Preliminary modelling work on market-based approaches for mitigating GHG emissions in the Canadian primary agriculture

Forestry and Agriculture Greenhouse Gas Modeling Forum

Shepherdstown, West Virginia

September 25-28, 2016

Canada

Objectives

- This presentation is on possible market-based approaches for tackling GHG emissions in the agricultural sector, voluntary efficiency gains in the supply side have already been analyzed in a previous study.

  - Agriculture Canada conducted a quantitative analysis to estimate primary agriculture's mitigation potential assuming implementation of a voluntary carbon offset system and various carbon prices. Results showed limited potential.

Outline of the presentation

- Canadian Regional Agricultural Model (CRAM) and the Canadian Economic and Emissions Model for Agriculture (CEEMA)

- Two simplified approaches which have been developed in CRAM:
  - Partial analysis of a cap and trade system for the primary agricultural sector emissions.
  - Partial analysis of a carbon tax on primary agricultural emissions.

- Preliminary results

- Additional statistics that help to frame the results

- Discussions and next steps

Canadian Regional Agricultural Model (CRAM)

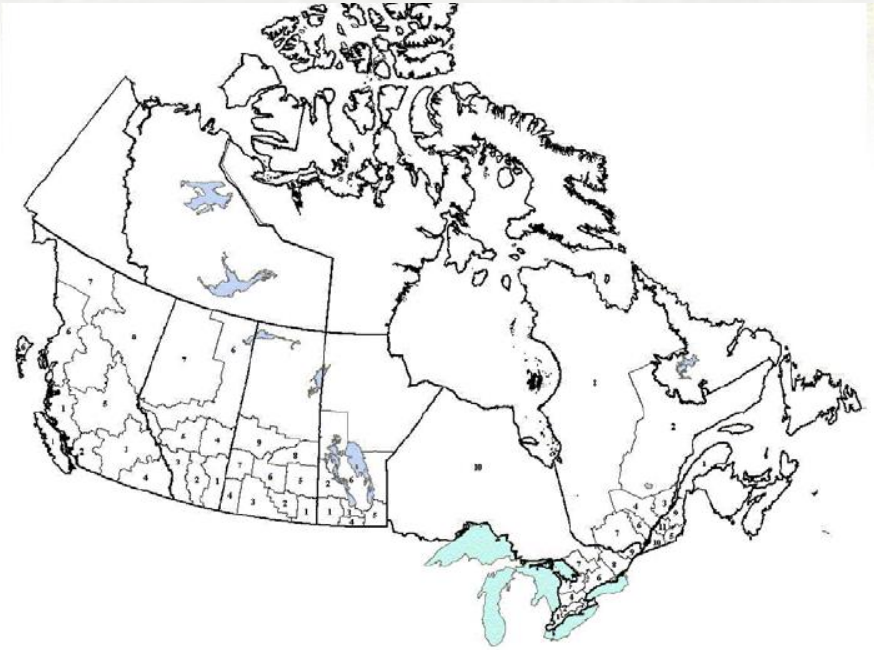
- CRAM is a static partial equilibrium model of the Canadian Agriculture sector, covering all of primary production (crops and livestock) and some processing activities.

- CRAM is divided into 55 regions and can provide a very detailed regional breakdown of scenario results.

- The underlying strength of CRAM is the specification of production responses at the regional level and linking of output with provincial demand and world markets through a transportation matrix.

- CRAM uses the Positive Mathematical Programming (PMP) methodology to calibrate marginal cost curves for all cropping and livestock activities except for supply managed industries.

- CRAM is of very similar structure to the USDA REAP model except it is applied to Canada.



Canadian Economic and Emissions Model for Agriculture (CEEMA)

- CEEMA is used by AAFC to generate baseline emissions projections and to quantitatively assess the impacts of policy scenarios on greenhouse gas (GHG) emissions from the agricultural sector.

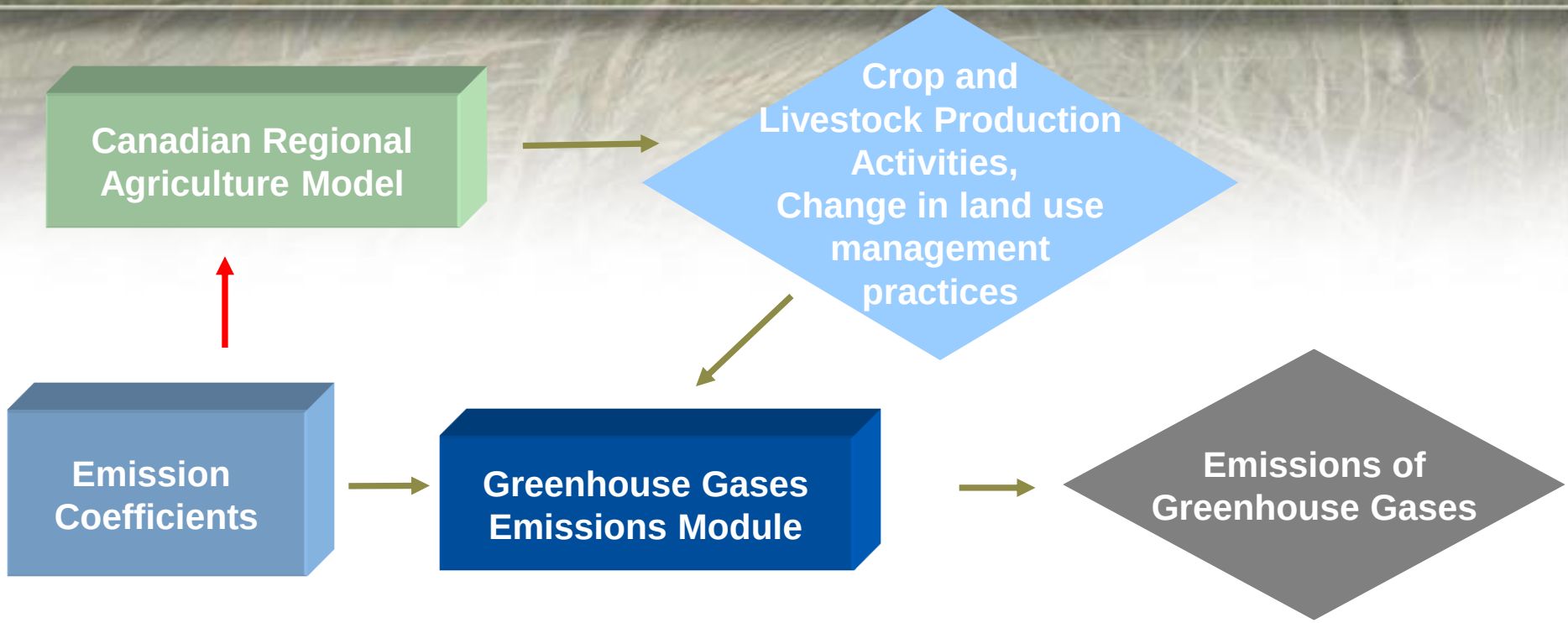
- Integrated modelling exercise that incorporates science with economic policy analysis.

- Estimate emissions of carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O), which are the three GHGs emitted by the agricultural system.

- One important feature of this model is that it takes into account the interdependency of crop and livestock production.

- The final set of results of the CEEMA can be used to identify any trade-off situations that may exist for a given mitigation measure that might be considered for adoption.

CEEMA Modeling Framework



- Based on the policy analysis model (Canadian Regional Agricultural Model - CRAM)
- Greenhouse Gas Emissions module links levels of agricultural activities to emission coefficients (CEEMA)
  - Total emissions are calculated on a CO2-equivalent basis based on 100-year global warming potential conversion factors of 25 for methane and 298 for nitrous oxide.
  - Emission coefficients based on the latest scientific information
    - biophysical models held by the NCGAVS team
    - researches (AAFC Research Branch, IPCC and Environment Canada)

Enhance CEEMA by endogenizing emissions estimates within CRAM

- The emission coefficients are now incorporated directly into CRAM

  Emission coefficients (parameters) * Activity levels (variables) = GHG output (variables)

- **This allows the model to analyze different structures to repress the production of GHGs, with all the behavioral effects taken into account in the objective function.**

  - Partial analysis of a cap and trade system for the primary agricultural sector

    *Equation .. Emission coefficients (parameters) * Activity levels (variables) =L= Bound*

  - Partial analysis of a carbon tax on primary agricultural emissions

    *OBJ .. CPS = - Emission coefficients (parameters) * Activity levels (variables) * carbon price (scalar)*

- In this preliminary framework the results are analyzed in the optic that the primary agricultural sector is affected by only negative incentives (penalties) imposed on the agricultural producers for their GHG emissions. However, further reforms of overall corporate taxation could be analyzed with this tool; other tax levy may be reduced in compensation.

Assumptions

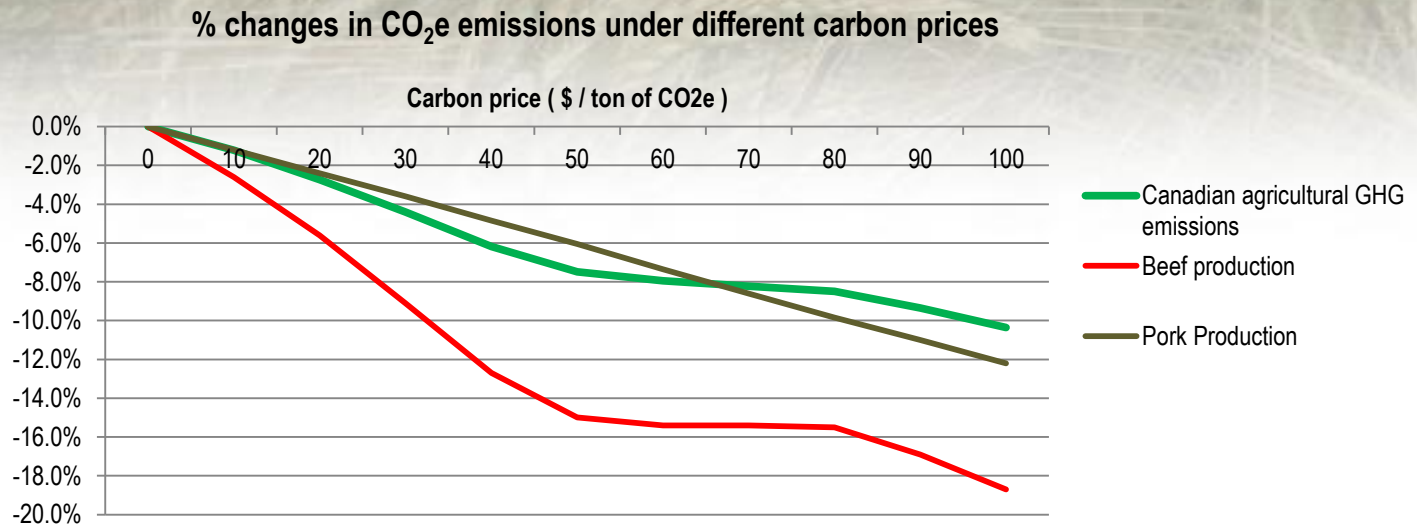
- The carbon tax and the cap and trade affect only the primary agriculture sector emissions.
  - Not taking into account the whole value chain (input prices and/or other emissions in the processing industries).
  - Not taking into account any relationship with possible bioenergy production.

- The international prices are not affected in the system.
  - The consumer can always rely on the world market prices, and the Canadian producers are price takers.

- The money generated from the tools is not redistributed in the system.
  - Such as decreasing other corporate taxes.

- The emissions coefficients are fixed for each region and there is no transaction costs - emissions of each GHG are estimated for each CRAM region, crop and livestock production activities, and source of GHG emissions.
  - A key technical challenge moving forward with the implementation of a carbon price affecting the agricultural sector is robust measurement of emissions at the field level.
    - The diffuse nature of agricultural GHG emissions and lots of regional variation across the country make measurement a unique challenge.
    - The potential high transaction costs have to be taken into consideration.
    - Trade-offs will need to be made, for example, between designing systems for monitoring and verifying farm emissions, which would create the most effective incentives, and the high transaction costs this could impose.

Preliminary results in CRAM with the carbon price structure



- Other things being equal, such as administrative costs, the impact of implementing a carbon tax or a cap and trade on the sector activities are identical.
  - With a tax of $97 per ton of CO2eq, it is equivalent to a cap on emissions at 90% of the baseline.
- The emissions decrease in almost entirely driven by a reduction in red meat production (Beef -18% and Pork -12%).
- Other than some reductions in feed grains production, the Canadian grain sector remains profitable and do not decrease.
- In the global economic context, emissions "leakage" due to the lack of comparable emissions pricing abroad will necessarily happen.
  - Border tax adjustments could be suggested, but such trade measures may not be compatible with World Trade Organization (WTO) obligations, and Canada is a net exporter of agricultural output.

Impact on the crop and livestock productions
($97 carbon tax = 90% Cap on base emissions)

Carbon tax impacts = Cap and Trade impacts

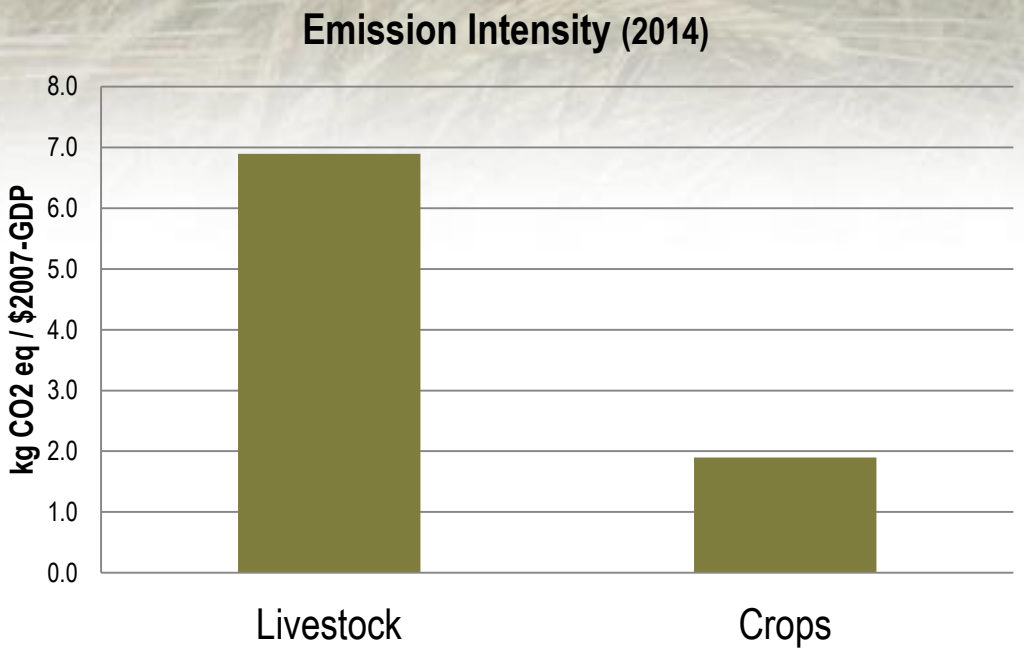
	%DIFF
AREA.SUMFAL	0.78
AREA.WHEAT	-2.51
AREA.DURUM	0.45
AREA.BARFD	-4.35
AREA.BARMT	2.75
AREA.OATS	0.65
AREA.FLAX	2.89
AREA.CANOLA	-0.26
AREA.LENTILS	0.87
AREA.FLDPEAS	-2.12
AREA.SOYBEANS	7.17
AREA.CORNG	-4.1
AREA.CORNS	0.43
AREA.CEREALS	-49.51
AREA.OTHER	-15.38
AREA.HAY	-15.25
AREA.PAST	
AREA.UILPAST	-21.94
AREA.ALFALFA	-7.95
AREA.POTAT	-4.93

	%DIFF
COWCLF1	-18
BREPLACE	-18
STOCKER	-18
FEDCLF1	-19
FEDYER1	-18
SOWS	-12
GROWERS	-12
DCOWS	
DARYHEIF	
DHEIFCV	
BROILERS	
LAYERS	
TURKEYS	
BULLS	-19

- Other things being equal, such as administrative costs, the impact of implementing a carbon tax or a cap and trade on the sector activities are identical.

- The only difference is on the consumer-producer-surplus (CPS), because the money coming from the tax is removed from the system and the cap-and-trade creates economic rents. This difference vanish if the emissions rights are auctioned.

In 2014, overall emission intensity of the livestock production was 360% higher than in the crop production system

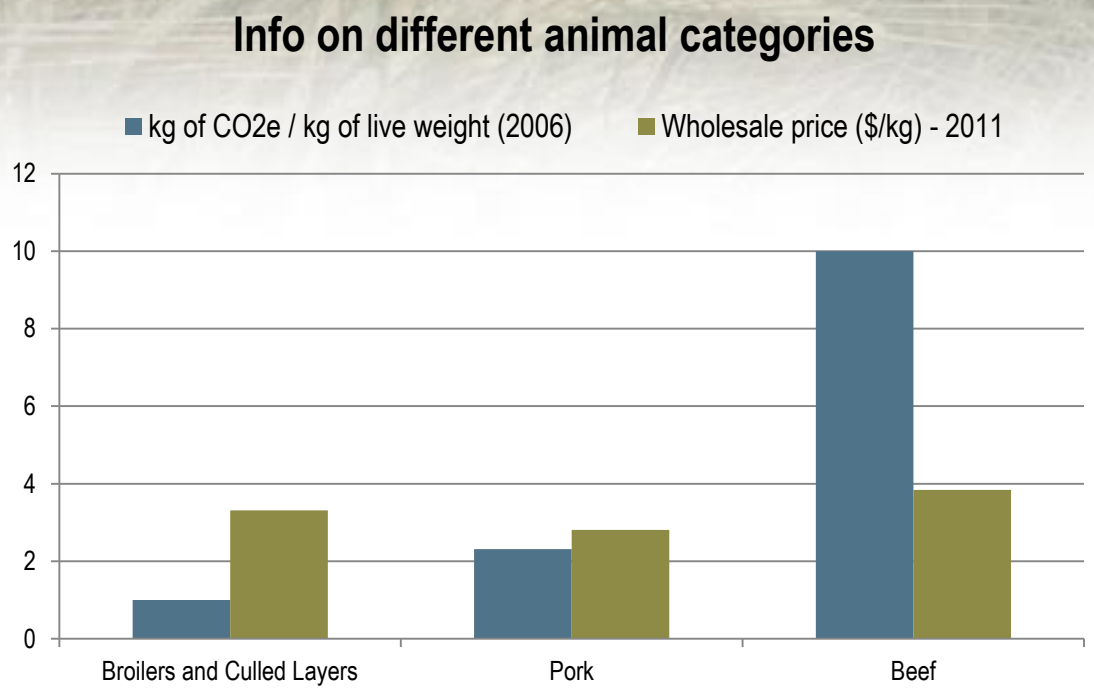


Source: Statistics Canada, CANSIM 379-0031 & Environment Canada, National Inventory Report 2016

- On-farm fuel emissions are not taken into account in this graph - but was taken into account in the CRAM simulation.

- The feed crops and pasture land are accounted in the crops production system.

Beef and pork produce more GHG emissions per kg of meat and their relative prices do not compensate for this lack of efficacy



Source: AAFC, Vergé, X.P.C., Dyer, J.A., Desjardins, R.L., et Worth, D.E. (2009) & AAFC, Medium Term Outlook 2015

- The number of breeding animals that must be maintained in order to produce one animal for slaughter is much higher for cattle than for swine or poultry. The slow means of reproduction of beef cattle is a better explanation for the observed difference between the GHG emission intensities of ruminants and non-ruminants than is enteric methane.

Measures to insure competitiveness and reduce leakage

Revenue-neutrality can be designed to avoid production losses and still create incentives to change behavior.

- Under a cap-and-trade program, one way to fully recycle money is to allocate permits to firms within the affected sectors based on their output ("output-based allocation").
- Another way is to set performance standards with a carbon price; in this case, each sector must meet an average emissions requirement or pay for the extra emissions or be rewarded for lower emissions.

A performance standard approach was modelled at the provincial level for the beef sector*:

• By setting a standard based on the average performance of the whole Canadian industry in terms of GHG intensity (ton of GHG per ton of meat), the results showed an increase in the beef production by 3.6% and an increase in emission by 1% at the Canadian level. As a result, while there is no net emission reduction, the emission intensity of the whole industry can be decreased.

• However, the production in the West would increase while the production in the East would decrease. This reflects the comparative advantage of the Western provinces compared to the east when it comes to GHG emissions per output of beef.

• The more differences there are among producers in GHG efficiency, the more potential gain such a policy can bring.

• Moving production to locations where it is most efficient is an effective way to reduce emission-intensity, and the bigger the jurisdiction is the more effective the policy can be. (i.e., a national policy is more effective than individual provincial policies).

* The results should be taken more as an illustrative example due to the low resolution of the data.

Next steps: More complex analyses can be performed if there is a political appetite for them

- The carbon tax and the cap and trade affect only the primary agriculture sector emissions.
  - Not taking into account the whole value chain (input prices and/or other emissions in the processing industries).
  - Not taking into account any relationship with possible bioenergy production.
- A more holistic view of the supply chain can be taken into consideration
  - Processing emissions associated with meat vs cereal consumption.
  - End use of the product (food waste in meat vs cereal products, bioenergy)

- The international prices are not affected in the system.
  - The consumer can always rely on the world market prices, and the producers are price takers.
- Standards can be set for partners who want to gain access to markets (e.g.: canola access in Europe)

- The money generated from the carbon price is not redistributed in the system.
  - Such as decreasing other corporate taxes.
- Different setups can be modelled.

- The emissions coefficients are fixed for each region and there is no transaction costs.
- Different technological choices are available, and transactional costs can be investigated. Firm level analyses are important, but data issues remain.

Questions?

Comments?