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Assessment and exploitation of energy-related externalities in the industrial sector

D. Diakoulaki[a,*], S. Mirasgedis[b], C. Tourkolias[a]

[a]*Laboratory of Industrial and Energy Economics, School of Chemical Engineering, National Technical University of Athens, Zografou, 15780 Athens, Greece*
[b]*Institute of Environmental Research and Sustainable Development, National Observatory of Athens, Lofos Nimfon, Thission, 11810 Athens, Greece*

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Abstract

The scope of this paper is to comparatively evaluate the effectiveness of alternative policy measures in reducing impacts from atmospheric pollution generated from industrial energy use. The evaluation procedure relies on the assessment of energy-related externalities by exploiting the methodology developed in the framework of the ExternE project. The analysis focuses on 2 industrial units located in the Greater Athens area and examines three types of abatement measures that can be used independently of the extent energy saving or end-of-pipe emission reduction measures are used: substitution of fuel oil with natural gas, relocation of the units several hundreds of kilometers far from Athens and increase of stack height in the same site. It results that the use of natural gas is by far the most effective among these measures, leading to a reduction of more than 90% of both local and regional damages. The relative effectiveness of the examined measures does not change if the significant uncertainties associated with the accounting procedure are taken into account, while inclusion of the external cost due to greenhouse gases emissions is further accentuating the advantages of natural gas. Moreover, it is shown that the quantifiable energy-related external costs of a single industrial product, may be very low compared to the corresponding private costs, but they sum up to significantly high damages to society if we take into account the total energy consumption in the industrial sector.

Keywords: External cost; Atmospheric pollution; Industry

1. Introduction

The industrial sector is a major contributor to atmospheric pollution, with energy consumption in the plant representing a significant source of atmospheric releases, especially of SO_2, NO_x and particulate matter. Depending on the temperature of exhaust gases and the stack's design parameters, as well as on the meteorological conditions at the site, these primary pollutants are dispersed in the atmosphere before precipitating and negatively affecting human health and ecosystems. Moreover, following chemical reactions in the atmosphere, SO_2 and NO_x are gradually transformed into secondary pollutants (ozone and aerosols), which are responsible for severe impacts on various receptors located at several hundreds of kilometers far from the source.

Impacts of atmospheric pollution impose costs on society which are often not at all or only partly considered in the production cost and in the market prices of the respective industrial products. In addition, greenhouse gases (GHG) and especially CO_2 emissions released from fossil fuel combustion constitute another source of social damages, in particular to forthcoming generations. The existence of these costs—the so-called external costs—constitute a severe market failure leading to the misallocation of scarce resources, since producers and consumers come to decisions that may be optimal for them but not for the society as a whole.

Although the concept and implications of environmental externalities were well founded within neoclassical economics, attempts for their quantification have basically started only in late 1980s. The focus was on the external

*Corresponding author. Tel.: +30 2107723254; fax: +30 2107723155.
E-mail address: diak@chemeng.ntua.gr (D. Diakoulaki).

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cost of electricity generation because of the key-role electricity plays in modern economies and the existence of several competing technologies, each with different environmental side-effects. Early studies were based on a top-down approach by first estimating aggregate damages for different impact categories that are subsequently attributed to various emissions for calculating external costs per unit of emission on the basis of emission inventories (Hohmeyer, 1988, 1992). The bottom-up approach—known also as the impact pathway approach—was developed in early 1990s and is generally considered as providing more reliable external cost estimates that are site- and technology-specific. The analysis begins with determining the pollutants released from a specific source, uses dispersion models together with detailed information on the distribution of receptors and dose–response functions for calculating physical impacts, which are translated into monetary terms by means of economic valuation techniques. The so calculated marginal damages have the additional advantage of allowing for the consideration of variations due to technology choices and siting decisions.

The ExternE project of the European Commission is one of the largest in scope and most widely appreciated studies using the bottom-up approach. Starting from the electricity generation sector, the developed methodological approach has subsequently been accommodated to the particular characteristics of the transport sector which is another major contributor to atmospheric pollution (European Commission, 1998; Friedrich and Bickel, 2001). Results of these studies and their exploitation in policy making are already abundant in the literature (e.g. Eyre, 1997; Krewitt et al., 1999; Krewitt and Nitsch, 2003; Mirasgedis et al., 2004; Int Panis et al., 2004). Energy-related externalities of the industrial sector have only partly addressed, as fraction of the overall damages produced by selected industrial processes. Specifically, the ECOSIT project has adopted and extended the ExternE methodology with the objective to quantify for specific innovative industrial technologies the damages associated with as much of the products' life cycle as was relevant (European Commission, 2003). The results of the study show that the calculated external costs strongly depend on the nature of the product, the process layout and the location of units, and should not be generalized and extrapolated to other situations.

However, if the focus of the analysis is restricted to energy-related externalities of industrial activities the results can provide valuable information to policy making, independently of the products' type. It is true that the external costs associated with industrial energy use are relatively small if reduced to the total production cost, because energy itself represents in most cases only a small part of the products' added value. Moreover, they could be small in comparison to total external costs produced by the specific industrial process. Nevertheless, the industrial sector as a major energy consumer is expected to significantly contribute to total energy-related externalities and their quantification could significantly assist in combating atmospheric pollution and climate change, especially if due to the location of industrial units the released emissions affect densely populated areas. It is clear that energy saving and end-of pipe emissions abatement measures are the priority actions that should be implemented in all industries in order to enhance their eco-efficiency. However, emissions concentrations in urban centers can be further alleviated by adopting more drastic interventions such as fuel shifts and relocation of units.

The aim of this paper is to exploit the ExternE methodology for assessing the relative effectiveness of alternative abatement measures in reducing damages caused by energy-related atmospheric pollutants emitted from two industrial units located in the Greater Athens area in Greece. The focus is on measures that can be implemented independently of the extent energy saving or end-of-pipe emission reduction techniques are already introduced in the units under consideration. Namely, three types of commonly implemented abatement measures are considered: increase of stack height for facilitating the rapid dispersion of the exhaust gases, substitution of heavy fuel oil by natural gas and relocation of plants to industrial parks in the North or South of Greece. Additional information is provided to policy makers by estimating climate change externalities in each case.

The obtained results are verified by taking into account the many uncertain parameters involved in the assessment of externalities. Among the different approaches used to handle uncertainty in external cost estimates, sensitivity analysis is clearly the simplest one producing "low", "medium" and "high" cost values by altering a small number of crucial parameters (European Commission, 1995). However, total uncertainty results as the combination of the uncertainties characterizing the several input parameters used in the accounting procedure. Thus, more sophisticated approaches relying on probability theory (IVM, 1995; Rabl and Spadaro, 1999), Monte Carlo techniques (Morgan and Henrion, 1990) or fuzzy logique (Mirasgedis et al., 1999) have been proposed in order to provide more reliable estimates of the plausible range of relevant values. In the context of this study, the uncertainties of the estimated externalities have been analyzed on the basis of the probabilistic quantitative approach presented in the most recent update of the ExternE methodology (European Commission, 2005).

The remainder of this paper is structured as follows: the accounting procedure is presented in Section 2 providing a summary description of the Impact Pathway Approach (IPA) developed and continuously improved in the framework of the ExternE project, as well as of the technique used in the treatment of uncertainties. Section 3 gives the necessary information regarding the contribution of industry to total atmospheric emissions in Greece and the details specifying the two case studies. Section 4 presents and discusses the obtained results, while concluding remarks are included in Section 5.