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Carbon pricing and the diffusion of renewable power generation in Eastern Europe: A linear programming approach

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Abstract

The purpose of this paper is to analyze the costs for reducing CO_2 emissions in the power-generating sectors in Croatia, the European part of Russia, Macedonia, Serbia and the Ukraine in 2020 by using a linear programming model. The model takes into account the impact of technology learning and is based on the underlying assumptions of the so-called RAINS model frequently used to assess the potential and the costs for reducing air pollution in Europe. The results based on an exogenously given 15 percent reduction target for CO_2 emissions show that the marginal cost for switching from a carbon-intense fuel to either a low-carbon or to a renewable energy source differs significantly among the countries. The marginal costs range from 4 to 90€ per ton CO_2, and are mainly due to country differences in the availability of renewables, existing technologies and costs. The results also indicate that although it is clear that the Eastern European countries are not homogeneous in terms of CO_2 abatement potential and costs, no general conclusions can be made of the region. This may have important implications for future JI/CDM activities. For instance, risk factors such as policy uncertainty and institutional obstacles may become crucial in determining the future allocation of JI/CDM projects across the region.

Keywords: Climate policy; Power generation; Renewable energy

1. Introduction

The adoption of the Kyoto Protocol in 1997 marks an important first step in the process of addressing the problem of global carbon dioxide (CO_2) emissions. A significant step towards compliance with the Kyoto Protocol will be the European Union's emissions trading scheme (EU ETS), which was implemented in the beginning of 2005 and that will make it possible for selected sectors of the European economies to trade CO_2 emission allowances within as well as across countries. Another measure for fulfilling the commitment is another so-called flexible mechanism, namely Joint Implementation (JI).[1] JI implies that Annex I countries can engage in JI activities where the country (or corporation) finances emissions reduction activities in another Annex I country, most likely in Eastern European countries. The rationale for JI is that Annex I countries with high marginal costs of CO_2 reduction will benefit from investing in other Annex I countries with relatively low marginal costs. High marginal cost countries such as Sweden can thus potentially make use of this option at a relatively large scale since it is unlikely that some of the low-cost countries will invest since they de facto do not face any binding abatement requirements.[2] It is commonly accepted that the Eastern European countries, or the so-called economies in transition, will be important host countries for future JI activities and consequently important for other European countries in order to fulfill the Protocol (e.g., Victor et al., 2001; Fankhauser and Lavric, 2003). From a Western European point of view it thus becomes important to assess the correct costs for CO_2 abatement in the power generation sectors among the Eastern European countries.

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[1]The Kyoto Protocol mentions three flexible mechanisms that can be used for emission reductions: Emissions Trading, Clean Development Mechanism (CDM) and Joint Implementation (JI). For a more comprehensive discussion of these mechanisms, see Ellerman (2000).

[2]See also Section 2.

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The purpose of this paper is to analyze the costs of reducing CO_2 emissions until 2020 in the power sectors in a number of Eastern European countries and regions: Croatia, Former Yugoslav Republic of Macedonia (Macedonia), European part of Russia, Serbia and Montenegro (Serbia), and the Ukraine. Particular attention is paid to how the pricing of carbon emissions may affect the diffusion of renewable power technologies in these countries. The study employs the underlying methodological framework of the RAINS model, which has been used to assess the potential and the costs for reducing air pollution in Europe.[3] Specifically, a linear programming model is used to estimate the costs of complying with pre-determined emission targets in each country given the available potential for renewables and low carbon-content fuels. The model takes into account the effect of technology learning on power generation costs The results from the analysis can be used to: (a) indicate how the diffusion of renewable energy resources will be affected by the combination of carbon pricing and an exogenously decided emission reduction in each country and (b) assess the overall economic conditions for JI activities in the selected countries.

There are at least three reasons for studying the above countries in the aforementioned context. First, there exists a gap in previous research concerning the impact of climate policy on the economics of power generation and technology choice in Eastern Europe.[4] Second, apart from the potential for JI activities, these countries will become important in a European perspective if they are incorporated in the EU emissions trading scheme. For instance, the Eastern European countries can, to the extent that they can offer low-cost carbon mitigation options, put a downward pressure on allowance prices. Third, a comprehensive assessment of the cost for utilization of renewable power in these countries will be important for projecting the future price on carbon and consequently facilitate investment decisions in the power sectors all over Europe.

In general, countries can comply with their reduction targets through achieving a lower final demand for energy, energy efficiency improvements and fuel switching. This paper is limited to only consider the latter measure. The focus lies on the potential to either switch to renewable energy sources, e.g., hydro, wind and solar, or to low-carbon intense technologies such as gas. The present paper does not attempt to provide an economy-wide analysis of carbon mitigation options, instead the focus lies on the power sector. In 1990 the power sectors accounted for some 36 percent of the total CO_2 emissions in Europe (Klaassen et al., 2004). Among the greenhouse gases (GHG) covered in the Protocol, CO_2 is the most critical one from a global warming perspective, and accounts for some 60 percent of the greenhouse effect (Houghton et al., 2001).[5] The power industry is a relatively attractive target for mitigation actions since power generation provides much flexibility in terms of fuel choices and the different fuels have significantly different carbon contents. Other sectors are often more difficult to target; for instance, the transportation sector relies almost exclusively on oil products and few substitute fuels exist.

The paper proceeds as follows. Section 2 briefly discusses European climate policy and the importance of the Eastern European countries. Section 3 describes the RAINS model and the methodology underlying the linear programming model used in this paper. Section 4 reviews the baseline scenarios and the potentials for different power generation sources in the selected countries. Section 5 presents the results of the model simulations and, finally, Section 6 discusses some limitations of the results and sums up the main findings.

2. Climate policy and the role of the Eastern European countries

The Annexes to the Kyoto Protocol not only states the amounts of reduction for each participating country, it also allows for Annex B countries to form a bubble to trade emission allowances. The bubble is given an aggregate reduction target and the countries within the bubble can thus reduce different amounts of emissions as long as the total emissions in the bubble are below or just at the target. The aforementioned EU trading scheme is one example of such a bubble policy. The scheme implies that the EU member countries listed in Annex B should together decrease their emissions by eight percent compared to their 1990 levels. Emissions trading prove its advantages over many other policies since it gives firms an incentive to reduce emissions cost-effectively but also provides continuous incentives for innovations in the environmental technology field. The latter is what Jaffe et al. (2005) refer to as "policy instruments that induce technological change". The EU emissions trading scheme can thus help to stimulate the development of new technologies and promote the diffusion of renewable energy technologies. There is, however, no guarantee that emissions trading alone will induce enough of technological change; one important reason why this may be the case is the presence of positive externalities related to technical development (ibid.). For this reason it may be necessary with additional polices that implicitly foster the diffusion of renewable energy sources, such as for instance R & D support and subsidy schemes targeted at infant energy technologies such as wind and solar power.

The EU trading scheme will allow for Kyoto offsets such as CDM and JI (EC, 2003b). Apart from the member states other Eastern European countries are currently not

[3]See Section 3.1 for a brief description of the RAINS model.

[4]See Section 2 for previous research covering this area.

[5]The remaining GHGs are methane (CH_4), nitrous oxide (N_2O), Hydroflourcarbons (HFCs), perflourcarbons (PFCs) and sulphur hexafluoride (SF_6).