hog operations

AND GREENHOUSE GASES

Alberta
AGRICULTURE, FOOD AND
RURAL DEVELOPMENT

Disclaimer

The primary purpose of this Alberta Agriculture, Food and Rural Development publication titled *Hog Operations and Greenhouse Gases* is to assist producers in implementing greenhouse gas management practices.

It is important to be aware that while the authors have taken every effort to ensure the accuracy and completeness of this document, this document should not be considered the final word on the area of practices that it covers. Producers should seek the advice of appropriate professionals and experts as the facts of individual situations may differ from those set out in this document.

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Front page photo credit: Canadian Pork Council

contents

Linking Greenhouse Gases to the Farm Gate: What Makes Sense?

Today's food and agriculture system faces ever-widening challenges as it reacts to policy changes, market trends, new research, technologies, and growing regulatory pressures. Industry leaders in partnership with other stakeholders, government agencies, public representatives, and the scientific community have all recognized that the issue of greenhouse gases (GHGs) will continue to play an increasing role in management decisions at the farm gate. Although it is important to recognize uncertainties associated with the science surrounding GHGs exist, it is equally important to recognize that the science is maturing. With maturing science, policies at the local, provincial, and federal level will unfold and impact future management decisions. As producers know, keeping an eye to the horizon as new information becomes available is a fundamental component of managing a successful business.

GHG issues were brought to the forefront through Canada's involvement with and subsequent ratification of the Kyoto Protocol in December of 2002. In addition, the Kyoto Protocol came into force on February 16, 2005. Canada is now required to reduce its GHG emissions by six percent below its 1990 GHG emissions by 2008-2012. However, several additional drivers have reframed this issue into one that has significance to both producers and agri-food processors as day-to-day business activities are carried out.

Production Efficiencies

Most agricultural activities operate within a slim profit margin. Simply put, GHG emissions represent a loss of production efficiency that translates into higher costs and lower profits. Conversely, minimizing GHG emissions can translate into reduced costs, higher productivity, and increased profits.

Short-Term Opportunity

Regulation of GHG emissions in the energy, manufacturing, and chemical industries has the potential to raise agricultural input costs. This is also creating a demand for agricultural GHG carbon or "offset" credits as a means to compensate for rising costs. Opportunities exist for the agricultural sector to create offset credits by implementing certain management practices to reduce or remove GHG emissions. In Alberta, as of March 2005, there will be a provincial demand for offset credits because new coal plants are required to offset their GHG emissions to equate to emissions from natural gas fired plants.

Stewardship

Stewardship and sustainability go hand in hand on any agricultural operation that is planning for long-term viability. Many of the management practices that address GHG emissions have a direct link to appropriate stewardship on agricultural production bases. Through the Canada Alberta Farm Stewardship Program, in conjunction with the Alberta Environmental Farm Plan, incentives will be provided to agricultural producers who adopt certain management practices that mitigate or minimize negative impacts and risks to the environment by maintaining or improving water, land, air quality, and biodiversity.

Due Diligence

Due diligence is the level of judgment, care, prudence, determination and activity that would reasonably be expected of a person under particular circumstances. Like all major industries, agriculture continues to come under close public scrutiny. Although no specific compliance requirements for primary producers under the Kyoto Protocol exist, management practices that reduce or remove GHG emissions from agricultural sources and the resulting positive effects will showcase due diligence from the farm gate right through the industry as a whole.

Adaptation

Weather plays a key role in how agricultural producers adapt or change their management practices to maintain productivity and sustainability. The impact of climate variability, along with changes in markets, environmental, societal, and economical conditions will impact management decisions for crops, livestock, water, pests, and diseases. The agricultural industry has a history of adaptation and innovation - a legacy that has producers well positioned to make the best decisions for their land, their families, and their businesses. There is little choice but to respond and adapt to change, no matter what the source. Both agricultural sustainability and prosperity depend upon it.

GHG management may not be seen as a high priority when agricultural producers already have a full plate. However, after a closer look at the information, one may well come to see that the GHG issue is more about reframing existing knowledge under a new umbrella. Many of the management strategies associated with the reduction and removal of GHGs from the atmosphere also protect the environment, improve production efficiencies, and may offer a return on investment. In addition, Canada's ratification of the Kyoto Protocol and commitment to meet GHG emission reduction targets has channeled new research dollars into the agricultural industry. As the science community continues to research new technologies and strategies, this research may increase the suite of management practices currently available to agricultural producers.

What Greenhouse Gases are Produced by Agriculture?

The main GHGs emitted by agriculture are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) (Figure 1). While carbon dioxide is the main gas emitted by other industries, methane and nitrous oxide warm the atmosphere 21 and 310 times more than carbon dioxide, respectively. In agriculture, the majority of on-farm carbon dioxide emissions comes from:

- fuel combustion for heating farm buildings, farm machinery, and
- intensive tillage regimes
- summerfallow when soil organic matter is decomposing

The primary on-farm sources of methane emissions include:

- enteric fermentation from ruminant livestock (cattle, sheep, goats)
- anaerobic respiration of organisms in riparian areas and
- manure storage systems (stockpiled solid, liquid storage)

The primary on-farm sources of nitrous oxide emissions all involve soil nitrogen management:

- wet soils containing nitrogen fixing plants like alfalfa or pulses
- manure nitrogen application
- commercial nitrogen fertilizer application

Figure 1 – Farm Sources and Sinks of GHGs

Legend

1 – Soils and Crop Management

2 – Manure Management

3 – Livestock Management

4 – Land Use and Energy

What is the Greenhouse Gas Contribution from Agriculture in Alberta?

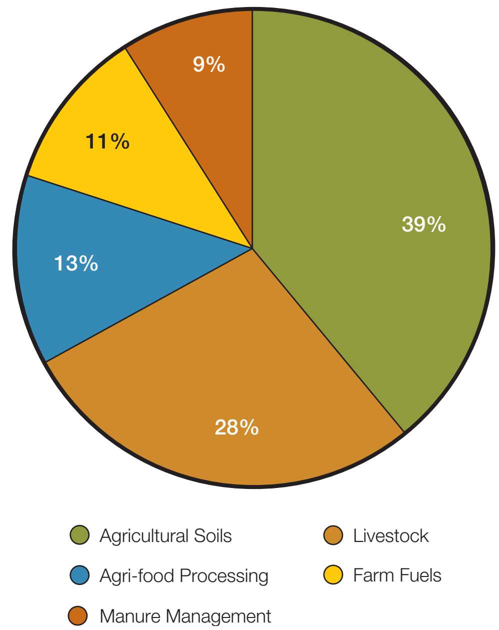
The most recent GHG inventory estimated that in 2002 nationwide, agricultural related GHG emissions contributed about 59,000 kt (kilotonnes) of carbon dioxide equivalents (CO_2e), which is about eight percent of Canada's total GHG emissions[1]. Of Alberta's total 2002 GHG emissions, the agricultural sector contributed about nine percent[1].

In 2003, Alberta Agriculture, Food and Rural Development (AAFRD) and the University of Alberta[2] completed the Alberta Agricultural GHG Assessment Emissions Inventory (Figure 2). From this report, total GHG emissions from the agriculture sector in Alberta were estimated to be 26.3 Mt (Megatonnes) CO_2e per year. In addition to emitting GHGs, agricultural soils along with pastures and rangelands in Alberta can sequester an estimated 5.9 Mt CO_2e and 23.4 Mt CO_2e per year, respectively. These large amounts of carbon sequestered by pasture and rangeland soils results in a net negative GHG emission estimate for Alberta's agriculture industry as a whole. The rate of carbon sequestration by these soils is expected to increase by 2008-2012 as more producers adopt sustainable management practices that reduce carbon losses associated with soil cultivation.

What Greenhouse Gases are Produced by the Livestock Sector in Alberta?

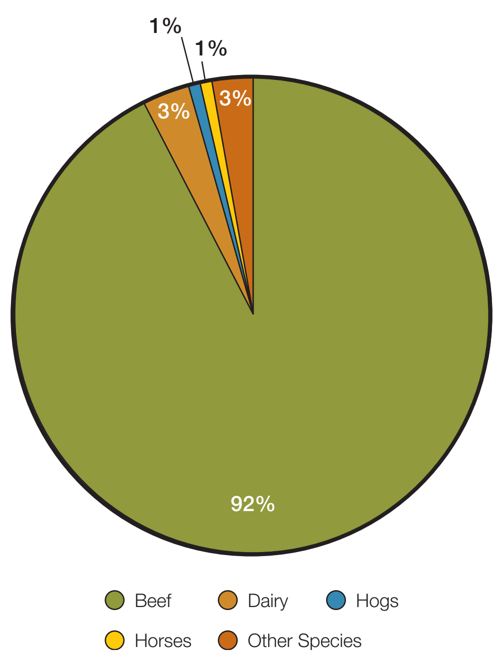
The main GHGs emitted by the livestock industry are methane (CH_4) from the digestive process (enteric fermentation) and methane and nitrous oxide (N_2O) from manure. Methane produced during digestion contributes an estimated 7.4 Mt CO_2e per year, approximately three percent of Alberta's total GHG emissions. The large methane contribution may be attributed to the fact that beef cattle make up the largest portion of livestock in Alberta, producing about 92 percent of the provincial livestock sector's GHG emissions (Figure 3). This compares with GHG emissions from manure management, which contributes 2.4 Mt CO_2e per year. Because GHG emissions from all livestock represent a loss of costly feed energy and nutrient inputs, the livestock industry has an economic stake in reducing its GHG emissions.

Figure 2 – Percent Contribution of GHG Emissions from Alberta's Agricultural Sector



Source: Alberta Agriculture, Food and Rural Development and University of Alberta 2003[2]

Figure 3 – Percent Contribution of 2001 GHG Emissions from Alberta's Livestock Sector



Source: Alberta Agriculture, Food and Rural Development and University of Alberta 2003[2]

How Can the Pork Sector Help to Address Greenhouse Gas Emissions?

In general, implementing management practices can reduce total GHG emissions for the agricultural sector by:

- Reducing emissions through management practices such as improved feeding efficiency or manure management;
- Removing emissions through management practices that increase carbon in soils, pastures, and trees; and
- Replacing fossil fuels with renewable energy

The majority of methane and nitrous oxide from pork operations come from buildings, manure storage, and land application of manure[3]. The GHG emissions produced by the Alberta swine industry in 2002 amounted to approximately 733 kt of CO_2e, of which methane accounted for more than 50 percent[4]. This contributes about one percent of Alberta's total GHG emissions (Figure 3). Although the GHG emissions estimated by the swine industry are not substantial in comparison with other industries in Alberta, they are large enough to consider options to reduce them[4]. Experts estimate that the swine industry in Alberta could reduce GHG emissions by as much as 300 kt of CO_2e annually[4].

Credit: Alberta Agriculture, Food and Rural Development

Research is ongoing as how to best reduce GHG emissions in many aspects of hog operations. In the meantime, a number of common sense approaches exist to improve production efficiency which minimizes GHG emissions produced by hog operations. One key method in reducing GHG emissions is to formulate diets to match nutritional requirements as much as possible. This helps minimize excess feed protein lost as manure nitrogen and reduces the amount of nitrogen added to the atmosphere as nitrous oxide.

Did You Know These Terms?

Anthropogenic
An action or activity caused by humans.

Carbon Dioxide Equivalent (CO_2e)
Is a universal standard of measurement against which the impact of different GHGs in the atmosphere can be evaluated. It is calculated using the global warming potential (GWP), which is a measurement of how much heat is retained by the Earth's ecosystem through the addition of a particular gas to the atmosphere. Nitrous oxide (N_2O) and methane (CH_4) are 310 and 21 times more powerful, respectively, than carbon dioxide (CO_2) at trapping heat in the atmosphere.

Carbon Sequestration
The uptake and storage of carbon. Trees and plants, for example, absorb carbon dioxide, release the oxygen, and store the carbon through photosynthesis.

Climate
The average weather for a specific region and time period (usually for 30 years). Elements of climate include temperature, precipitation, sunshine, humidity, and wind velocity.

Climate Change
A slow change in the composition of the global atmosphere, which is thought to be caused directly and indirectly by various human activities that is in addition to natural climate variability over time.

Denitrification
A process, that occurs in the absence of oxygen, where nitrate (NO_3) is converted to nitrous oxide gas, a potent GHG and to dinitrogen gas (N_2).

Feed Efficiency (FE)
Is the relative amount of feed per unit of live weight gain for an animal.

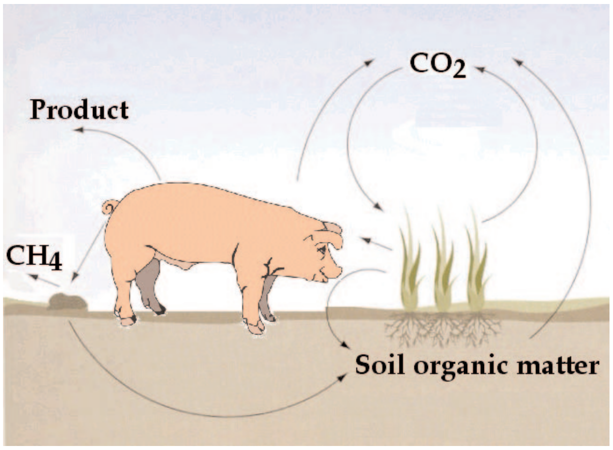
Global Warming
An average increase in the earth's atmospheric temperature, caused by increasing levels of atmospheric GHGs trapping more and more of the sun's heat energy in the atmosphere as it is reflected off of the earth's surface.

Global Warming Potential
The relative potential of a specific GHG to trap the sun's heat energy in the earth's atmosphere relative to carbon dioxide. The global warming potentials of CH_4 and N_2O are 21 and 310, respectively.

Greenhouse Gases (GHGs)
Are gases that trap the sun's heat in the atmosphere, preventing its release into space, thus creating a warming effect on the surface of the earth. While GHGs such as water vapour, carbon dioxide, nitrous oxide, and methane occur naturally, human activities increase the levels of these gases and are responsible for creating new ones (e.g. hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride).

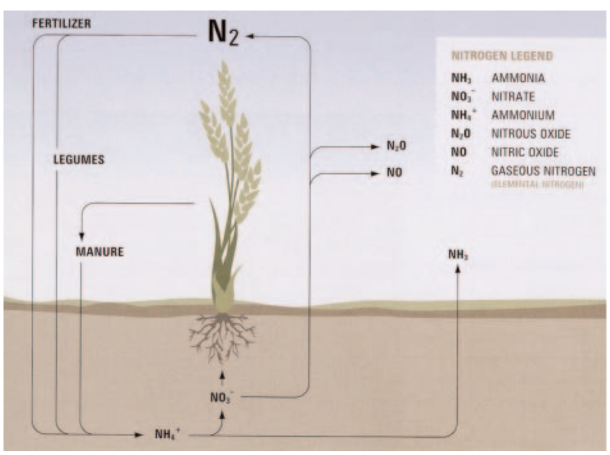
- ***Carbon Dioxide (CO_2)***
  The most common GHG which is produced from respiration (Figure 4) and when any carbon-containing compound is burned. Its atmospheric levels have increased by 30 percent above levels known to exist before the industrial revolution[1].
- ***Methane (CH_4)***
  A GHG produced by bacteria when organic matter decomposes in the absence of oxygen (anaerobic). Some of the main sources of methane include wetlands, digestion of livestock feed (Figure 4), and fossil fuel extraction. Methane is 21 times more potent a GHG than CO_2 and its atmospheric levels have increased by 145 percent above pre-industrial levels[1].
- ***Nitrous Oxide (N_2O)***
  A GHG produced naturally in soils and water without the presence of oxygen through incomplete denitrification (Figure 5). Humans contribute to nitrous oxide through the application of nitrogen fertilizers and manure. Nitrous oxide is 310 times more potent a GHG than CO_2. Its atmospheric levels have increased by 17 percent above pre-industrial levels[1].

Figure 4 – The Carbon Cycle



Credit: Adapted from: Figure 9 in Janzen, H.H., Desjardins, R.L., Asselin, J.M.R., and Grace B. (eds). 1999. The Health of Our Air: Toward Sustainable Agriculture in Canada. Agriculture and Agri-Food Canada, Publication 1981/E. Reproduced with the permission of the Minister of Public Works and Government Services Canada, 2005.

Figure 5 – The Nitrogen Cycle



Credit: Adapted from: Figure 21 in Janzen, H.H., Desjardins, R.L., Asselin, J.M.R., and Grace B. (eds). 1999. The Health of Our Air: Toward Sustainable Agriculture in Canada. Agriculture and Agri-Food Canada, Publication 1981/E. Reproduced with the permission of the Minister of Public Works and Government Services Canada, 2005.

Greenhouse Effect
The warming of the Earth's atmosphere caused by the presence of GHGs in the atmosphere that trap the sun's heat energy. This effect is responsible for maintaining the Earth's surface at a temperature that makes it habitable for life as we know it. However, the concentrations of GHGs in the atmosphere are increasing and as such, they are preventing more heat from escaping which means the earth slowly heats up. This is called the enhanced greenhouse effect – which causes global warming and it is changing our climate.

Offsets
GHG reductions and/or removals arising from an eligible management practice that a producer has implemented.

Removal
The process of removing GHGs from the atmosphere by sinks. For example, planting tree shelterbelts would remove some carbon dioxide out of the atmosphere by storing it in the trees.

Sinks
A process that removes GHGs from the atmosphere, either by destroying them through chemical processes or storing them in another form. As an example, carbon dioxide is often stored in ocean water, plants or soils.

Sources
Any process or mechanism, which release GHGs in the atmosphere; the opposite of sinks.

Weather
State of the atmosphere with respect to temperature, moisture, sunshine, and wind velocity for a certain period of time at a specific location.

Volatilization
Process where a substance is converted from liquid to a gaseous state. For example, nitrogen exists in the liquid ammonium (NH_4^+) form in liquid hog manure but can be given off, or volatilized, as ammonia gas (NH_3) when liquid manure is surface applied.

how to use this booklet

This booklet provides information on different management strategies associated with the reduction and removal of GHGs from the atmosphere. Reducing an agricultural operation's GHG production can help to reduce its environmental footprint, improve production efficiencies, and may offer a return on investment. The following table allows a producer to evaluate different management practices that could be implemented on an agricultural operation and also provides references for additional sources of information. Many such practices are already in use on Canadian hog operations, however under the guise of improving production efficiencies. It is important to note that while improving production efficiency, these practices also have a positive impact on reducing agricultural GHG emissions.

Table 1 – Management Practices that Reduce Greenhouse Gases and/or Sequester Carbon

Put a check (✓) in the box that best reflects your management strategy.

Description of Management Practice	Is this a Current Practice?	Is this Worth Considering?	Is this not Feasible?	For more Information see
Herd Health • Use genetic selection to improve nutrient utilization and feed conversion				*Section 1* Page 10
Feed Management • Feed reduced protein diets, balanced with amino acids				*Section 2* Page 11
• Include phytase enzymes in feed rations				Page 13
• Phase feeding				Page 14
• Split-sex feeding				Page 15
• Move to wet/dry feeding systems				Page 15
Barn Management • Maintain efficient operation of barn climate control systems and components				*Section 3* Page 16
Manure Handling and Storage Management • Manure storage cover systems				*Section 4* Page 17
• Anaerobic biodigestor technology				Page 19
• Compost manure				Page 20
• Manure storage and the barn				Page 20
Manure Application Management • Analyze both manure and soil prior to application				*Section 5* Page 21
• Apply manure rates that match crop nutrient requirements				Page 21
• Apply manure to cropland in spring, or in-crop, rather than in fall				Page 22
• Inject manure to minimize ammonia nitrogen losses				Page 22
Controlling Odours and GHGs • Use shelterbelts and natural windbreaks to disperse odours and sequester carbon				*Section 6* Page 23

Section 1
Herd Health

Strategies that improve herd health will improve feed efficiency. Converting to a specific pathogen free herd health status can improve feed efficiency by an almost estimated 10 percent, causing a 10 percent decrease in nitrogen excretion in the manure[5].

Use Genetic Selection to Improve Nutrient Utilization

Greenhouse Gas Benefit

Genetic selection can contribute to reducing GHG emissions by:

- Selecting animals with high feed efficiency genetically improves production efficiency and reduces the amounts of nutrients excreted in urine and feces; therefore reducing GHG emissions. An improvement of 0.1 percentage points of feed efficiency results in a 3.3 percent reduction in nutrient excretion in swine, assuming a similar growth rate and nutrient retention is maintained throughout the pig's life[6].
- Studies with cattle have shown that genetics influence the amount of GHG emissions directly from livestock and the chemical composition of feces[7].

Improving the efficiency of nutrient utilization through genetics reduces total nutrient output from the swine operation leading to an increase in production efficiency. Genetic improvement can also be an economical choice over time, because improved feed efficiency will be passed on to successive generations.

Credit: Alberta Agriculture, Food and Rural Development

Section 2
Feed Management

Approximately 70 percent of the nitrogen in the pig's diet is voided/excreted by the pig as feces and urine[8]. This excess nitrogen can be released into the atmosphere as nitrous oxide or ammonia. A reduction in these gas emissions from hogs can be achieved by adopting various feeding strategies.

In addition to reducing GHG emissions, improving feed efficiency also improves production efficiency, by reducing the amount of feed required to achieve a similar rate of weight gain. Most scientists agree that a combination of genetic selection and feed management are two important strategies that lead to a reduction in nutrient excretion, and therefore a reduction in GHG emissions from swine.

Economics

Recent research determined that for each 0.1 unit of improvement in feed efficiency an Alberta producer could save a $1.80 dollar per pig, assuming a feed cost of $200 per tonne[9].

Credit: Alberta Agriculture, Food and Rural Development

Feed Reduced Protein Diets Balanced with Synthetic Amino Acids

Greenhouse Gas Benefit

Reducing dietary protein in feed is an effective strategy to reduce nitrogen excreted in urine and manure. Increasing the quality of protein in feed while decreasing the total amount of protein in the diet can directly reduce the resulting GHG emissions from both the pig and manure.

The effect of reducing nitrogen excretion through manipulating dietary protein is well documented. Several studies conducted at the Prairie Swine Centre Inc. in Saskatoon, Saskatchewan have showed a 22 to 48 percent reduction in urinary nitrogen excretion and a 23 percent reduction in fecal nitrogen excretion from pigs fed low crude protein diets (CPs of 13.8 percent and 15.7 percent) supplemented with amino acids compared to high protein diets (CPs of 18.5 percent and 19.7 percent)[10,11,12]. A reduction in total nitrogen excretion may reduce the land base needed for sustainable manure application providing other nutrients do not become a limiting factor[11]. Thus, reducing nitrogen excretion from the animal ultimately reduces both nitrous oxide and ammonia gas emissions directly from manure.

Researchers at the University of Alberta indicate there may be an additional benefit to reduced protein diets. Studies have shown reduced CO_2 emissions from the animal are possible due to improved utilization of dietary energy[13]. Researchers found that reducing dietary protein in a barley based diet, while supplementing with amino acids, reduced GHG production by 14.3 percent and 16.4 percent in sows and finisher pigs, respectively or approximately 10 percent for each 10 percent reduction in the ration crude protein content[14]. Animal performance was not affected by the dietary protein content reduction in this study. Therefore, feeding strategies that result in more efficient nutrient use help to maintain healthy, productive livestock, and may improve profitability. However, please note that the pigs themselves emit little direct GHGs relative to the GHG emissions from the manure itself.

Impact on Odour

Practices that reduce nutrient intake and improve the nutrient availability of feed will impact the amount of nitrogen in the manure. Less nitrogen in the manure will result in less volatilization of nitrogen into ammonia, thereby reducing odour emissions during storage. In addition, decreasing the amount of fermentable material in manure can reduce odour[15]. Ammonia emissions have been found to decrease by 8.1 percent for every 0.1 percent reduction in crude protein between 20 percent and 13 percent of total dietary content[16]. Other research has determined similar results between dietary levels of 18.7 percent and 13 percent and between 16.5 percent and 12.5 percent crude protein levels, respectively[17,18].

Economics

Researchers at the Prairie Swine Centre Inc. assessed the economic value of low protein pig diets compared to high protein diets and determined that feed costs were about $5 per pig (assuming November 2003 feed prices) less for the low crude protein diet compared to the high crude protein diet[19]. However these researchers did also state that the economics depends on the cost of the raw crude protein source versus the cost of the synthetic amino acids supplements.

A study conducted by researchers[20] examined the reduction of GHG emissions in swine through diet manipulation. They found that a diet low in protein, with amino acid supplements, reduced CO_2 production by pigs by 2.5 percent to 6.1 percent compared to conventional diets. The overall reduction in GHG emissions (measured in CO_2 equivalents) by finishing pigs was 7.4 percent on a low protein corn based diet, and 14.3 percent on a low protein barley based diet. GHG emissions from sows were reduced by 16.4 percent on a low protein barley based diet. They concluded that diet manipulations reduce GHG emissions from both the pig and from manure.

Include Phytase Enzymes in Feed Rations

Greenhouse Gas Benefit

Phosphorous is an important nutrient for swine growth and development. However, hogs cannot digest much of the phosphorus contained in cereal grains. As such, mineral phosphorus is added to many swine diets to provide the necessary nutrient content. Unfortunately, much of this phosphorous is not easily utilized by the animal, resulting in a large proportion of the phosphorous being excreted in the manure. The addition of the phytase enzyme as a feed additive can reduce the amount of phosphorous in hog manure by increasing the digestibility of the phosphorus found in cereal grains, thereby reducing the need for inefficient phosphorous supplements.

In general, the addition of phytase in swine diets will allow the phosphorous content of the diet to be reduced by 0.1 percent and will improve feed utilization by one to two percent[21]. In addition, the benefits of phytase can be realized without an effect on hog performance, carcass quality, or bone strength[21].

Credit: Alberta Agriculture, Food and Rural Development

In addition to improving the digestibility of phosphorous by 27 to 30 percent, phytase also improves the digestibility of protein, thus reducing nitrogen excretion in manure[21]. Similar research results showed that phytase supplementation results in a 28 percent reduction in fecal and total nitrogen excretion[10]. This reduction of nutrients in the manure in turn will reduce the land-base requirements for manure phosphorous application. Including phytase in the diet also has additional benefits, such as:

- *Environmental benefits:* Since phosphorous in feed is poorly digested, most of it ends up in manure. With the use of phytase, the buildup of soil phosphorus levels is reduced when the manure is continually spread on a limited land base.
- *Improved nutrient efficiency:* Phytase can also increase the digestibility and availability of calcium and other trace minerals, which can improve feed utilization[5].
- *Economics:* Currently, phytase addition to the hog ration may increase feeding costs. The cost of the phytase may be offset by the savings associated with lower amounts of phosphorous and calcium supplements in the diet[5]. However, this depends on current prices of feed and supplements. Continual refinement of ration costs, based on available ingredients is recommended in order to balance minimal manure nutrient excretion with the lowest cost ration formulation.

Phase Feeding

Greenhouse Benefit

Hogs require different amounts of protein as they grow, therefore, protein content in feed needs to change for hogs in different growth stages to avoid feeding excess protein. Therefore, frequent changes in diet formulation to more closely match the changing requirements of the hog as it grows will decrease the quantities of excreted nitrogen, phosphorus, and other nutrients. Phase feeding allows rations to be modified to the nutrient requirements of the hog as it grows to limit the nitrogen and phosphorus excesses associated with feeding a single ration. Phased feeding also allows a producer to tailor energy requirements to the needs of the hog, thus reducing manure carbon content and methane production potential during manure storage.

Phased feeding combined with a reduced protein diet formulation can significantly reduce a farm's manure nitrogen production. Potentially, as a sample calculation, an operator, who is finishing 1000 hogs from 23 to 110 kg, and lowers crude protein by half a percent, about 1458 kg of manure nitrogen can be reduced (Table 2) if feed conversion efficiency remains constant.

Similarly, formulating separate diets for gestating and lactating sows may reduce nitrogen, phosphorus, and other mineral excretions by as much as 20 percent. In Ontario, calculations show that changing to a two-phase feeding system, the pigs' nitrogen needs would be met more precisely which would result in a 12 percent reduction in the amount of nitrogen in manure[5]. Therefore, this helps to limit the amounts of nitrous oxide emitted into the atmosphere, when the manure is land applied to meet the appropriate crop nutrient needs.

Table 2 – Potential Nitrogen Reduction in Manure[22]

Ration	High CP %	Low CP %
Grower	19.5%	19%
Finisher I	17.5%	17%
Finisher II	17%	16.5%
Manure Nitrogen Produced	5678 kg	4220 kg

Split-Sex Feeding

Greenhouse Gas Benefit

Split sex feeding also helps to reduce the amounts of nitrogen and phosphorus excreted in hog manure. Gilts fed to appetite consume less feed than barrows, but gilts have similar or greater lean tissue growth rates. Therefore, diets for gilts need higher levels of amino acids and other nutrients than barrows. When put in mixed sex groups, diets tend to be over-formulated for barrows, which result in greater amounts of nutrient excretion. Furthermore, an increased fat deposition and decreased rate of lean deposition occur at an earlier growth stage in barrows than in gilts; thus dietary protein and amino acid levels can be more precisely changed at different growth stages for each sex[23]. Through split-sex feeding, feed intake for each gender can be met, which reduces input costs and the amounts of nitrogen and carbon excreted in the manure.

Credit: Ontario Farm Animal Council Animal Agricultural Photo Library

Wet/Dry or Liquid Feeding Systems

Greenhouse Gas Benefit

Wet/dry feeders increase feed efficiency by reducing the amount of feed required to achieve a desired weight gain. This means less nitrogen is excreted in the manure and also decreases the amount of manure produced. Preliminary results from the Prairie Swine Centre Inc. indicated that manure volume was reduced by up to 43 percent and average daily gain of pigs was 1.2 to 7.4 percent higher using wet/dry feeders versus dry feeders[24].

An additional benefit is that wet/dry feeders are reported to reduce pig water usage by 10 to 40 percent in the growth-finisher area[21], therefore reducing both energy costs and GHG emissions. Reduced barn water use produces a less-dilute manure, which translates into reduced energy and transportation costs to handle the manure nutrients. This will allow manure to be transported further at a similar cost, and allows a producer to apply manure nitrogen to a larger land base and avoid a high nitrogen concentration buildup close to the production site. Spreading a less-dilute manure can also reduce the production of nitrous oxide emissions from soil as soils will be less saturated after manure application, compared to a more watered down manure product.

Currently Alberta Pork is conducting a year long research and demonstration study in High River comparing different nipple drinkers to water conserving ball-bite drinkers to determine their impact on pig water consumption in a fully slated grower barn. The impact on the ease of manure handling, manure nutrient composition, and the effect of feed crude protein content on water use will also be examined. If the manure volume can be reduced by using a water conserving drinker system, the GHG emissions associated with handling manure from the farm may be reduced. For more information about this study, contact Dennis McKerracher at Alberta Pork at (780) 474-8288.

Section 3 Greenhouse Gases and the Barn

Maintain Efficient Operation of Barn Climate Control Systems and Components

Greenhouse Gas Benefit

Energy consumption produces carbon dioxide (CO_2) released by the burning of fossil fuels to maintain climate control systems in barns. Maintenance of fans and heating systems will help to maintain good barn air quality and climate control of powering the system[25]. Other energy saving options in the barn include:

- Efficient heating sources for farrowing crates to eliminate less energy efficient heat lamps.
- Climate control systems that automatically reduce barn nighttime temperatures slightly relative to the daytime climate.

Producers are encouraged to seek out new opportunities for providing heat to piglets in the farrowing crate to replace low energy efficient incandescent heat lamps. Options for your operation may include solar power, hot water heating pads, and new highly efficient bulb systems.

Credit: AgViro Inc.

Credit: Alberta Agriculture, Food and Rural Development

Section 4 Manure Handling and Storage Management

On the farm, pig manure is the largest single source of GHG emissions. Numerous ways to reduce GHG emissions from manure exist however, many of which provide significant non-GHG benefits as well. Hog manure, being a mixture of urine and feces, is primarily composed of undigested and indigestible feed nutrients, wasted drinking water, wash water, and wasted feed. The GHGs produced by manure are methane (CH_4) and nitrous oxide (N_2O). Methane is produced during manure storage, where anaerobic (without oxygen) conditions occur, and where the organic carbon left in the manure is decomposed. Nitrous oxide, on the other hand, is emitted following manure application to cropland and will be discussed in subsequent sections.

The amount of methane emitted from manure is influenced by different manure management practices (e.g. collection, storage, application, treatment). Also, many of the feeding strategies mentioned earlier, impact the amount of methane produced from manure and the amount of manure produced. Generally, any improvement in feeding efficiency will reduce the feed carbon that enters a manure storage structure, therefore reducing the potential for methane production.

Credit: Agriculture and Agri-Food Canada

Manure Storage Cover Systems

Greenhouse Gas Benefit

The majority of hog manure is stored in a liquid form either in an earthen storage basin, in deep pit under barn storages, or in round concrete or steel storage structures. A liquid storage system creates anaerobic (oxygen free) conditions. Under these conditions, specific anaerobic bacteria breakdown organic matter (waste feed and feces), producing methane as a by-product. Impermeable cover systems, installed on the manure storage's surface, reduce the transfer of manure gases to the atmosphere; therefore minimize GHG emissions from the manure storage. However, the cover does not actually reduce GHG emissions by itself, as the cover provides a better environment for the decomposition and the stabilization of the organic material in the manure[26]. In addition, the manure gases need to be captured and flared in order to reduce GHG emissions. This methane gas can be captured by using a negative pressure blower and fed into a small power generation facility, heating unit, or simply flared[4]. This provides a revenue stream[4].

Several types of covers exist that can be used on manure storage systems. However, the costs of these systems can be expensive to establish, maintain, and to replace.

Organic covers from straw work by establishing an aerobic (oxygen rich) layer between the manure and the atmosphere, which allows for the break down and release of less offensive gases and odour causing compounds. Straw covers are a low cost option to control emissions of manure gases including ammonia and odours. However, the straw must remain dry to be effective and a reapplication of straw may be required a number of times before emptying the manure storage facility. In addition, this type of cover does not allow for the capture of methane.

Further, weather dynamics dictate whether straw covers reduce or increase the GHGs produced during storage and are therefore not recommended as a GHG reduction strategy.

The most effective option for reducing manure storage GHG emissions are the impermeable covers mentioned earlier. Several designs exist depending on the type of storage to be covered. Positive pressure covers are available and form a dome over the storage but are prone to damage by heavy snow loads or during power outages, which causes the dome to deflate. Several system designs allow the cover material to rest on the surface of the manure and use either negative air pressure or a series of weights to maintain the cover on the manure surface to avoid weather damage. One benefit of an impermeable cover is that less manure nitrogen will be lost to the atmosphere from storage. In Manitoba, an earthen manure storage basin covered with a negative air pressure cover, was able to reduce nitrogen loss by 82 percent compared to an open earthen manure storage basin[26].

To facilitate manure removal from a covered storage, the Canadian Pork Council recommends installing a below cover agitation system capable of agitating manure without removing the cover itself. Several below cover agitation systems are commercially available using forced air agitation for earthen storage basin covers or a modified pump for round concrete or steel storage systems.

Impact on Odour

Covering the manure storage system reduces the release of odour causing compounds from the manure into the atmosphere above the storage. Cover systems allow gases to be managed in a controlled manner, reducing the escape of odourous gases off of the farm site.

Credit: Nova Scotia Agricultural College

Did You Know?

The benefits of impermeable covers include:

- *Addition of rainwater to manure is eliminated, thus reducing manure volume and application costs.*
- *Improved odour control.*
- *Increase of the manure's nitrogren content for land application due to less ammonia loss.*
- *Allows for collecting and utilizing the trapped methane gas as a heat and electricity source or to burn the gas.*

Anaerobic Biodigester Technology

Greenhouse Gas Benefit

Anaerobic digestion uses naturally occurring bacteria to transform organic material into a source of combustible gas. Manure is warmed and mixed in a tank that is free of oxygen, or anaerobic, which is the same condition that exists in liquid manure storages. In these warm conditions, bacteria become very active and begin to digest carbon. In the case of hog manure this consists of the feed carbon not used in the animal digestive system, which has become part the manure stream. The goal of anaerobic digestion is to produce methane, a combustible GHG, for use in producing heat or electrical energy. New technology allows methane from anaerobic digestion to be purified to the same quality as natural gas.

The on-site production of methane can be used to fire a boiler system where the hot water is used to heat hog barns and/or other farm buildings, reducing the need to purchase other sources of heating fuel. Small generator sets may also be operated on digester methane, reducing the need for importing electricity to the farm site. A large digester will be capable of producing sufficient methane to produce power for export to the local grid. Some Saskatchewan research has determined that for about every 1 m^3 of biogas generated from digestion per day about 6.5 to 6.7 kilowatt hours of energy are produced per day[27]. However, it is hoped that down the road, new technologies will exist to address the biodigester size and feasibility issues.

Digestion systems will reduce GHG emissions through:

- The capture and combustion of manure storage methane.
- Heat and energy generated on-farm reduces the need for generating heat and energy off-farm using GHG intensive fossil fuels.
- Manure that has been digested intensively in an anaerobic system has an altered chemical composition. Due to this, digested manure will produce less nitrous oxide gas after manure application to cropland compared to raw, undigested manure. In Quebec, after 3 years of research, soil nitrous oxide emissions were reduced by 50 to 75 percent where anaerobically digested manure was applied to the crop as compared to applied undigested raw manure[28].

Impact on Odour

Digestion systems utilize the carbon compounds responsible for odour production to produce methane and carbon dioxide gas instead. As a result manure odours during storage and application are significantly reduced. It is important to note however that digested manure has an increased tendency to produce ammonia gas and should therefore be stored in a covered storage system to prevent significant nitrogen gas loss.

Credit: Agriculture and Agri-Food Canada

Compost Manure

Greenhouse Gas Benefit

Composting is a controlled biological process that changes manure into a stabilized, safe, odourless, and organic rich product[29]. Composting also eliminates any potential pathogens and weed seeds that are in the manure. In order to compost the manure, dry and carbon rich material needs to be added so that its humidity and carbon:nitrogen ratio are balanced. This may involve mixing and/or forced ventilation in which the costs of adding the carbon source (straw or sawdust) and of new machinery are important factors to consider. To get more information on how to compost hog manure, see AAFRD and Alberta Pork's publication titled Environmental Manual for Hog Producers in Alberta (Agdex 440/28-1)[21]. Composting hog manure would reduce GHG emissions during storage and land application if the composting process is done correctly. The composted manure is also more concentrated which means that the manure can be transported further from the sites of manure production, and would offset commercial fertilizer needs. Compared to composting solid manure, there is little research into composting liquid manure. However, currently research is still determining if composting liquid hog manure has an effect on GHG emissions.

Credit: Alberta Agriculture, Food and Rural Development

Manure Storage and the Barn

Greenhouse Gas Benefit

Removing manure from animal rooms to separate long term storage locations reduces the risk of exposing animals and barn workers to toxic and odourous gas emissions produced in the barn environment. Past research has determined that the weekly removal of manure in the barns allows for reductions of ammonia and methane emissions by approximately 10 percent[30]. Manure stored in the barn for extended periods will tend to be maintained at a higher temperature, encouraging the rapid growth and activity of methane producing bacteria. Removing manure to a cooler, covered manure storage will ensure that methane production potential is minimized and any GHGs produced during storage are trapped and managed.

Section 5 Manure Application Management

Analyze Both the Manure and Soil Prior to Manure Application

Greenhouse Gas Benefit

Nitrous oxide emissions from soils during land application of manure can be reduced by appropriate manure application rates and utilizing manure application equipment, which prevents pooling of liquid nutrients. To guarantee that the right amount of nutrients are applied to the crop, it is essential to test the nutrient content of the manure. Also, testing the soil indicates how much nitrogen and other nutrients are already present in the soil. Both of these practices allow the operator to calculate the proper amount of nutrients needed for crop growth. To obtain more information on how to properly conduct soil and manure testing, see AAFRD's Environmental Manual for Crop Producers in Alberta (Agdex 100/25-1)[31].

Apply Manure Rates that Match Crop Nutrient Requirements

Greenhouse Gas Benefit

Over application of manure can substantially increase nitrous oxide losses from soils because manure adds nitrogen and carbon to the soil, both of which promote denitrification. Applying manure at rates that supply plant demands for growth can greatly reduce nitrous oxide emissions. Also, applying manure when needed by the crop increases nitrogen use efficiency by the plant, thereby reducing nitrogen losses.

Economic work completed by the Canadian Pork Council illustrates how manure compares to a commercial nitrogen fertilizer.

Nitrogen Rate (lbs) [1]	Gallons/acre	Manure Price/acre[2]	Urea Price/acre[3]
90	3,000	$25.50	$37.82
180	6,000	$51.00	$75.64
270	9,000	$76.50	$113.46

[1] Nitrogen content of the manure: 30 lbs N/1000 gallons

[2] Application cost: $0.0085/gallon

[3] Urea cost: $425.26/tonne based on August 2003 numbers

Timing of Manure Application to Reduce Nutrient Losses

Greenhouse Gas Benefit

The proper timing of manure application to land is essential to ensure maximum nitrogen use efficiency by the crop occurs and to minimize nitrous oxide emissions. Ideally, the best time to apply manure is in the spring, or as close to crop seeding as possible. Applying manure in the fall increases the amount of nitrogen lost from the soil over the winter and in early spring.

Another practice to consider that maximizes nutrient use and minimizes GHG emissions is to apply manure during crop growth and development. Research done by the Prairie Agricultural Machinery Institute (PAMI) indicates that post-emergent manure injection, under the right conditions, will cause minimal crop damage and increase yield[32]. In crop application of manure reduces GHG emissions by improving nutrient efficiency of the growing crop, which reduces the amounts of nitrogen lost to the atmosphere as nitrous oxide and/or as ammonia gas.

Inject Manure to Minimize Ammonia Nitrogen Loss

Greenhouse Gas Benefit

Injecting manure increases nutrient use efficiency by the crop by increasing the amount of nitrogen available. This reduces the risks associated with runoff and losses to waterways and in the atmosphere via volatilization during surface application. In terms of reducing GHG emissions, manure injection reduces manure nitrogen loss to the atmosphere through volatilization and denitrification. This contrasts with surface application of manure (broadcast) where research indicates that as much as 30 percent of manure nitrogen can be lost to the atmosphere[33].

Impact on Odour

Injecting manure beneath the soil surface can effectively reduce odours by trapping the gases and by allowing for microbial processes to change the gases into less odourous ones[34].

Credit: Reduced Tillage Linkages

Section 6 Controlling Odours and Greenhouse Gases

Gases can be generated in the barn and during manure storage and land application. These gases include methane and nitrous oxide, as well as odourous compounds such as ammonia, hydrogen sulphide, and sulphur. Although the intensity and offensiveness of an odour may be high, it is not necessarily an indication of the presence of GHGs. Research is examining if there is a relationship between GHGs and odours. Certainly it is understood that reducing nutrient losses in the production system will reduce odours, so any practice that reduces odours will likely reduce GHGs.

The primary complaint about livestock operations is odour. Completely eliminating odour from livestock operations is not feasible. However, management practices exist that can control odour impact by minimizing the intensity, frequency, duration, and offensiveness of odours.

Use Natural Windbreaks or Shelterbelts to Disperse Odours from Hog Barns and to Sequester Carbon

Greenhouse Gas Benefit

By acting as filters, the trees in the shelterbelts will remove carbon dioxide from the atmosphere. Studies performed at Agriculture and Agri-Food Canada's (AAFC) Prairie Farm Rehabilitation Administration (PFRA) Shelterbelt Centre have shown that the above-ground portion of a mature popular tree in shelterbelts will store an average of 974 kg of carbon dioxide[35]. While green ash, white spruce, and caragana trees average about 231 kg, 523 kg, and 143 kg of carbon dioxide that they can sequester, respectively[35].

In addition, shelterbelts protect soil from wind erosion by reducing wind speeds for distances up to 20 times the height of trees[32]. They also trap snow for increased spring soil moisture, reduce wind damage to crops, and decrease evaporation of soil moisture[32]. These benefits will then help to improve soil quality, which will help the soil store more carbon.

Impact on Odour

Trees can be used to control odour from hog manure storage facilities by creating turbulence that breaks up and disperses the odour in the air, in addition to providing a visual barrier for the agricultural operation. Shelterbelts can be relatively inexpensive to establish, but may take 3 to 10 years to fully develop.

Although more research is needed, it is believed that windbreaks reduce odours and dust by dispersing and mixing the odourous air with fresh air. Windbreaks downwind of animal houses create mixing and dilution, whereas placed upwind deflects the air over the houses so it picks up less odourous air[36].

Credit: Alberta Agriculture, Food and Rural Development

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