Atmos. Chem. Phys. Discuss., 12, C5224–C5234, 2012
www.atmos-chem-phys-discuss.net/12/C5224/2012/

Atmospheric Chemistry and Physics Discussions

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

L. Höglund-Isaksson

hoglund@iiasa.ac.at

Received and published: 1 August 2012

Author Reply to Referee #2: Global anthropogenic methane emissions 2005-2030: technical mitigation potentials and costs Anonymous Referee #2 Received and published: 29 June 2012

This is an excellent and comprehensive study that shows an estimate of 2005 global methane emissions, emissions projected for 2030, and the availability of methane reduction measures for 2030 as a function of cost. This work will clearly be among the studies that will be widely referenced as a source of emissions estimates and for its estimates of the availability of emission reductions at different costs. The paper is strong in the comprehensiveness and detail in its estimates; while the paper is not highly detailed in all of the assumptions used, the extensive supporting information provides ample detail.

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

1.While I expect that this will be a publishable paper of high quality, I thought that there was one important omission that limits the usefulness of this paper in its current form. The author is careful to compare estimates of 2005 emissions with other studies. However, I think it would be relevant also to compare with the RCP scenarios, as these will be widely used, particularly for the 2030 projection. In addition, there is no comparison of the cost curves with previous work. As I understand it, many global integrated assessment models now use methane cost curves from the EPA and Stanford EMF. It would therefore be relevant to compare these cost curves with those used previously – at least to say whether this new study has identified new measures that were not included previously.

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 in Figure 8 by sector and discussed in the text in the revised version.

2. I also think that there is a missed opportunity to present results that are more policy relevant. The author focuses on the costs associated with “max implementation”. But some of the measures included here are so expensive that they would not likely be chosen. Instead there is an opportunity to discuss the emission reductions available at a net cost-savings or at modest prices (such as 25 Euros per ton CO2 equivalent).

ACPD

12, C5224–C5234, 2012

Reporting these figures not only provides a point of comparison with previous studies, but also might get the attention of people who could actually make decisions on methane control. These quantitative indicators could then be featured in the abstract and conclusions sections.

Author response: This suggestion is much appreciated. In the revised version I have extended Table 8 with estimates of emission reductions and costs for marginal costs in the ranges <50, <20, <10 and <0 Euro/t CO2eq. Results are also presented by world region. I hope this table can be useful for policy-makers. As this table hopefully presents regional results in a more useful way than the display of regional marginal mitigation cost curves included in the previous version, these graphs were removed in the revised version. Findings from Table 8 are featured in the abstract as well as in the conclusions as suggested.

More specific comments and questions:

- The abstract is short for my taste, and in particular, it lacks any results regarding the analysis of mitigation costs. This might be a good place to summarize how much reduction is available at a cost savings.

Author response: The abstract has been extended with a mentioning of how much of the technical mitigation potential that is available at a marginal cost less than 20 Euro/t CO2eq.

- In equation 1, it looks like different mitigation measures are added together. If we took two technologies that each reduced emissions by 50% from the same source, and applied both, would the net reduction be 100% or 75%? I would think 75%, but perhaps I am wrong. I'd like to see the author justify the treatment of multiple measures.

Author response: It would be 75% in GAINS. When there are multiple technologies in one sector, each technology is added sequentially, so that the first technology (usually the cheapest one) is applied to its maximum applicability rate (say 100% to make it simple) and if the removal efficiency is 50%, then 50% of emissions are removed. The next technology (second cheapest one) is then applied on the residual emissions to its maximum applicability (say 100%) and with a removal efficiency of 50%, it removes half of the remaining emissions. Hence, when both technologies have been applied, 75% of emissions have been removed. In some cases applicability of a certain technology is restricted due to political barriers, because other concerns than purely greenhouse gas limitations are weighed into adopted regulations. In such cases, the sequential adoption of technologies will not primarily follow the cost criteria (starting with the cheapest option), but first make sure the political limitations are met. An example is the solid waste sector, where the GAINS model defines an optimal technology adoption path adhering to the EU waste hierarchy, where separation and recycling/energy recovery of biodegradable waste is preferred to mixed treatment through, e.g., waste incineration, and diversion of waste away from landfills through different types of treatment is preferred to continued landfill disposal with landfill gas recovery. In the sequential adoption of technologies these rules are then met first before using cost as selection criteria. In Section 2.2.2., an explanation for the case of several technologies in one sector has been added in the text.

- I think Equation 3 would be better if it specified units in the description. This is important for equation 4, as this equation would only hold for some set of units that are not specified in the paper (that is, the 3 should have units).

Author response: It is difficult to specify the units in the descriptions in Equation 3 because they vary by sector, e.g., Euro per cow, Euro per GJ oil produced or Euro per ton waste generated.To make this clearer, I have added a paragraph with these examples below the descriptions. 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.

- Section 2.2.3 – I understand the motivation that a social perspective should consider a longer lifetime than the private. But shouldn't that lifetime also be a function of the technology? I'm surprised to see a uniform lifetime applied to all measures.

Author response: That equipment lifetimes are the same for all measures is a misunderstanding. The equipment lifetime is specific for each technology in GAINS. In the case of CH4 technologies, it varies between two years for small-scale household digesters to twenty years for e.g, a biogasification plant. The difference between the social and the private cost perspectives when it comes to equipment lifetime is that with a social perspective the entire lifetimes are anticipated (be they 2, 10, 15 or 20 years), while with a private cost perspective lifetimes exceeding 10 years are not accounted for in the investment decision. Hence, only technologies with a lifetime exceeding 10 years will have a different equipment lifetime in the private cost perspective. To make this clearer in Section 2.2.3 in the revised version I have added regarding equipment lifetime "..., which for CH4 mitigation technology included in GAINS varies from two to twenty years, ...", in the text. I have also put a technology index Tm on the equipment lifetime in Equation 3 to reflect that it is technology specific.

- Section 3.3 and figures 8 and 9 – I don't know what the "weighted marginal cost" means.

Author response: You are right that this was a sloppy way of expressing that I refer to a weighted average of the marginal cost, meaning that for the aggregation I have added up the total cost for all technology adoptions and divided it with the total reduction achieved by the same technology adoptions. In the revised version in Tables 7 and 8, I have tried to make this clearer by writing "Marginal cost (weighted average)" instead of "Weighted marginal cost".

ACPD
12, C5224–C5234, 2012

- Section 4 – since this deals with uncertainty in emissions and not in mitigation costs, would this be better before 3.3?

Author response: Since the other reviewer asked me to include a discussion about uncertainty in mitigation potentials and costs (or rather motivate why I have not included it), I decided to keep uncertainty as a separate Section 4 but include discussions about all types of uncertainty, i.e., in baseline emissions, in mitigation potentials and in costs.

- Conclusions – consider whether this section can be more quantitative, particularly for the mitigation measures.

Author response: In the revised version I have included quantitative results for how much global emissions can be reduced at a net profit and below 20 Euro/t CO2eq with a social and a private cost perspective, respectively.

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

ACPD

12, C5224–C5234, 2012

Interactive Comment

ACPD

12, C5224–C5234, 2012

Interactive Comment

		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.

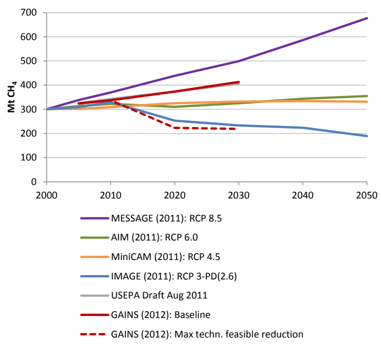

Fig. 2. Figure 9: Projection of baseline global anthropogenic CH4 emissions in GAINS in comparison to other models.

ACPD

12, C5224–C5234, 2012

Interactive Comment

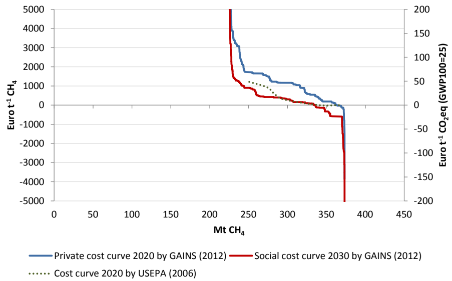

Figure 1: Global CH_4 mitigation cost curve 2020 with private and social cost perspectives and in comparison to USEPA (2006).

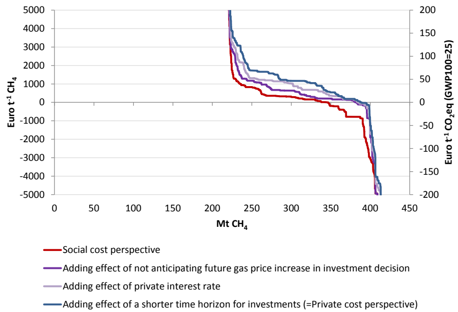

Figure 2: Global CH_4 mitigation cost curve 2030 with private and social cost perspectives including a separation of the effects of the differences in assumptions between the social and private cost perspectives.

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

ACPD

12, C5224–C5234, 2012

ACPD

12, C5224–C5234, 2012

Interactive Comment

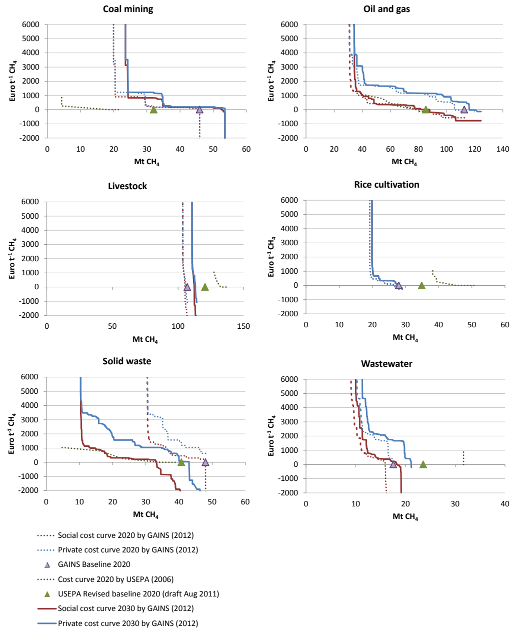

Figure 1: Global CH_4 mitigation cost curve 2020 and 2030 by sector with private and social cost perspectives and in comparison to USEPA (2006).

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).

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

Table 1: Costs for CH_4 technical mitigation potentials in 2030 by world region.

		Social cost perspective			Private cost perspective		
Cost range	World region	Emission reduction Mt CH_4	Marginal cost (weighted average) Euro t^{-1} CH_4	Total cost 10^9 Euro	Emission reduction Mt CH_4	Marginal cost (weighted average) Euro t^{-1} CH_4	Total cost 10^9 Euro
Max technical reduction 2030	Africa	24.4	-252	-6.1	24.4	1067	26.1
	Asia -rest	26.8	-257	-6.9	26.8	847	22.7
	Australia & N Zealand	1.7	395	0.7	1.7	1923	3.3
	China	31.0	-149	-4.6	31.0	568	17.6
	EU-27	4.5	-35	-0.2	4.5	1925	8.7
	Europe -rest	4.7	-100	-0.5	4.7	946	4.4
	India	8.3	-221	-1.8	8.3	866	7.2
	Latin & Central America	25.7	-287	-7.4	25.7	696	17.9
	Middle east	24.0	-683	-16.4	24.0	1140	27.4
	Russia	31.2	104	3.3	31.2	907	28.3
	USA & Canada	12.3	829	10.2	12.3	2344	28.8
	World	195	-151	-30	195	988	192
whereof < 1250 Euro t^{-1} CH_4 (i.e. < 50 Euro t^{-1} CO_2eq.)	Africa	23.2	-408	-9.5	9.2	-217	-5.0
	Asia -rest	25.6	-398	-10.2	14.7	-149	-3.8
	Australia & N Zealand	1.5	-109	-0.2	1.0	253	0.4
	China	30.5	-183	-5.6	25.2	133	4.0
	EU-27	3.9	-602	-2.3	2.6	210	0.8
	Europe -rest	4.5	-263	-1.2	3.3	48	0.2
	India	7.4	-650	-4.8	4.3	-446	-3.3
	Latin & Central America	24.7	-414	-10.2	22.0	241	5.9
	Middle east	23.9	-701	-16.7	21.6	855	20.4
	Russia	29.7	36	1.1	17.4	164	4.9
	USA & Canada	9.0	-310	-2.8	6.4	187	1.7
	World	184	-339	-62	128	205	26
whereof < 500 Euro t^{-1} CH_4 (i.e. < 20 Euro t^{-1} CO_2eq.)	Africa	20.1	-612	-12.3	3.7	-563	-11.3
	Asia -rest	20.5	-696	-14.3	9.3	-453	-9.3
	Australia & N Zealand	1.3	-263	-0.4	0.9	173	0.2
	China	19.0	-817	-15.5	15.2	-374	-7.1
	EU-27	3.1	-1033	-3.2	1.4	-135	-0.4
	Europe -rest	3.5	-599	-2.1	1.8	-336	-1.2
	India	5.9	-1034	-6.1	3.9	-631	-3.7
	Latin & Central America	21.6	-593	-12.8	5.3	-280	-6.1
	Middle east	22.1	-830	-18.4	1.6	-116	-2.6
	Russia	26.4	-56	-1.5	9.9	-73	-1.9
	USA & Canada	8.0	-496	-4.0	5.2	37	0.3
	World	152	-597	-90	58	-740	-43
whereof < 250 Euro t^{-1} CH_4 (i.e. < 10 Euro t^{-1} CO_2eq.)	Africa	8.0	-2020	-16.2	3.6	-1410	-11.3
	Asia -rest	11.4	-1513	-17.3	7.3	-874	-10.0
	Australia & N Zealand	1.3	-300	-0.4	0.0	-29	0.0
	China	16.0	-1024	-16.4	13.9	-474	-7.6
	EU-27	2.7	-1204	-3.3	1.1	-192	-0.5
	Europe -rest	3.2	-690	-2.2	1.6	-387	-1.2
	India	2.0	-3799	-7.5	1.3	-2339	-4.6
	Latin & Central America	19.0	-733	-13.9	3.4	-363	-6.9
	Middle east	21.8	-850	-18.5	1.6	-118	-2.6
	Russia	14.8	-379	-5.6	9.1	-151	-2.2
	USA & Canada	7.0	-602	-4.2	3.7	-13	-0.1
	World	107	-984	-106	47	-1008	-47
whereof < 0 Euro t^{-1} CH_4	Africa	3.7	-4494	-16.6	3.1	-3079	-11.4
	Asia -rest	6.4	-2773	-17.9	5.0	-1614	-10.4
	Australia & N Zealand	0.5	-1135	-0.5	0.0	-79	0.0
	China	5.0	-3629	-18.2	2.9	-1931	-9.7
	EU-27	1.6	-2200	-3.4	0.7	-389	-0.6
	Europe -rest	1.6	-1486	-2.4	0.6	-847	-1.4
	India	1.8	-4110	-7.5	1.3	-2523	-4.6
	Latin & Central America	14.3	-1026	-14.7	3.0	-488	-7.0
	Middle east	20.1	-938	-18.9	1.6	-128	-2.6
	Russia	8.5	-716	-6.1	7.7	-284	-2.4
	USA & Canada	5.6	-820	-4.6	0.5	-64	-0.4
	World	69	-1602	-111	26	-1911	-50

Fig. 5. Table 8: Costs for CH4 technical mitigation potentials in 2030 by world region.

ACPD

12, C5224–C5234, 2012