# DairyGEM: Software for Evaluating Gaseous Emissions from Dairy Farms

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Emissions Management Practices

Protecting Air Quality

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**Developed by:**

**Livestock GRACEnet**
*leading the development of mitigation practices to reduce emissions from livestock production*

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## Definition:

The Dairy Gas Emissions Model (DairyGEM) is a process level simulation that predicts the important gaseous emissions from dairy production systems.

## Purpose:

Many compounds are emitted from dairy farms. Those of current interest are ammonia, hydrogen sulfide, and greenhouse gases (GHG) of methane, nitrous oxide and carbon dioxide. The evaluation of mitigation strategies is complex because strategies that reduce one type or source of emission may increase others. A proper evaluation requires a comprehensive assessment of all important emissions and their interactions. Measurement of emissions from dairy farms is difficult, expensive, and ultimately, time and location specific. DairyGEM was created as an easy to use tool for estimating dairy farm emissions and evaluating the impact of management on those emissions.

## How Does This Software Work:

Researchers over the past century have developed a good understanding of how volatile compounds in solution form, migrate, react, and volatilize to the atmosphere. As this understanding evolved, mathematical models were developed and validated to represent these processes of dissociation, diffusion, aqueous-gas partitioning, and mass transport into the air. By linking these relationships, emission rates of ammonia and hydrogen sulfide are predicted for each of the four major sources on farms: housing facilities, manure storage, field applied manure, and deposits on pasture.

Important sources and sinks of GHG are predicted using process simulation and process driven emission factors. A major carbon dioxide sink is the fixation of carbon in crop growth with emission sources including plant respiration, animal respiration, and microbial respiration in the soil and manure. Major sources of methane include enteric fermentation and the long term storage of manure. Minor methane sources include the barn floor, field applied manure, and feces deposited by grazing animals. Nitrous oxide is a product of the nitrification and denitrification processes in soil. These processes can also occur in the crust on a slurry manure storage, on a pen surface, or during the storage of solid manure in a bedded pack or stack. All individual processes and their interactions are integrated in the software to determine a whole-farm net emission. Through a partial life cycle assessment, energy and carbon footprints are also determined that include secondary sources during the production of fuel, electricity, machinery, fertilizer, pesticide, feed and any off-farm raised heifers used in the production system.

## Where This Software Applies and Its Limitations:

DairyGEM can be generally applied to a wide range of dairy production systems varying from small grazing-based operations to large confinement feeding operations. To maintain simplicity in use, options for describing the details of a farm are limited, but many of the more important options can be represented. Location weather files are only provided for regions of the United States, but the model can be used for other regions of the world with similar production practices.

The software is not intended for use in predicting emission values for regulatory or similar purposes, but rather for determinig and comparing relative differences obtained through management changes and mitigation



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strategies. The model and documentation are distributed "as is", with no warranty expressed or implied. Because of the many variables involved and the judgments that must be made in choosing inputs, interpreting outputs, and general use of this software, the USDA's Agricultural Research Service is not responsible for any problems, damages, or losses caused either directly or indirectly by use of the model.

## Effectiveness:

The DairyGEM software is provided as an educational aid for individual, workshop, and classroom use in evaluating dairy farm emissions and the effect of management changes on those emissions. Most model options have been verified to provide reasonable emission predictions, and further evaluation of the model continues by comparing predictions to experimental and farm measurements.

## Cost of Software:

DairyGEM is available at no cost through Internet download. The software and further information are available at http://www.ars.usda.gov/Main/docs.htm?docid=21345. The software can be installed and used on computers using a Windows® operating system.

## Operation:

Input information is supplied through the farm and location parameter files. The farm file contains data describing the production system, which includes feeds and pasture available, animal and herd characteristics, housing facilities, and manure handling strategies. These parameters are conveniently modified through menus or dialog screens in the user interface. Many files can be created to store parameters for different farms for later use. The location file contains 15 years of recent historical daily weather data for the selected location.

The model provides output in four files: summary, full report, optional, and parameter tables. The summary provides the option for three tables that contain average feed use, gaseous emissions, and environmental footprints. In the full report, values are given for each simulated year as well as the mean and variance over all years. Optional output tables are available for a closer inspection of animal rations, feed use, secondary GHG emissions, and annual weather. Parameter tables summarize the input parameters specified for a given simulation. At the completion of a simulation, a bar graph illustrates the predicted emissions. A pie chart is also available that provides a breakdown of the major components of the carbon and energy footprints. Plots can be viewed of the daily emissions of each gas and the total GHG from the barn and manure storage, as well as that from the whole farm over a full year.

## References:


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## For Further Information:


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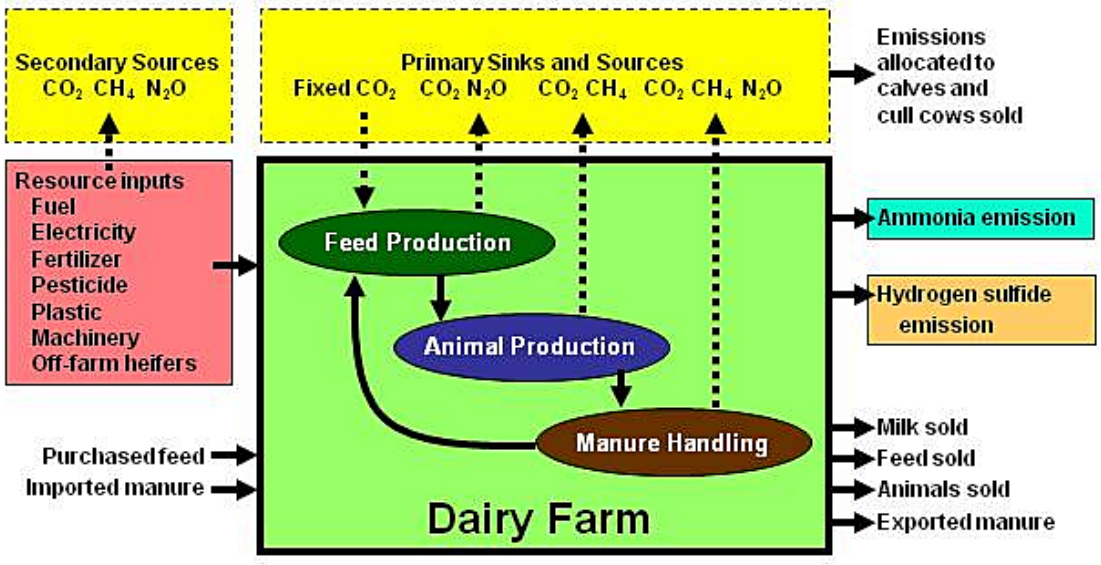


**DairyGEM**

**A farm gate Life Cycle Assessment is used to model greenhouse gas emissions along with simulated emissions of ammonia and hydrogen sulfide**