Alberta’s experiences with Greenhouse Gases:
The Beef Cattle Protocols

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Carbon as a New Commodity

- Improving efficiency of nutrient use reduces cost of production; “just good practice”.
- World interest in reducing greenhouse gas (GHG) emissions is increasing
- The World Bank estimated the 2008 global carbon market at $126 B USD, doubling from the year previous

Capor and Ambrosi, 2009
Global Climate Change Initiatives

The Evolving Global Carbon Market

- California & West Coast Govs
- Canada (?)
- RGGLI
- UK
- Norway
- EU ETS
- Switzerland
- Japan?

Alberta
US Fed
CCX (Voluntary)

- Actual or imminent
- Proposed

CDM (Non-Annex 1)
Australian states & National program
New South Wales
Alberta’s GHG Emissions in the Canadian Context
(MT of CO₂ e/yr; 2006=759.2 MT)

Alberta contributes 39% to Canada’s GHG;
Agriculture in Alberta/Canada = 8/10% of AB’s GHG
Project 26% increase by 2020
How did Alberta get there

• 2002 - Taking Action on Climate Change
• 2003 - Climate Change & Emissions Management Act
  ➢ Mandatory Reporting for large industry
  ➢ Specified Gas Emitters Regulation
    • Intensity reduction targets for large facilities starting July 1, 2007
    • Requires companies emitting > than 100,000 T of CO2e y-1 to reduce emission intensities by 12 % annually
  ➢ Offset Trading System
Large Industrial Emitters Profile
(>100,000 tonnes CO2e/yr)

- About 100 facilities representing 50% of AB’s emissions

- **Power Plants**: 48%
- **Oil Sands**: 18%
- **Chemicals**: 7%
- **Heavy Oil**: 7%
- **Gas Plants**: 8%
- **Other**: 12%
- **Forest Products**: 0.5%
- **Heavy Oil**: 7%

Alberta Reporting Program - 2006
Options to Achieve Targets

1. Facility Improvements
   - adapting new technologies, retrofitting existing equipment, or changing to more efficient practices

2. Emission Performance Credits
   - Credits for better than target performance (implementation of operational improvements)

3. Alberta Technology Fund Credits
   - Invest in the Climate Change and Emissions Management Fund at $15/tonne – funds used to develop or invest in Alberta based technologies, programs, and other priority areas

4. Emission Offsets
   - Voluntary emission reduction opportunities in support of achieving environmental objectives
Offset Demand Increases, 2007 to 2009

2007 SGER Compliance
- CCEM Fund Payments: 2.7 Mt, 47%
- Internal Improvements: 1.7 Mt, 30%
- Alberta Offsets: 1.0 Mt, 18%
- EPCs Retired: 0.3 Mt, 5%

2009 SGER Compliance
- CCEM Fund Payments: 4.2 Mt, 40%
- Internal Improvements: 1.4 Mt, 13%
- EPCs Retired: 1.2 Mt, 11%
- Alberta Offsets: 3.8 Mt, 36%

SGER, Specific Gas Emitters Regulation; CCEM, Climate Change Emission Management; EPCs, Emission Performance Credits
No Till largest 2009 Offset Project type

2009 Retired Offsets by Project Type

- AWWT, Anaerobic Waste Water Treatment
- EOR, Enhanced Oil Recovery
- Wind
- Landfill Gas

ENVIROMENTAL STEWARDSHIP DIVISION
# Credits from Ag totals 3.2 mt CO$_2$e worth >$35 million

<table>
<thead>
<tr>
<th>Alberta Offset System Activity</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Projects</td>
<td>7</td>
<td>25</td>
<td>26</td>
<td>58</td>
</tr>
<tr>
<td>Tillage Management</td>
<td>3</td>
<td>10</td>
<td>15</td>
<td>28</td>
</tr>
<tr>
<td>Other Types of Projects</td>
<td>4</td>
<td>15</td>
<td>11</td>
<td>30</td>
</tr>
<tr>
<td>Total Registered (tCO$_2$e)</td>
<td>1,555,037</td>
<td>3,471,495</td>
<td>4,432,124</td>
<td>9,458,656</td>
</tr>
<tr>
<td>Total Retired (submitted for compliance)</td>
<td>986,700</td>
<td>2,845,763</td>
<td>3,828,232</td>
<td>7,660,695</td>
</tr>
<tr>
<td>Agriculture tonnes registered (tCO$_2$e)</td>
<td>558,714</td>
<td>1,000,976</td>
<td>1,654,084</td>
<td>3,213,774</td>
</tr>
<tr>
<td>Agriculture tonnes retired</td>
<td>202,210</td>
<td>821,836</td>
<td>1,584,108</td>
<td>2,608,154</td>
</tr>
</tbody>
</table>

Note: Tonnes must be registered first and then they can be “retired” (used) or kept for he next year.
Source: Climate Change Central.
Fundamentals of Offset Projects: Offsets=Baseline - Project

Fundamental Principle:
- ISO 14064-2 Standard
- *above and beyond Business as Usual.*
- Need to be quantified
- Requires data monitoring and management

Baseline Condition:
- common industry practice before the change?

Project Condition:
- What is the improved technology?
Alberta Approved Quantification Protocols – Agriculture (28)

- **GHG Emission Removals** = Carbon Sinks (remove GHGs from atmosphere)
  - **Reduced/No-Tillage**
  - **Afforestation** (Planting Trees)

- **GHG Emission Reductions**
  - **Pork** (Feeding/Manure Storage & Spreading)
  - **Biogas** (Anaerobic Decomp. Ag Materials)
  - **Feeding Edible Oils to Beef Cattle**
  - **Reducing Days On Feed for Beef Cattle**
  - **Reducing Age at Harvest in youthful Beef Cattle**
  - **Biofuels**
  - **Biomass** (Combustion facilities)
  - **Energy Efficiency** (pork, dairy, poultry facility process changes/retrofit)
Potential Alberta Quantification Protocols for Agriculture

Potential Protocols Under Review
- Nitrogen Efficiency Reduction
- Reducing Summerfallow
- Selection for low Residual Feed Intake (RFI) in Beef cattle

Other Protocol Areas Under Consideration
- Wetlands Management
- Conversion to Perennial Forages
- Lagoons
- Pasture Management
- Dairy Cattle
Relative proportion of various GHG emissions (CO$_2$e) resulting from a beef farm in western Canada

1. **Enteric CH$_4$**
   - Eq. 10.21 (IPCC 2006)
   - Ration comp., DOF, N, DMI

2. **Manure CH$_4$**
   - Eq. 10.23 & 10.24 (IPCC 2006)
   - DMI, DOF, TDN or DE of ration
   - Defaults for UE, ASH of manure, etc

3. **Manure N$_2$O direct**
   - Eq. 10.32, 10.25 & 10.26 (IPCC 2006)
   - DMI, CP of ration, NE
   - Defaults for NR or 7%

4. **Soil N$_2$O**
   - Eq. 10.27 & 10.28 (IPCC 2006)
   - Volatilization & leaching
   - DOF, NE, default values

**GHG Intensity** = 13 kg CO2e/kg live wt
22 kg CO2e/kg carc wt

**Simulated over an 8-yr production cycle**
Beauchemin et al. 2010, Ag. Systems
1. Feeding edible oils to beef cattle

- Edible oils including tallow – 20% decrease in methane
  - oilseeds processed or masticated for reductions to be realized
  - requires the free oil to interact with rumen microbes

- Total fat should not exceed 6-7% of dietary DM
  - reduced DMI and performance

- Biological mechanisms:
  i) decreasing fibre digestibility,
  ii) suppressing the metabolic activity of methanogens & protozoa,
  iii) enhancing relative propionate production and,
  iv) through provision of an alternative means of electron disposal.
**Enteric Methane emissions**

Each Animal Group within ration

\[ = \text{SUM} ( N \text{ cattle} \times \text{DOF} \times \text{DMI} \times \text{GE}_{\text{diet}} \times (\text{EF}/100)/\text{EC}) , \]

\( \text{GE}_{\text{diet}} = \) gross energy content of the diet or \(18.45\) MJ/kg DM
\(19.10\) MJ/kg DM for diets containing 4%-6% edible oils

\( \text{EF} = \) default \(\text{CH}_4\) emission factor;
- 4.0% for diets greater or = 85% concentrates, no edible oil;
- 6.5% for diets <85% concentrates, no edible oil
- 3.2% for diets greater or = 85% concentrates, 4%-6% edible oil
- 5.2% for diets <85% concentrates, 4%-6% edible oil

\( \text{EC} = \) conversion factor of energy to methane or \(55.65\) MJ/kg \(\text{CH}_4\)

**BASELINE vs. PROJECT**

calculated on actual pen-average mid-point weights and DMI
Table 1. Diet ingredients and composition for FEEDLOT 1.

<table>
<thead>
<tr>
<th>Diet Ingredients and composition</th>
<th>Baseline Diets (No Oil)</th>
<th>Project Diets (Oil Added)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Days on diet</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>Barley grain</td>
<td>50.3</td>
<td>62.5</td>
</tr>
<tr>
<td>Barley Silage</td>
<td>23.4</td>
<td>17.1</td>
</tr>
<tr>
<td>Corn Silage</td>
<td>21.8</td>
<td>15.9</td>
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<tr>
<td>Canola oil</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Supplement</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Dry matter, %</td>
<td>53.6</td>
<td>59.9</td>
</tr>
<tr>
<td>NEm, Mcal/kg DM</td>
<td>1.71</td>
<td>1.83</td>
</tr>
<tr>
<td>NEg, Mcal/kg DM</td>
<td>1.09</td>
<td>1.20</td>
</tr>
<tr>
<td>Crude Protein, %</td>
<td>12.5</td>
<td>12.2</td>
</tr>
<tr>
<td>Cost, $/kg DM</td>
<td>0.132</td>
<td>0.140</td>
</tr>
</tbody>
</table>
Production parameters for feedlot steers under BASELINE and PROJECT conditions

<table>
<thead>
<tr>
<th>Diet</th>
<th>DOF</th>
<th>N</th>
<th>Wt in, kg</th>
<th>Wt out, kg</th>
<th>ADG kg/day</th>
<th>DMI kg/day</th>
<th>DMI kg/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14</td>
<td>117</td>
<td>392</td>
<td>411</td>
<td>1.32</td>
<td>9.60</td>
<td>9.41</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>117</td>
<td>411</td>
<td>421</td>
<td>1.40</td>
<td>9.80</td>
<td>9.51</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>117</td>
<td>421</td>
<td>431</td>
<td>1.47</td>
<td>9.81</td>
<td>9.49</td>
</tr>
<tr>
<td>4</td>
<td>130</td>
<td>117</td>
<td>431</td>
<td>631</td>
<td>1.54</td>
<td>11.41</td>
<td>11.00</td>
</tr>
</tbody>
</table>

**BASELINE EF, kg CH4/hd/period**

\[=\left(\frac{9.60 \text{ kg/day} \times 18.45 \text{ MJ/kg DM} \times 6.5}{100} / 55.65\right) \times 14 \text{ d} = 2.90 \text{ kg/hd}\]

**PROJECT EF, kg CH4/hd/period**

\[=\left(\frac{9.41 \text{ kg/day} \times 19.10 \text{ MJ/kg DM} \times 5.2}{100} / 55.65\right) \times 14 \text{ d} = 2.35 \text{ kg/hd}\]
The Size of the Prize

Alberta’s potential – 223,856 to 302,769 t CO₂e/yr
Worth $2.2 to $3.0 million/yr in carbon credits (@ $10/t CO₂e)

However,

At $800-900/t for edible oils, the cost of mitigation would be very high at ~ $0.27 to 0.30/kg CO₂e, while the benefit in carbon credits would only be worth $0.01/kg CO₂e

Edible oil price would need to drop to $400-500/t to be economically feasible

Feasible with corn grain (4% fat) & corn-based DDGs (11% fat) wheat-based DDGs (5-7% fat)??
2. Reducing days in the feedlot

Feeding ractopamine hyrochloride
- beta 1 adrenergic agonist similar to natural catecholamines
- increases muscle mass through increased protein synthesis with minimal effect on protein breakdown

Fed to cattle at 200 mg/hd/day during the last 28 days before slaughter

- Improves ADG and gain to feed by 20%
- Carcass weight by 1.9-2.8%
- No effect on DMI and USDA quality and yield grade
Example

BASELINE
- Steers, entry weight=700 lb (317.5 kg)
- 28 day adj. period, ADG= 1.0 kg/day
- Diet - 84.2% barley, 10.5% barley silage, 5.3% sup
- DM basis, 13.1% CP, 80% TDN
- ADG = 1.50 kg/day; DMI = 10 kg DM/day over 178 days
- 612.5 kg live slaughter wt or 355.25 kg carcass wt

PROJECT
- 200 mg RAC/hd/day during last 28 days
- ADG = 1.50 kg/day during first 144.4 days
- ADG = 1.80 kg/day during last 28 days
- DMI = 10 kg DM/day
- slaughter wt = 612.5 kg; carcass wt = 357.03 kg
- DOF = 172
Example

BASELINE
- 355.25 kg carcass in 178 days

PROJECT
- 357.03 kg carcass in 172.4 days
- 1.78 kg more carcass wt or 2.1 fewer days on feed
  \((1.78/0.58)/1.5 \text{ kg/day} = 2.1\)

TOTAL = 7.7 fewer days on feed (5.6 + 2.1)
GHG Sources:

1: CH$_4$ from enteric fermentation, kg/hd/period

Total Volatile Solids Excreted, kg/hd/day
2: CH$_4$ from manure handling, storage & land app, kg/hd/period

Nitrogen excreted, kg/hd/day
3: Direct manure N$_2$O, kg/hd/period
4. Direct manure storage N$_2$O, kg/hd/period
5. Indirect volatilization N$_2$O, kg/hd/period (NH$_3$ & NO$_x$)
6. Indirect manure leaching N$_2$O, kg/hd/period

$0.38$/animal fed RAC during last 28 days before harvest
3. Reducing Age at slaughter in youthful beef cattle

Mechanism: fewer days on feed, less CH₄, manure and N₂O

Source: CCIA database as of June 1, 2009

- n = 1,722,322 cattle
- 50% slaughtered younger than 19 mo of age
- 50% slaughtered older than 19 mo of age
- Avg. age = 18.6 mo

Calf-fed = ~45% of youthful cattle
Yearling-fed = ~55% of youthful cattle

Age at slaughter may be over-estimated by 0.5-1 months as some producers register birth date for a group of calves as the date of first born. This only affect the average birth date slightly as most (75-79%) calves are born in the first 42 days of the calving season (Alberta Cow-Calf Audit 2001).
# BASELINE diets

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Calf</td>
<td>0-3 months</td>
<td>91 days on pasture</td>
<td>100% milk</td>
</tr>
<tr>
<td>2.</td>
<td>Calf</td>
<td>3-6 mo</td>
<td>92 days on pasture</td>
<td>43% milk, 57% Alf-MBG</td>
</tr>
<tr>
<td>3.</td>
<td>Calf</td>
<td>6-9 mo</td>
<td>92 days on pasture</td>
<td>100% Alf-MBG</td>
</tr>
<tr>
<td>4.</td>
<td>Feeder</td>
<td>9-12.6 mo</td>
<td>104 days in feedlot</td>
<td>35% barley silage, 40% barley grain; 23% hay 1% molasses &amp; 1% beef sup</td>
</tr>
<tr>
<td>5.</td>
<td>Feeder</td>
<td>13-16 mo</td>
<td>92 days on pasture</td>
<td>100% Alf-MBG</td>
</tr>
<tr>
<td>6.</td>
<td>Feeder</td>
<td>16-18 mo</td>
<td>75 days in feedlot</td>
<td>10.5% barley silage, 84.2% barley grain, 1.6% molasses &amp; 3.6% beef sup</td>
</tr>
</tbody>
</table>
## PROJECT diets

1. Calf 0-3 mo 91 days on pasture | 100% milk
2. Calf 3-6 mo 92 days on pasture | 43% milk, 57% Alf-MBG
3. Feeder 6-7 mo 31 days in feedlot | 40.0% barley silage, 58.0% barley grain, 1.0% molasses & 1.0% beef sup
4. Feeder 7-14 mo 212 days in feedlot | 10.5% barley silage, 84.2% barley grain, 1.6% molasses & 3.6% beef sup
The Size of the Prize
Reducing age at slaughter by 1-4 months

$2.84 to $11.35/hd or about $2.83/mo reduction

Additional benefits from reduced yardage, interest costs and possible increased selling price – could be substantial

Alberta’s potential – 0.681 to 2.73 million t CO$_2$e/yr
Worth $6.81 to $27.3 million/yr in carbon credits (@ $10/t CO$_2$e)
4. Selection For Low Residual Feed Intake in Beef Cattle
4. Selection for improved efficiency of feed utilization; LOW Residual Feed Intake (RFI)

Mechanism (s):
1. Reduces feed intake at equal body size & ADG
   \[ r_p = 0.60-0.72; \ r_g = 0.69-0.79 \] (Arthur et al. 2001; Basarab et al. 2003; Herd et al. 2002)

73 hybrid bulls
Olds College,
Fall 2006
\[ r_p = 0.64 \]

RFI = difference between actual feed intake & expected feed intake based on size & production
Mechanisms, independent of intake, are related to metabolizability and animal variation in NEm, HIF & host mediated methanogenesis

\[ \text{MEI} = \text{RE} + \text{HP} \]

\[ \text{HP} = \text{NE}_m + \text{HIF} \]

**In LOW RFI:**

\[ \text{MEI} = \uparrow \text{RE} + \downarrow \text{HP} \]

- Decreased HP = Decreased NEm + Decreased HIF

- **Lower NEm**
  - Lower visceral organ wt
  - Protein turnover
  - Ion pumping
  - Protein leakage
  - Leptin, IGF1, UCPs, ATP synthase, NPY

- Increased apparent digestibility
  - Ruminal retention time
  - Feeding behavior
  - Saliva production

- Decreased HIF at lower levels of DMI (Ferrell and Jenkins 1998)
Progeny Test Diet (as fed basis):

- 73.3% barley grain
- 22.0% barley silage
- 1.6% molasses
- 3.1% Feedlot sup (32% CP)

*ad libitum* twice daily

Feb 2003 – Jul 2006 (113 d)
Estimated Breeding value
A Simple Example

Bull RFI-p EBV = -1.25 kg DM/day x 0.40 = -0.5 kg DM/day
Cow RFI-p EBV = 0.00 kg DM/day X 0.40 = 0.0 kg DM/day

Expected Progeny Difference =
\((-0.5 + 0.0)/0.5 = -0.25 \text{ kg DM/day}\)
BASELINE (EBV=0 or ?) vs. PROJECT (EBV=-0.5 kg DM/day)

100 cows; 4 low RFI bulls (avg. EBV=-0.5 kg DM/day)
- 86% calf crop weaned; 43 steers; 23 heifer; 20 repl. Heifer
- slaughtered at 18 months of age
- monitored for 3 years from bull purchase

- Diet composition was determined for each category of beef cattle
- CowBytes used to formulate diet
- DMI at the desired ADG was predicted using CowBytes

Assumed: thermal neutral environmental conditions, average mid-point weight & days on each diet

NOTE: EBV=Estimated Breeding Value
PROJECT feed intake and emission factors

FOR SIRES:

- RFI-p = -1.25 kg DM/day
- Average DMI in bull test = 10 kg DM/hd/day
- % Change = (-1.25 kg DM/day x 0.75)/10 kg DM/day
  = 9.375% less DM/day
- So if BASELINE is 12 kg DM/day then the reduced feed intake
  = 12 kg DM/day x (1-0.09375) = 10.875 kg DM/day
- Similarly, PROJECT methane lost as % of GEI
  = 6.5 x (1-0.09375) = 5.89%
PROJECT feed intake and emission factors

FOR PROGENY:
- Certified RFIp EBV, kg DM/day; Sire = -0.5; Dam = 0.0
- Base year DMI in bull test = 10 kg DM/day
- Change in progeny = [(-0.5 + 0.0)/2] = -0.25 kg DM/day
- % Change = (-0.25 kg DM/day/10 kg DM/day) x 100 = 2.5%
- If BASELINE feed intake is 12 kg DM/day then PROJECT feed intake = 12 kg DM/day x (1-0.025) = 11.7 kg DM/day
- Similarly, PROJECT methane lost as % of GEI = 6.5 x (1-0.025) = 6.34%
GHG Sources: Baseline (no selection for RFI)

1: CH$_4$ from enteric fermentation, kg/hd/period

Total Volatile Solids Excreted, kg/hd/day
2: CH$_4$ from manure handling, storage & land app, kg/hd/period

Nitrogen excreted, kg/hd/day
3: Direct manure N$_2$O, kg/hd/period
4. Direct manure storage N$_2$O, kg/hd/period
5. Indirect volatilization N$_2$O, kg/hd/period (NH$_3$ & NO$_x$)
6. Indirect manure leaching N$_2$O, kg/hd/period

Conversion of CH$_4$ to CO$_2$e = x 21
Conversion of N$_2$O to CO$_2$e = x 310
Adjusted for carcass weight (kg CO$_2$e/kg carcass beef)
Comparative Greenhouse Gas emissions from selecting for low RFI (EBV of 0 vs. -0.5 kg DM/day) in beef cattle

GHG emissions of 4 bulls, slaughter steers & slaughter heifers and replacement heifers; 3 years from bull purchase

Baseline  EBV=0.0, 372.6 t CO2e
Project  EBV=-0.5, 348.3 t CO2e

$  243 CAN @ $10/t CO2e
$2150 CAN in feed savings
CONCLUSION

- 4 beef cattle protocols developed
- reduce GHG by 0.02-1.0 t CO$_2$e/hd
- guidance documents developed

http://environment.alberta.ca/02275.html

Barriers to Adoption

- Informational barriers-LCA, FAO
- Complexity of establishing baseline
- Acceptance of IPCC/Nat. Inventory
- Social Barriers – farms/ranchers??
- Investment/Cost Barriers
- Institutional barriers