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ANALYSIS

EU low carbon roadmap 2050: Potentials and costs for mitigation of non-CO_2 greenhouse gas emissions

Lena Höglund-Isaksson [a,*], Wilfried Winiwarter [a,b], Pallav Purohit [a], Peter Rafaj [a], Wolfgang Schöpp [a], Zbigniew Klimont [a]

[a] International Institute for Applied Systems Analysis, Schlossplatz 1, A-2361 Laxenburg, Austria
[b] University of Graz, Institute for Systems Science, Innovation and Sustainability Research, Merangasse 18, A-8010 Graz, Austria

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ABSTRACT

This paper describes the development of emission scenarios for non-CO_2 greenhouse gases in the European Union as consistent with the energy scenarios used for the EU Low carbon Roadmap 2050. The analysis includes estimates of technical mitigation potentials and costs for mitigation of these gases until 2050 in the 27 EU member states. Results show that it would be technically possible to cut overall emissions of non-CO_2 greenhouse gases by about half between base year 2005 and 2050 in both of the energy scenarios defined. The adoption of mitigation efforts already in the baseline will, however, significantly depend on the expected development in the carbon price levels in the EU-ETS and non-ETS sectors.

1. Introduction

This paper describes the development of emission scenarios for non-CO_2 greenhouse gases (GHGs) in the European Union as consistent with the energy scenarios used for the EU Low carbon Roadmap 2050 [1,2]. In February 2011 the European Council confirmed the EU objective of reducing greenhouse gas emissions by 80–95 percent by 2050 compared to 1990 [1]. Between 1990 and 2005 GHG emissions in the EU-27 are estimated to have declined by seven percent, which means that to meet the target in 2050 emissions must decline by almost 80 percent compared to 2005 [1]. Non-CO_2 GHGs currently make up almost a fifth of total GHGs emitted in the EU-27 [3].

The analysis on projected emissions of non-CO_2 GHGs includes estimates of technical mitigation potentials and costs until 2050 for each of the 27 EU member states as well as for the EU as a whole. All non-CO_2 GHGs addressed under the Kyoto Protocol are considered, i.e., methane (CH_4), nitrous oxide (N_2O), and the three groups of fluorinated gases, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6). The conversion of non-CO_2 GHGs to CO_2 equivalents uses greenhouse warming potentials over 100 years corresponding to 21 times that of CO_2 for CH_4, 310 times that of CO_2 for N_2O and a range of 815–23,900 times that of CO_2 for the F-gases [4].

The analysis was performed using the simulation mode of IIASA's GAINS model (http://gains.iiasa.ac.at/) in its version of November 2011. This version includes a few methodological updates as compared to the September 2010 version that was used for the EU Low carbon Roadmap 2050 [1]. Main updates include revised methodologies for estimations of CH_4 emissions from gas distribution networks, long-distance gas pipelines, oil and gas production, coal mining, and industrial wastewater. Instead of relying primarily on reported emissions to UNFCCC and IPCC Tier 1 default emission factors, CH_4 emissions from gas transportation are modelled bottom-up using country-specific information e.g., on the structure of low and high pressure distribution mains in the national consumer gas networks as well as the length of on-shore gas pipelines and the volume of gas transported through. For oil and gas production, CH_4 emissions are estimated separately for intended flaring and venting of associated gas and for unintended leakage. CH_4 emissions from coal mining are estimated separately for pre-mining, mining and post-mining emissions. To estimate CH_4 emissions from industrial wastewater, the activity data is the COD content,

* Corresponding author. Tel.: +43 2236 807368; fax: +43 2236 71313.
E-mail address: hoglund@iiasa.ac.at (L. Höglund-Isaksson).

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which is derived from primary activity data on production volume in relevant industries. In total for EU-27, these updates increase baseline CH_4 in 2005 by four percent between the 2010 and 2011 versions of the GAINS model. A detailed description of the GAINS CH_4 estimation methodology by sector can be found in the Supplement of Ref. [5].

To facilitate a comparison with the analysis performed for the EU Low carbon Roadmap 2050 [1,2], the same base year 2005 is chosen in this analysis.

Two non-CO_2 GHG emission scenarios for 2050 were developed using input activity data consistent with the two energy scenarios "Reference 2050" and "Decarbonization with effective and widely accepted technology under global climate action". These scenarios were developed by the PRIMES model (National Technical University of Athens) for the EU Low carbon Roadmap 2050 [6] and were submitted to IIASA in April 2011. Further details on these scenarios can be found in Section 2.2. Both energy scenarios are consistent with a macroeconomic and population forecast for EU-27 provided by DG-ECFIN [7,8]. Data on animal numbers and fertilizer use consistent with the two PRIMES energy scenarios and with the macroeconomic projections by DG-ECFIN, were estimated by the CAPRI model (Bonn University) and provided to IIASA in November 2011. The work for this analysis extends and updates a previous scenario developed by IIASA to estimate non-CO_2 GHG emissions until 2030 [9].

The scope of this report is an assessment of the technical potentials to mitigate non-CO_2 GHGs based on the results of a literature survey of the current knowledge on mitigation technology, see Section 2.3. In addition to technical options, there are potentials for changes in consumer preferences and human behaviour, e.g., changes in human diets, which would be important options for achieving substantial and lasting reductions in non-CO_2 GHGs. However, these options are not within the scope of this analysis.

The structure of the paper is as follows: Section 2 describes the applied methodology. Section 3 presents results for baseline non-CO_2 GHG emissions, mitigation potentials and costs. Section 4 concludes the analysis.

2. Methodology

2.1. Emission estimation

In the general GAINS methodology described in Ref. [10], emissions from source s in region i and year t are calculated as the activity data A_{its} times an emission factor ef_{ism}. If emissions are controlled through implementation of technology m, the fraction of the activity controlled is specified by Appl_{itsm}, i.e.,

$$E_{its} = \sum_m [A_{its} * \mathrm{ef}_{ism} * \mathrm{Appl}_{itsm}], \quad (1)$$

where

$$\mathrm{ef}_{ism} = \mathrm{ef}_{is}^{\mathrm{NOC}} * (1 - \mathrm{remeff}_{sm}) \text{ and } \sum_m \mathrm{Appl}_{its} = 1, \quad (2)$$

and where A_{its} is the activity (e.g., number of animals, amounts of fuel or waste), ef_{ism} is the emission factor for the fraction of the activity subject to control by technology m, Appl_{itsm} is the application rate of technology m to activity s, $\mathrm{ef}_{is}^{\mathrm{NOC}}$ is the no control emission factor for activity s, and remeff_{sm} is the removal efficiency of technology m when applied to activity s.

The methodology applied for estimating baseline non-CO_2 GHG emissions in EU-27 has been described in detail for each emission source sector in Ref. [11] with recent CH_4 updates described in the Supplement of Ref. [5]. The general features of the GAINS methodology for the non-CO_2 gases have been described in previous reports [12–15]. This particular analysis builds on previous work by IIASA on non-CO_2 GHGs using GAINS for analysing the EU Climate & Energy Package [9,16].

In brief, the methodology (i) adopts exogenous projections of future economic activities as a starting point, (ii) develops a corresponding baseline projection of greenhouse gas emissions by primarily following the estimation approaches recommended in the IPCC guidelines [17,18] complemented with information, e.g., on current control, derived

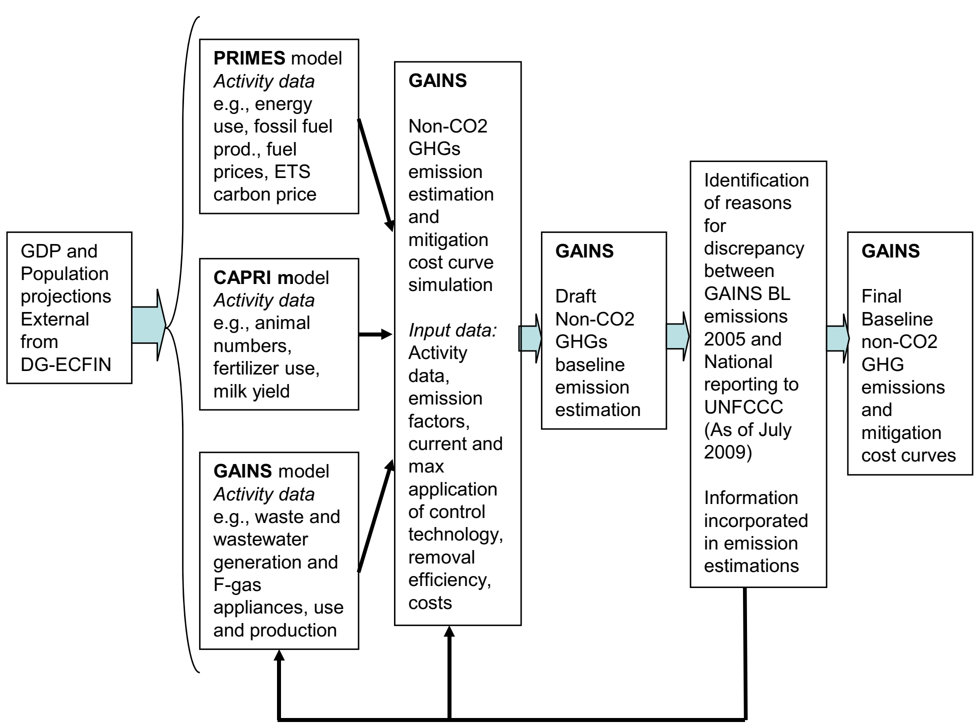

Fig. 1. Work procedure for the final estimation of 2050 emission scenarios for non-CO_2 greenhouse gases in EU-27 in the GAINS model.