Pathway to Climate Neutrality for U.S. Beef and Dairy Cattle Production

Net zero has been an increasingly popular topic in agriculture, but how should it be applied to U.S. beef and dairy? Climate neutrality, opposed to the more common net zero carbon, should be used for cattle operations as it level-sets targets with other sectors that are also aiming for climate neutrality.

By Sara E. Place, Elanco Animal Health and Frank M. Mitloehner, University of California, Davis

The Paris Agreement set a goal to limit global warming to 2 degrees Celsius – preferably 1.5 – compared to pre-industrial levels. The Paris Agreement is unique compared to past global climate agreements such as the Kyoto Protocol that centered on greenhouse gas emissions targets.

Rather than emissions targets, the Paris Agreement focuses on temperature change. Thus, we should judge greenhouse gas emissions by how they impact temperature over time.

For sectors primariy emitting carbon dioxide and other long-lived greenhouse gases, net zero carbon is an appropriate target to achieve climate neutrality – the point in which they are no longer contributing warming to our atmosphere. Since the primary greenhouse gas that arises from live cattle production – methane – warms differently than CO2, reaching climate neutrality can be achieved by reaching near-constant rate emissions instead of a net zero emissions.

Undoubtedly, climate neutrality should be viewed as a mile marker on the sectors journey toward climate sustainability, as it is one of a few sectors that can be part of a climate solution and pull carbon out of the atmosphere, offsetting emissions of other societal sectors

Current trends in direct greenhouse gas emissions from U.S. beef cattle

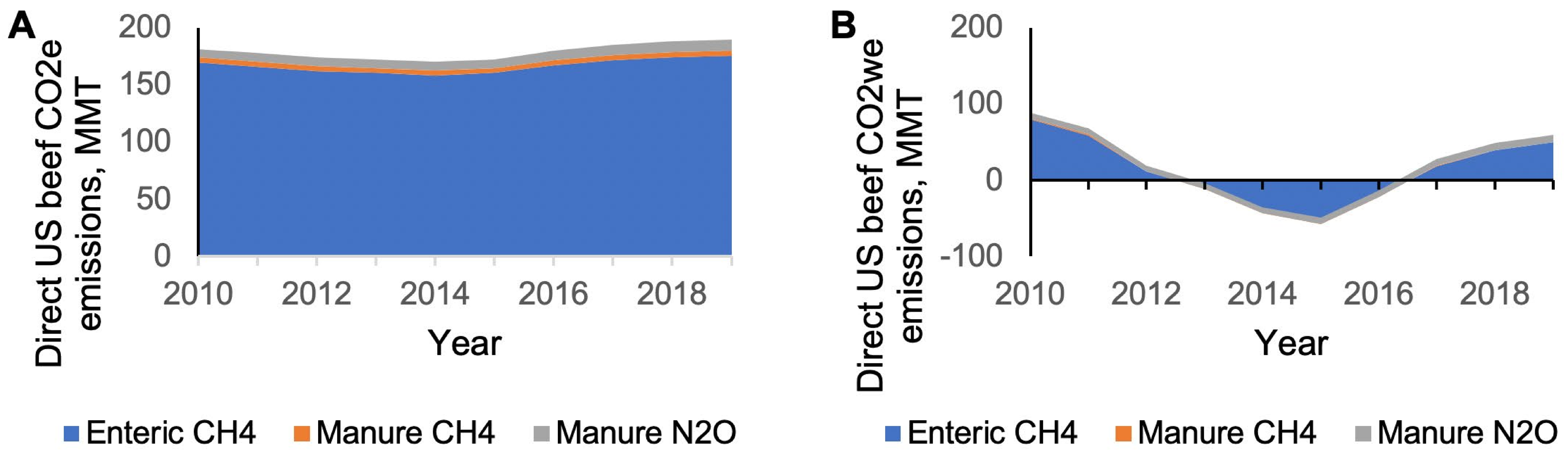

Figure 1. Direct greenhouse gas emissions from the U.S. beef cattle industry from 2010 to 2019 expressed as carbon dioxide equivalents (CO_2e; Panel A) and carbon dioxide warming equivalents (CO_2we; Panel B).

In 2019, enteric methane emissions were 93 percent of beef cattle's direct greenhouse gas emissions, while in dairy they were 54 percent. This can be explained by the larger number of beef vs. dairy cattle – 80 million vs. 14 million, respectively – and differences in how manure is managed between the two industries.

In January 2010, there were 80.4 million beef cattle in the U.S., and by January 2014, that number had dropped to 74.5 million cattle. This decrease was largely driven by a historic drought in the Southern Great Plains region of the U.S. that is home to both cow-calf operations and feedyards. The decline in enteric methane emissions driven by depopulation resulted in cumulative CO_2we emissions of 208 MMT as compared to 1791 MMT of CO_2e in the decade of 2010 - 2019. In this falling emissions scenario, using GWP_{100} leads to an overestimation of the warming impact of beef cattle's direct greenhouse gas emissions by 88 percent.

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Current trends in direct greenhouse gas emissions from U.S. dairy cattle

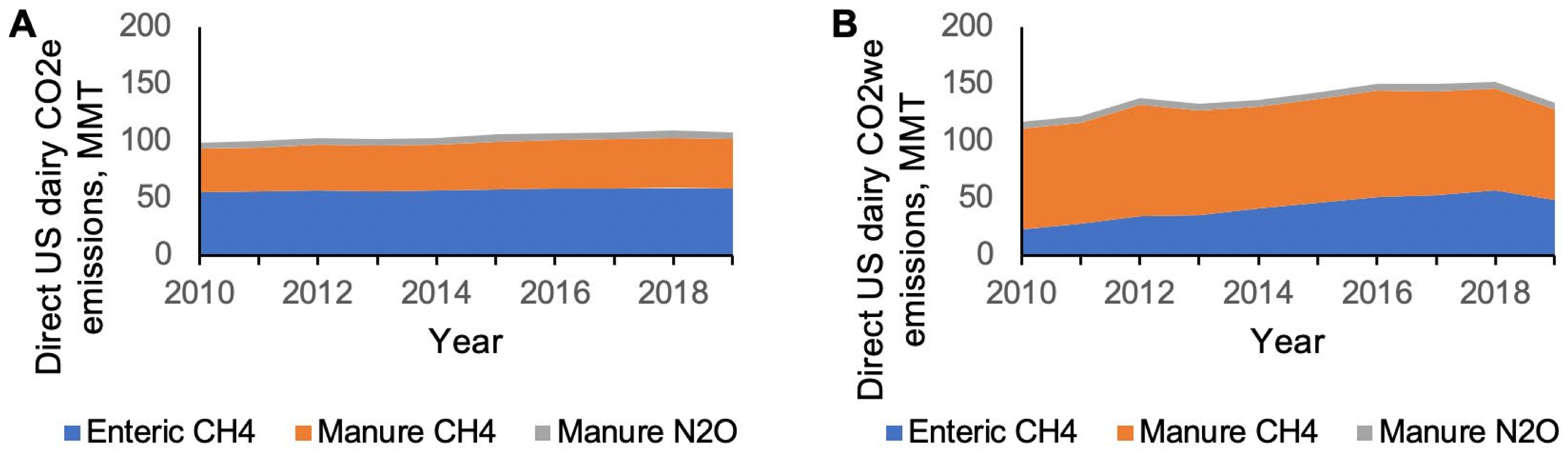

Figure 2. Direct greenhouse gas emissions from the U.S. dairy industry from 2010 to 2019 are expressed as carbon dioxide equivalents (CO_2e; Panel A) and carbon dioxide warming equivalents (CO_2we; Panel B). Using GWP increases the assumed warming impact of the U.S. dairy industry in this time frame by 32 percent.*

From 1990 to 2019, the number of dairy cows in the U.S. decreased 6 percent, but milk production per cow increased 56 percent. As dairy cattle have increased their productivity, they have increased feed consumption, which is a key driver of methane emissions. Thus enteric methane emissions per cow in the U.S. have increased.

However, increases in methane emissions per cow have been offset as enteric methane emissions per lb. of milk have declined. Solutions that further decouple milk production from methane production, such as improvements in feed efficiency and enteric methane inhibitors, can help stabilize and decrease total enteric methane emissions coming from the U.S. dairy industry.

How do we measure the warming impact of methane?

In cattle production, the choice of climate metric (e.g., GWP_{100} or GWP_{20}) is particularly important, as the primary greenhouse gas arising from the live cattle production phases of beef and milk foods, is methane (CH_4). Recent research has demonstrated that the widely used GWP_{100} poorly represents the impact of methane emissions on global temperature change when emissions are stable or falling, as it fails to account for the atmospheric removal of methane.

To overcome those challenges, a new metric named GWP* (GWP star) has been proposed. GWP* considers the change in methane emissions rates over a specified time frame (typically, 20 years for methane) and the small stock component to calculate carbon dioxide warming equivalent (CO_2we) emissions. GWP* also highlights how increases in methane emissions rates can lead to increases in warming more accurately than GWP_{100}.

For the following scenarios outlined in the figures, it is assumed that the beef and dairy cattle herds will remain stable through 2050. It is also assumed that both sectors will manage to reduce direct and indirect emissions, such as utilizing feed additives to reduce enteric emissions or moving away from CO_2 emitting energy sources.

Figure 3, right, shows the annual CO_2we emissions from U.S. beef and dairy cattle production, with the combined industries CO_2we emissions reaching zero in 2044 given the emissions scenarios analyzed. Figures 4 and 5, next page, provide more context on the emissions scenarios for both sectors and highlight the cumulative emissions from 2010 to 2050 in both CO_2e and CO_2we emissions. Climate neutrality is achieved when the cattle production activities do not add additional CO_2we emissions to the total. In these scenarios, both U.S. beef and dairy cattle production would add to warming in the near term, but once annual CO_2we emissions reach zero and are maintained at or below that level, the industries would not contribute to warming thereafter.

In both scenarios outlined, emissions need to decline per lb. of beef and milk produced, but also on an absolute basis, meaning the total emissions from the cattle industries must decline. This would be a departure from the trends of the past 30 years according to U.S. EPA data.

Additionally, in these scenarios, beef and milk production expands as a result of each sector continuing to meet U.S. consumer demands, along with growing export markets. As the population continues to grow globally and beef and dairy are important sources of high-quality protein and micronutrients to the human diet, achieving climate neutrality while still increasing total output will be essential.

All scenarios require reducing enteric methane emissions per animal. It will take a substantial departure from business-as-usual and will require development and adoption of new innovations. Of particular importance is development of solutions to lower enteric methane emissions in extensively managed cattle, such

The path to climate neutrality for U.S. beef and dairy cattle production

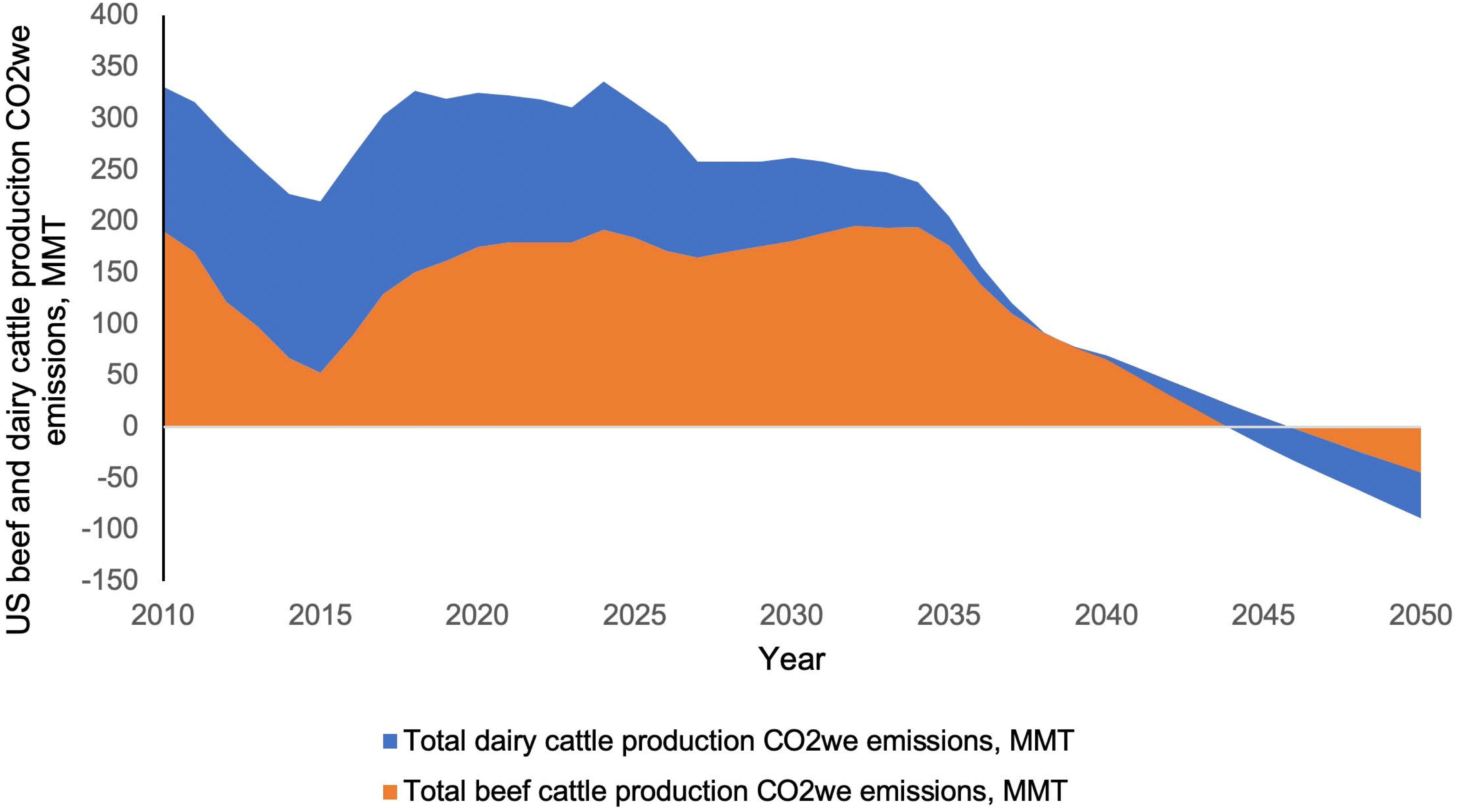

Figure 3. Annual U.S. beef and dairy cattle production cradle-to-farm gate CO_2we emissions expressed as MMT from 2010 to 2050 for the case study scenarios. Achieving reductions in emissions as outlined in Figures 4 and 5 results in 2050 emissions from U.S. beef and dairy cattle production of -89 MMT of CO_2we, meaning that no additional warming would occur from cattle production activities in that year.

The path to climate neutrality for U.S. beef and dairy

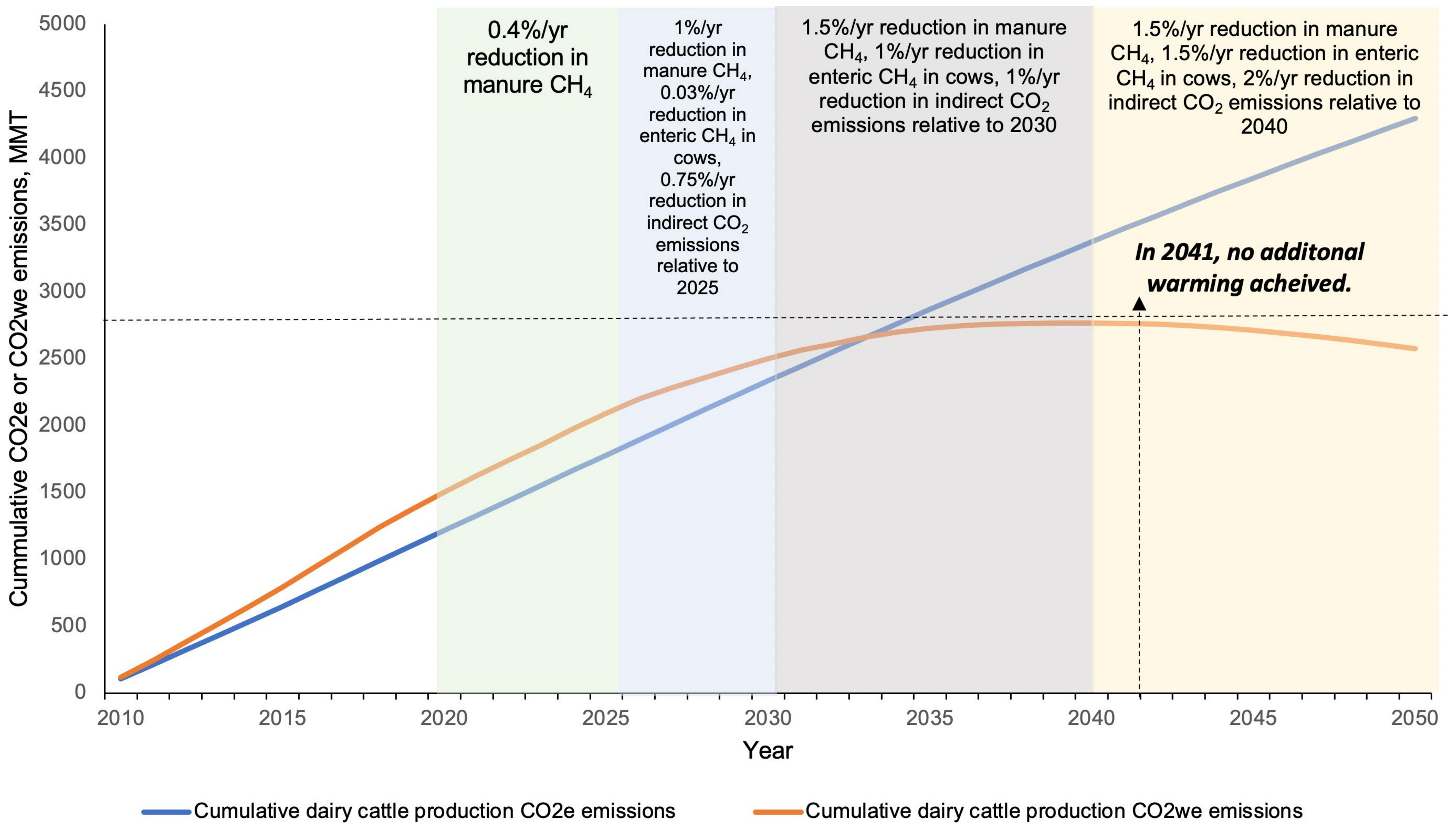

Figure 4. Cumulative carbon dioxide equivalent (CO_2e) or carbon dioxide warming equivalent (CO_2we) for U.S. dairy cattle production from 2010 to 2050 for the case study scenario. Assumed changes in emissions by time period are indicated on the graph. The point at which annual CO_2we emissions do not add to further warming is indicated on the graph.

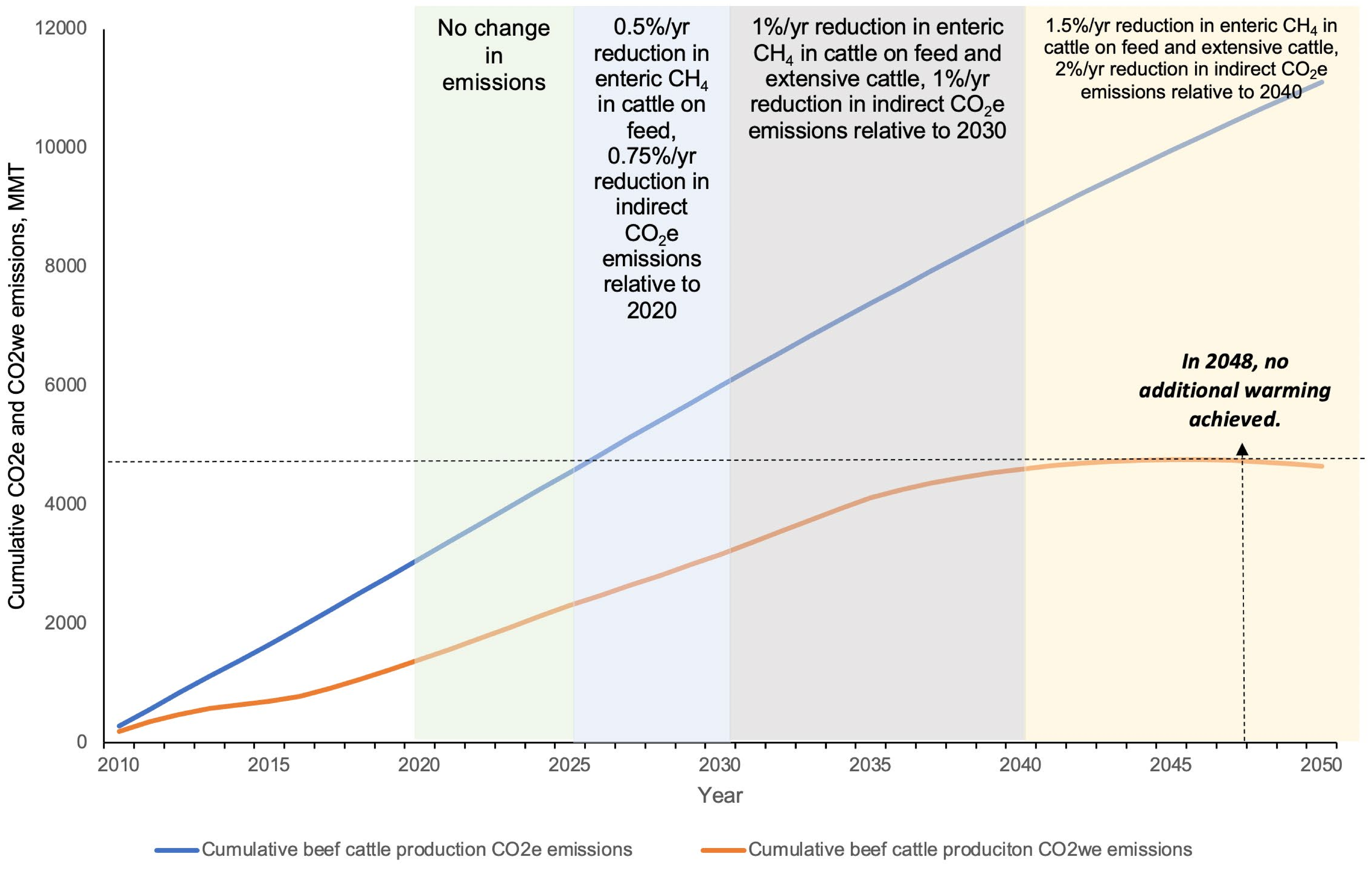

Figure 5. Cumulative carbon dioxide equivalent (CO_2e) or carbon dioxide warming equivalent (CO_2we) for U.S. beef cattle production from 2010 to 2050 for the case study scenario. Assumed changes in emissions by time period are indicated on the graph. The point at which annual CO_2we emissions do not add to further warming is indicated on the graph.

as grazing. As the bulk of methane emissions from beef cattle production come from cattle on pastures and not those in feedyards, delivering feed additives, developing low-methane emitting breeding strategies, and/or other innovations will be required.

For dairy production, enteric and manure methane emissions reductions will be critical. New manure management techniques, such as anaerobic biogas digesters are one such strategy that is growing in importance in California. Indeed, the dairy industry within the state has already achieved a 25 percent reduction in manure methane emissions since 2013. Thus, the estimated reductions within the case study scenario are feasible but will require the right incentives or policies to achieve.

It is also assumed that the cattle industries will be able to reduce the indirect CO_2e emissions from feed production and other inputs per lb. of milk or beef produced. This could include moving to more non-CO_2 emitting energy sources, reducing nitrous oxide emissions from feed production, or increasing soil carbon stocks to offset CO_2e emissions.

As the climate crisis is upon us, it will be critical for all components of the U.S. economy to do their part to stabilize the climate and stay within 1.5 to 2 degrees Celsius temperature change globally. The U.S. beef and dairy cattle industries are no different. However, it will be paramount to use metrics that are fit-for-purpose if the goal is not contributing to additional warming. As the cattle industries' emissions profiles are dominated by short-lived, high radiative forcing methane emissions, the U.S. cattle industries should set emissions reductions goals and targets on a basis of achieving net zero warming defined as 0 CO_2 warming equivalent emissions, rather than net zero as defined by 0 CO_2 equivalent emissions.

As outlined in the case study scenarios, beef and dairy cattle production that no longer contributes to warming in 2050 could be achieved by lowering methane emissions by 18-32% in the coming decades depending upon the species and source. However, these reductions only achieve climate neutrality when also coupled with substantial reductions in emissions of CO_2 and N_2O from feed production, land use, and energy use and other inputs.

Business-as-usual will not allow the U.S. beef and dairy industries to achieve climate neutrality; however, it is within reach as new and existing innovations that lower greenhouse gas emissions become more widely available, and adoption of those innovations are incentivized.

About the authors

Dr. Sara E. Place is the chief sustainability officer at Elanco, where she provides customers with technical expertise on sustainability issues and supports Elanco's Healthy Purpose initiative.

Prior to joining Elanco, Place served as the senior director for sustainable beef production research at the National Cattlemen's Beef Association and was an assistant professor in sustainable beef cattle systems at Oklahoma State University.

Place received a doctoral degree in animal biology from the University of California, Davis; a bachelor's degree in animal science from Cornell University; and an associate's degree in applied science with a focus on agriculture business from Morrisville State College.

Dr. Frank Mitloehner is a professor and air quality specialist in cooperative extension in the Department of Animal Science at UC Davis. As such, he shares his knowledge and research with students, scientists, farmers and ranchers, policy makers, and the public at large. Frank is also director of the CLEAR Center, which has two cores – research and communications. The CLEAR Center brings clarity to the intersection of animal agriculture and the environment, helping our global community understand the environmental and human health impacts of livestock, so we can make informed decisions about the foods we eat and while reducing environmental impacts.

Frank is committed to making a difference for generations to come. As part of his position with UC Davis and Cooperative Extension, he collaborates with the animal agriculture sector to create better efficiencies and mitigate pollutants. He is passionate about understanding and mitigating air emissions from livestock operations, as well as studying the implications of these emissions on the health of farm workers and neighboring communities. In addition, he is focusing on the food production challenge that will become a global issue as the world's population grows to nearly 10 billion by 2050.

Frank received a Master of Science degree in animal science and agricultural engineering from the University of Leipzig, Germany, and a doctoral degree in animal science from Texas Tech University. Frank joined UC Davis in 2002, to fill its first-ever position focused on livestock and air quality.

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For more detail and information, you are encouraged to read the full white paper where you can dive further into the case studies and even use the spreadsheet behind the calculations to explore the range of possible scenarios that would yeild net zero warming. You can find the paper and spreadsheet at clear.ucdavis.edu/news/climate-neutrality.