FARMERS ASSURING
FARM
RESPONSIBLE MANAGEMENT

Environmental Stewardship

Version 2.0 User Guide

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Chapter 1: Introduction

Customers and retailers are increasingly looking to tell a positive story about their commitment to the environment. To develop that story, customers are exerting pressure up the supply chain – asking farmers to provide information about the impacts of food production. While their demand certainly presents a challenge, it is also an opportunity for the dairy industry to highlight its current and future accomplishments.

U.S. dairy farmers have a longstanding history of environmental stewardship. As dairy production has become more efficient, it requires fewer resources to produce the same amount of milk. Compared to 70 years ago, producing a gallon of milk uses 65 percent less water, requires 90 percent less land and has a 63 percent smaller carbon footprint.[1] In fact, the U.S. dairy industry may be the world's most efficient. According to a study by the United Nations Food and Agriculture Organization, dairy farming in North America has the lowest greenhouse gas emissions intensity of any region in the world.[2]

FARM Environmental Stewardship (ES) is designed to capture those improvements and ensure consumer confidence. Dairy farmers can assure food companies and consumers of our commitment to continuous improvement by using the FARM ES online tool to measure greenhouse gas emissions and energy intensity. At the same time, dairy farmers can use the results to identify opportunities for improvement that benefit both the planet and the farm's bottom line.

The carbon footprint of a gallon of milk has **decreased by 63% since 1944.**

One cow produces as much milk as five cows did in 1944.

[1] *Capper, J. L., Cady, R. A., & Bauman, D. E. (2009). The environmental impact of dairy production: 1944 compared with 2007. Journal of Animal Science, 87(6), 2160-2167. doi:10.2527/jas.2009-1781*

[2] *Gerber, P., et al. (2010). Greenhouse Gas Emissions from the Dairy Sector, a Life Cycle Assessment. FAO Food and Agriculture Organization of the United Nations. Animal Production and Health Division. http://www.fao.org/docrep/012/k7930e/k7930e00.pdf*

The Environmental Stewardship Program

FARM Environmental Stewardship provides a comprehensive estimate of the greenhouse gas (GHG) emissions and energy use associated with dairy farming. The tool is based on a life cycle assessment (LCA) of fluid milk conducted by the Applied Sustainability Center at the University of Arkansas, incorporating data from more than 500 dairy farms across the United States. The FARM ES online tool asks a limited set of questions to assess a farm's carbon and energy footprint – reducing the burden on farmers while still providing reliable, statistically robust estimates.

The purpose of the User Guide is to enable co-op field staff, FARM evaluators and individual farmers to input their data into the FARM ES online evaluation tool – explaining which resources may contain the data on their farm, as well as answering common questions about how to interpret each measure. The User Guide also explains how to understand the results.

Accompanying this User Guide is a supplemental FARM ES Reference Manual detailing the science used to develop FARM ES and best management practices that can improve performance. The FARM ES Reference Manual should be consulted to understand the specifics of how the user's data is reflected in the FARM ES evaluation results.

Getting Ready

FARM ES uses data from a consistent year – a 12-month period that does not necessarily reflect a calendar year. The same 12-month period (for example, March 1 to February 28) should be used each time the farm enters data into the FARM ES online tool. Before entering information, operations should gather the following:

- Obtain milk production records, including total production as well as average protein and fat percentages. Operations can find production information in the DHIA report or other dairy record management systems. The farm's cooperative would also be able to provide milk production data.
- Assess the average herd size, including the average number of lactating cows, dry cows, replacement heifers under 2 months (both on- and off-farm) and replacement heifers over 2 months (both on- and off-farm). This information may be available in the DHIA report or other dairy record management systems.
- Collect records on mature cows culled for beef and calves sold for beef production.
- Contact the nutritionist to obtain average feed ration for lactating cows, including concentrate and forage, preferably on a dry matter basis.
- If it applies to the operation, consult grazing records or pasture management spreadsheets. A Nutrient Management Plan may also contain pasture information.
- Collect documents on electricity and fuel consumption. Utility bills may be useful for determining electricity and natural gas usage. Information on other fuels may be found in purchase records or usage logs.
- Obtain information on manure management systems. The farm's Nutrient Management Plan or Comprehensive Nutrient Management Plan may contain details on manure management.
- For operations with anaerobic digesters, contact the company that installed or operates the digester for information on conversion efficiency and the percentage of electricity or heat utilized.

FARM ES Version 2.0 Update

FARM Environmental Stewardship is committed to remaining scientifically up-to-date. In 2019, FARM ES launched a model update process. The Innovation Center for U.S. Dairy collaborated with the University of Wisconsin-Madison on thee significant changes:

- **Updated Crop Emissions Factors** FARM ES generates an estimate of the GHG and energy footprint associated with feed production using crop emissions factors. The factors were updated using the latest information from USDA and other publicly available data on crop production practices and yield. Additionally, the update process entailed methodology updates.
- **Solid-Liquid Separation** Farms continue to implement advanced manure management systems that reduce GHG emissions, including solid-liquid separators (SLS). FARM ES Version 2.0 includes solid-liquid separation as a manure management option to capture the benefit that comes from separately managing the solid and liquid fractions.
- **Gas Type Breakdown** FARM participants can now see their farms' GHG emissions results broken down by type of gas (methane, nitrous oxide, or carbon dioxide). This can help with continuous improvement planning as well as with external reporting to initiatives such as CDP.

FARM ES Version 2.0 also captures solar and wind energy being generated on the farm. And it asks about the use of Nutrient Management Plans in alignment with the U.S. Dairy Stewardship Commitment.

FARM ES Version 2.0 updates are described throughout this User Guide.

Access and Documentation

The FARM ES evaluation is available through the same application used for the FARM Animal Care Program. The portal can be accessed via desktop or the mobile app. More information can be found by clicking "Participant Login" on the FARM website: www.nationaldairyfarm.com.

There are "Notes" fields throughout the FARM ES evaluation. Evaluators should use these fields to specify what records or software they referenced, any assumptions made to calculate the data or any other pertinent information about the evaluation. These notes will be saved with the evaluation and can be referenced the next time that farm goes through a FARM ES evaluation. Keeping good documentation helps maintain consistency.

Thank you for your participation. U.S. dairy farmers have a longstanding commitment to positive environmental stewardship and outcomes. Your decision to be a part of the FARM ES program is an important step in communicating that dedication to customers and consumers.

If you have questions about the FARM ES online tool, please call NMPF at (703) 243-6111 or log on to www.nationaldairyfarm.com.

A Reminder on FARM ES Data:
All data entered into FARM ES should represent a consistent 12-month period, typically a calendar year.

Glossary

Consistent Year: Data in the FARM Environmental Stewardship module should be entered for a 12-month period. The same 12-month period should be used each time the farm enters data in the FARM ES module. This may or may not align with the calendar year. For some farms, this will mean March 1 to February 28; others may have a financial year of July 1 to June 30.

DHIA: Dairy Herd Improvement Association.

Enteric Methane: Methane livestock produce via the digestive process.

FPCM: Fat and Protein Corrected Milk. A measure of milk production that normalizes milk output to an average content of 4 percent fat and 3.3 percent protein.

GHG: Greenhouse Gas. A gas that absorbs and re-emits heat in the Earth's atmosphere.

LCA: Life Cycle Assessment. A life cycle assessment is a type of analysis that assesses the environmental impacts associated with a product across all stages of production.

Milk Marketer: The entity that sells or markets the operation's milk. This may include a cooperative, processor or other entity.

Chapter 2: Production

The total number of animals present on a farm impacts an operation's carbon footprint. Cows emit greenhouse gases (GHGs) directly during digestion as well as indirectly via manure decomposition. This section records milk output, herd averages and beef production data used in emissions calculations. Milk production is used to normalize results in order to compare performance year to year and across farms that differ in milk output. Improved efficiency, animal health, herd management and nutrition continue to generate positive returns for dairy producers across the country. Managing production efficiencies also translates into better GHG and energy use performance for U.S. dairy producers.

What's Included This section covers milk production, herd size and animals culled/sold for beef production. Exclude crop production totals as well as any other non-dairy enterprises.

Values Reported Milk production and herd data are reported as totals or averages over the course of a consistent year, depending on the specific data requested.

What's Needed Data on milk production, including fat and protein content, herd data and animal sales are required. Operations can find production, herd and animal sales information in the DHIA report or other dairy record management systems. The farm's milk marketer would also be able to provide milk production data. Additional sales records may be consulted as needed.

Reporting Guidance

Milk Production

Total annual milk production *Pounds of milk shipped, used ON-farm, or other*	________________ **lbs.**
Average milk protein content	________________ **%**
Average milk fat content *Enter true protein content*	________________ **%**

Report total milk production for a consistent year, including pounds sold, used on-farm or other, as well as the average milk protein content and milk fat content.

What if I only have the crude protein content?

If only crude protein is available, subtract 0.19% to estimate the true protein percent. Report as a percent.

Herd Size

Annual average herd size *Lactating and dry cows*	____________ **cows**
Annual average dry cows *% of total cows*	____________ **%**
Annual average number of heifer calves: *Less than 2 months raised ON-farm*	____________ **calves**
Less than 2 months raised OFF-farm	____________ **calves**
Annual average number of heifers: *2 months to first calf raised ON-farm*	____________ **cows**
2 months to first calf raised OFF-farm	____________ **cows**

The average herd size includes both lactating and dry cows. For heifers and heifer calves, record the running herd average of the replacement animals, not the annual total.

In other words, if in any given month, there are 20 calves present on the farm on average, users should enter the running average of 20 calves. Users should not enter the annual total of heifer calves that were born that year. This is the same logic as “herd size” for cows; enter the typical number of heifers or heifer calves present on the farm or being raised off-farm.

?

What if the herd is seasonal and typically dry at the same time?
For seasonal herds, report the average fraction of a consistent year that the herd is dry. For example, if the herd is dry for 45 days per year, enter 45/365 or 12.3 percent.

?

What is the difference between on-farm and off-farm?
For the purpose of FARM ES, use the following definitions:

- ON-farm: Calves and heifers raised on the farm where the milk production is occurring.
- OFF-farm: Calves and heifers raised elsewhere such as at a neighbor’s farm down the road or another operation many miles away.

Beef Production

Total annual number of mature cows culled for beef	___________ **cows**
Average weight per culled cow (value between 700 lbs. and 2,000 lbs).	___________ **lbs.**
Total annual number of calves sold for beef	___________ **calves**
Average calf weight at time of sale (value between 50 lbs. and 699 lbs.)	___________ **lbs.**

In addition to milk production, most dairy farms market animals for beef. As such, a portion of the environmental footprint associated with raising the animals should be allocated to beef production instead of milk production. This section asks for information on culled mature cows and calves sold for beef in order to determine how best to allocate the environmental footprint between beef and dairy.

For mature cows culled for beef, exclude cows sold to other farms for additional production as well as cows that die of natural causes or are otherwise euthanized. For calves sold for beef, do not include calves sold as replacement animals to other dairies.

Chapter 3: Energy

From powering tractors to lighting barns and cooling milk, energy is a critical piece of dairy farm activities. Managing energy use and pursuing energy efficiency can help farmers reduce costs and lessen exposure to price volatility. At the same time, energy reductions can lower a farm's carbon footprint. Addressing energy consumption presents a win-win for both the farm's profitability and GHG emission reductions. Options for reducing energy use will vary by farm, but opportunities include servicing and maintaining equipment, installing efficient lighting and equipment upgrades. Knowing the operation's current energy use can help determine the best strategy.

What's Included The focus is on energy used for dairy activities only. This includes uses such as heating water, milking, cleaning, scraping, ventilating, grinding and mixing. Renewable energy from wind and solar is also included.

As much as possible, exclude crop production activities like planting, irrigation and harvest, as well as any other non-dairy enterprises on the farm. Impacts from these activities are already estimated in FARM ES using information from the dairy LCA. Crop production should be excluded even if the crop is used as feed for the operation's cows. However, activities that occur starting with the removal of feed from storage, such as feed mixing and conveyance, should be included.

Values Reported Figures for energy consumption are reported as total use over the course of a consistent year.

What's Needed Utility bills may be useful for determining electricity and natural gas usage. Information on other fuels may be found in purchase records or usage logs. If the farm has solar or wind energy on-site, it may be useful to consult the lease, contract or Power Purchase Agreement associated to determine ownership of the Renewable Energy Certificate (REC). Another resource is this database of state programs: www.dsireusa.org.

Reporting Guidance

Renewable Energy

FARM ES asks about solar and wind energy being generated on the farm. In order to determine how much the renewable energy impacts the GHG footprint, the tool asks about Renewable Energy Certificates (RECs) associated with the renewable energy. If the farm has sold the credit, the greenhouse emissions associated with the solar or wind energy go to the buyer of the credit. For example, a utility may purchase RECs from businesses that install solar panels or wind turbines. To determine who owns the REC, consult the lease, contract or Power Purchase Agreement. Another resource is this database of state programs: www.dsireusa.org. If you or the farm are uncertain, select "None Generated."

If the dairy does NOT participate in net metering, the tool will ask a follow-up question about whether the energy is exported off-site or used on-site.

Should I include the farm's renewable energy in the kWh of electricity? Only enter the electricity purchased, not any electricity generated on-site from renewable energy. The renewable energy generated on the farm is accounted for in the Renewable Energy section for solar and wind, and in the Manure section for electricity from an anaerobic digester.

How should I handle net metering? If the farm has a net metering utility bill, enter the total amount of energy used in the electricity section – not the net balance. In the solar or wind section, you'll enter the kwh of renewable energy generated. For example, a farm has a "net" energy use at the end of the year of 0, but generated and used 100,000 kwh of on-site solar energy: enter "100,000 kwh" in the solar energy section and specify that net metering is used. Under electricity, enter "100,000 kwh." The model will subtract accordingly.

Solar Energy

Total annual solar energy generated on site	___________ **kWh**
Does the farm own the Renewable Energy Certificates (RECs) or other energy certificates associated with the solar energy? *If unsure, select None Generated*	*Circle one:* **Owns / Sold None Generated**
Does the farm participate in net metering?	**Yes / No**
If not, is the solar energy used on-site or exported off-site?	**On-Site / Off-Site**

Wind Energy

Total annual wind energy generated on site	___________ **kWh**
Does the farm own the Renewable Energy Certificates (RECs) or other energy certificates associated with the wind energy? *If unsure, select None Generated*	*Circle one:* **Owns / Sold None Generated**
Does the farm participate in net metering?	**Yes / No**
If not, is the wind energy used on-site or exported off-site?	**On-Site / Off-Site**

Energy

In general, any energy use associated with the dairy operation should be included. The following table can be used to determine which activities to include and exclude. However, this table may not represent an exhaustive list of practices and equipment that use energy on every dairy farm. Please consider how each unique operation uses energy for dairy activities.

? ***What if equipment is also used for crop production or other non-dairy activities? Similarly, what if the utility bill includes the home or other non-dairy buildings?*** It is common for equipment and utility bills to be shared across farm activities and buildings not associated with the dairy operation. Recognizing this constraint, the module allows users to enter in the total use and then estimate the percentage used on dairy activities. Another option is to look at energy use during months where the operation is not conducting any crop production activities. An annual estimate can be derived based on those months. Any assumptions or estimates used to report energy should be logged in the notes section.

? ***What if the only known information is the total amount spent on electricity or fuel, not the total use?*** Use the average price per kWh of electricity or price per gallon of fuel to estimate the total usage. For example, if the average price of electricity is $0.12 per kWh and the farm's expenditure for a consistent year was $48,000, then the total annual usage was approximately 48,000 / 0.12= 400,000 kWh.

Category	Unit	Include	Exclude	Farm's Annual Usage
Electricity	kWh	• dairy parlor use (compressors, pumps, etc.) • lighting • ventilation • feed conveyance • manure management • other	• crop production activities (e.g. irrigation, drying) • non-dairy enterprises on your farm • home electricity use	_________ kWh _________ % used on dairy activities
Diesel	Gallons	• machinery for feeding • manure management, except for spreading • transporting heifers or cows	• crop production activities (e.g. tillage, planting, harvest) • non-dairy enterprises on your farm	_________ gal. _________ % used on dairy activities
Biodiesel	Gallons	• machinery for feeding • manure management, except for spreading • transporting heifers or cows • for blended fuels, report only the biodiesel portion: gallons x % biodiesel	• crop production activities (e.g. tillage, planting, harvest) • non-dairy enterprises on your farm	_________ gal. _________ % used on dairy activities
Fuel Oil	Gallons	• heating/water heating when used for dairy activities	• home heating • non-dairy enterprises on your farm	_________ gal. _________ % used on dairy activities
Propane	Gallons	• heating/water heating when used for dairy activities	• home heating • non-dairy enterprises on your farm • crop production activities, such as grain drying	_________ gal. _________ % used on dairy activities
Natural Gas	Therms	• heating/water heating when used for dairy activities • 1 Therm=1 CCF = 100 cubic feet	• home heating • non-dairy enterprises on your farm • crop production activities, such as grain drying	_________ therms _________ % used on dairy activities
Gasoline	Gallons	• machinery for feeding • manure management • transporting heifers or cows • vehicles used in other dairy management activities	• crop production activities (e.g. tillage, planting, harvest) • non-dairy enterprises on your farm	_________ gal. _________ % used on dairy activities

Chapter 4: Feed

Ruminant livestock have a four-compartment stomach within their digestive tract that promotes microbial fermentation. The process of fermentation helps cows break down roughage, but it also results in the production of methane, a potent greenhouse gas. The total amount fed significantly contributes to how much methane is released. So improvements in feed efficiency – more milk production per unit of dry matter intake – can address both profitability and the farm's environmental footprint. Ongoing research continues to deepen our understanding of how to manage enteric methane. Additionally, this section includes questions about ration composition. Crop production and feed processing both require energy, which varies by feed ingredient. Therefore, understanding ration formulations is important for estimating the farm's carbon and energy impacts.

Pasture

What's Included Pasture questions refer to lactating cows, dry cows and young stock. This section is only applicable to farms that utilize pasture as one of their feedstuffs.

Values Reported Time in pasture is recorded in weeks/year and average hours/day for a consistent year.

What's Needed Grazing records or pasture management spreadsheets may be consulted. A Nutrient Management Plan may also contain information on pasture utilization.

Why does FARM ES ask about time in pasture? For FARM ES, time on pasture relates to manure emissions. The more time on pasture, the more manure is deposited on pasture.

What if only part of the herd is pastured? If only a portion of the animals in a particular group graze, you can account for this by adjusting your response to one of the time questions appropriately. For example, if 25% of the dry cows are on pasture for 15 weeks, 24 hours per day, you could enter 0.25x15=3.75 weeks/year.

Reporting Guidance

Animal Type	Time in Pasture	
	Weeks per Year (0 to 52)	*Average Hours per Day (0 to 24)*
Lactating cows		
Dry cows		
Young stock		

Enter the weeks per year and average hours per day spent in pasture for lactating cows, dry cows and young stock.

Rations

What's Included Ration questions refer to lactating cows only. FARM ES estimates dry cow and heifer rations based on survey data from the dairy LCA. Details on these estimates can be found in the accompanying FARM ES Reference Manual.

Values Reported Ration and feed figures are reported as the average daily intake per head of lactating cow during a consistent year.

What's Needed The farm's nutritionist may be able to provide a printout or electronic copy of feed rations for lactating cows. Ration data may also be available in the operation's dairy management software system or in written records.

Reporting Guidance

Users may need to average values across varying rations to come up with a single average for the entire lactating herd as well as convert from an as-fed basis to a dry matter basis.

Average Dry Matter Intake

Report the average dry matter intake (DMI) per head for lactating cows only in pounds per day (lbs./day). This figure should be available from the farm's nutritionist. If multiple rations are fed throughout the lactating phase and the overall average ration is not known, the following worksheet can be used to determine a time-weighted, overall average of the rations:

Ration	DMI *lbs./day*		Average Days in Ration		Total Lactating Days		Time-Weighted DMI *lbs./day* *(Total this column to find the overall average)*
E.g. High	50	X	150	/	300	=	25
E.g. Low	30	X	150	/	300	=	15
		X		/		=	
		X		/		=	
		X		/		=	
		X		/		=	
						Total:	____________

Percent Make-Up of Average Lactating Cow Ration

Report the percent make-up, on a dry matter basis, of ingredients in the average lactating cow ration. The following table can be used to convert from an as-fed basis to a dry matter basis.

What if the ration includes ingredients that are not listed in the table? If the operation's rations contain ingredients that are not listed below, such as barley grain or legume silage, they can be entered into the "All Other Feed" category. In the future, FARM ES will ask more detail about what is included within "all other feed" to enhance the science behind the tool

Feed Ingredient	As-Fed *lbs./day*		Average % Dry Matter Content		Dry Matter Intake *lbs./day*	Feed Ingredient % of Total DMI *(dry matter basis)*
Corn grain (including cracked, ground and steam-flaked)		X	85%	=		
Corn silage		X	35%	=		
Wet DGS		X	40%	=		
Dry DGS		X	91%	=		
Soybean (raw or roasted)		X	91%	=		
Soybean meal		X	89%	=		
Alfalfa hay		X	84%	=		
Alfalfa silage		X	39%	=		
Grass hay		X	84%	=		
Grass silage		X	35%	=		
Pasture		X	20%	=		
All other feed		X	85%	=		

Feed Production

Farm ES collects data on crop production for informational purposes so that scientists can refine FARM ES over time. It does not impact the GHG or energy footprint results within FARM ES. In general, crop production activities like tillage, planting and harvest all use fossil fuels that emit greenhouse gases. The decision to purchase feed or produce it on-farm depends on the operation's unique circumstance. For operations engaged in feed production, best practices like ensuring equipment is in good working shape and limiting idling time to less than 10 minutes can help reduce fuel use and the operation's carbon footprint.

FARM ES estimates the greenhouse gas impacts associated with producing crops for dairy feed. As part of this estimate, the module differentiates between the impacts from purchased feed versus feed produced on-farm. Purchased feed, for example, must be transported and delivered to the farm, which entails using fuel for transit. In general, crop production activities like tillage, planting and harvest all use fossil fuels that emit greenhouse gases. The decision to purchase feed or produce it on-farm depends on the operation's unique circumstance. For operations engaged in feed production, best practices like ensuring equipment is in good working shape and limiting idling time to less than 10 minutes can help reduce fuel use and the operation's carbon footprint.

What's Included This section refers to the crops produced on the farm that are used as feed for the dairy operation. It does not encompass crops grown for other purposes (i.e. sold or used for the production of other animals).

Values Reported Crop production data is reported as annual average percentages for a consistent year.

What's Needed The operation's feed purchase records or written records may be consulted for crop production information.

Reporting Guidance

For each of the crops listed that are used as dairy feed on the operation, specify the portion that is self-produced.

Crop Type	Soybean	Corn grain	Alfalfa hay	Alfalfa silage	Corn silage	Grass hay	Grass silage
% That is Self-Produced	_____%	_____%	_____%	_____%	_____%	_____%	_____%

? ***What's considered self-produced versus purchased?*** For the purpose of FARM ES, consider "self-produced" any crop production where the dairy operation has operational control over crop production decisions. This can mean crop production happening on the dairy itself, or on a related LLC or entity in which the dairy owner has part ownership. "Purchased" would be anything where the dairy does not have any operational control, for example grain or forage purchased from a neighbor.

Chapter 5: Manure

Over time, manure decomposes and releases greenhouse gases – methane and nitrous oxide – during the process. The amount and rate of emissions depends on how much manure is present and how the manure is stored. Nitrous oxide emissions will also vary with the carbon and nitrogen content. However, greenhouse gas emissions are not the only important factor in choosing a manure management system – one must also balance the issues of cost, regional constraints, nutrient management and more.

Nutrient management is certainly an important part of any dairy operation's manure management strategy. It entails the efficient use of nutrients to maximize forage and crop growth while safeguarding natural resources. FARM ES now asks about the farm's use of a Nutrient Management Plan (NMP). NMPs help guide management decisions to ensure nutrients are applied in an economically efficient and environmentally sound manner.

What's Included This section covers all manure management for the entire dairy operation, including the lactating cows, dry cows, heifers and calves. Manure deposited onto pasture should be excluded from reporting because the model uses the time spent on pasture, as inputted in Chapter 4, to estimate the associated emissions.

Values Reported Manure management data is reported as the average over the course of a consistent year.

What's Needed The farm's Nutrient Management Plan or Comprehensive Nutrient Management Plan may contain details on manure management.

Reporting Guidance

Manure Management Systems

Report the estimated percentage of excreted manure handled in each manure management system.

What if the fraction of manure handled by each system is not known? One option is to use the time spent in various farm areas as a proxy for manure distribution. For example, consider a case where manure from the milking parlor is sent into an anaerobic lagoon and manure in the freestall barn is scraped into solid storage. If each lactating cow spends about 3 hours per day in the milking parlor and 21 hours per day in the freestalls, then about 3/24 or 13 percent of manure goes to the anaerobic lagoon and 21/24 or 87 percent goes to solid storage.

Are there other tips for gathering this information from the farm? Rather than listing all of the options, ask the farm to explain how they manage their manure. As they walk you through the process, you'll be able to identify their primary manure management system(s).

If assumptions are made to estimate the fraction of manure going to each system, record those in the notes section for use in subsequent years.

System	Description	% of Manure
Daily spread	Manure is collected and land applied within 24 hours.	%
Solid storage	Storage of manure, often for several months, in unconfined piles or stacks.	%
Dry lot	A paved or unpaved open confinement area without any significant vegetative cover where accumulating manure may be removed periodically.	%
Liquid/slurry with natural crust	Often in earthen structures, basins or tanks. Slurry is usually between 5% and 15% dry matter. There is little added water. A natural crust is allowed to form.	%
Liquid/slurry without natural crust	Often in earthen structures, basins or tanks. Slurry is usually between 5% and 15% dry matter. There is little added water. A natural crust is NOT allowed to form.	%
Uncovered anaerobic lagoon	Lagoons combine waste stabilization, treatment and storage. Water is added. Solids volume is typically less than 5%. Uncovered lagoons are open to the ambient air.	%
Covered anaerobic lagoon	Lagoons combine waste stabilization, treatment and storage. Water is added. Solids volume is typically less than 5%. Uncovered lagoons are open to the ambient air.	%
Pit storage less than 1 month	Usually with little or no added water, collected below a slatted floor, with storage LESS THAN one month.	%
Pit storage greater than 1 month	Usually with little or no added water, collected below a slatted floor, with storage GREATER THAN one month.	%
Deep bedding less than 1 month	Bedding is continually added to absorb moisture over a production cycle LESS THAN one month (a.k.a. bedded pack).	%
Deep bedding greater than 1 month	Bedding is continually added to absorb moisture over a production cycle GREATER THAN one month (a.k.a. bedded pack).	%
Composting in-vessel or static	In-vessel: typically in an enclosed channel, with forced aeration and continuous mixing. Static pile: in piles with forced aeration but no mixing.	%
Composting intensive with forced aeration	Composting in windrows with regular (daily, 2 to 3 times per week, or weekly depending on stage) turning for mixing and aeration.	%
Composting natural aeration	Composting in windrows with infrequent turning for mixing and aeration, often with installed pipes for passive aeration (no blower or other forced air).	%
Aerobic treatment with forced aeration	Liquid handling with the addition of oxygen through forced aeration.	%
Aerobic treatment with natural aeration	Liquid handling with the addition of oxygen through natural aeration, such as facultative ponds and wetland systems that rely on photosynthesis.	%
Anaerobic digester	Encourages the bacterial decomposition of manure in the absence of oxygen, producing biogas, which is collected and utilized or flared.	%
Solid-liquid separation	Processing technology that partially separates the solids from liquid manure using gravity or mechanical systems.	%

Source: Manure management system descriptions are derived from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.[3]

[3] *IPCC. (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme. Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). IGES, Japan.*

Anaerobic Digester Details

For operations with anaerobic digesters, FARM ES contains additional questions to estimate the carbon footprint reduction associated with the digester.

If electricity is generated from the digester, additional questions ask about on-site or off-site use as well as Renewable Energy Certificates (RECs). If the farm has sold the RECs, the greenhouse emissions associated with the electricity from the digester go to the buyer of the credit. To determine who owns the REC, consult the lease, contract or Power Purchase Agreement. Another resource is this database of state programs: www.dsireusa.org. If you or the farm are uncertain, select "None Generated."

Item	Description	Value
Conversion efficiency	Solids-to-gas conversion efficiency of the digester. Typical values range from 20% to 65%.	__________%
Manure management system for effluent *(after digester)*	Select the manure management system (MMS) from the previous table that best describes how the effluent is treated after exiting the digester.	**Choose one MMS from the options in the previous table:** ______________________ ______________________
Percent of electricity generation potential utilized	Fraction of electricity generated potential that is actually converted to electricity. Ranges from 0% to 40%.	__________%
	If electricity is generated, is it used on-site or sold off-site?	**On-Site / Off-Site**
	If electricity is generated, does the farm own the Renewable Energy Certificates (RECs) or other energy certificates associated with the electricity generated from the digester? *If unsure, select None Generated.*	**Owns** **Sold** **None Generated**
Percent of heating potential utilized	Fraction of heating potential utilized. Ranges from 0% to 40%.	__________%

Solid-Liquid Separation Details

If the farm uses SLS, additional questions appear to specify how the solid and liquid fractions are managed after going through solid-liquid separation. Double check that you do not duplicate the manure management strategy in this section and the second above. In other words, if all manure goes through the solid-liquid separator and the liquid fraction goes to an anaerobic lagoon and the solid to compost, select SLS as the only MMS and mark it as 100%.

<table>
<tr><td colspan="2">Does the Solid-Liquid Separation happen before or after an anaerobic digester?</td><td>Circle one:
Before / After
Without Digester</td></tr>
<tr><td colspan="2">Separation efficiency</td><td>__________ %</td></tr>
<tr><td colspan="2">Liquids management
Select an MMS from the table on Page 16</td><td>Liquid MMS:
__________</td></tr>
<tr><td rowspan="2">Total for solids management must equal 100%.</td><td>Solids management #1
Select an MMS from the table on Page 16.</td><td>Solid MMS:
____
% of Manure: ______</td></tr>
<tr><td>Solids management #1
Select an MMS from the table on Page 16.</td><td>Solid MMS:
____
% of Manure: ______</td></tr>
<tr><td colspan="2">Which type of solid-liquid separator does the farm use?</td><td>• Belt press
• Centrifuge
• Gravity settling
• Roller press
• Rotating screens
• Screw press
• Stationary screens
• Other (please specify):
__________</td></tr>
</table>

How do I determine the separation efficiency? Separation efficiency varies greatly based on many factors, such as separator type and design, manure consistency, total solids content and flow rates. Talk to the manufacturer for more information. Suggested values for separation efficiency: screw press (25% to 45%); centrifuge (50% to 61%); stationary screens (15% to 50%), rotating screens (1% to 14%); belt press (30% to 50%); roller press (10% to 40%).

Nutrient Management Plans

For the questions below, Nutrient Management Plan includes a Nutrient Management Plan (NMP), a Comprehensive Nutrient Management Plan (CNMP) or a Manure Management Plan (MMP).

Does the farm have a written Nutrient Management Plan?	**Yes / No**
If yes, which type(s) of written Nutrient Management Plan does the farm have? *Select all that apply.*	**a. Nutrient Management Plan (NMP)** **b. Comprehensive Nutrient Management Plan (CNMP)** **c. Manure Management Plan (MMP)**
Does the farm maintain the Nutrient Management Plan? *Maintained means it is reviewed regularly and updated as needed. Indicate "yes" if the NMP is reviewed at least every five years to determine if updates are needed. State or local regulations may require the plan to updated more frequently.*	**Yes / No**
Does the farm implement the Nutrient Management Plan? *Implementation means that the farm follows the NMP's guidance around nutrient testing, nutrient application, recordkeeping and any other requirements.*	**Yes / No**

Chapter 6: Results

Increasingly, customers demand proof of sustainability and stewardship from their supply chain. From farm to retail, the U.S. dairy industry has become vastly more efficient over the years, enabling overall reductions in resource use per gallon of milk. However, tracking and communicating that efficiency story has not always been easy or straightforward for farmers or cooperatives. FARM ES results help prove a piece of dairy's sustainability story – continued efficiencies enabling industry-wide reductions in greenhouse gas emissions and energy use.

Interpreting Results

Overview

The module uses the information entered in the previous steps to estimate the farm's greenhouse gas emissions and energy use. The results are scaled by pounds of milk produced in order to compare performance year-to-year and across farms that differ in milk output. Specifically, milk output is converted to fat and protein corrected milk (FPCM), which is a measure of milk production that normalizes milk output to the same scale (to an average content of 4% fat and 3.3% protein).

Users can record their first set of footprint results as the farm's baseline. Recording results annually creates a history of the farm's performance over time. Because farming relies on natural systems and external markets – both of which can be unpredictable – there may be no observable improvements year-to-year. The goal is to capture long-term trends, regardless of annual ups and downs.

The output of FARM ES is an LCA footprint of GHG emissions and energy use. That means that the results represent all emissions and energy use from "cradle" to farm gate. For example, the GHG emissions associated with energy use represent both emissions from fuels directly burned and used on the farm, as well as the emissions required to drill or mine and process the fuel.

Greenhouse Gas Emissions

Background

A greenhouse gas (GHG) is a gas that absorbs and re-emits heat in the Earth's atmosphere. GHGs differ in their ability to trap and emit heat. For example, carbon dioxide has a Global Warming Potential of 1, whereas methane is rated a 25. In other words, methane has 25 times the potential impact as carbon dioxide.[4] To compare across these gases, they are all converted into carbon dioxide equivalents (CO_2e).

Results

The graph and table in Figure 1 (Page 16) show the pounds of CO2e per pound of FPCM.

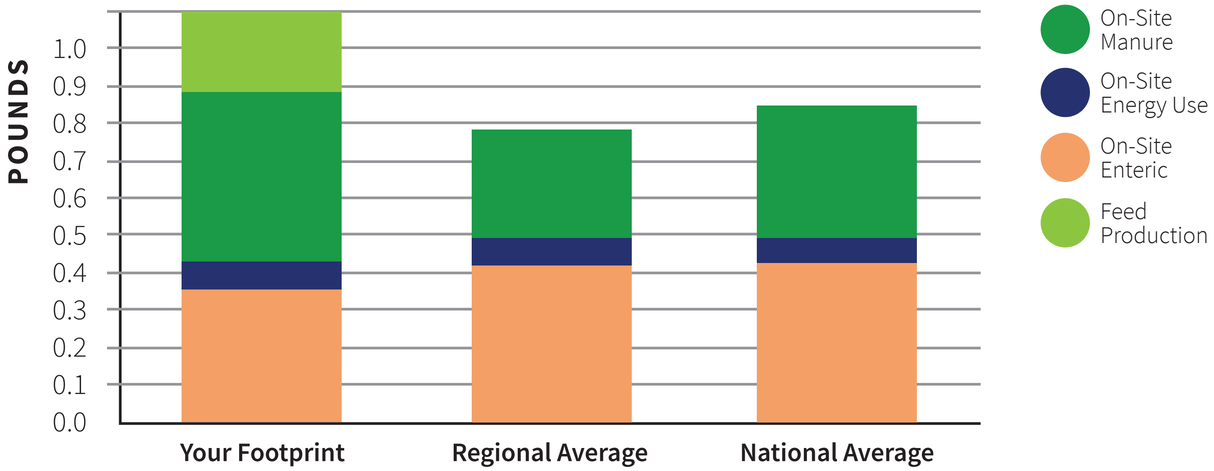
The results are divided into areas of production: feed production, on-site enteric, on-site manure and on-site energy use. "On-site" refers to dairy activities on the farm. If the operation purchases feed and does not engage in crop production activities, the output will still generate an estimate for the impacts of the purchased feed.

The table provides greater insight into how the operation's results compare to regional and national averages. Benchmarks are not available for Feed Production emissions in FARM ES Version 2. Regions are shown in Figure 2 (Page 21).

[4] *IPCC. (2007). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.*

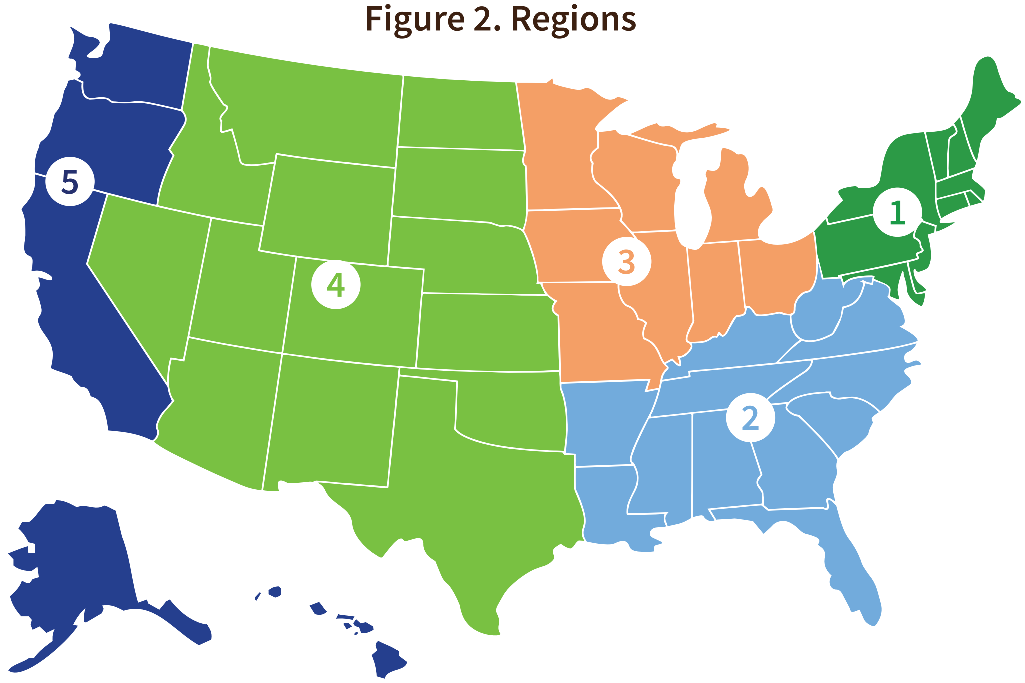
Figure 1. Your Farm Greenhouse Gas Emissions

lb CO_2e / lb FPCM produced



	Your Footprint	Regional Average	Regional Difference	National Average	National Difference
Feed Production	0.187				
On-Site Manure	0.467	0.296	*-0.171*	0.358	*-0.109*
On-Site Energy Use	0.057	0.072	*0.015*	0.067	*0.009*
On-Site Enteric	0.367	0.418	*0.051*	0.431	*0.064*
TOTAL (without Feed Production)	**0.891**	**0.786**	***-0.105***	**0.856**	***-0.035***
TOTAL	**1.079**				

Figure 2. Regions



Energy Intensity

Background

The energy used to produce milk – in the form of gasoline, electricity, propane or other – is converted into megajoule (MJ) and divided by the pounds of FPCM.

Results

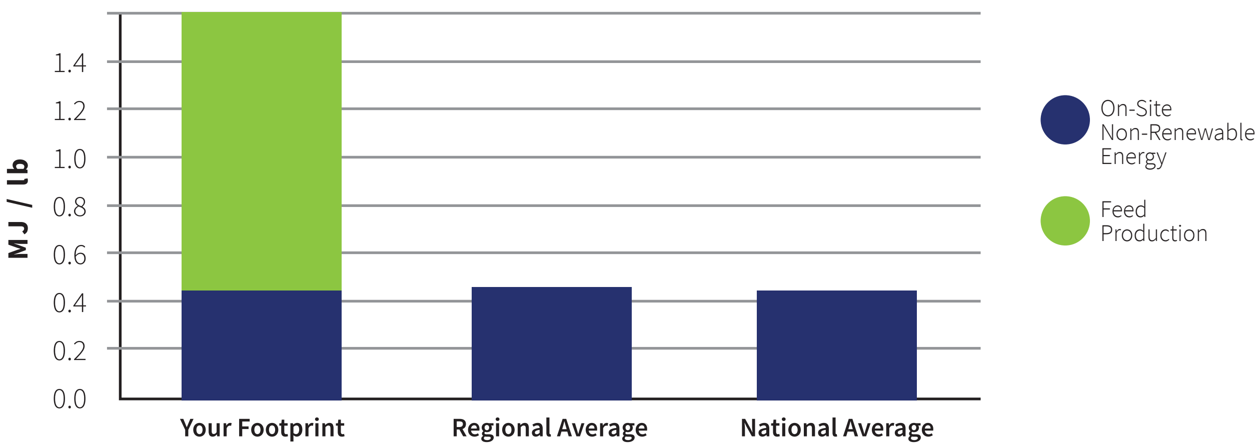
The graph and table in Figure 3 show the MJs of energy per pound of FPCM. The results are divided into areas of production: feed production and on-site energy. "On-site" refers to dairy activities on the farm. If the operation purchases feed and does not engage in crop production activities, the output will still generate an estimate for the impacts of the purchased feed categories under "feed production."

In FARM ES Version 2, on-site energy is divided into renewable and non-renewable. Renewable energy, like solar and wind, have less greenhouse gas emissions than non-renewable energy, like diesel or gas. Grid electricity is included within "non-renewable" energy, even though some electric grids in the U.S. do in fact use renewable energy. This is because FARM ES is a simplified tool and does not yet capture the structure of each individual grid in the U.S.

The table provides greater insight into how the operation's results compare to regional and national averages. Benchmarks are not available for Feed Production emissions in FARM ES Version 2. Regions are shown in Figure 2.

Figure 3. Your Farm Energy Use

MJs / lb FPCM produced



	Your Footprint	Regional Average	Regional Difference	National Average	National Difference
Feed Production	1.159				
On-Site Renewable Energy	0.000				
On-Site Non-Renewable Energy	0.437	0.467	*0.030*	0.430	-0.006
TOTAL (without Feed Production)	**0.437**	**0.467**	***0.030***	**0.430**	***-0.006***
TOTAL	**1.595**				

Renewable Energy

Background

The use of renewable energy can lower greenhouse gas emissions. FARM ES captures the use of solar and wind energy as well as electricity or heat from an anaerobic digester.

Results

The table below shows an example of how FARM ES results display the benefits of using renewable energy. The results capture the "avoided" emissions in the FARM ES online tool. In other words, if a farm starts using solar energy, that means it uses a smaller amount of conventional electricity from the utility grid – it "avoids" using regular electricity, so it also "avoids" the greenhouse gas emissions that would come with that grid electricity.

Note: The avoided emissions figures are provided for illustrative purposes only and only apply to FARM ES results. They are based on LCA emissions and cannot be used for GHG credits or other environmental crediting.

Renewable Energy Benefits		
Solar / Wind Benefits	**By using solar / wind energy on-site, the farm avoided this amount of emissions:**	**0.04 kg CO2e / kg FPCM**
	And it reduced its non-renewable energy footprint by approximately:	**0.05 MJ / kg FPCM**

The numbers will likely be small, unless the farm is using a very large amount of renewable energy.

If the farm generates renewable energy, but sells the credits associated with it, it can no longer claim greenhouse gas benefits from the energy. The buyer of the credit (such as a utility company) has essentially purchased the right to the greenhouse gas benefits. However, the farm is still benefiting society by creating those credits and selling them. FARM ES would capture that benefit as follows:

Renewable Energy Benefits		
External Benefits	**Because the farm exported renewable energy off-site or sold its RECs, it helped another organization(s) avoid GHG emissions by:**	**0.04 kg CO2e / kg FPCM**

Gas Type Breakdown

Background

Greenhouse gas emissions from dairy farms are in the form of carbon dioxide, methane and nitrous oxide. FARM ES provides a breakdown of the results by type of gas to help FARM Participants with supply chain reporting to customers or other organizations, like CDP.

Results

The table below shows an example of how FARM ES results display the breakdown by gas type. The FARM ES Reference Manual contains more information about the types of greenhouse gases.

Gas Type Breakdown		
Carbon Dioxide (CO_2)	0.369 kg CO_2e / kg FPCM	20.8%
Methane (CH_4)	0.862 kg CO_2e / kg FPCM	48.6%
Nitrous Oxide (N_2O)	0.544 kg CO_2e / kg FPCM	30.7%
TOTAL	1.775 kg CO_2e / kg FPCM	100.0%

Limitations Farm ES does not directly measure a farm's actual environmental footprint; it relies on a model to produce a reliable, statistically valid estimate. Models are used to estimate GHG emissions because it would be impractical to actually measure them for an entire farm. For example, to measure the gas that a cow emits, you would have to put her in an enclosed chamber. Instead, a model estimates the gas she emits using formulas and input data that are easier to gather, such as dry matter intake. The formulas and input data that make up the model are scientifically shown to accurately estimate GHG emissions. Scientists created the FARM ES model using findings from the life cycle assessment (LCA) research conducted by the Applied Sustainability Center at the University of Arkansas supported by the Innovation Center for U.S. Dairy. The FARM ES model explains 98% of the variability in carbon footprint among farms in the LCA analysis.[5]

Because they are estimates, FARM ES results are most useful for tracking the direction of change over time, rather than understanding the absolute measure of the farm's GHG emissions at any given point in time. That is because estimates always have a margin of error associated with them. Additionally, the tool does not take into account the details of every on-farm management practice or technology. For example, the farm may use feed additives to reduce methane emissions. But the benefits of certain practices and technologies are not yet reflected in FARM ES results.

Additional Resources Interested users should consult the FARM ES Reference Manual for suggested practices that farmers can implement on their farms to improve both economic and environmental performance.

[5] *Asselin-Balençon, A. C., et. al. (2013). Dairy farm greenhouse gas impacts: A parsimonious model for a farmer's decision support tool. International dairy journal, 31, S65-S77. https://www.sciencedirect.com/science/article/pii/S0958694612001999*

To learn more about the National Dairy FARM Program, visit

NATIONALDAIRYFARM.COM

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