Review of "Test Procedure for Determining Annual Flash Emission Rate of Methane from Crude Oil, Condensate, and Produced Water Tank and Separator Systems"

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On August 10, 2016 Elizabeth Scheehle of the California Air Resources Board signed the memorandum: “Request for External Peer Review of the Test Procedure for Determining Annual Flash Emission Rate of Methane from Crude Oil, Condensate, and Produced Water Tank and Separator Systems”. In response, my review below was solicited by Dr. Gerald Bowes of the State Water Resources Control Board on October 26, 2016 and contains my professional opinion on this work. **Specifically, my report comments on Conclusion #3 of the memorandum "The Test Procedure provides a sound approach for calculating the emissions of methane and various other pollutants from flashed gases from oil and gas production separator and tank systems"**, but also contains some additional scientific comments.

The report is part of a detailed plan to mitigate methane emissions associated with oil and natural gas production in California. A strong case is made that methane emissions can be significantly reduced using a combination of emissions avoidance, leak detection and repair, and replacement of specific components of the infrastructure.

In response to the conclusion "**The Test Procedure provides a sound approach for calculating the emissions of methane and various other pollutants from flashed gases from oil and gas production separator and tank systems**", I have the following comment:

Methane emissions, and the proposed reductions therein, are calculated based on activity (e.g. produced oil, natural gas and water) and emission factors for each of these processes. Activities are obtained from operator surveys and emission factors are, in part, determined from measurements in California described in the report. These are certainly defensible choices. However, there are uncertainties in these estimates and those need to be acknowledged and addressed. Recent work has shown, for example, that emission factors are not constant values as assumed in the report, but depend strongly on the type of well (conventional vs. unconventional) as well as the throughput (Omara et al., 2016). There is evidence to suggest that higher producing natural gas wells leak a smaller fraction of their produced methane to the atmosphere. Higher producing wells are often newer, have more modern equipment and the operators have more incentive to maintain them properly, so this makes sense. While there is

insufficient information to improve the emissions estimates in the report, the resulting uncertainties should be described and can even be quantified to some extent. For example, the functional dependence of methane emission factors on throughput can be taken from the literature (Omara et al., 2016) and used for the present analysis to quantify how sensitive the emission results are to these different assumptions. Also, a more detailed analysis of the extensive results listed in Tables D-12 and D-13 might give information on how emission factors depend on throughput for wells in California. As far as I could tell, these results are only used in the report to determine average emission factors for different parts of the oil and gas production infrastructure. Evidence from the Uintah basin in Utah has shown that emissions estimates based on the same methods as used here underestimated methane emissions by a factor of ~5, underestimated VOC emissions by factor of ~2, and overestimated NOx emissions by a factor of ~4 (Ahmadov et al., 2015). Similarly large uncertainties in emissions estimates for methane have also been reported in the Denver-Julesburg basin in Colorado (Petron et al., 2012). These are not small effects and this needs to be acknowledged and addressed in the report.

I also have the following **Big Picture Comment**:

Given the uncertainties described above, a verification effort to evaluate the regional emissions of methane before, during and after the implementation of the proposed regulation appears to be a highly desirable addition to the plans. This would provide evidence for the success of the regulations and could also be useful to adjust the regulation to be more (cost)effective. In addition, by documenting the effects on methane and air pollutant emissions of these regulations, the State of California has the unique opportunity to provide a blueprint for other states on how to effectively reduce methane emissions from the oil and gas industry. The report describes that most of the emissions reductions are anticipated in the San Joaquin Valley. A monitoring program or a series of targeted studies would allow the quantification of regional emissions of methane and air pollutants in the San Joaquin Valley before, during and after the implementation of the proposed regulation.

Detailed comments:

Many of the figure references in the "Staff Report: Initial Statement Of Reasons" are off. In most cases, it was clear what figure or Table was referred to, but some more careful proofreading would have been useful.

Page ES-1, "*Methane is 72 times more potent than CO2 as a GHG when considered on a twenty year time frame.*": please add a reference. Also, note that the IPCC AR5 report has a different number for the 20-year global warming potential of methane (84, as mentioned later in the report). The difference is due, in part, to the way that the direct and indirect effects of reactive trace gases on radiative forcing were accounted for in AR5.

Page 2, "*Their relative climate forcing (or impact), when measured in terms of how they heat the atmosphere, (see explanation of global warming potential in footnote 10) can be tens, hundreds, or even thousands of times greater than that of CO2.*": more accurately, the climate forcing on a per-molecule basis can be much larger than for CO2. As written, the sentence may be understood that the total forcing of methane is higher than of CO2, which is not the case.

Page 29 and 30, Tables 5 and 6: the source of these numbers was unclear.

References

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