CARB Letter

**Summary**

The Compliance Offset Protocol Task Force (Task Force) should revisit the science underlying the Maximum Methane Potential (MMP) by Livestock Category employed in the Compliance Offset Protocol for Livestock Projects Livestock Projects (LOP). As a result of these MMP factors potentially being outdated, the Protocol may be underestimating—by as much as 40%—the true Maximum Methane Potential values for manure from dairy cows.

The MMP value for dairy cows found in Table A.2 of the LOP is 0.24 m3 CH4/kg VS.[[1]](#footnote-1) Early in efforts to account for the greenhouse gas (GHG) emissions from these sources, this MMP number was identified by the United States Environmental Protection Agency (EPA) using literature dating back to 1976, when cows did not have a proper feeding regimen. We believe that the change in diet in more recent years may account for the difference between the MMP values used in the LOP and our “current day” observations of recent manure samples.[[2]](#footnote-2)

**About Digester Doc**

Digester Doc is a full-service laboratory testing and analysis firm for the anerobic digestion (AD) industry.[[3]](#footnote-3) One of our firm’s specialties is Biochemical Methane Potential (BMP) tests, which are used to determine the anaerobic biodegradability and ultimate methane potential of feedstocks under laboratory conditions. Our laboratory frequently conducts BMP analysis for customers wishing to optimize dairy digester operations.[[4]](#footnote-4) As a result of conducting these analyses for a variety of dairy manure streams submitted for our clients, we believe the LOP may be underestimating the true BMP value for most manures.

**Recommended Areas for Investigation**

We recommend that the Task Force explore the following three areas that may be creating the divergence between the LOP’s legacy MMP value for dairy cows and our testing of current samples:

1. ***Availability of Any More Current Literature Specific to MMP***

We believe the LOP MMP values are derived from the same literature used by US EPA for this factor when developing the *National Inventory of U.S. Greenhouse Gas Emissions and Sinks*.[[5]](#footnote-5) The earliest study cited (Morris 1976) appears to be the derivation of the MMP value of 240 ml CH4/ g VS BMP for dairy cows. Although this number is a well-established standard for calculating dairy and swine emissions, which both the EPA and CARB use across a variety of programs, the literature has not been updated to account for constant changes in dairy and swine practices over time.

More recent research (1) has found that the enteric emissions of cattle have shifted due to change in diet—from being grass/hay fed in the 1970’s to the current regiment of feeding cows a balanced feed regiment. This change has resulted in cows producing less enteric emissions,[[6]](#footnote-6) improved conversion of organic matter to milk and body fat as well as retention of more methane potential within the manure itself. This makes the manure a better feedstock for Anaerobic Digestion, but it is bad for the environment because (when AD is not utilized) methane emissions associated with manure degradation in storage lagoons are increased.

Digester Doc BMP studies have demonstrated up to a 41% increase beyond the 1976 number (240 ml CH4/g VS) in some manures, but this is not a standardized result and the range is significant depending on the energy values of the feed rations fed to cows and other factors. As a further example of observed variability based on diet, one set of BMP tests done with a client of Digester Doc over 6 months, was done while 30% of the feeding was done in field as opposed to 6 months later when the animals were entirely fed on a specific diet regiment. The result was nearly 200 ml CH4/g VS change in the BMP value with one compared to the other.

In 2015 a dairy study was conducted by Kun Li, (2) found that a 270 ml CH4 / g VS was accomplished, thus having an increase over the standard 240 BMP. Another study completed by Chen Fen noted results in 2017 of 290 ml CH4 / g VS (3) as well as in 2020 a study by Naseefa Batool discovered a BMP value of 358.7 ml CH4 / g VS (4). Most recently at our facility we have accomplished an achieved a dairy manure BMP value of 408 ml CH4 / g VS. Knowing this we realize that the low-rated value of 240 can be significantly increased.7

These early studies were designed with a 25% to 45% COD conversion to CH4 in the 30-day study window. The findings from numerous scientists including that of Digester Doc has been that a study of manure taken for a full 200- to 300-day timeframe (more similar to a lagoon at a dairy) reveals much greater methane potential.

1. ***Availability of Literature on How Dairy and Swine Diets Have Changed***

As CARB recognizes, there are regional differences in feed rations and animal weight as well as differences in manure handling practices. This indicates that CARB is aware that feed nutrition differs from site to site (farm to farm) and therefore even the manure itself will vary from farm to farm based on the nutrients provided in those dairy feed rations. Even the amount of manure generated on a specific farm will vary depending on local situations. This same diversity is impacted in the manure energy potency as well. When comparing COD, TS and VS you can see a tremendous variety in the manure numbers that indicate varying potency of potential methane generation. As outlined by John P. Chastain, and James J. Camberato of Clemson University (5).

In 2018 study “A comparison of milk yields and methane production from three contrasting high‐yielding dairy cattle feeding regimes: Cut‐and‐carry, partial grazing and total mixed ration” (6). Found that providing fixed mixed rations decreased enteric methane production as opposed to cut and carry practices as well as grazing practices by 17% and 39% respectfully. Again, supporting the understanding and belief that more energy is travelling to the manure as well as to the milk and body weight growth of the cow. It makes sense then that feed diet rations themselves, and the composition in them, carry a significant impact on the total energy value (and likely methane generating potential) of the ending manure.

1. ***Advancements in Research and Knowledge in Other Related Areas***

The scientific communities’ understanding of the microbiology present in anaerobic digesters (AD) has greatly advanced in the last 20 years. Ten years ago, there were only 30 cataloged methanogens; today there are hundreds. Identifying which methanogens are present in the AD enables laboratories (like Digester Doc) to develop an optimization plan for each individual feedstock. Methanogens, like all organisms, require certain trace elements, micro- and macronutrients to function properly. Other improvements in AD design and monitoring have been updated to reflect the growing knowledge that the biological health of an AD is important for uninterrupted methane production.

There have also been recent developments in the science that underlies the full impacts of trace elements (think vitamins and nutrients like B12 and D) on microbes involved in AD. When these trace elements are properly balanced, microbes are able to more completely and efficiently break down the feeds they are presented with. We have found that methane that would have take 240 days, now is obtained in 23 to 45 days in a controlled BMP study, with this corrective chemistry. This implies that, historically, shorter studies to determine MMP from various materials may have not captured the full potential, due to not fully understanding these impacts.

**Conclusion**

While we recognize that the observations of one analytical laboratory is not a substitute for peer-reviewed studies on this topic, we believe our analysis strongly implies that the current MMP values for dairy manure used in the LOP are likely outdated and should be revisited. We look forward to the Task Force exploring the literature around this issue, and we’d be happy to provide any insights based on our experience if that would be helpful. The consequences of not investigating this issue might be continued significant underestimation of emissions from dairy manure and significant under crediting of the benefits of projects following the LOP.

Yours Sincerely,

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3. Chastain, John P. and James J. Camberato. “Dairy Manure Production and Nutrient Content”, 2015, pp. 1-16, www.clemson.edu/extension/camm/manuals/dairy/dch3a\_04.pdf. Accessed 4 November 2020.
4. Cameron, L., Chagunda, DJ Roberts, and M.A. Lee, “A Comparison of Milk Yields and Methane Production from Three Contrasting High-Yield Dairy Cattle Feeding Regimes: Cut-And-Carry, Partial Grazing and Total Mixed Ration”, 2018, pp. 1-32, pure.sruc.ac.uk/ws/files/18136412/14885681.pdf. Accessed 4 November 2020.

1. Equivalent to 240 ml CH4/ g VS, which is how the units are most frequently expressed in our tests. [↑](#footnote-ref-1)
2. There may be similar issues with the Swine MMP value, but only have 5 tests to base this evidence on currently compared to a much larger dataset for dairy manure. [↑](#footnote-ref-2)
3. <https://www.digesterdoc.com/about> [↑](#footnote-ref-3)
4. We also conduct other related tests, such as chemical oxygen demand (COD) analysis. A COD equation based on analyzed COD with a % conversion factor is another method of estimating Maximum Methane Potential of a given manure (in the absence of a measured BMP analysis). Digester Doc, using a calculation matrix balancing COD to total solids (TS)/volatile solids (VS), can establish an estimated or theoretical methane potential that can be used as a consideration or quick estimation, but this does not replace the purpose or value of conducting a proper BMP study. [↑](#footnote-ref-4)
5. The most recent US EPA GHG inventory is here (see page 5-14 for a list of references on MMP): <https://www.epa.gov/sites/production/files/2020-04/documents/us-ghg-inventory-2020-main-text.pdf> [↑](#footnote-ref-5)
6. A comparison of milk yields and methane production from three contrasting high-yielding dairy cattle feeding regimes: Cut-and-carry, partial grazing and total mixed ration. <https://www.researchgate.net/publication/323524726_A_comparison_of_milk_yields_and_methane_production_from_three_contrasting_high-yielding_dairy_cattle_feeding_regimes_Cut-and-carry_partial_grazing_and_total_mixed_ration>. These studies have found varying reductions from 25% to 39% less enteric emissions.

   7 Comparison of anaerobic digestion characteristics and kinetics of four livestock manures with different substrate concentrations. <https://www.sciencedirect.com/science/article/abs/pii/S0960852415012675> [↑](#footnote-ref-6)