FUTURE EMISSIONS OF GREENHOUSE GASES AND SULPHUR DIOXIDE FROM THE POWER SECTOR IN CHINA AND INDIA

Carolien Kroeze[1], Joyeeta Gupta[2], Jaklien Vlasblom[3], Kornelis Blok[3], Christiaan Boudri[1]

[1] Environmental Systems Analysis Group, Wageningen University, The Netherlands, carolien.kroeze@wur.nl

[2] Institute for Environmental Studies, Free University of Amsterdam, The Netherlands, joyeeta.gupta@ivm.vu.nl

[3] Department of Science, Technology and Society, University Utrecht, The Netherlands, k.blok@chem.uu.nl

ABSTRACT

We present results of a scenario analysis, focusing on emissions of greenhouse gases and sulphur dioxide from the electricity sector in China and India. The aim of the study was to quantify the technical potential of various options to reduce these emissions in the year 2020. More specifically, we aim to quantify the potential effect of climate policy in China and India on emissions of acidifying compounds. Our study indicates that it is possible to formulate different scenarios for the coming decades in which greenhouse gas and sulphur dioxide emissions are reduced simultaneously. In these scenarios, the envisaged growth in emissions is reduced to about half the *business-as-usual* trends. It should be noted that none of these scenarios include the typical end-of-pipe technologies usually applied to reduce acidifying compounds, like flue gas desulphurisation. The sulphur dioxide reductions therefore could be considered a side effect of climate policy. End use efficiency improvement may be one of the most effective ways to reduce emissions, in particular when combined with fuel switches.

INTRODUCTION

In many Asian countries, the electricity sector will be expanding during the coming decades. As a result, emissions of air pollutants are expected to increase as well. Kroeze et al. (2004) show that by the year 2020, greenhouse gas emissions from the power sector in China and India may increase considerably if emissions are not controlled. They also present scenarios indicating a potential to reduce these emissions to about half the unabated 2020 level. These reductions result from assumed reduction strategies ranging from efficiency improvement to fuel switch.

Many measures to reduce greenhouse gases are known to also affect emissions of other air pollutants. In this paper we take the abovementioned scenarios for emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), and present their effects on emissions of sulphur dioxide (SO_2) from the electricity sector in China and India. In other words, we aim to quantify the potential effect of climate policy in China and India on emissions of acidifying compounds.

SCENARIO DESCRIPTION

First, we analysed possible increases in emissions assuming that current trends continue in a so-called *Business-as-Usual* (BAU) scenario up to 2020. As described by Kroeze et al. (2004), this scenario was originally developed for the air pollution model RAINS-ASIA (Foell et al., 1995; Shah et al., 2000) that includes regional projections for future fuel in China and India as described in Amann et al. (2000), Boudri et al. (2000) and TERI et al. (1999). It is consistent with IPCC SRES scenarios A1 and B1 (IPCC, 2000). We used information on the power sector in China and India from these scenarios in our scenario analyses. Emissions of air pollutants were estimated based on emissions factors from the IPCC Guidelines for National Greenhouse Gas Inventories, country-specific emission factors or emission factors from the RAINS model (see Gupta et al., 2001). The RAINS *Business-as-Usual* scenario includes short-term policies and trends to 2020 including considerations on sustainability, existing institutional barriers, and economic constraints. The scenarios have taken into account policy plans for the period up to 2020 that were developed during the nineties.

Next, we analysed four alternative scenarios, the so-called Best-Practice-Technology (BPT) Scenarios, reflecting the combined technical potential of selected options to reduce greenhouse gas emissions. First, in a *Mixed Options* scenario (BPT1) we combine BPT options that were considered the most promising by Gupta et al. (2001), given their technical potential to reduce emissions and the views of stakeholders. These include some energy efficiency improvement, some replacement of coal by renewables, and reducing transmission and distribution losses. Second, the *Efficiency Improvement* (BPT2) scenario assumes that all options improving the efficiency of the power sector are fully implemented. Third, the *Fuel Switch* (BPT3) scenario assumes that policies are largely focusing on a switch from coal to other fuels, including both natural gas and renewables. Finally, the *Theoretical Maximum* scenario combines options for efficiency improvement and fuel switches (BPT4). This last scenario may not be realistic, because it does not consider the feasibility of reduction options. Details on these scenarios can be found in Kroeze et al. (2004).

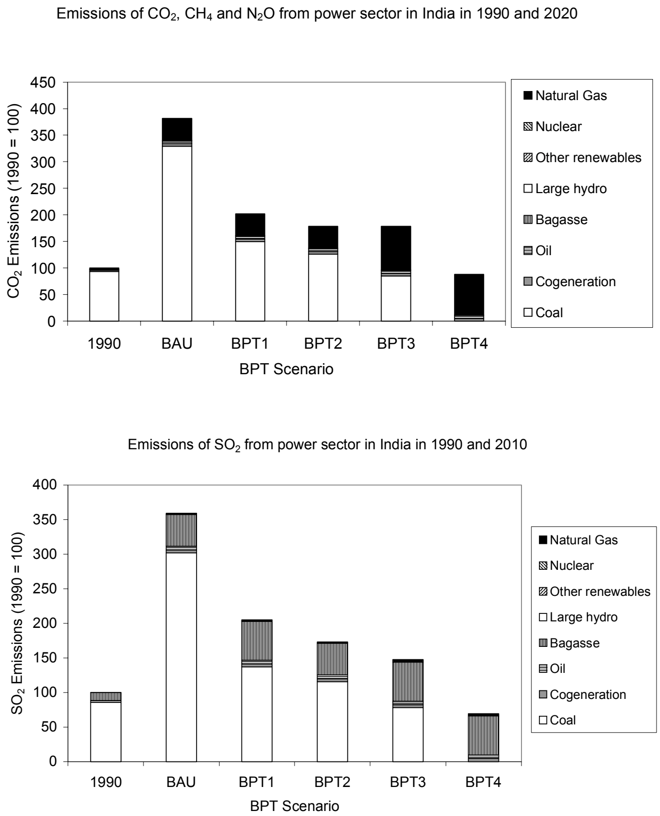

Fig 1. Emissions of greenhouse gases (CO_2, CH_4 and N_2O) and SO_2 from the power sector on India in 1990, and in 2020 in five scenarios (see text). Modified from Kroeze et al. (2004)

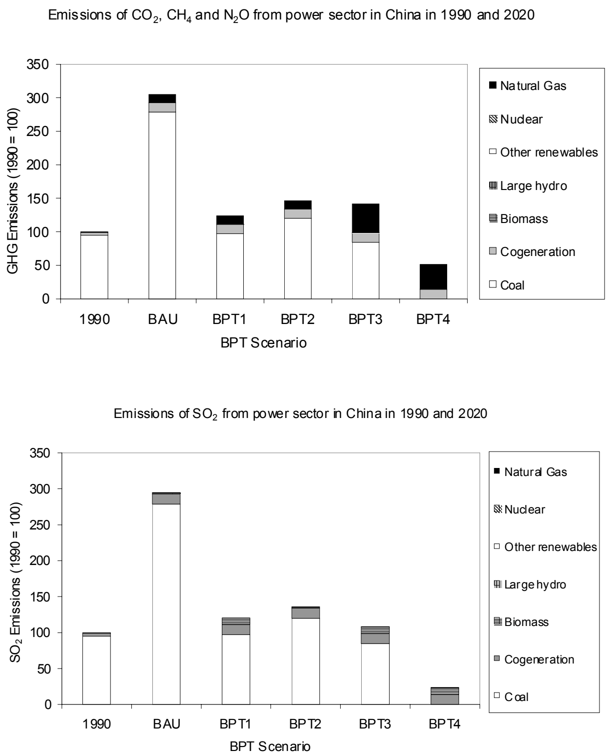

Fig. 2. As Fig. 1 but for China.

GREENHOUSE GAS EMISSIONS

Figures 1 and 2 present the resulting greenhouse gas emissions in 1990 and 2020 for the different scenarios. In the BAU scenario, electricity production increases by a factor of five between 1990 and 2020 in both countries. The associated greenhouse gas emissions increase by a factor of three in China, and a factor of four in India. In the BPT scenarios, emissions are reduced to about half of the 2020 BAU levels. This reduction is achieved in each of the three scenarios, indicating that there are different ways to considerably reduce greenhouse gas emissions from electricity generation in these countries. Figures 1 and 2 show that coal is the main source of greenhouse gases in both India and China.

SIMULTANEOUS REDUCTION OF GREENHOUSE GASES AND SO_2

Figures 1 and 2 illustrate the effects of climate policies on emissions of SO_2. Clearly, trends in emissions of SO_2 follow those of greenhouse gas emissions. Thus the envisaged growth in sulphur emissions is reduced to about half the BAU level in the different BPT scenarios. It should be noted that none of the scenarios presented here include the typical end-of-pipe technologies usually applied to reduce SO_2, like flue gas desulphurisation. The reduction therefore could be considered side effects of climate policy.

The options included in the scenarios are: efficiency improvement (both in end use and in power plants), a switch from coal to other fuels, closing small (old) power plants, increased cogeneration, and reducing transmission and distribution losses. When analysing the results, we observe that of these, end use efficiency improvement has a relatively large potential to reduce emissions both in China and India. A switch from coal to renewables or natural gas is also relatively effective. In addition, the feasibility to implement the technologies involved differs as well as their availability. Several technologies are readily available in China and India. For instance, China is leading in solar energy technologies. Likewise, India is advanced in wind energy. Also China will launch new plans to increase wind energy in the near future.

Like in many Asian countries, the economies in China and India will be growing fast during the coming decades. As shown in the BAU scenario, emissions of air pollutants are expected to increase as well. Nevertheless, China and India are in fact reducing the growth in emissions of greenhouse gases and acidifying compounds even in our BAU scenario. This is a result of policies driven not primarily by the large-scale environmental problems such as climate change, but rather an indirect result of actions aiming improving the local environmental quality.

As mentioned above, our scenarios do not include typical end-of-pipe technologies to reduce emissions of sulphur dioxide. For the electricity sector, these include low sulphur fuels (coal, oil), limestone injection, and flue gas desulphurisation. The technical potential of these options to reduce sulphur emissions from fuel use has been investigated in the RAINS-Asia model, indicating that it is technically possible to reduce SO_2 emissions from the power sector by at least 90% (Foell et al., 1995; Amann et al., 2000). Implementation of these technologies would, however, not reduce greenhouse gas emissions.

Our study indicates that it is possible to formulate different scenarios in which greenhouse gas and sulphur dioxide emissions are reduced simultaneously, relative to *business-as-usual* trends. There are different strategies possible for realising relative large emission reductions in China and India.

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