factsheet
Pork Information Gateway

Pork Production and Greenhouse Gas Emissions

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Introduction

Regardless of whether or not global warming is resulting from human activity, the amount of attention given to greenhouse gases (GHG) released by human activity is increasing. Major greenhouse gas initiatives, such as the Kyoto Protocol and the Chicago Climate Exchange, are propelling the adoption of carbon reporting and reduction activities. Agriculture in general, and livestock production in particular, is in the middle of the discussion. In one situation, livestock producers in the U.S. are showing interest in the opportunity to be paid for capturing methane from manure storage. In another, many people cite a United Nations study which attributes animal agriculture for 18% of all GHG emissions measured in CO2 equivalents to advocate less meat consumption.

This publication draws heavily upon a report issued in 2008 by the U.S. Environmental Protection Agency (EPA) entitled *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006* and a United Nations report entitled *Livestock's Long Shadow – Environmental Issues and Options*.

Objectives

This factsheet is intended to assist pork producers 1) to present the known facts regarding livestock production and GHG emissions and 2) to provide insight into how GHG emissions from pork production can be minimized.

Greenhouse Gasses

Greenhouse gases are gases in the atmosphere that capture the earth's infrared radiation and warm the surface of the earth. Without the greenhouse effect, the temperature of the earth would be about -2oF rather than its current temperature of about 59oF [1]. The concern among many scientists is that the concentration of GHG has increased significantly since the beginning of the industrial revolution. It is hypothesized that these increased concentrations of GHG can warm the surface of the earth and cause changes in climatic conditions.

The naturally occurring GHG, in order of relative abundance, include: water vapor, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and ozone (O3). GHGs that are not naturally occurring are substances containing fluorine, chlorine, and bromine.

This factsheet will focus on the GHG emissions affected by agriculture, with particular emphasis on the role of swine production. Carbon dioxide is the most well know GHG because it is the most prevalent (over 80% of greenhouse emissions related to human activity) and is associated with burning fossil fuels. However, methane and nitrous oxide are the GHGs most associated with pork production. Pound for pound, methane contributes 21 times the impact of carbon dioxide to global warming. Nitrous oxide contributes 310 times that of carbon dioxide [2]. All GHG are reported as carbon dioxide equivalents (CO2 Eq) in this factsheet.

Sources of GHG

In 2006, U.S. GHG emissions totaled 7,054 million metric tons (MMT) CO2 Eq. The EPA distributes GHG emissions among five economic end-user sectors – industrial, transportation, residential, commercial, and agriculture (see figure 1). GHG emissions from electricity generation are allocated to each sector according to each sector's electricity consumption. Agriculture is estimated to emit 596 MMT, or almost 9%, of the GHGs emitted in the U.S. in 2006. Breaking agriculture into various sources, crop and soil management emitted 4%, enteric fermentation 2%, electricity used in agriculture 2%, and manure management 1% of all U.S. emissions.

The EPA also reports GHG emissions by Intergovernmental Panel on Climate Change (IPCC) sectors. IPCC sectors, listed in descending order by quantity of emissions, are energy, agriculture, industrial processes, waste, land use (emissions only), and solvent and other product use. Though agriculture is the second largest source of GHG, it is estimated to be responsible for only 6% while energy is responsible for 86%.

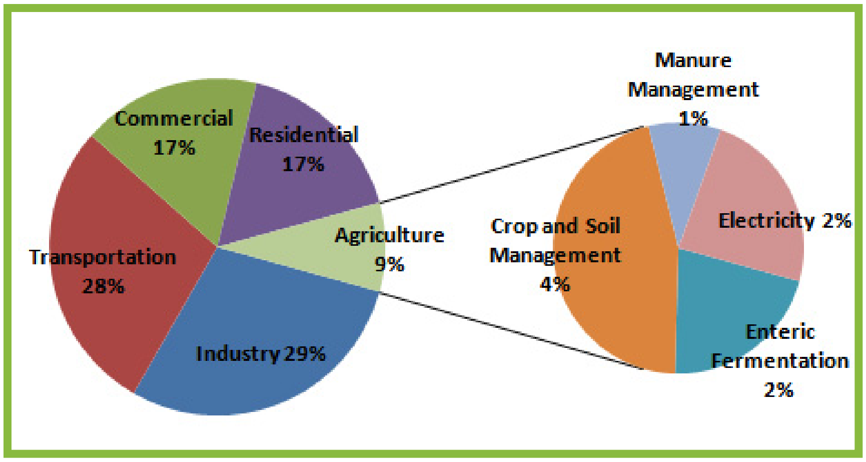


Figure 1. Greenhouse Gas Emissions by Economic Sector

Livestock is estimated to have directly released 182 MMT of CO2 Eq in 2006 (almost 3% of U.S. emissions), through enteric fermentation and manure management. Crop and soil management will be discussed briefly because manure applied to soils emits GHG and the UN study attributes crop production for animal feed as a source of emissions from livestock production.

Enteric Fermentation

Methane is produced as a part of normal digestive processes in animals, especially ruminant animals such as cattle, sheep, and goats. The process with which methane is produced by animals during digestion is called enteric fermentation. The amount of methane produced through enteric fermentation in the U.S. is affected by the number and type of livestock and by the quality, amount, and type of feed consumed. Livestock fed higher quality feed tend to produce less methane than those fed low quality feed.

Swine, since they are not ruminants, have the lowest emissions factor of any class of livestock. The IPCC methane emission factor used by EPA to estimate enteric fermentation from swine is 1.5 kg methane/head/year. This means a 2,500-head facility is estimated to emit, 3,750 kg (3.75 metric tons) of methane per year, which is equivalent to 79 metric tons CO2 Eq.

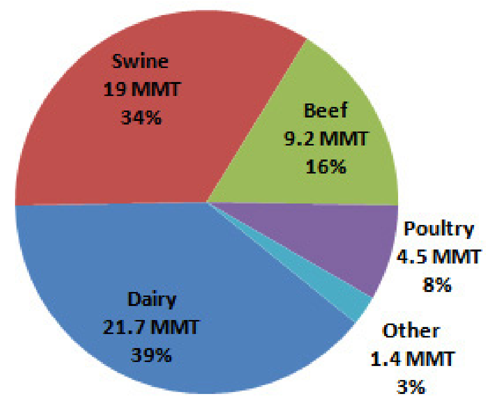
The EPA estimated that enteric fermentation was responsible for 126 MMT of CO2 Eq in 2006. The level and trend of methane emissions is sufficient for the U.S. EPA to consider methane emissions from enteric fermentation to have a significant influence on the country's total inventory of direct greenhouse gases. However, of this 126 MMT of CO2 Eq for all livestock, only 1.9 MMT of CO2 Eq is attributed to swine production. This equals about 1.5% of all GHG emissions due to enteric fermentation; or .03% of all GHG emissions due to human activity in the U.S. Swine production in the U.S. is not considered a major source of methane through enteric fermentation, the bulk of the emissions from enteric fermentation come from the cattle sector (beef and dairy).

Manure Management

Manure management is a source of both methane and nitrous oxide emissions. Most GHG emissions from manure management are in the form of methane and come from dairy and swine production, which tend to use liquid manure management systems. The pork production industry over the several decades has adopted the use of liquid manure management systems, which tend to increase methane emissions from manure management over dryer management systems. The total quantity of volatile solids (the portion of manure that can be converted to methane) has increased by 15% from 1990-2006 according to EPA estimates.

The EPA estimated that manure management was responsible for 56 MMT of CO2 Eq in 2006. Methane emissions were 41 MMT of CO2 Eq, including reductions due to anaerobic digestion. Emissions of nitrous oxide, both direct and indirect, accounted for 14 MMT of CO2 Eq . Figure 2 shows the total emissions from manure management by livestock category.

Of the 41 MMT of CO2 Eq in the form of methane, swine production was considered responsible for 18 MMT. Methane production occurs when manure is handled under anaerobic conditions such as in liquids and slurries. When manure is handled as a solid, little or no methane is produced. The amount of methane produced is affected by diet, temperature, moisture, manure composition, storage system, and time in storage. Higher energy feed generally have a greater potential for manure methane emissions. However higher energy feeds can be more digestible than lower quality feeds leading to less overall manure produced by the animal. Intensive livestock production, as occurs in the U.S. swine industry, produces less GHG per unit of meat produced than do less intensive production systems.



Note: Includes methane emission reductions due to anaerobic digestion and direct and indirect nitrous oxide emissions.

Figure 2. CO2 Eq Emissions from Manure Management

Of the 14 MMT of CO2 Eq in the form of nitrous oxide, swine production was responsible for 1.5 MMT. Nitrous oxide is produced from organic nitrogen in both manure and urine. Solid manure management systems produce nitrous oxide because they have both aerobic and anaerobic decomposition that nitrifies and then denitrifies the nitrogen in the manure and urine.

Manure management from swine production emitted a total of 19 MMT of CO2 Eq in 2006. This equals about 34% of all GHG emissions due to manure management; or .3% of all GHG emissions due to human activity in the U.S. In terms of total U.S. GHG emissions, swine production is not a major source of GHG through manure management.

Though not a major source of GHG emissions in the United States, manure management offers the greatest opportunity for swine producers to lower GHG emissions. Some producers are already covering their lagoons to capture methane emissions. These emissions can be flared off and considered a reduction in emissions. They can also be used to fuel electric generators that not only reduce methane emissions but also provide what is called green electricity, or electricity generated without additional carbon dioxide emissions. Currently, both the burning of the methane and the generation of green electricity are considered carbon credits marketable on the Chicago Climate Exchange (see text box below).

The Chicago Climate Exchange

The Chicago Climate Exchange is a trading system to reduce GHG emissions by facilitating the trading of carbon credits. Entities that emit GHG agree to reduce their emissions. If they are unable to reduce their emissions to an agreed upon level, they are able to purchase carbon credits from other entities that lower their emissions below their targets or from entities that sequester carbon. The actual trade is conducted in what are called Carbon Financial Instruments which equals 100 metric tons of CO2 Eq.

Crop and Soil Management

The EPA report lists crop and soil management as separate from the predominately livestock GHG sources of enteric fermentation and manure management. Emissions from manure applied to cropland are included in the agricultural soil management section under direct nitrous oxide emissions from organic amendments. In 2006, total nitrous oxide emissions from manure applied to cropland from all livestock classes was 11.2 MMT of CO2 Eq. Assuming that swine's contribution to manure applied to cropland was the same as its contribution to manure management, it would be responsible for 3.8 MMT of the 11.2 MMT CO2 Eq attributed to agricultural soil management.

Swine manure applied to cropland contributes about 1.8% of all GHG emissions due to crop and soil management; or .05% of all GHG emissions due to human activity in the U.S. Swine production in the U.S. is not a major source of GHG through manure applied to agricultural soils.

The UN study on livestock's impact on GHG emissions considers one of livestock's biggest impacts to be related to crop production and soil management. In order to conclude this, they attribute the GHG emissions due to feed production to livestock production. If the EPA study had assumed the same methodology, they would have attributed about 10% of corn production and 4% of soybean production GHG emissions to U.S. swine production [4,5].

The EPA study does not list GHG emissions by crop. If a conservative estimate of 10% of all crops produced in the U.S. were used in swine production, the estimated GHG emissions that could be attributed to swine production would be 21.5 MMT of CO2 Eq emissions in 2006.

Therefore roughly 42 MMT of CO2 Eq is attributed to swine in enteric fermentation, manure management, and manure applied to cropland. Swine account for about 9% of GHG emissions from agriculture, or less than 1% of total U.S. emissions.

Processing and Transport

The U.S. EPA study assigns all processing of livestock to the industry sector and the transportation of all livestock and meat products to transportation sector. The UN study estimated that processing and transportation of livestock and meat was due to intensive production practices such as occur in the U.S. They estimate that for the world as a whole, somewhere between 10 and 50 MMT of CO2 Eq emissions are released in processing and transportation (about .4% of all world GHG due to human activity).

Kyoto Protocol Emissions Targets

The Kyoto Protocol is an international attempt to reduce GHG emissions around the world. Different countries have different targets depending on their economic strength. The targets range from -8% to +10% of a specific country's 1990 emissions level. Because emissions have increased from 1990 to the present, even countries with a +10% target may need to reduce their GHG emissions to meet their targets.

The method of achieving reductions in GHG emissions are flexible. Regulations could mandate reductions in all sectors or target efforts on reducing emissions in sectors that contribute the most or are easy to reduce. Reductions could also include a cap and trade system which allows certain emitters who can't meet their target to purchase credits from other entities that were able to meet and exceed their target reductions.

If the U.S. signed on to the Kyoto Protocol, it would need to reduce its GHG emissions 8% from its 1990 emission level of 6,148 MMT CO2 Eq. That would require the U.S. to reduce its total CO2 Eq emissions to 5,656 MMT, a decrease of 1,398 MMT (20%) from its 2006 emissions of 7,054 MMT.

Table 1 summarizes the U.S. EPA emissions directly attributable to swine production. If pork production were included in an across the board reduction and given a cap of -8% of its 1990 emissions (the overall target for the U.S. in the Kyoto Protocol), the swine industry would be required to reduce its current emissions of CO2 Eq by 6 MMT, or about a 30% reduction of its current emissions.

The major increase in emissions from pork production from 1990 to 2006 has come from the increase in liquid manure systems in swine production. Significant reductions would likely require a modification of manure management such as capturing the methane.

The 6 MMT CO2 Eq emissions target reduction for swine would be .4% of the U.S. targeted reductions of 1,398 MMT CO2 Eq emissions. Such a small percentage reduction would indicate that swine production would not be a target of efforts to reduce GHG emissions in the United States. However, the EPA has indicated that methane emissions from manure management have a significant influence on the country's total inventory of direct greenhouse gases. Any efforts to reduce GHG emissions from swine production would likely concentrate on capturing methane from liquid manure systems.

Table 1. MMT of CO_2 Eq Emissions Attributable to Swine Production

Source	1990 Emissions	2006 Emissions	Percent change 1990 to 2006
	MMT of CO_2 Eq		
Enteric Fermentation	1.7	1.9	12%
Manure Management	14.3	19.0	33%
Eight percent reduction from 1990 levels		14.7	
Necessary Reductions from 2006 Emissions		6.2	
Percent Change from 2006 Emissions			30%

Summary

Understanding the debate over GHG emissions offers an opportunity to benefit from opportunities to reduce emissions and to participate intelligently in the policy discussions about limiting GHG emissions. The greatest opportunity for swine producers to lower GHG emissions is in improved manure management. Livestock production contributes to GHG through enteric fermentation in domestic livestock, and through livestock manure management and crop production to feed livestock. All livestock in the U.S. are estimated to have directly released 182 MMT of CO2 Eq in 2006 through enteric fermentation and manure management. Swine are estimated to have released 21 MMT of CO2 Eq in 2006 from these two source categories. The EPA estimates agricultural activities contribute almost 9% to U.S. GHG emissions, which is considerably lower than the often quoted United Nations estimate of 18% attributable to livestock alone. The efficiency of U.S. pork production causes it to be recognized as a relatively minor livestock source of GHG emissions.

Summary of Livestock's Long Shadow.

The Food and Agriculture Organization of the United Nations published a report in 2006 entitled "Livestock's Long Shadow: environmental issues and options." The report attempts to estimate the impact of livestock production on climate change, water quality and quantity, and biodiversity. Perhaps, its most quoted statistics is that livestock production is responsible for 18% of the GHG emissions in CO2 equivalents from human activity. A closer look at the full report brings out details that are not conveyed in the single value of 18%.

The estimate is based on all GHG emissions associated with livestock and meat production. It includes all emissions from crop production associated with livestock, to livestock feeding and manure management, to livestock transport to market, to livestock processing and transport of meat and products to retail. If no livestock were raised, the GHG emissions would not decrease by 18%. Undoubtedly, grain would be grown (perhaps less), and food would be processed and transported.

The authors divide the impact between intensive livestock systems (common in the U.S.) and extensive systems (pastoral type systems). The intensive systems produce the most food (meat, milk, or eggs) with the least amount of GHG emissions. Extensive systems are responsible for 2/3 of the GHG emissions, due mainly to deforestation to obtain grazing land.

The largest contributors to GHG emissions are deforestation (34%) and enteric fermentation (25%). Both of these categories are predominately a problem in extensive systems where land is being converted from forests to grazing land and where poor quality feed increases enteric fermentation per unit of meat produced. The intensive livestock production systems, common in the U.S., are reducing the carbon footprint per unit of meat produced – precisely the objective of environmental activists.

The authors admit that many estimates are relatively imprecise because of lack of data in many countries. Of the estimated 7 billion metric tons of CO2 eq emitted in livestock production, 52% is designated as "imprecise estimates." The 7 billion number should be viewed as an upper bound rather than an accurate estimate, as would be provided by the U.S. EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks.

References

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5. USDA National Agriculture Statistics Service http://www.nass.usda.gov/QuickStats was used to estimate production of corn and soybeans.