Cornell University
Cooperative Extension

Agronomy Fact Sheet Series Fact Sheet #136

Quantifying GHG Inventories for Dairy Farms

Introduction

The US Dairy industry has set ambitious Environmental Stewardship Goals including greenhouse gas (GHG) neutrality by 2050 (Environmental Stewardship | Innovation Center). Agriculture emits three main GHGs: methane (CH_4), nitrous oxide (N_2O), and carbon dioxide (CO_2). In dairy farming, methane represents about 50-60% of the farm footprint, nitrous oxide about 20-30% and the balance is carbon dioxide, but these estimates will vary across farms. Methane in dairy is produced by microbes called methanogens; they thrive in the digestive tract of cows and in anaerobic manure storage. Nitrous oxide can be released from dry lots or barnyards but is mainly from nitrogen (N) transformations when manure or N fertilizer is applied to cropland. Carbon dioxide comes from combustion engines and breakdown of soil organic matter from cropland. While achieving GHG neutrality will be very difficult for dairy, there are things dairies can do to reduce emissions and still be profitable. To know what the options are, dairy farmers need to know what emissions look like for their farm. A farm specific GHG inventory or "footprint" is the way forward. This factsheet describes information needed to determine GHG assessments.

Direct measurements

Direct measurements of GHGs on thousands of individual dairy farms is impractical, inaccurate, and costly. Greenhouse inventory tools use science-based emission factors and equations to estimate emissions. As scientists conduct more direct measurement of emissions from farm practices, new and revised emission factors will continue to improve the tools to better reflect individual farm conditions.

GHG inventory

There are several GHG inventory tools available. These tools generally take a "cradle to farm-gate" approach to inventory emissions. The inventory includes emissions that are a result of producing items the farm purchases ("cradle"). This includes feed, fertilizer, chemicals and all emissions generated in the production of each. The inventory also includes emissions from on-farm sources and activities such as cows, manure storage, truck and tractor emissions. Some emission sources can be deducted from the inventory. For example, increasing soil carbon in cropland occurs when plants take up carbon dioxide from the atmosphere and store it in the soil as organic matter from crop residue. Inventory deductions are also taken when dairy cows sold for beef are assigned to the beef industry. The dairy farm GHG inventory boundary stops at the point at which milk is loaded onto a truck ("farmgate"), and this is where the dairy processor inventory boundary begins.

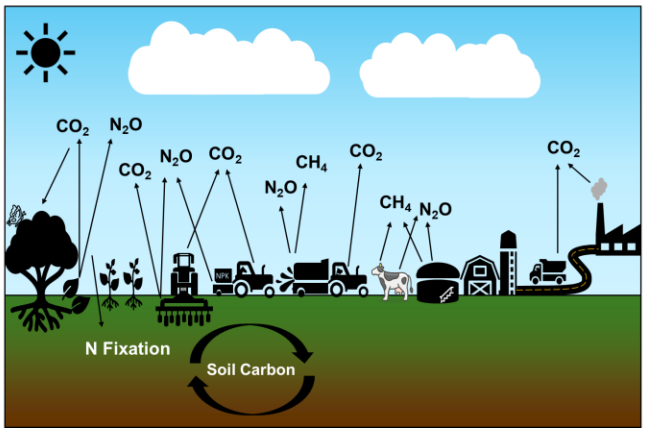

Figure 1: The sources of greenhouse gas emissions, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), on a whole-farm dairy farm greenhouse gas assessment.

Information needed for a GHG inventory

Greenhouse gas inventory tools require farm specific details on crops, animals, manure, and energy. This includes:

- Crop rotation, yield, residue management.
- Tillage practices.
- Cover crop practices (type, establishment, termination).
- Fertilizer and manure inputs for each home-grown crop (source, rate, method, timing).
- Crop protection chemicals used (product type, rate, method).
- Woodland, long-term fallow, pasture or grassland that has been converted to cropland (land use change).

- A minimum of 5 years of field management history if carbon sequestration estimations are to be included.
- Milk production, fat, protein.
- Cow breed, inventory by animal category, average weight, number of animals imported and exported).
- Grazing practices, including time spent grazing per animal category, pasture quality, fertilizer and manure inputs.
- Dry matter intake by feed ingredient and animal category.
- Housing type, bedding, manure storage system and duration of storage per source
- Fuel and energy use including electricity, fuel, transport of purchased products, and any on-farm energy generation.

Good record keeping throughout the year makes data collection more efficient and inputs into the tools more accurate.

GHG tool outputs; intensity and total

Key outputs for GHG tools typically include (1) emission intensity; and (2) total emissions, including a breakdown of the farm's emissions by gas, source, and animal category. A farm's GHG emission intensity is calculated by dividing the total farm emissions by fat and protein corrected milk (FPCM) yield. The use of FPCM standardizes milk production allowing for comparison across farms, regions, and supply chains. Both intensity and total emissions are important to understanding the environmental impact of GHG emissions and setting targets for emission reduction. These outputs allow users to track progress over time and compare themselves with peers (Fig. 2).

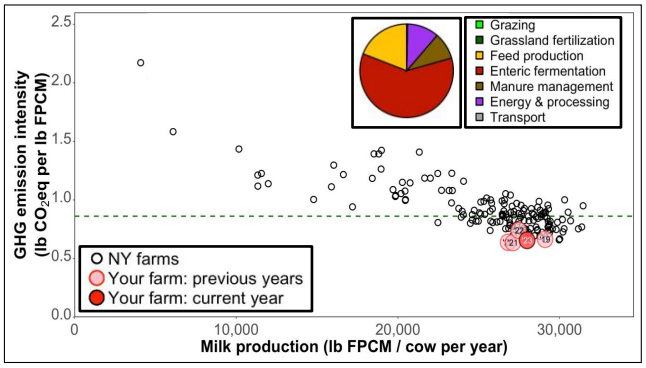

Fig. 2: An example of greenhouse gas inventory report figure showing emission intensity, source of emissions and a comparison to peers.

Greenhouse gas inventory tools can be used to identify progress made over time with continued annual assessments and by running scenarios with and without the implementation of various beneficial management practices. Tools can also be used to conduct "what-if" scenarios to evaluate potential impact that future improvements could have on the farm's emission intensity and total emissions (Fig. 3).

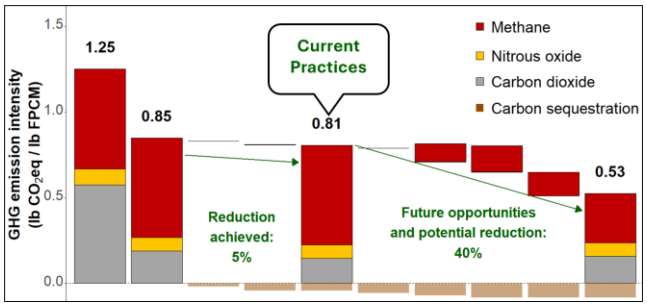

Fig. 3: An example that shows the farm's emission intensity, progress made so far ("current practices"), and potential for future opportunities.

In summary

To reduce GHG emissions on dairy farms, reasonably accurate farm-level assessments are needed. While tools vary, most require crop, herd, feed, manure management, and energy data. The tools typically report total emissions and emission intensity, as well as GHG emissions by gas, source and animal category. Effective tools allow users to track progress over time and identify improvement opportunities. Dairy GHG inventory tools will improve with continued scientific development.

Additional resources

- Overview of Greenhouse Gases | US EPA
- IPCC — Intergovernmental Panel on Climate Change

Disclaimer

This fact sheet reflects the current (and past) authors' best effort to interpret a complex body of scientific research, and to translate this into practical management options. Following the guidance provided in this fact sheet does not assure compliance with any applicable law, rule, regulation or standard, or the achievement of discharge levels from agricultural land.

For more information

Cornell University Cooperative Extension

Nutrient Management Spear Program
http://nmsp.cals.cornell.edu

Camron Ray, Olivia Godber, Karolyn Auer, Karl Czymmek, Kitty O'Neil, Owen Weikert and Quirine Ketterings

2026