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Cooperative Extension Service

Going Green: Ten Fundamentals of Greenhouse Gas Emissions for Beef Systems

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Global warming has become a key focus of all agricultural sectors during the late 2010s and early 2020s. Discussion on identifying and increasing adoption of sustainable practices, shifting from gasoline to electric automotive engines, and producing alternative sources of energy continually permeate the airwaves. These various proposals are accompanied with new terminology and concepts that may not be fully defined for the audience. As a livestock producer, it is important to know and understand how new legislation for limiting greenhouse gas emissions in the agricultural sector could be directed toward the farm gate.

1. What are greenhouse gases?

Greenhouse gases (often abbreviated as GHGs) are defined by the U.S. Environmental Protection Agency as "gases that trap heat in the atmosphere." The four main greenhouse gases measured as a percentage of total 2020 U.S. emissions are carbon dioxide (CO_2) at 79 percent; methane (CH_4) at 11 percent; nitrous oxide (N_2O) at 7 percent; and fluorinated gases at 3 percent. Fluorinated gases are most often emitted from household, commercial, and industrial applications. The gases commonly associated with agriculture are CO_2, CH_4, and N_2O, as these are commonly derived from equipment exhaust (CO_2), microbial digestion (CH_4), and use of chemical fertilizers (N_2O).

However, simply knowing the overall concentrations of these GHGs is not informative when attempting to reduce overall emissions. Decision-makers must understand the extent to which these gases are emitted over an extended period and how these emissions relate to the formation and subsequent dissemination of various products, materials, or services, as the emission rates of GHGs are not uniform across all industries and products (Figure 1). Furthermore, attempting to calculate the given impact of an industry using individual values for each GHG can lead to confusing equations and potential errors in estimates. These estimates need to be relatable both within and across industries if effective recommendations for improvement are to be made. Thus, a more standardized approach is needed, which is where the concepts of lifecycle analyses, carbon footprints, and CO_2 equivalents come into focus.

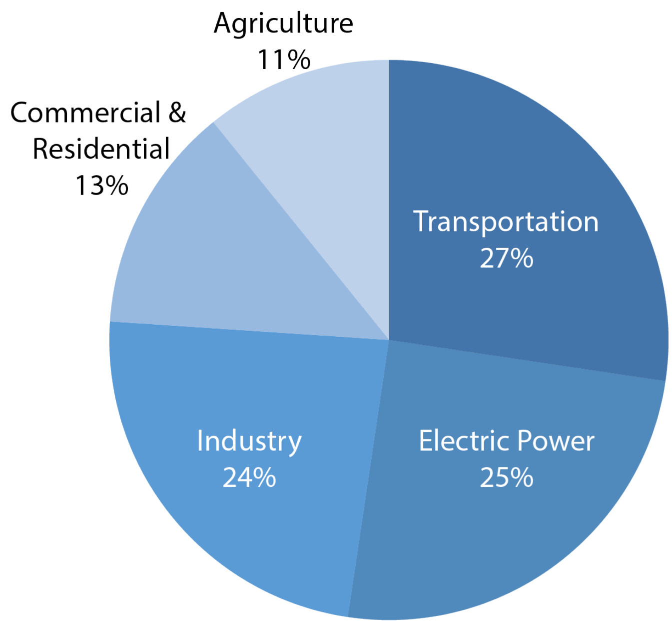

Figure 1. Percentage of total U.S. greenhouse gas emissions by economic sector in 2020.
Source: US Environmental Protection Agency (2022). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020 (https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks).

2. What is a lifecycle analysis?

A lifecycle analysis (LCA) examines each stage of production of a commodity, from start to finish, to determine its overall impact on GHG emissions. However, LCAs differ among and within industries, as inputs and outputs vary based upon the end products. Additionally, the scope for determining what is and is not included in calculating GHG emissions generated by an industry can be subjective (e.g., do you only include emissions from the growing calf, or do you also account for the emissions associated with feeding the calf, transporting the calf from the farm to market, etc.). Currently, the livestock industry considers all contributing sources when calculating the LCA, not just those contributions from the animals themselves. To normalize the lifecycle development process across industries, the International Organization for Standardization developed criteria a LCA must include to be deemed interpretable. Lifecycle analyses are often quantified using what are known as carbon footprints.

3. What is a carbon footprint?

The Food and Agriculture Organization of the United Nations defines the carbon footprint of a food product (e.g., cattle and other livestock species) as "the total amount of GHG emitted throughout its lifecycle, expressed in kilograms of CO_2 equivalents. GHG emissions of the production phase (including all agricultural inputs, machinery, livestock, and soils) and successive phases (such as processing, transportation, preparation of food, and waste disposal) are all included in this calculation." Thus, an LCA expresses the carbon footprint in units of CO_2 equivalents. However, the way this is estimated differs based on the industry due to differences in emission rates, activities, etc. As mentioned above, animal agriculture is associated with the release of three GHGs: methane, carbon dioxide, and nitrous oxide.

4. What is a CO_2 equivalent?

When a new program is introduced, the end user ultimately benefits when the system architects simplify procedures. The same is true with the proposed carbon credit system, which is based on estimating the emission rates of different gases and their effects on the environment. Rather than proposing a complex system of equations for estimating total pollution rate, the carbon credit system converts each gas into a CO_2 equivalent. This is accomplished through a system of values that equates one unit of CO_2 with a relative number of units of a given GHG. By placing everything in equal terms, the end user simply needs to sum all the CO_2 equivalents together to determine the GHG potential of the entire production system and the number of carbon credits used during a given period.

5. Where does CH_4 come from?

Methane gas is emitted from a variety of sources, including coastal wetlands, termites, natural gas leaks, and processes associated with the refinement of crude oil, to name a few. Within agriculture, methane is produced as an end product of microbial metabolism of feed in all livestock species and manure, which accounts for most of the methane produced by agricultural activities. The EPA estimated that approximately 27 percent of total 2020 U.S. methane emissions were attributed to enteric fermentation. Ruminants are the largest contributors of GHG emission from livestock because of the microbial contribution to digestion in the rumen that produces methane and CO_2. Methane represents a large source of energy loss by the animal, resulting in a decrease in potential growth efficiency. Therefore, minimization of methane formation is a common goal for producers and sustainability advocates. However, GHG emissions attributed to the livestock industry are also generated in manure (Figure 2). The storage pits and piles continue to release methane from microbial degradation of undigested feed. The EPA estimates that approximately 9 percent of livestock-related methane production is generated from manure systems. Such manure collection points are common in ruminant, poultry, swine, and equine industries.

6. What is carbon sequestration?

Carbon sequestration refers to proposed methods of storing carbon. There are two main types of carbon sequestration: geologic and biologic. According to the U.S. Geological Survey, a division of the U.S. Department of the Interior, geologic carbon sequestration requires carbon to be pressurized into liquid form. After the desired pressure is attained, the liquified carbon is then pumped into porous rock located in the geological basin for storage. By comparison, biologic carbon sequestration refers to methods of storing gaseous CO_2 in biological systems such as aquatic environments, soil organic matter, and woody products. Biologic sequestration is the most common of the two methods and can occur without human intervention. Specifically, trees and other vegetation use ambient CO_2 in their photosynthetic processes.

Sequestration methods may offer a viable means of offsetting excess GHG emissions. For example, the California Global Warming Solutions Act of 2006 encourages corporations with higher emissions to invest in U.S. and urban forests (i.e., biological sequestration potential) as options for offsetting the excess GHGs.

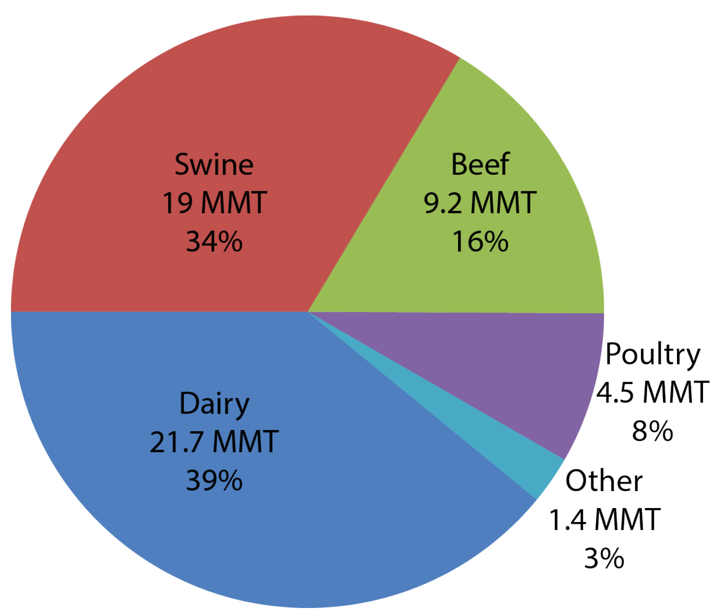

Figure 2. Total greenhouse gas emissions from manure management only by livestock category, as measured by million metric tons (MMT) of CO2 equivalents.
Source: Pork Production and Greenhouse Gas Emissions (https://porkgateway.org/resource/pork-production-and-greenhouse-gas-emissions/).

Such efforts form the backbone of the carbon credit system, which relies on entities seeking ways of achieving carbon neutrality.

7. What does it mean to be carbon neutral, carbon negative, or carbon compliant?

From a global perspective, GHGs can be evaluated on an individual company contributory basis. Such a view requires placing emission levels in terms that reference the overall effect of a company's carbon footprint on global net GHG concentrations. Thus, *carbon neutral* refers to net emission levels neither increasing or decreasing global GHG emissions, whereas *carbon negative* is when net GHGs are lowered by an entity's overall activities (i.e., carbon sequestration).

While achieving carbon neutral or carbon negative status is an end goal for many sustainability programs, improvement is often a gradual process. It would be impossible for today's society to smoothly transition from its current state to a thriving, highly sustainable world overnight. Therefore, it is important to have benchmarks in place that serve as short-term goals for individuals to reach as they continue to become more sustainable. In relation to GHGs, this means that set levels of permissible emissions over a defined period must be established (determined from LCA). However, to reach this level of *carbon compliance* may require the use of offsets in the form of purchased carbon credits. It is important to note that because permissible rates for GHGs are constantly changing with updated scientific estimates of current atmospheric concentrations of these gases, changes in emission rates must be viewed from the perspective of absolute reduction rather than as percentage of the total.

8. What are carbon credits?

One way to encourage participation in a new program is to provide incentives. For proponents of sustainability, carbon credits may afford this opportunity. The basic idea relies on a set limit for permissible GHG emissions during a given period. To incentivize continued improvements in sustainable practices, the program permits transfer of unused amounts, or credits, to others if the allotted quota of GHG is not produced. As an example, a row crop farm and a cattle farm might each be allowed 20 units of GHG emissions annually, but the cattle farm might only produce 15 units while the row crop farm produced 25 units. The cattle farm could sell its unused 5 credits to the row crop farm, thereby allowing both farms to remain within their given production limits (i.e., carbon compliance). Although these programs are not quite developed, producers should keep abreast of information regarding formation of carbon credit systems, particularly regarding the potential of using grasslands for carbon credit provisions.

9. CO_2 versus methane half-life: which is worse?

The amount of time it takes for the removal, through natural processes, of half the amount of a GHG released is referred to as its "half-life." Although there is some disagreement regarding what these values are for carbon dioxide and methane, the consensus among scientists is that CO_2 has a longer half-life than methane. Thus, when considered only from a duration standpoint, methane appears to be of less concern than CO_2. However, persistence is not the only determining factor for rating GHGs in terms of danger to the environment.

10. If CO_2 has a longer half-life, why are cattle operations drawing so much scrutiny?

When looking at potentially harmful effects of a GHG on the environment, it is important to consider the contributory effect of a given gas on the overall warming of the atmosphere, also known as its "global warming potential" (GWP). Although both methane and CO_2 emissions cause a rise in temperature, methane is reported by the University of California-Davis to have a GWP 28 times greater than an equivalent amount of CO_2 (reference gas for all GHG; GWP = 1) over a 100-year period. By comparison, N_2O has a GWP of 273 and chlorofluorocarbons have a GWP greater than 1,000 during the same time period, per the EPA. However, due to the differences in half-life, decreasing methane emissions is associated with an almost immediate decrease in ambient temperatures, whereas temperatures continue to increase with a similar decrease in CO_2. Thus, decreasing methane emissions is of two-fold benefit, as both the rate of global warming and overall ambient temperatures are expected to decrease much quicker with reduction of this GHG than with reduction of CO_2.

Conclusion

Sustainability is a very popular topic right now, with many companies seeking new product developments for use in animal agriculture. The key takeaway from these questions is to stay informed and updated on policy that may impact livestock production. Becoming familiar with these concepts now will help to ensure a better understanding of the necessary changes required by new sustainability regulations that may arise.

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