What the Kyoto Protocol means to the Pork Industry

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▪ Introduction

Human activities have changed the gaseous composition of the Earth's atmosphere. Among the gases that have been added to the atmosphere are greenhouse gases (GHG): nitrous oxide (N_2O), carbon dioxide (CO_2) and methane (CH_4). The GHG absorb solar radiation (heat) near the earth's surface and release it in the cooler upper atmosphere. The concern of climate scientists is that as the atmosphere warms the processes that control climate dynamics will be altered, resulting in global climate change.

Human activities, such as the burning of fossil fuels or nitrogen fertilization of crops, have significantly increased the size of the carbon and nitrogen cycles of the planet. For example, Marland et al. (1999) estimate that global CO_2 emissions have risen from about 6.4 Pg[1] per year in 1951 to 23.9 Pg per year in 1996. That human activities have increased GHG in the atmosphere is certain. What is less certain is how (or for skeptics – whether) an increase in atmospheric GHG is linked to global climate change and what will be the magnitude of the change.

Climate change predictions are based on mathematically modeled projections. The modeling of a system as large and intricate as global climate is extremely complex. Many of the climate drivers occur at the scale of oceans or continents; these are well beyond the scope of laboratory or field experiments. Because experimental science cannot provide conclusive answers about the potential, extent or timing of climate change, most scientists and policy makers have adopted a precautionary approach on the weight of the theoretical evidence. They have decided that it is prudent to take action to reduce GHG emissions now rather than to wait for proof, because once we can measure a

[1] Petagram = 10^{15} grams

change in climate it may be too late to either reverse the process or reduce its severity.

Even to slow the increase in the atmospheric concentration of the GHG, and thereby minimize or slow climate change will require large reductions in GHG emissions. The Kyoto protocol, an agreement among 38 developed countries, was negotiated to begin the process of reducing GHG emissions in highly industrialized countries by 5.2% below 1990 levels before 2012. For its part, Canada agreed to reduce GHG emissions to 94% of 1990 levels by 2012.

▪ Canadian Greenhouse Gas Emissions

Canada's greenhouse gas emissions from anthropogenic sources[2] were approximately 599 Tg[3] CO_2 equivalents[4] (CO_2e) in 1990 (Jaques et al., 1997; McIlveen and Desjardins, 1998). To meet its Kyoto target, Canada must lower greenhouse gas emissions to ~563 Tg CO_2e by 2012 (Figure 1). The difficulty for Canada, and for many industrialized nations, is that emissions have continued to increase since the Kyoto Protocol was signed. Projections indicate that if GHG emissions continue to rise along the business-as-usual path, Canada will have to cut emissions in 2012 by ~140 to 185 Tg CO_2e (20 to 25%) to meet the target.

Canada produces only about 2% of total global emissions from human activities, compared with about 25% in the U.S. and 17% among the European Union countries. However, our emission intensity, at 22 Mg[5] CO_2e per capita in 1990, is among the highest in the world (Neitzert et al., 1999). Most of Canada's emissions are associated with the energy and transportation industries (Figure 2).

[2] GHG emissions result from both natural and human (anthropogenic) activities. Under the Kyoto Protocol, countries are responsible for reduction of only the human-induced emissions.
[3] Teragram = 10^{12} grams
[4] The GHG are converted to CO_2 equivalents for comparison. Over 100 years, 1 kg of CH_4 has the same warming potential as 21 kg of CO_2, and 1 kg of N_2O has the same warming potential as 310 kg of CO_2 (IPCC, 1996). Methane and N_2O are multiplied by their global warming potentials for conversion to a CO_2 equivalent.
[5] Megagram = 10^6 grams

Greenhouse Gas Emissions from Agriculture

Agriculture produces about 9% of Canadian emissions, most of which are CH_4 (34%) and N_2O (61%) (Janzen et al., 1998). Crop production activities account for about one third of agriculture emissions and grazing land management and livestock production produce about two thirds of the emissions (Table 1). Carbon sequestration in agricultural soils (sinks), associated with the adoption of soil conserving land management practices, are projected to offset up to 20% of those emissions (Table 1).

Table 1. Canadian GHG emissions (Tg CO_2e per year) from primary agriculture in 1990 and projected for 2010.

Activity	Emission	1990	2010	Difference
Cropland management & crop production	source	19.8	23.5	-5.9
	sink	0	-9.6	
Grazing land management & animal production	source	37.7	41.2	-1.7
	sink	0	-5.2	

Source: AAFC

Estimates made with the Canadian Economic and Emissions Model for Agriculture (CEEMA) (Junkins et al., 2000) indicate that if agricultural activities follow a business-as-usual path, GHG emissions from agriculture will reach 65 Tg in 2010, up 13% from 57 Tg in 1990 (Table 1). Therefore, to reach the Kyoto Protocol target would require an emission reduction of 19% by 2012.

Livestock Emissions

The amount and type of GHG emissions from livestock production vary among animal types. Most of the GHG emissions associated with hog production are CH_4 and N_2O from manure, whereas direct production (enteric fermentation) of CH_4 is the largest source associated with beef production (Table 2). CEEMA estimates for 1996 production levels indicated that cattle production accounted for about five times more GHG emissions than hog production. On a per unit of production basis, cattle produced about six times more GHG than hogs (Figure 3). It is important to understand how GHG emission sources and levels vary among livestock production systems for development of appropriate mitigation strategies.

Table 2. Greenhouse gas emissions (Gg[6] CO_2e) associated with beef and pork production in Canada in 1996.

Source	Gas	Beef	Pork
Direct	CH_4	14,234	350
Manure	CH_4	252	2,331
	N_2O	8,411	1,046
Feed grain: fuel	CO_2	161	121
Fuel	N_2O	8	6
SOM	CO_2	232	174
Crop residue	N_2O	233	175
Fertilizer	N_2O	227	171
Total		**23,758**	**4,375**

[1] Beef production was 976 Gg and pork production was 1,228 Gg in 1996 (Statistics Canada).

[6] Gigagram = 10^9 grams

GHG Mitigation in Hog Production Systems

The issue of climate change and the Kyoto Protocol challenge policy makers to develop policies that will encourage agricultural producers to adopt production systems and technologies that reduce greenhouse gas emissions. The challenge is a large one, particularly within the agricultural sector, given that:

- There is still large uncertainty about the magnitude of greenhouse gas emissions associated with many agricultural management practices.
- There are 250,000 farm businesses, all of which vary in their management systems and for which mitigation strategies will vary.
- There is uncertainty about future climatic conditions, and the best management practices for mitigation of GHG may change as the climate changes.

The Agriculture and Agri-Food Issue Table, one of about twenty national issues tables assembled to develop GHG mitigation options for the various sectors of the Canadian economy, studied and analyzed options for GHG reductions in agriculture (Agriculture and Agri-Food Climate Change Table, 2000). The goal was to understand how to reduce GHG emissions in agriculture, while adhering to the overall goal of sustainable development within the agriculture sector.

Manure is the largest single source of GHG emissions from the hog production system (Table 2). Strategies to reduce the emissions have focussed on the handling, storage and field application of manure, and reducing the nitrogen content of the hog diet to reduce the potential for N_2O emissions from manure.

Manure Management

A substantial proportion of the GHG emissions from manure occurs during the several months when it is handled and stored. Microorganisms decompose (break down) the manure and release GHG gases, which vary in type and amount depending on the composition of the manure and the type of storage system. Methane production occurs when decomposition takes place in the absence of when oxygen (anaerobic conditions), and is therefore highest in liquid manure (Pattey et al., 1997). Nitrous oxide is produced by denitrifying bacteria which function oxygen availability is limited, such as in solid manure with about 60 to 70% water content (Brown et al., 2000) or in the crusts that form on liquid slurry (Wagner-Riddle et al., 2000).

There is also potential for GHG production when the manure is applied to the field. The potential is greatest if manure application occurs after the growing season or during the winter. Manure applied in the fall is present in the soil during spring snowmelt. At snowmelt, the soil becomes saturated and its environment is anaerobic. There is a significant potential for release of CH_4

and N_2O from manure that decomposes during that period. In addition, manure can be carried with melt water into water bodies, such as sloughs, where the period of saturation (and therefore reduced oxygen content) is extended and anaerobic decomposition and CH_4 or N_2O emissions continue until either the carbon and nitrogen sources are consumed or the soils dries.

The Agriculture and Agri-Food Table investigated the potential for GHG emissions reductions from several manure storage and management strategies, which included reduced fall and winter applications of manure in the field, improved storage methods, and a move toward solid rather than liquid storage. The Table found, however, that the ability to do quantitative analysis was limited by the lack of empirical data and that more research was required before the mitigation potential of these strategies could be determined. Research funding, such as the that provided by the Climate Change Funding Initiative in Agriculture through the federal government, has been targeted at research on GHG emissions levels from various manure handling, storage and application systems.

Feeding Strategies

Reduction of the protein content in the hog diet can reduce CO_2 emissions from hogs and N_2O emissions from manure (Mathison et al., 1999). Möhn et al. (2000) have reported that reduced dietary protein in the hog diet is associated with an increase in utilization of dietary energy and a reduction in CO_2 emissions. Möhn and Susenbeth (1995) have also shown that hog diets with adequate amino acid intake but reduced protein can substantially reduce the nitrogen content of manure and therefore, the potential for N_2O emissions.

The addition of phytase to hog diets not only reduces phosphorus excretion; it also increases protein digestibility and feed efficiency (Ketaren et al., 1991). Although little direct research with respect to GHG emissions has yet been completed, phytase addition to rations should reduce CO_2 emissions from the animals and the potential for N_2O emissions from manure.

The Agriculture and Agri-Food Table undertook analysis of feeding strategies that reduced the protein intake of hogs with and without phytase. The CEEMA analysis indicated that these strategies reduced manure emissions by 19% for N_2O and 2% for CH_4, but also increased feed costs and therefore reduced hog marketings (by 1.3%). For Canadian agriculture, those declines would result in a small decrease in GHG emissions of about 0.5 Tg CO_2e compared to the business-as-usual scenario (Junkins et al., 2000).

Biodigestion of hog manure

New research into the use of anaerobic sequencing batch reactor (ASBR) systems, biodigesters or other technology for recycling of the methane from manure to produce electricity is beginning in Canada and abroad. These systems convert waste from hog production into electricity, organic fertilizer, and recycled water. In terms of GHG mitigation, they represent the opportunity to reduce emissions of CH_4 from hog manure and to generate electricity from a non-fossil fuel, renewable source.

Systems are currently under construction or in the testing phase on the Prairies, and there are still questions about their performance under Canadian climate conditions. However, this technology has the potential to convert a "waste" product of the hog production system into a source of energy.

▪ The Road Ahead

Canada and agriculture's response to the climate change issue and the Kyoto Protocol could follow different paths, determined by our beliefs and the assumptions that we make:

- **Do nothing.** If the dominant belief is that climate change will be minor, or it will benefit Canadian agriculture, or Canada will be better off (less affected) than other countries, or Canada is better able to adapt to climate change than other countries, the decision might be to take no mitigative action;
- **Adopt "no-regrets" options.** If it is assumed that there is risk to agriculture from climate change, it would be rational to take at least those mitigative actions that also provide other benefits, such as economic efficiency or improved environmental quality;
- **Act to mitigate.** If it is assumed that the risk to Canadian agriculture and other countries from climate change is potentially severe, the rational approach would be to mitigate to the fullest extent possible.

Climate change may be the most complex problem ever faced by the global community. It will affect every region and economic sector. Its solution will require fundamental changes in how we do business and even how we solve problems. What seems most certain is that the difficulty will diminish in proportion to our ability to act early and creatively to develop new technologies and practices that reduce GHG emissions and also make economic and environmental sense. It is in our best interest to at least identify and adopt the "no-regrets" options. Those will vary among sectors and regions and their development will require the expertise and imaginations of all the participants.

Identifying the best mitigation options is especially difficult for an environmentally and economically diverse country like Canada. Achieving the targets of the Kyoto Protocol may result in a decline in fossil fuel demand as energy efficiency increases in response to future emission limitations – while that is good for Canadian energy consumers, it may be bad for Canadian energy producers and exporters. The outcome will depend to some extent on how (or if) the Kyoto Protocol is implemented. The Umbrella Group of countries, which includes Canada, has negotiated for flexibility in how countries can meet their reduction targets, and for inclusion of a broad range of flexibility mechanisms, that include biological sinks and market mechanisms, such as emission reduction and carbon trading. The more we can use biological removals (sinks) and harness the creativity of markets to move toward a less GHG-emitting economy, the greater our chance of achieving real reductions at the lowest cost within all sectors, including agriculture.

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