

University of Arkansas and Michigan Technological University

Executive Summary

10/1/2010

1 Executive Summary

1.1 Introduction

Consumers are becoming more aware of their impact on the environment. They are changing their consumption in order to lead a more environmentally friendly lifestyle, and want to know that what they buy has been produced in an environmentally sustainable way. At the same time, major brands and retailers such as McDonald's and Wal-Mart are adding environmental reporting requirements for their suppliers and for the products they purchase from those suppliers.

To proactively meet the needs of the marketplace, the U.S. dairy industry is working together to further improve environmental performance in a way that makes good business sense for the entire supply chain. In January 2009, the Innovation Center for U.S. Dairy -- which represents approximately 80% of the dairy industry -- endorsed a voluntary goal to reduce greenhouse gas (GHG) emissions of fluid milk by 25% by 2020. Based on a preliminary assessment of GHG emissions, a portfolio of ten mitigation projects across the supply chain were launched in 2009.

At the same time, the industry commissioned a greenhouse gas life cycle assessment, or carbon footprint study, for fluid milk in order to identify where the industry can innovate to reduce GHG emissions across the supply chain to achieve the greatest gains. Additionally, the study provides a benchmark to measure the industry's progress toward achieving its voluntary reduction goal. The data will serve as the foundation for the creation of best practices and decision-support tools for producers, processors and others throughout the dairy supply chain.

The Innovation Center for U.S. Dairy selected the Applied Sustainability Center at the University of Arkansas to conduct the first U.S. national-level fluid milk carbon footprint study, and Michigan Technological University was chosen to assist, primarily in the crop and feed mill analyses.

For the purposes of this study, the analysis was limited to GHG emissions in order to estimate a carbon footprint for U.S. dairy operations (fluid milk). The study follows ISO protocols to provide credibility, transparency and objectivity of the methods, data and results. Part of the ISO compliance is an external review by a panel of LCA and agricultural experts. Their full review is included as an appendix to the main report. Fully ISO-compliant life cycle assessments are required to include additional environmental impact areas such as water quality or air quality; interpretation of the results presented in this document, and more importantly, actions taken in response to the reported results should be used with caution because GHG emissions represent only a single dimension of the

environmental impacts of fluid milk production. The Innovation Center has commissioned a separate project to expand this work to include other environmental impact categories.

1.2 LCA Methods

The greenhouse gas LCA is comprehensive and includes all inputs to the dairy industry, from crop farming to the final disposition of the packaging at the end of the supply chain. The dairy supply chain is broadly divided into 8 stages; each received separate analyses that were combined to provide the life cycle footprint. These stages are: feed production; milk production; delivery to processor; processing; packaging; distribution; retail; consumption; and disposal as shown in Figure 1-1.

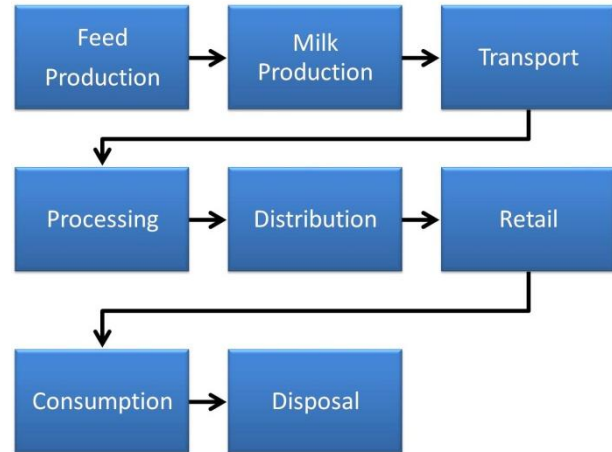


Figure 1-1. Fluid milk production and supply system.

Data were collected from many sources including the USDA’s National Agricultural Statistics Service and Economic Research Service, an extensive survey of dairy farming practices by region (Figure 1-2), a survey of fluid milk processing facilities, the peer reviewed literature relating to LCA of milk, databases of information regarding retail operations, other technical literature and consultation with experts in different fields. All data were critically assessed



Figure 1-2. Dairy production regions used for this study

as to the quality and suitability for use in this analysis. SimaPro© 7.1 was used as the primary modeling software; the EcoInvent database provided information on the ‘upstream’ burdens associated with materials like primary fuels and refrigerants. Data from the surveys and other US specific information was incorporated into the model to the extent that it was available.

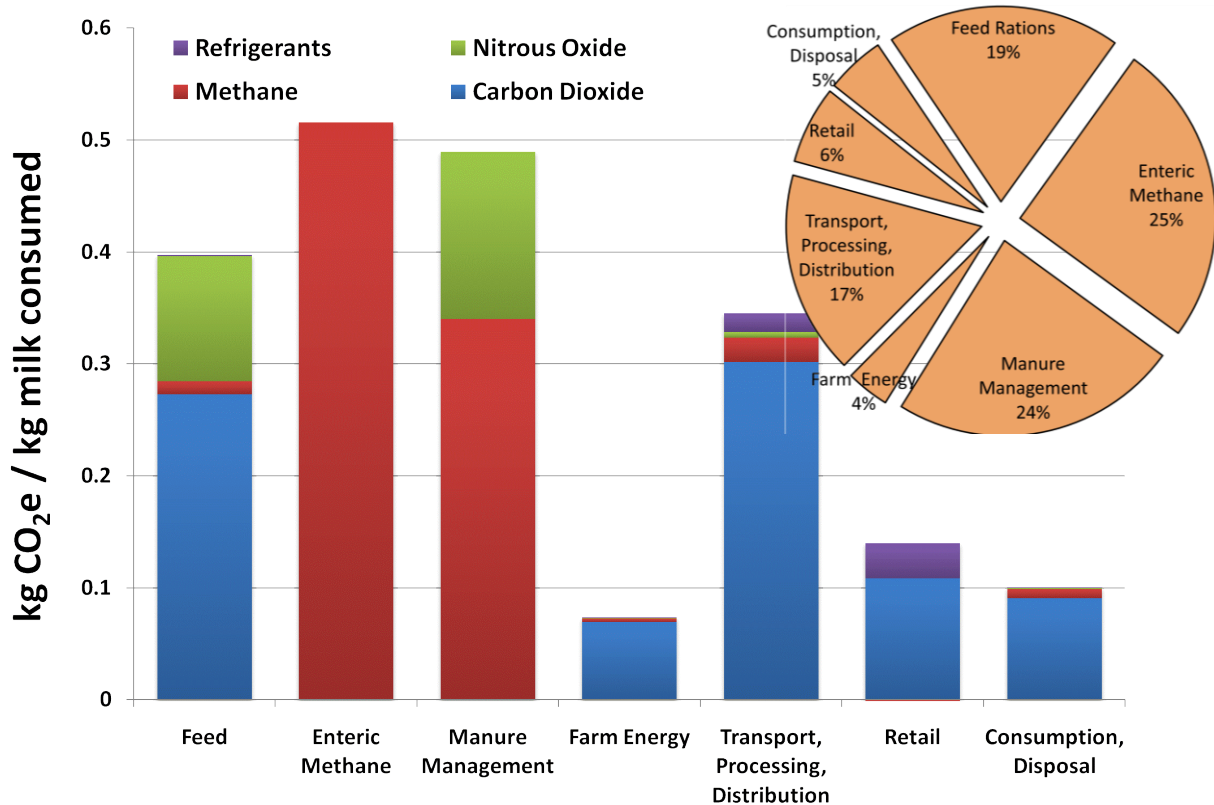


Figure 1-3. Supply chain contribution to carbon footprint of 'generic' milk. Generic milk refers to regional-production-weighted (raw milk input) and purchase-volume-weighted (milk fat content) average milk consumed in the U.S. during 2007.

1.3 Results

Fluid milk is consumed in four primary varieties with different milk fat content: whole milk, skim milk, 2% and 1% milk. Figure 1-3 presents the supply chain contribution to the overall footprint of 'generic' milk which is defined by the relative consumption patterns of the 4 milk fat varieties. Individual carbon footprints are reported for each variety in the report, but the aggregated total, based primarily on 2007-2008 data, for fluid milk consumed in the US is 17.6 lb CO₂e per gallon of milk consumed (2.05 kg CO₂e per kg milk consumed). There is, of course, natural variability in production and supply chain activities as well as uncertainty in reported values for many parameters necessary for computation of the footprint. To account for this, a standard Monte Carlo uncertainty analysis was performed with the result that the 95% confidence band ranges from 15.3 to 20.7 lb CO₂e per gallon of milk consumed (1.77 to 2.4 kg CO₂e /kg milk consumed). In this project, we have explicitly accounted for estimated product loss through the supply chain. Based on USDA food loss reports, we accounted for a 12% loss (return) at retail and an additional 20% loss to spoilage by the consumer. In the report proper,

we present scenario analysis for this product loss, and while reduction of retail loss is important, predicting the consequences, in terms of total supply chain GHG emissions reductions, of changes in consumer behavior is difficult, thus this issue will require additional analysis to assess potential GHG emissions mitigation.

Figure 1-4 shows the cumulative greenhouse gas emissions associated with the consumption of fluid milk in the U.S. The majority of the GHG emissions occur by the farm gate, shown region-by-region, at approximately 72% of the total. The implications for this with regard to lowering the industry footprint are clear: on-farm practices provide the most significant opportunities. These opportunities are not limited to any particular region(s) or herd size(s). In particular, the relative contribution of manure to the total footprint is larger than previously estimated from the scan analysis of previous literature, while feed and on-farm fuel has smaller relative contributions compared to the initial scan. This indicates an even greater importance to manure management opportunities in terms of meeting industry GHG reduction goals than previously anticipated. Deep bedding (stored longer than one month) and anaerobic lagoons are two of the largest sources of methane from manure management, and opportunities for reduction of GHG emissions associated with modification to these practices should

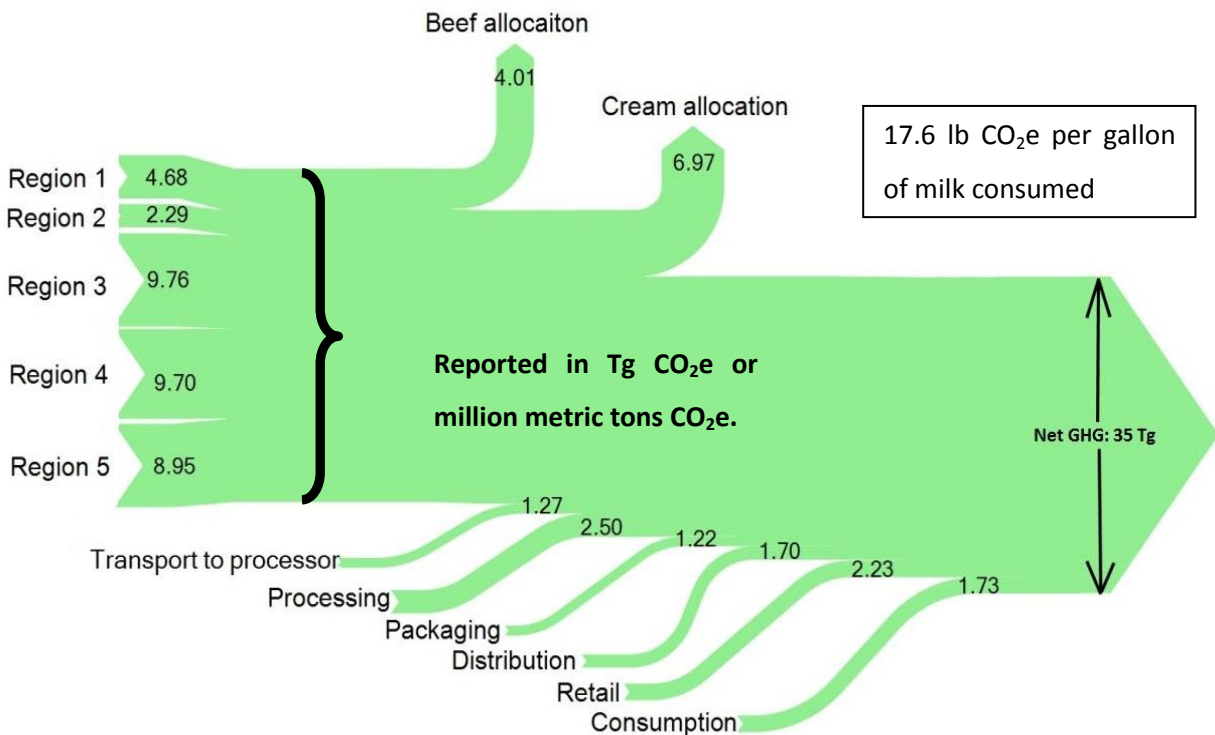


Figure 1-4. GHG flow through the milk supply chain. All values (including beef and cream allocation) are Tg CO₂e for all fluid milk consumed in 2007. This diagram includes an accounting for both the regional production of milk destined for consumption as a beverage and the national mix of whole, skim 1%, and 2% milk for 2007.

continue to be explored; the ongoing digester work sponsored by the Innovation Center is clearly an important avenue for GHG emissions reductions.

Feed still represents a major contributing factor and the opportunity associated with conservation and no-till operations in the feed supply chain remains; it is a singular opportunity for the dairy farmers who grow their own feeds or have some control through contracts with the crop production farms. This study considered biogenic carbon, which is carbon in the relatively short-term cycle from the atmosphere through crops and back to the atmosphere, to be neutral with respect to GHG emissions; therefore carbon sequestration by plants and the respiration of the animals were considered to balance and were not specifically accounted. Long-term sequestration of carbon associated with crop and pasture management is being studied, and it appears that tillage practices significantly influence sequestration in the soil. As more detailed, process based, models are incorporated into LCA, the ability to capture an appropriate portion of the carbon in biomass that is incorporated into the soil as a sequestration credit will become feasible; however at the scale of this analysis, uncertainty in the tillage practices of commodity crops precluded this accounting.

1.4 Dairy Producer Survey

Significant effort was put into creating, distributing, and analyzing the dairy farm survey. Two principal questions were posed at the time the survey was created: are there significant regional or farm/herd size differences in the carbon footprint? The simplistic answer is yes. However, there is not strong explanatory power in these differences because region and size are surrogates for more fundamental explanatory factors. That is, the basis for differences in farm level carbon footprint is specific on-farm management practices such as manure management. As a specific example: if a statistical test to evaluate the influence of 'region' alone is conducted, then different regions have different footprints; however, if 'region' and 'manure management' are tested together, then 'region' has much less influence – this is because manure management practices tend to be similar within a production region. Therefore the factor 'region' used alone significantly overlaps the factor 'manure management' (and other factors such as climate), and much of the observed differences between regions are therefore more properly attributed to the on-farm practice rather than the geographic location. One of the criteria used to define the regions was that they represent different climates, and the remaining effect of 'region' is very likely the result of differences in average annual temperature: the IPCC models for manure management predict higher methane emissions in warmer regions.

The significantly more relevant result of this work is the degree of variability across the farms in the survey. This variability results from on-farm practices and means that, even with current practices there are substantial opportunities for the dairy sector to reduce GHG emissions by adopting best management practices. The overall on-farm footprint is created from the combination of fuel, feed, enteric and manure management contributions. Figure 1-5 presents a summary of the dairy farm-gate average carbon footprint from the analysis of all respondents and illustrates that a wide degree of variability exists across farms. In the figure, the open box represents the 25th to 75th percentile for each category; the narrow gray boxes represent the 10th and 90th percentile; and the horizontal red line represents the weighted mean value for the category calculated using the statistical procedures described in Appendix F. The weighted mean value is shifted in the box in the direction of farms that have larger annual milk production, which is, obviously, strongly correlated with herd size.

For most categories, the weighted mean value is closely approximated by the median; however,

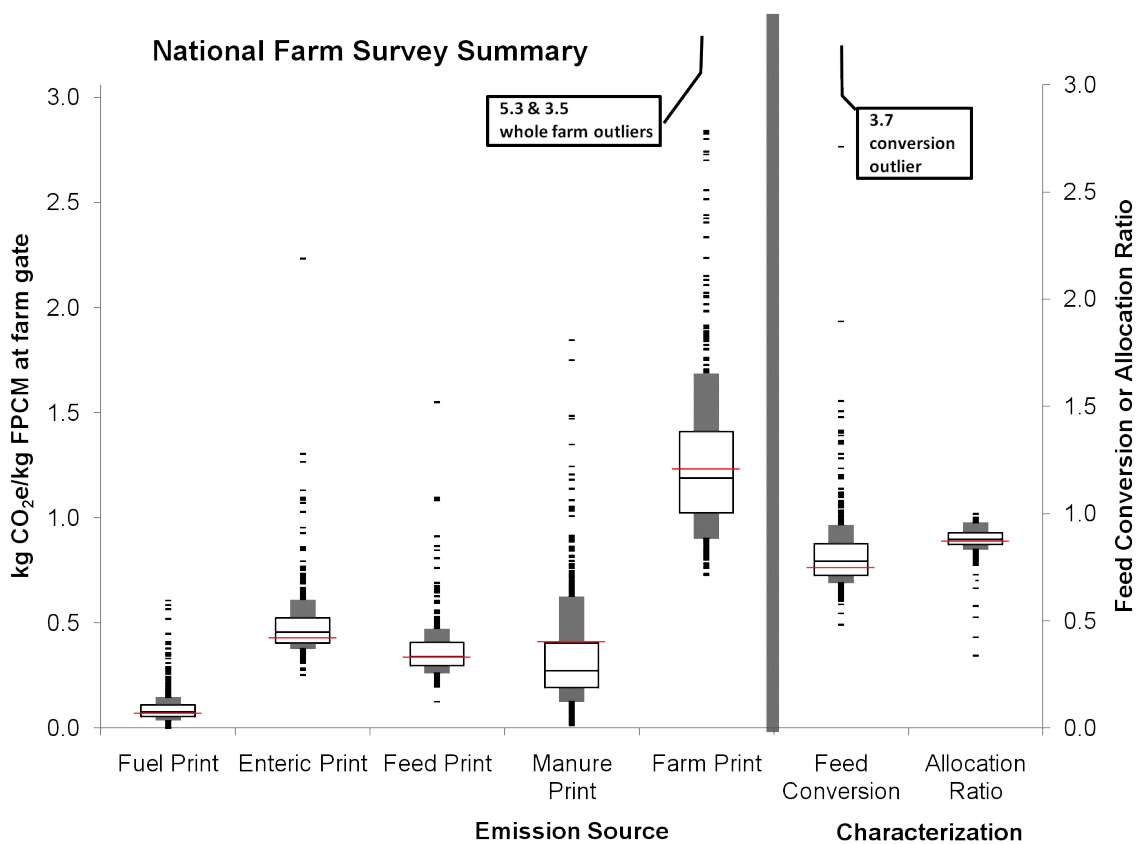


Figure 1-5. Box-whisker plot showing the range of carbon footprint found in the study. The box bounds the 25th and 75th percentiles of the data. The median or 50th percentile is marked by the black horizontal line. The narrow solid gray boxes show the 10th and 90th percentiles, and individual markers are given for the outliers. The red line is plotted at the production-weighted mean value of the specific emission total.

for manure management the mean value is closer to the 75th percentile. The reason for this is that the statistics used to create the mean value are weighted by each farm's milk production, and larger farms tend to have manure management practices which emit more methane than practices more common on smaller farms. It is not clear that this currently represents an opportunity for reduction because the economics of manure management may dictate the practice as a function of size; as digesters become more cost effective, there will be significant opportunity for GHG reduction on these farms. Other comparisons of the weighted mean with the median farm for other categories from Figure 1-5, the feed conversion data suggest that larger farms have slightly better feed conversion efficiency (lower = less feed per kg milk produced) and somewhat lower enteric methane emissions per kg milk produced (also the result of better feed conversion efficiency).

A full statistical analysis of the farm survey is presented in the report. Some important results of this analysis are:

- Feed conversion efficiency is the most important individual factor in explaining differences in the footprint. Not surprisingly, more efficient feed conversion results in a lower footprint.
- Solid storage, dry lot, and deep bedding (stored more than one month) are the top 3 manure management practices nationwide; anaerobic lagoons were in the top ten practices only in regions 2 and 4.
- Only 55% of respondents reported the use of production enhancement practices, such as milking 3 times per day or extended photoperiods during early lactation.
- The top four feeds, accounting for approximately 55% of all feeds are corn silage, alfalfa hay and silage and corn grain. These feeds plus distiller's grains, supplements, protein mix and soybean meal account for 70% of the carbon footprint of the feed. Supplements, distiller's grains and protein mix have a disproportionately large contribution to the footprint due to the additional processing necessary for their preparation.
- Region 2 (the southeast) has the largest feed footprint for most crops grown locally. This is the result of higher fertilizer application rates – both N and lime fertilizers are notably higher for this region. Lime, more precisely crushed limestone, is applied at 1.5 to 2 times the levels of other regions, and as it neutralizes the acidic soils, releases carbon dioxide.

The single most important factor in explaining differences in GHG emissions across all farms is feed conversion efficiency. This is not a particularly surprising result: feed is a major farm input and directly affects both enteric emissions and the quantity of manure excreted. Opportunities with some of the larger farms in Region 4 where anaerobic lagoons are a common management system may be significant. In addition, further work to continue increasing feed conversion efficiency is also important,

as this variable alone explains over ½ of the observed variability in the feed and enteric methane contribution to the farm-gate footprint.

1.5 Milk Transport and Processing

Several dairy cooperatives provided detailed information regarding transportation of milk from farms to processing facilities. As shown in Figure 1-4, this contributed 1.27 Tg CO₂e or approximately 0.05 kg CO₂e per kg milk delivered to processors. Additionally, fifty fluid milk processing facilities provided data on energy use and production to help develop the processing footprint. The gate-to-gate resulting carbon footprint is 0.2 kg CO₂e/kg milk delivered to retail. Two interesting observations were associated with analysis of survey results from the milk processing industry: first, that there was not a strong correlation between processing plant age and GHG emission intensity (kg CO₂e/kg packaged milk), and second, there was also no correlation between plant size and GHG emission intensity.

1.6 Interpretation

The reader must be cautious in interpreting the results of this, or any, LCA. The goal and scope of different LCA studies may differ, thereby rendering comparison difficult. Additionally, this LCA exclusively focuses on carbon emissions, and does not account for other environmental impacts, such as water or air quality. Decisions made solely on the basis of GHG emissions do not account for potential trade-offs with other environmental impacts, and caution should be exercised in making decisions based on a single metric. See chapter 7 for a more detailed interpretation of this study.

1.6.1 Uncertainty and Variability

The results reported from this study are not exact due to both lack of detailed knowledge of the true value of model parameters and from natural variability in the system studied. The former highlights need for improved data collection, while the second may point to areas that are likely to provide opportunities to learn why some specific operators have low emissions and then transfer that knowledge to other operators at the high end of the spectrum.

1.7 National GHG Emissions Inventory for Fluid Milk

The cumulative total emission of greenhouse gases associated with consumption of all fluid milk in the US was approximately 35 Tg CO₂e in calendar year 2007. The breakdown of these emissions is shown in Figure 1-6. Nearly ¾ of the total emissions occur by the time the milk reaches the farm gate. These results are similar to the results from the scan level analysis that was performed in 2008. The

major difference is that the total emissions estimate increased from 28 Tg to 35 Tg (million metric tons), with some changes in GHG emissions occurring in most of the supply chain stages.

Feed production impacts are 13.8% larger than the scan estimate (6.6 vs. 5.8), and on-farm emissions are 12% larger (18.5 vs. 16.5). The increase in feed production can be attributed to several factors: better information on fertilizer impacts and a higher resolution view of additional processing of many feeds, for example distiller’s grains and supplements which both have higher incoming burdens than traditional grains. The increased estimate for on-farm emissions is due to a combination of factors: first, the model used for enteric methane emissions estimates, an IPCC Tier 2 approach, predicts larger enteric methane emissions than the Tier 1 approach used for the scan analysis. Second, this analysis used a Tier 2 analysis of manure management systems coupled with a higher resolution view of the frequency of use for manure management practices common in the US. Transport and distribution was found to be larger by a factor of 3 (0.8 Tg vs. 2.7 Tg), driven by better understanding of transport distances (~500 mile round trip vs. ~250 miles for the scan, and inclusion of mobile refrigerant loss). The

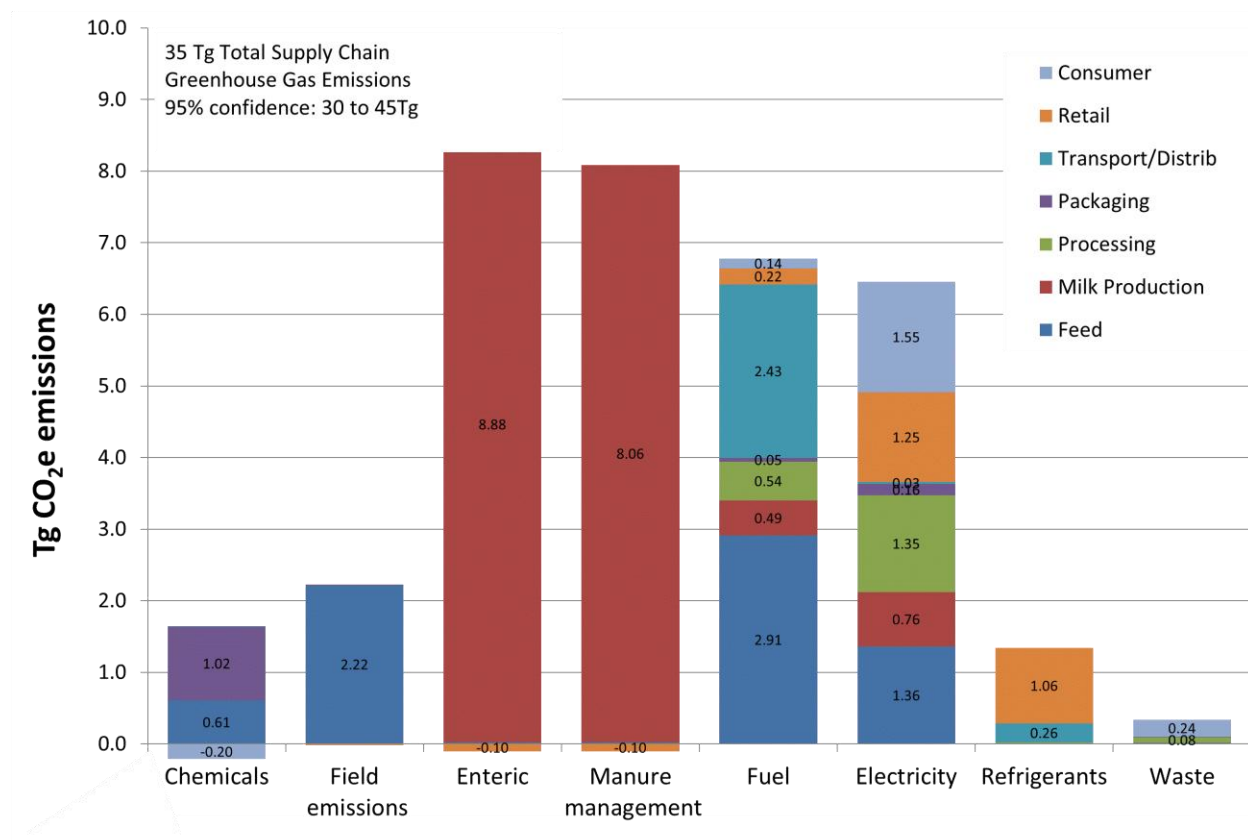


Figure 1-6. Cumulative GHG emissions for 2007 by source. Units are Tg or million metric tons; the total value chain emissions were 35 Tg. Values reported in the bars are Tg CO₂e (only values larger than 0.03 Tg are included to maintain readability).

retail stage was more than double the scan estimate (2.2 Tg vs. 1.0 Tg) due to better data and engineering estimates of refrigeration requirements. Finally, the scan analysis did not include product loss nor did it have the consumer use phase accounted (1.7 Tg).

1.8 Conclusions

This work represents one of the most comprehensive agricultural life cycle assessments ever undertaken, and establishes a scientifically sound and defensible baseline for GHG emissions associated with production and consumption of fluid milk in the United States in 2007. In the future, as the industry moves to meet its 2020 goals of 25% reduction GHG emissions, the progress can be assessed against this baseline emission level. The process has been open and transparent, and the work has been reviewed by an international panel of experts. Unit process data will be prepared for submission to databases that will allow public access to this information so that others can base LCA of products containing dairy products on the best available life cycle inventory data.

The study highlights manure management, feed production, and enteric methane as three areas for innovation research. The Innovation Center for US Dairy is currently supporting projects focused on bringing digesters into a more mainstream technology and other work focused on feed conversion efficiency to mitigate both enteric methane and manure management emissions. Opportunities for reductions also lie in other stages of the supply chain. Increasing energy efficiency at the processing plant, as well as reducing the fugitive emissions of refrigerants at both the distribution and retail stages would lower overall GHG emissions. The Innovation Center for US Dairy has also established projects to explore both milk processing and milk delivery system options to identify and develop optimal configurations to improve the sustainability of the US Dairy Industry.