 274 EU-28 large coal-fired power plants for the years 2004 – 2012, which are categorised into FGD and non-FGD (NFGD) plants. The paper identifies the particular contribution of four SO_2 emissions determining factors:
(1) Total plant activity, (2) the diffusion of FGD installations measured as the activity share of FGD plants, (3) fuel switching between fuel types with different levels of sulpfhur content and (4) the SO_2 intensity of fuel use.

The paper is organised as follows: In the first section the political context of EU SO_2 emission regulations is introduced by explaining the regulatory concept of “best available techniques” (BAT) for the setting of emission standards and by a brief historical overview of relevant EU SO_2 emission abatement policies. In the second section the principal SO_2 abatement measures within coal-fired combustion plants are outlined. A literature review of associated research is conducted in section four. In section five the methodology and datasets are explained. In section six we present and interpret the results of the performed decomposition analysis. In the last section we draw conclusions and discuss policy implications.

Methods

We apply a logarithmic-mean Divisia index (LMDI) decomposition analysis modelled after Ang (2005) to decompose total SO_2 emissions into the contributions of the four outlined determining factors. The major benefit of the LMDI method is that it provides a perfect decomposition, leaving no unexplained residual term.

For our decomposition analysis we use two main datasets: (1) the EEA publication of reported emissions and fuel use inventories of EU large combustion plants (LCP), which has been released in 3 waves (EEA, 2009, 2012, 2015b); and (2) a compilation of data extractions from the IEA Coal Power Database (IEA, 2012). The LCP inventories contain yearly plant-by-plant information on total levels of SO_2 emissions and on fuel use per fuel type for all EU LCP with a thermal input equal or greater to 50 MW. The IEA Coal Power Database comprises detailed information on coal-fired power stations worldwide, including their names, addresses and the year of FGD installation for those plants fitted with FGD.

Results

We find that SO_2 emissions arising from EU-28 large coal-fired power plants fell by 66% between 2004 and 2012. Two thirds of the emission reduction are attributed to a decrease in the SO_2 intensity of fuel use, followed by the impact of an increased activity share of FGD plants, accounting for almost one quarter of the total emission reduction. Fuel switching and a decrease in total plant activity have only minor impacts on total SO_2 emission levels, accounting respectively for a reduction of 1% and 7% of total base year emissions.

A marked decline in the SO_2 intensity of fuel use is observed within both FGD plants and NFGD plants. In FGD plants, the SO_2 intensity of fuel use (expressed as tonnes of SO_2/terajoule of fuel consumed) fell on average by 55% from 0,30t/TJ in 2004 to 0,13t/TJ in 2012. In NFGD plants, it fell by 50% from 0,83t/TJ to 0,42t/TJ. This suggests that effective alternative abatement measures other than the installation of FGD have been implemented in NFGD plants, such as the use of cleaner coal or the application of advanced combustion techniques (such as fluidised beds, which also reduce sulphur emissions). Further, our analysis shows that additional SO_2 abatement measures besides the installation of FGD have been carried out in FGD plants as well. We conclude this from an encountrered drop in SO_2 intensity of fuel use in plants which have been fully equipped with FGD over the whole time period 2004-2012. In these plants no further FGD installation could have caused the decrease in the SO_2 intensity of fuel use.

Conclusions

EU-28 SO_2 emission regulations have encouraged the implementation of effective plant-based SO_2 abatement measures, of which the installation of FGD equipment has had the most significant impact in EU-28 large coal-fired power plants. Nevertheless, plants without FGD equipment installation have also considerably reduced their SO_2 intensity of fuel use applying alternative abatement measures such as the use of cleaner coal or the application of advanced combustion technology. On this basis we conclude that the regulatory concept of BAT, which leaves freedom for the choice of compliance measure, has been a successful policy tool in reducing the SO_2 emissions of EU-28 large coal fired combustion plants.

References

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