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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Global anthropogenic methane emissions 2005–2030: technical mitigation potentials and costs" *by* L. Höglund-Isaksson

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I'd like to congratulate the authors with an excellent piece of work. This manuscript provides very useful quantitative information about the large mitigation potential of methane, which has already been pointed out before by several authors. To my knowledge, however, the quantitative side of the story – in particular concerning the costs involved - has not been analyzed to such a level of detail before. I have only a few comments that in my opinion should be addressed to make the manuscript understandable to a wider audience and would put the results in a wider perspective.

Author response: Thank you for very useful comments and suggestions. I have pre-

pared a revised version of the paper where I try to address all of the concerns you raise. The revisions made in response to your comments are explained below.

MAJOR COMMENTS

1.The costs in Figure 6-10 are expressed in euro, but it is unclear to me how they relate to the equations in section 2.2.2. For example, what is meant exactly by the 'unit cost of technology' in equation 3? I had expected C to be expressed in euro per avoided amount of CH4 or something like that. The term 'unit costs' suggests that it is some kind of normalized quantity and may apply to any currency. In that case, however, I don't understand equation 4, which clearly depends on the unit of "p". This should be clarified.

Author response: The unit mitigation cost refers to the annual mitigation cost per unit of activity. If the unit mitigation cost is multiplied by the activity level in a certain country and sector, you get the total annual mitigation cost. The marginal mitigation cost illustrated in the cost curves is derived by taking the additional total mitigation cost and dividing it by the emission reduction in the sector. In the revised version of the paper, Section 2.2.2 has been extended with the equations for the total cost and marginal cost in order to make clear how the marginal cost is derived from the unit cost. Regarding the generality of Equation 4, you are right that the way I had written it would require an explanation about the energy units used. However, I do not think it is necessary to specify exactly what energy units are used. Instead what is required for the generality of this equation to hold is that the price of electricity and the price of gas are expressed in the same energy units, e.g., Euro/GJ. As long as it is the same unit used for both prices, the generality of the expression holds. In the revised version I have added this requirement in the text proceeding Equation 4.

2. It is unclear how this work relates to what has been done before. The baseline emissions for 2005 are compared with other estimates. There is some discussion about the baseline of 2030. However, the text only mentions USEPA. More information

is actually provided in the tables. It is unclear why those estimates are not discussed in the text. Besides the baseline there must be other CH_4 mitigation scenarios to compare with, like those presented in some of the IPCC reports. In my opinion an extended comparison of the reported mitigation potential to other estimates is needed to put this work in the right perspective.

Author response: In the revised version, the comparison to other studies has been extended to also include the four RCP scenarios. To facilitate the comparison, baseline emissions have been aggregated to major sectors, see Table 9 of the revised version with illustration in Figure 9. In addition, the marginal mitigation cost curves have been compared to the USEPA (2006) cost curves for 2020. These are illustrated in Figure 6 in total and Figure 8 by sector and discussed in the text.

3.It is unclear why the uncertainty analysis only addresses the uncertainty of the baseline 2030 emissions and not the uncertainty of the mitigation scenarios both in terms of avoided CH_4 emissions and costs.

Author response: The reason for only discussing uncertainty in baseline emissions is that for these uncertainty ranges IPCC has specified such ranges for each emission source. The default uncertainty ranges from IPCC have been used as starting points for quantifying the uncertainty ranges by source. For mitigation potentials and costs, IPCC does not provide uncertainty ranges and these were therefore difficult to quantify. In Section 4 on Uncertainty, I have added two paragraphs about why uncertainty in mitigation potentials and costs is not quantified, but also included a sensitivity analysis of the gas price level on global mitigation costs, see also the illustration in Figure 11 in the revised version.

TECHNICAL COMMENTS

Page 11276, line 16: A CH_4 lifetime of 12 year seems rather long. It is true to there is some uncertainty in the estimates, but 10 year seems more appropriate (otherwise a reference is certainly needed here).

Author response: The reference used here is the Fourth Assessment Report from IPCC (2007), see http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html. For clarity, I have entered this reference next to the mentioning of the 12 years in the revised version.

Page 11281, Eq. 3: What is Iim?

Author response: Iim is the non-annualized investment cost for technology m in country i, i.e. the upfront investment cost. To make this clearer, Iim has been separated from the annualization factor in the text in the revised version. Further explanations have also been added in the descriptions.

Page 11283, Line 2: How realistic is this assumption? I have a hard time believing that investment decisions are made without consideration of the future fuel price development. To what extent does this assumption influence the difference between the private and social cost scenarios?

Author response: In the economics literature it is often assumed that if the future returns on investments are very uncertain then rational investors heavily discount such returns, meaning that investments will not take place unless expected future returns are very high and therefore compensate for the heavy discounting or uncertainty is reduced through e.g., future price guarantees. In a similar manner the slow adoption of low-carbon technology in response to the introduction of a carbon market with a positive carbon price, is often explained by high uncertainty about the future carbon price level as well as uncertainty about the survival of the carbon market as such. To strengthen this argument, I have rewritten the explanatory text in Section 2.2.3. and added a reference (Brunner et al., 2012).

Page 11289, Line 7: What is the problem to weighing the relative importance of different sectors to obtain global uncertainty estimates? Since you have an estimate of the emission per sector, wouldn't it be easy to weigh the uncertainty by that emission? This should be clarified.

Author response: Without knowing the probability distribution of the uncertainty ranges for each sector, it would be incorrect to simply add up the upper and lower end points for the uncertainty range of each sector to produce a global uncertainty range. If the probability distributions for each emission source were known, then the probability distribution for a global uncertainty range of say 95% confidence interval could be obtained through Monte Carlo simulation. However, as we only have the default IPCC uncertainty ranges for each emission source and don't know their probability distributions, a global aggregation of the uncertainty range is not possible. In the revised version this is clarified in Section 4 by adding the text "Merging up the sector uncertainty ranges to a global scale is not considered possible as it would require knowledge about the probability distributions of the sector ranges. With this knowledge a global uncertainty range could have been estimated using Monte-Carlo simulation (Winiwarter and Rypdal, 2001)".

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 11275, 2012.

		Model/Database								
		This study	GAINS UNEP (2011)	Cofala et al. (2007)	USEPA Draft Aug 2011	EDGAR v4.2	MiniCAM RCP 4.5	IMAGE RCP3 PD (2.6)	MESSAGE RCP 8.5	AIM RCP 6.0
	Major sector	Mt CH4								
Baseline 2005	Agriculture	123	123	130	133	143	126	133	134	136
	Waste & wastewater	57	50	69	57	58	63	55	73	62
	Fuel produc., transport. & energy use	140	112	96	114	122	85	92	104	87
	Burning of agr. waste, grassland, forest	3	3	11	20	24	27	27	26	27
	Industrial processes	0	0	0	0	0	2	2	1	1
	Total	323	288	305	325	346	302	309	339	314
Baseline 2030	Agriculture	143	143	149	157	n.a.	152	126	186	151
	Waste & wastewater	78	58	83	69	n.a.	67	28	127	56
	Fuel produc., transport. & energy use	189	160	190	159	n.a.	95	50	159	88
	Burning of agr. waste, grassland, forest	4	4	8	20	n.a.	16	26	25	28
	Industrial processes	0	0	0	0	n.a.	2	3	3	2
	Total	414	365	430	405	n.a.	332	233	499	325

Sources: UNEP (2011); Cofala et al. (2007); USEPA (2011); EDGAR (2012); IIASA (2012)

Fig. 1. Table 9: Comparison of GAINS model results for baseline global anthropogenic CH4 emissions with the results of other models.

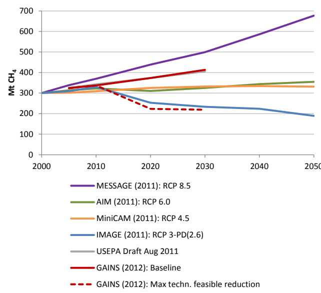

Fig. 2. Figure 9: Projection of baseline global anthropogenic CH4 emissions in GAINS in comparison to other models.

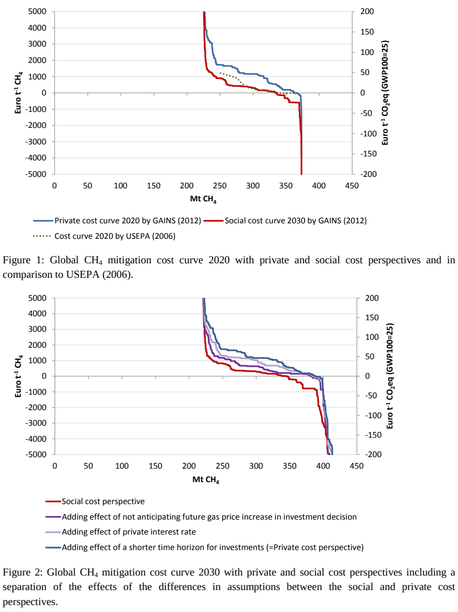

Fig. 3. Figure 6: Global CH4 mitigation cost curve 2020 with private and social cost perspectives and in comparison to USEPA (2006).

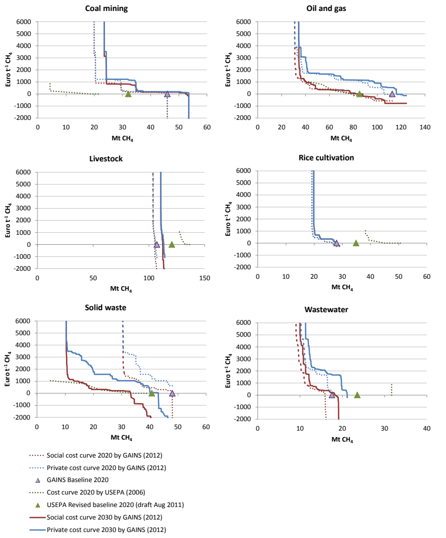

Figure 1: Global CH_4 mitigation cost curve 2020 and 2030 by sector with private and social cost perspectives and in comparison to USEPA (2006).

Fig. 4. Figure 8: Global CH4 mitigation cost curve 2020 and 2030 by sector with private and social cost perspectives and in comparison to USEPA (2006).

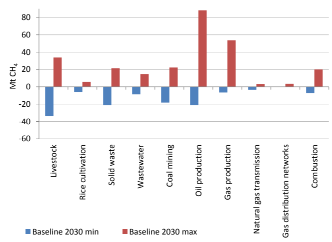

Figure 1: Uncertainty ranges by sector for global CH_4 emission estimates.

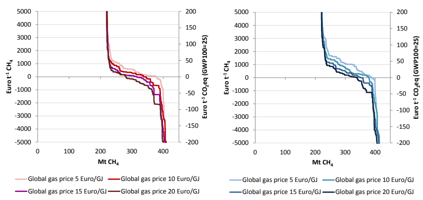

Figure 2: Sensitivity of the global marginal mitigation cost curve in 2030 to different assumptions of the future gas price level.

Fig. 5. Figure 11: Sensitivity of the global marginal mitigation cost curve in 2030 to different assumptions about the future gas price level.