International Dairy Journal 31 (2013) S1–S2

Contents lists available at SciVerse ScienceDirect

International Dairy Journal

journal homepage: www.elsevier.com/locate/idairyj

Carbon and water footprint of U.S. milk, from farm to table – Special issue: Editorial

The Innovation Center for U.S. Dairy with support from the Dairy Research Institute has begun a rigorous, innovative, life cycle assessment-based program to study and reduce the environmental footprint of the U.S. dairy industry.

This work, introduced in the first annual *U.S. Dairy Sustainability Commitment Progress Report*[1] is framing a roadmap of research, tool development, and knowledge sharing.

Life Cycle Assessment (LCA) is the leading framework to better understand, measure and reduce environmental impact—and the only one designed to provide a full evaluation of all sources and types of environmental impact at every step of a product's life cycle.

Because of the complexity of the dairy industry and the comprehensiveness that LCA demands, the U.S. dairy industry began their work with a green house gas (GHG) LCA for milk. Whole milk production represents one-third of the dairy market, and the GHG fluid milk LCA serves as a foundation for analysis of other dairy products, packaging, and delivery system.

The Innovation Center started in 2008 with the successful use of a 'scan-level' GHG LCA to identify 10 opportunities to reduce GHG emissions while generating business value across the supply chain.[2] When fully implemented, these projects are expected to reduce GHG emissions by 12% from 2007 levels by 2020. With this work in January 2009 the Innovation Center announced its voluntary and ambitious goal to reduce the carbon footprint of fluid milk by 25% by 2020, and launched the mitigation projects.

In the meantime, the Innovation Center for U.S. Dairy commissioned a U.S. national-level GHG life cycle assessment for fluid milk to (1) validate opportunities for innovation to reduce GHG emissions across the dairy value chain, and (2) provide a benchmark for the industry as they began working to meet the voluntary goal of reducing fluid milk GHG emissions by 25% by 2020.

Work by Thoma et al. provides the industry benchmark for future reductions. *Greenhouse Gas Emissions from Milk Production and Consumption in the United States* presents the full assessment of GHG emissions from U.S. fluid milk from cradle (fertilizer production) to grave (consumption and disposal of milk packaging) and finds that the overall life cycle GHG emissions per kilogram of fat and protein-corrected milk is 2.05 kg CO_2e.

Based on the amount of milk produced in the United States, the dairy industry accounts for approximately 2% of total U.S. GHG emissions.[3] This agrees with recent work by the Food and Agriculture Organization (FAO), which estimates the average emissions from its global dairy LCA showing that global milk production, processing and transportation contributes 2.7 percent of the total global GHG emissions.[4]

Findings of the GHG LCA were presented at the International Conference on Life Cycle Assessment in the Agri-Food Sector in Bari, Italy, in 2010 and are discussed in more detail in this special issue. This body of work is noteworthy for the industry-wide impact that it aims to inspire, catalyze, and lead. The Innovation Center's motivation for publication is to share these lessons learned and provide a catalyst to inspire the dairy industry to create more sustainability initiatives. Further, the tools generated from the study will help empower the industry to realize these goals. Last but not least, the Innovation Center endorses an open-source approach that will help inspire innovation and continuous improvement.

This work is noteworthy for its comprehensiveness in looking at every stage of the fluid milk life cycle and for its data collection method, which collected primary data from well over 500 individual dairy farms. While producer surveys and focus groups have been used for many types of dairy analyses, they have all used a much narrower focus and sample size for data collection. Work by Popp et al. describes the innovative model of data collection used in the fluid milk LCA GHG. It involved an expansive collaboration among researchers, dairy consultants, dairy industry representatives, dairy co-ops, non-profit and extension agents. The time-intensive work was important to meet the data needs of the LCA study for crop production and on-farm GHG emissions, and to inform future work. The paper highlights results of the research and offers advice to other agricultural industries attempting similar work.

The milk life cycle begins with the feed for dairy cattle, and work by Adom et al. estimated the GHGs of feed mill operations in the northern Midwest. The study includes raising, transporting feed to the mill, milling, and then transporting feed to the dairy farm

[1] U.S. Dairy Sustainability Commitment Progress Report, December 2010. Accessed at http://www.usdairy.com/Public%20Communication%20Tools/USDairy_Sustainability_Report_12-2010%20(4).pdf.

[2] Innovation Center for U.S. Dairy, www.usdairy.com.

[3] University of Arkansas and Michigan Technical University, Fluid Milk Carbon Footprint Study Executive Summary, October 2010. Accessed at http://www.usdairy.com/Public%20Communication%20Tools/Carbon%20Footprint%20Study%20of%20Fluid%20Milk/CARBON%20FOOTPRINT%20STUDY%20EXEC%20SUMMARY.pdf on 8/29/11.

[4] Greenhouse Gas Emissions from the Dairy Sector: A Life Cycle Assessment. Food and Agriculture Organization of the United Nations, Animal Production and Health Division, 2010.

0958-6946/$ – see front matter
http://dx.doi.org/10.1016/j.idairyj.2013.01.001

gate. This work also relied on data collection through surveys of mill managers as well as internet searches, peer reviewed journal articles, a mill site-visit, and direct communication with the feed mill manager. Feed inputs are responsible for the greatest share of GHG emissions, due to the use of commercial nitrogen fertilizer as well as manure that is applied to the field.

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. However, these emissions are beyond the control of feed mill operators, so opportunities for reduction occur through use of cleaner electricity and transportation fuels and better citing of mills for shorter transportation distances.

Thoma et al. then present a study of on-farm emissions, finding that the on-farm carbon footprint varies significantly between farms, and is not dependent on size. This variation is also not due to differences in location but, rather to the use of best management practices. Enteric methane and manure management offer the greatest opportunity to reduce on-farm GHG emissions. Feed conversion efficiency is the most important individual factor in explaining differences in the footprint.

Thoma, Jolliet, and Wang address allocation questions for farm emissions, focusing on questions surrounding milk and beef coproduct allocation. The paper presents an empirical relationship for allocating whole-farm emissions that are not clearly associated with dairy production.

Ulrich et al. describe the GHG emissions from transporting raw milk to the processing plants. The study taps two databases for mileage and delivery amounts for 141,617 and 69,599 round trips to deliver raw milk from farms to processing plants across the United States. The average round trip distance was 850 km resulting in tailpipe emissions that contributed 3.5% of the total greenhouse gas emissions for fluid milk consumed in year 2007. The total amount of milk transported was about 17% of the 2007 total U.S. production for use as fluid milk products.

Last, Nutter et al. estimate the GHG emissions from U.S. fluid milk processing plants, including every step from the refrigerated storage silo through processing, packaging and distribution to retailers. This study used data from 50 fluid milk processing plants. In particular, the study found that transportation emissions – the truck fleet tailpipes – contribute most intensively (29% of total system GHGs), followed by electricity of the processing plant (27% of overall system GHGs).

Thoma et al. describes the overarching project, combining data collected by Popp et al., Adom et al., Ulrich et al., and Nutter et al. In addition to the data described in other papers, retail and consumer GHG emissions were estimated from primary data, design estimates, and publicly available data. This includes a 12% loss at retail and an additional 20% loss at consumption. The majority of fluid milk life cycle GHG emissions (72% of the total) occur in production, in cradle-to-farm gate. In the plant, efficiencies in energy and fuel use represent the greatest opportunities for GHG reduction. In addition, many emissions occur due to the use of fossil fuels and electricity all along the value chain. Finally, refrigerants are a key source of emissions in the retail sector.

The results of the fluid milk GHG LCA are already informing efforts to reduce environmental impacts of milk production. Due to the diversity of production practices within the dairy industry, farm models were built to examine differences and variability among farms. In addition to scientific interest, this approach allows the development of tools to provide dairy producers with clear and specific advice for each farm's conditions. It is important for the industry's assessment to be able to support dairy producers, processors and distributors operating within a variety of contexts.

Asselin et al. describe work to develop an accurate and easy-to-use tool for farmers to identify economically-viable ways to reduce their on-farm carbon footprint. Data collected for the GHG LCA through the extensive survey process were analyzed to find the most important variables, and Asselin et al. present an elegant method for modeling on-farm emissions with a more limited amount of data collection.

The GHG LCA is also the first step in a more comprehensive series of LCA work in progress by the Innovation Center for U.S. Dairy, and the Dairy Research Institute. The Innovation Center is now sponsoring a number of additional efforts to further develop our understanding of the impacts and opportunities surrounding the industry.

First, a comprehensive LCA of fluid milk was launched in 2010 and the result will be used to develop an on-farm self-assessment tool in early 2013. A comprehensive cheese LCA has also been accomplished by the Innovation Center. In addition, an LCA of milk processing and packaging is underway to evaluate environmental performance of various packaging formats through science-based data and create a common framework to drive innovative new products, processes and services. These projects being undertaken are comprehensive LCAs – they evaluate impacts on a range of categories including climate change, human health effects, ecosystem quality, resource use and water use.

Two examples of work to examine additional impacts appear in Matlock et al.'s geospatial analysis of water impacts from U.S. dairy production and Leh et al.'s assessment of ecosystem service loss as a result of land changes.

Matlock et al. begin the complex process of analyzing water impacts including use, water stress, and eutrophication. These impacts are regional and location-dependent, but also extend into the entire watershed in which the dairy is located. The study finds that feed crops – irrigation water use and fertilizer run-off – may present the biggest water impacts for dairy production system.

Leh et al. examine the impact of land use changes in an agricultural watershed in Northwest Arkansas between year 1800 and 2006. The authors found that on the field level, dairy operations resulted in reduced land use change on ecosystem service loss, compared with the overall watershed.

The body of work presented in this special issue of the International Dairy Journal is a first example of the exciting projects being undertaken by the Innovation Center for U.S. Dairy. Due to these efforts, the dairy industry is now further advanced than nearly any other industry in identifying the sources of its environmental impact and identifying solutions.

Gregory D. Miller, President, Ying Wang, Director of Sustainability Research*
U.S. Dairy Research Institute, 10255 W. Higgins Rd., Suite 900, Rosemont, IL 60018, USA

* Corresponding author.
E-mail address: Ying.Wang@rosedmi.com (Y. Wang)