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Assessment of bottom-up sectoral and regional mitigation potentials

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ABSTRACT

The greenhouse gas mitigation potential of different economic sectors in three world regions are estimated using a bottom-up approach. These estimates provide updates of the numbers reported in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR4). This study is part of a larger project aimed at comparing greenhouse gas mitigation potentials from bottom-up and top-down approaches. The sectors included in the analysis are energy supply, transport, industry and the residential and service sector. The mitigation potentials range from 11 to 15 $GtCO_2$eq. This is 26–38% of the baseline in 2030 and 47–68% relative to the year 2000. Potential savings are estimated for different cost levels. The total potential at negative costs is estimated at 5–8% relative to the baseline, with the largest share in the residential and service sector and the highest reduction percentage for the transport and industry sectors. These (negative) costs include investment, operation and maintenance and fuel costs and revenues at moderate discount rates of 3–10%. At costs below 100 US$/$tCO_2$, the largest potential reductions in absolute terms are estimated in the energy supply sector, while the transport sector has the lowest reduction potential.

1. Introduction

An important question for climate policy making is how much greenhouse gas (GHG) emissions and energy can be saved, in which sectors and at what costs? Traditionally, two different approaches are used to answer this question: the **bottom-up and the top-down** approach. The bottom-up approach is based on technological and sectoral data and mostly physical indicators; the top-down approach describes processes within the economy as a whole including interactions on the basis of calibrated historical behaviour.

The Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC, 2007) includes both approaches to assess the medium-term sectoral potentials and costs of GHG mitigation. The results of the two approaches were found comparable on the global level. However, at a regional and sectoral level the results could not be compared due to various inconsistencies (Hoogwijk et al., 2008).

This study is part of a project in which bottom-up and top-down assessments of the sectoral and regional mitigation potentials are compared. In this paper the GHG emission reduction potentials are estimated at different costs levels for the timeframe 2030 using the bottom-up approach. A subsequent paper (Van Vuuren et al., 2009a) focuses on the top-down approach and compares the two approaches of bottom-up and top-down.

In this paper technical potential estimates are presented for four cost levels (0, 20, 50 and 100 US$/$tCO_2$) and three world regions (OECD, EIT and non-OECD[1]). Only the technical GHG abatement potentials associated with energy use are considered. Hence, the sectors included are the energy supply, transport, industry and residential and service sector, while the agricultural and forestry sectors are not considered. Further information can be found in the background project report (Hoogwijk et al., 2008).

The paper starts with a description of the general research methodology of the bottom-up approach (Section 2). In Section 3 the sectoral assessments are presented for the different sectors. Section 3.4 describes the energy supply sector and also corrections for possible overlap between sectors. The main findings are presented in Section 4, a discussion and conclusion in Section 5.

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[1] OECD includes all the countries of the Organisation for Economic Co-operation and Development excluding the economies in transition. EIT (Economies in Transition) includes the Eastern European countries as well as the countries formerly part of the Soviet Union. Non-OECD includes all other countries.

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2. Methodology

The general method of the bottom-up approach used in this study can be summarised by the following five steps:

1. Definition of the sector boundaries to avoid overlap between sectors.
2. Construction of the baseline for each sector (see Section 3).
3. Identification of the mitigation measures and related costs for all individual sectors (see Section 3).
4. Assessment of the sectoral mitigation potential at different cost levels for all individual sectors (see Section 3).
5. Aggregation of the sectoral potential to total potential including a correction of double counting potentials (see Section 3).

Below we describe the definitions of the sectors, the type of baselines and mitigation potential included. Detailed description of the assumptions used for the sectoral assessments can be found in Section 3 on transport, residential and service, industry and energy supply sector.

2.1. Sector definitions

2.1.1. Energy supply

The energy supply sector includes emissions from fuel use in centralised power generation and heat supply. It includes emissions from combined heat and power (CHP) if these are included in energy statistics as centralised distribution. Emissions related to extraction and distribution are not included in this sector.

2.1.2. Transport

The transport sector includes emissions from fuel use in passenger and freight transport, such as light duty vehicles (LDV), medium and heavy duty vehicles (MDV and HDV), emissions from public transport, motorcycles and emissions from aviation and navigation both inland and international.

2.1.3. Industry

The industry sector includes emissions from all industrial activities, both from fuel use and from major processes. Refineries are included in the industry sector. Both CO_2 and non-CO_2 emissions are included.

2.1.4. Residential and service[2]

The residential and service sector includes emissions from direct fuel use for space heating, water heating and cooking as well as the indirect electricity-associated emissions from space and water heating, space cooling and conditioning, appliances and lighting. A share of district heating emissions associated with heat supply to buildings is included into the buildings sector baseline but neither other emissions from the district heat sector nor options aimed to improve district heat production and distribution are studied. The research did not cover non-CO_2 emissions in the buildings sector (HFCs, HCFCs and CFCs) because their forecast and potential mitigation were recently reviewed in the IPCC/TEAP report (2005).

[2] The category of non-residential buildings is referred to by different names in the literature, including commercial, service, tertiary, public, office and municipal. In this study, all non-residential buildings are included in the service sector.

2.2. Differences compared to the IPCC AR4 (IPCC, 2007), baseline and sector

This study uses the AR4 analyses as a starting point. This was possible as most of the authors have been directly involved in the cost and potentials analyses for the IPCC AR4. However, in this study several additions have been made in order to make sectors more comparable and the reduction potential more complete.

The baseline used in this study is taken exogenously. For all sectors except the residential and service sector, the World Energy Outlook reference scenario, published in 2004 (IEA, 2004) has been used as the baseline scenario. For the residential and service sector a new baseline is constructed based on different aggregated literature sources (Ürge-Vorsatz and Novikova, 2008). However, in this study, the frozen reference parts are excluded in order to be more comparable to the baselines in other sectors. See Table 1 for an overview on where this study is additional to the AR4.

Sectoral baselines and potential estimates of the present research represent updated versions of those from the IPCC AR4. Table 1 summarizes the main updates which have been added to the initial assessment of each sector. Most of the updates in this paper are in the baseline. For instance, one of the major update in this study is the split between fuel, heat and power. This enables to show energy savings associated with electricity consumption in the end-use sectors or in the energy supply sector. This was one of the major differences with the top-down approach which shows electricity savings in the energy supply sector while the bottom-up approach tends to show these savings in the end-use sectors (Hoogwijk et al., 2008; Van Vuuren et al., 2009a).

2.3. Types of mitigation measures and costs included

This study focuses on the maximum technically deployment potential of energy savings at different carbon cost categories. The marginal costs are social turnkey abatement costs, including investment costs, operation and maintenance and fuel costs and revenues, using a discount rate in the order of 3–10%. The costs should be seen as costs in the timeframe considered using a current currency. In the Stern Review (Stern, 2007) the use of marginal costs is described as discussed. Marginal costs are useful for small changes. For large changes cost increases due to e.g. material shortage or cost decreases due to technological learning influence the costs to a large extend. The costs and the reduction potential in this study is calculated in isolation for all sectors. As such it can be used for decision making, but not to calculate overall societal costs of reductions.

The potential is based on physical and technical constraints as well as of the size of the market. Neither technical costs such as social or market nor non-technical barriers are included. The potential reduction at a sectoral level is estimated for a low and a high range representing the main uncertainties in the assumptions.

2.4. Aggregated mitigation potential

Interactions between the energy supply abatement options, i.e. the implementation of carbon free technologies, and the energy saving measures from the residential and industry sectors can cause double counting in the aggregated mitigation potential. The potential for carbon free power supply reduces if the total energy demand is reduced. At the same time, the CO_2 abatement from energy savings is reduced if the CO_2 emission factor is lowered because of more carbon free technologies. This is further