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

J.A. Basarab, P.Ag., Ph.D.

2010 ADSA, PSA, AMPA, CSAS and ASAS Joint Annual Meeting,
July 11-15, 2010, Denver, CO, USA

Alberta

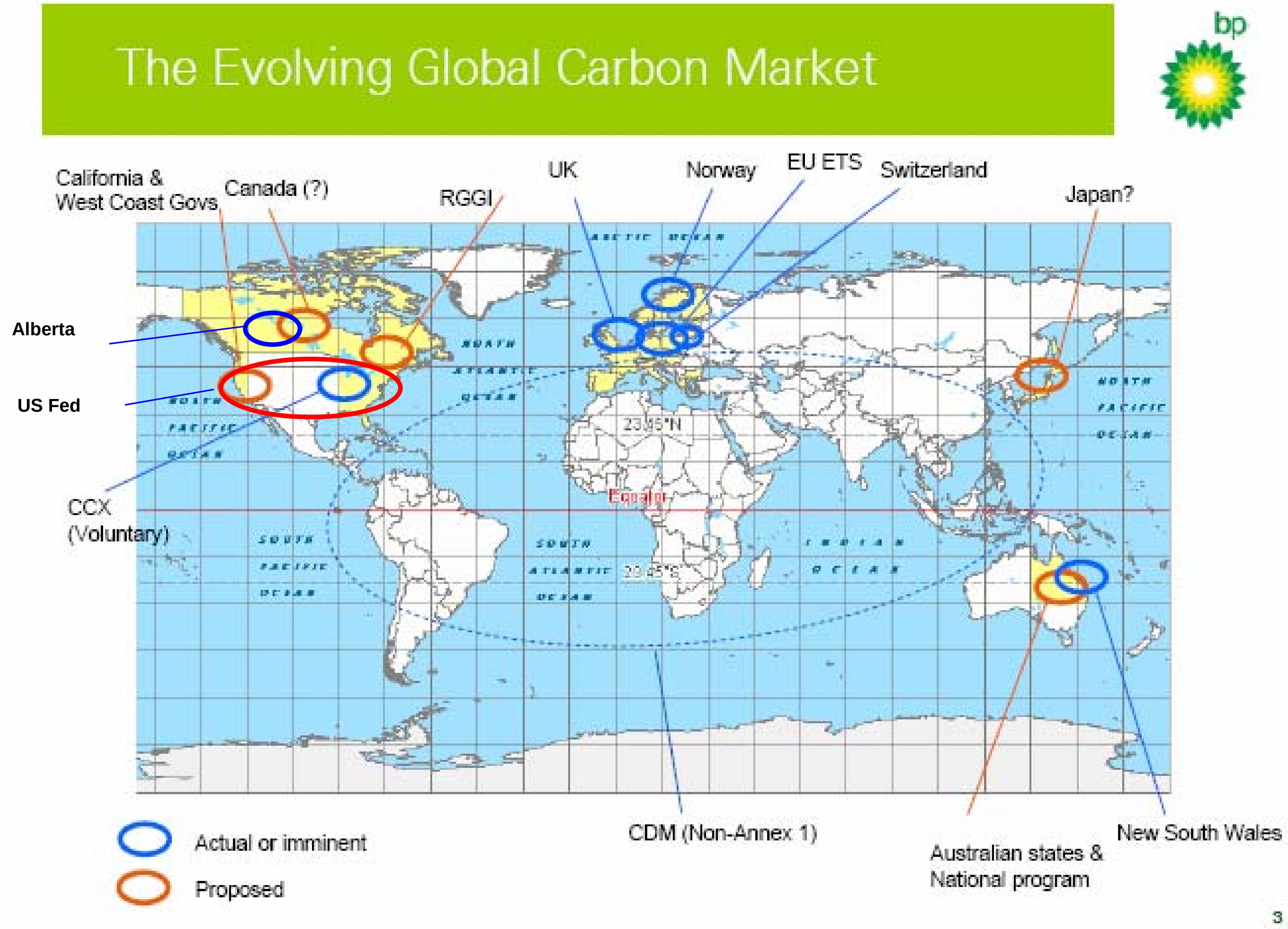
Freedom To Create. Spirit To Achieve.

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

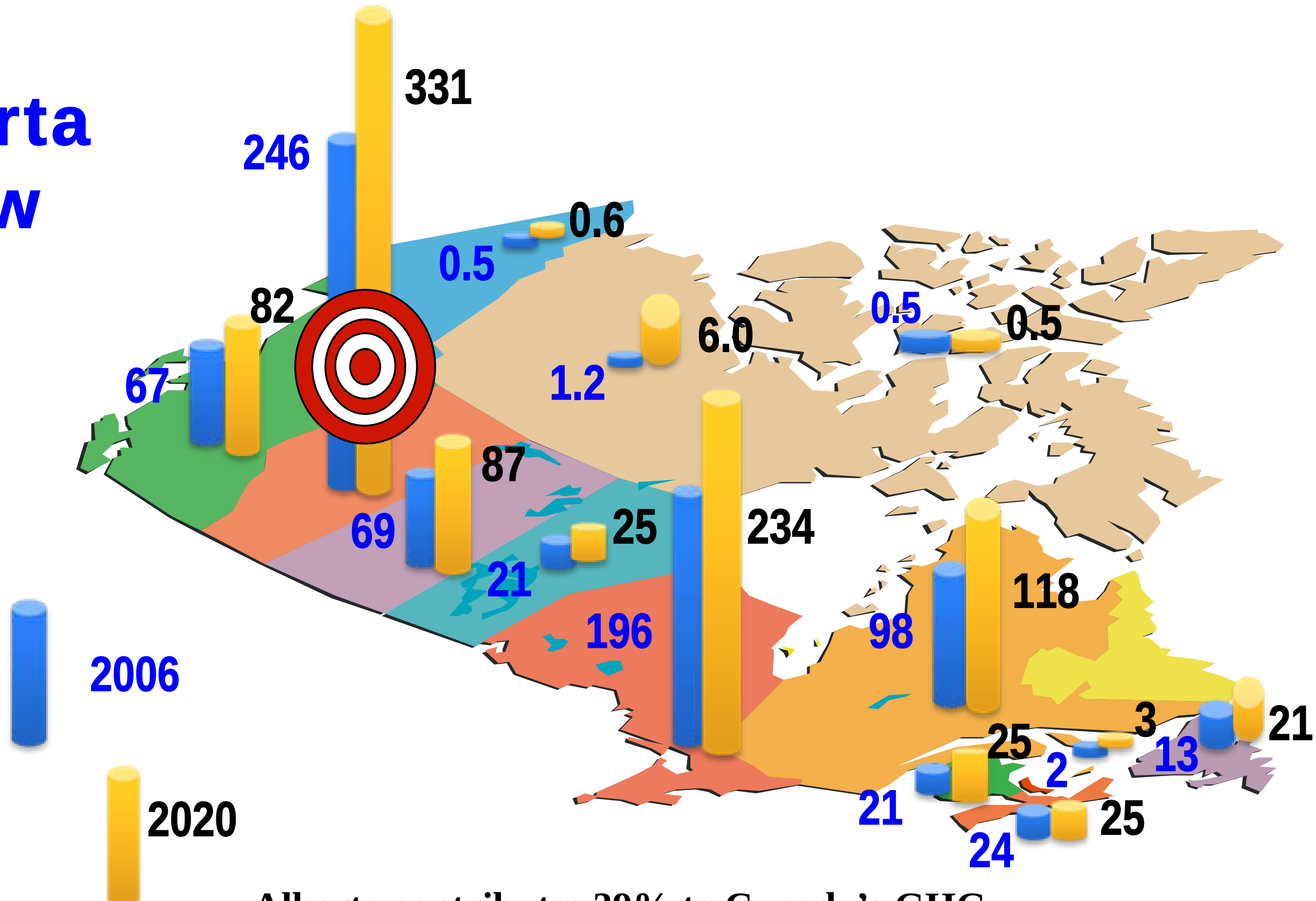
Capoor and Ambrosi, 2009

Global Climate Change Initiatives



Alberta's GHG Emissions in the Canadian Context
(MT of CO_2 e/yr; 2006=759.2 MT)

Why Alberta
Why Now



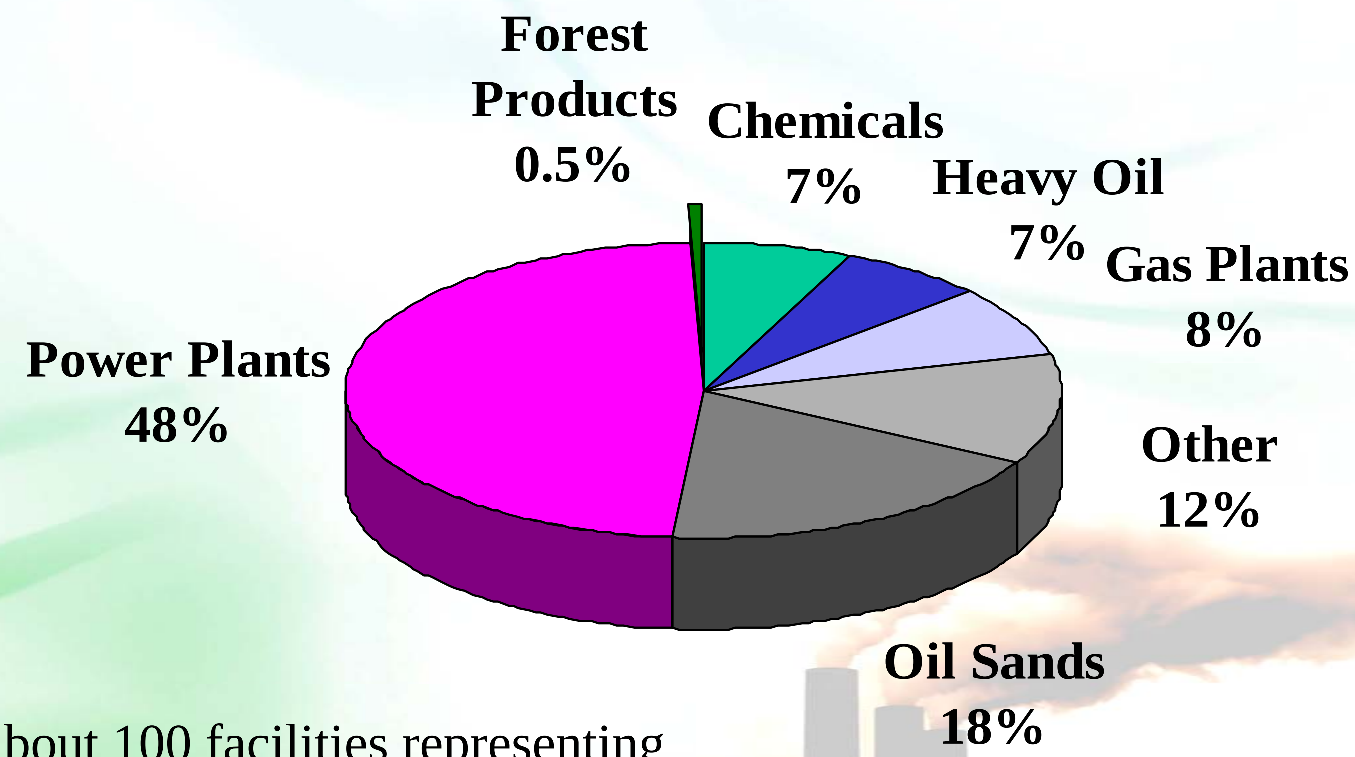
Alberta contributes 39% to Canada's GHG;
Agriculture in Alberta/Canada = 8/10% of AB's GHG
Project 26% increase by 2020

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

Alberta Reporting Program - 2006

Options to Achieve Targets

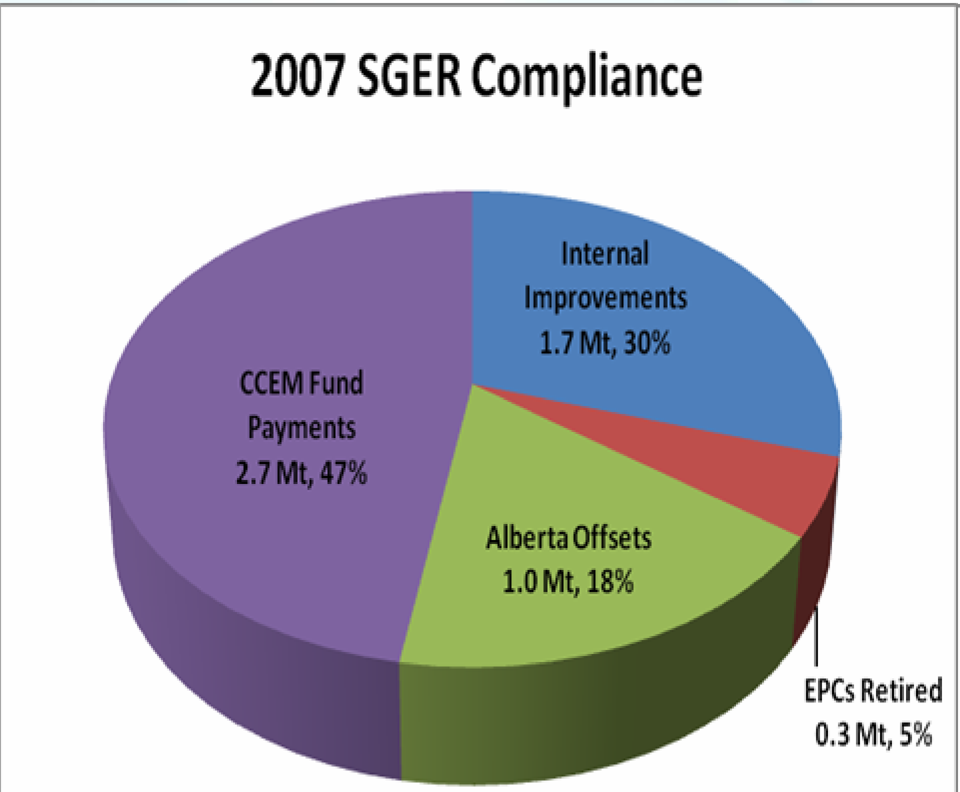
1. **Facility Improvements**
   – adapting new technologies, retrofitting existing equipment, or changing to more efficient practices

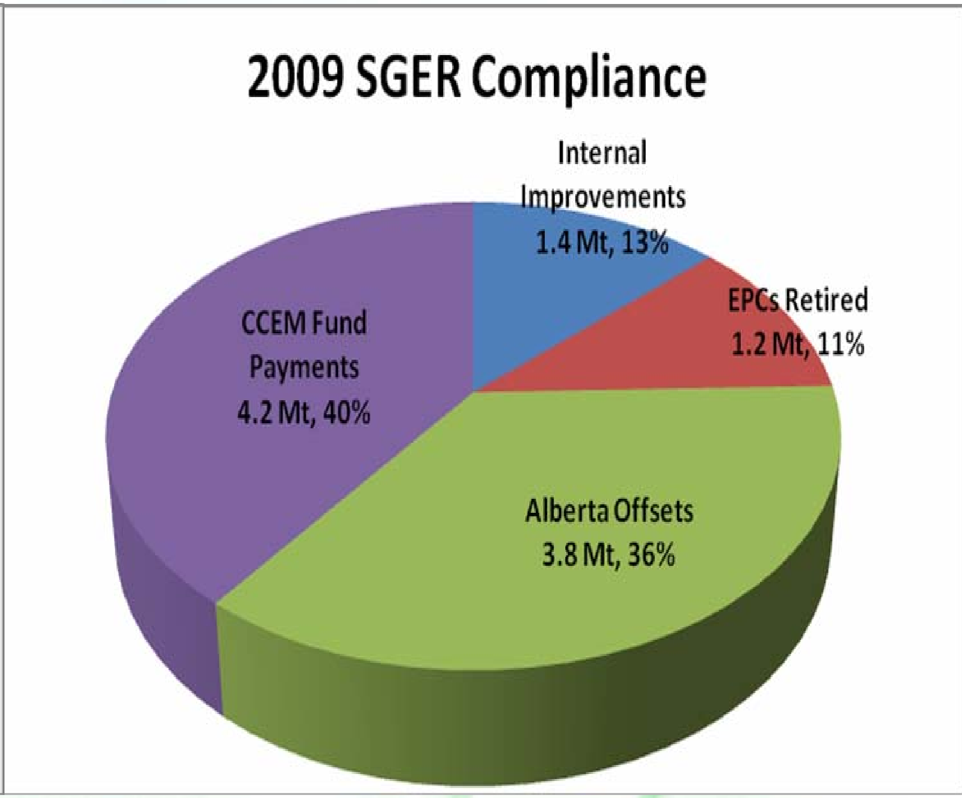
2. **Emission Performance Credits**
   – Credits for better than target performance (implementation of operational improvements)

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

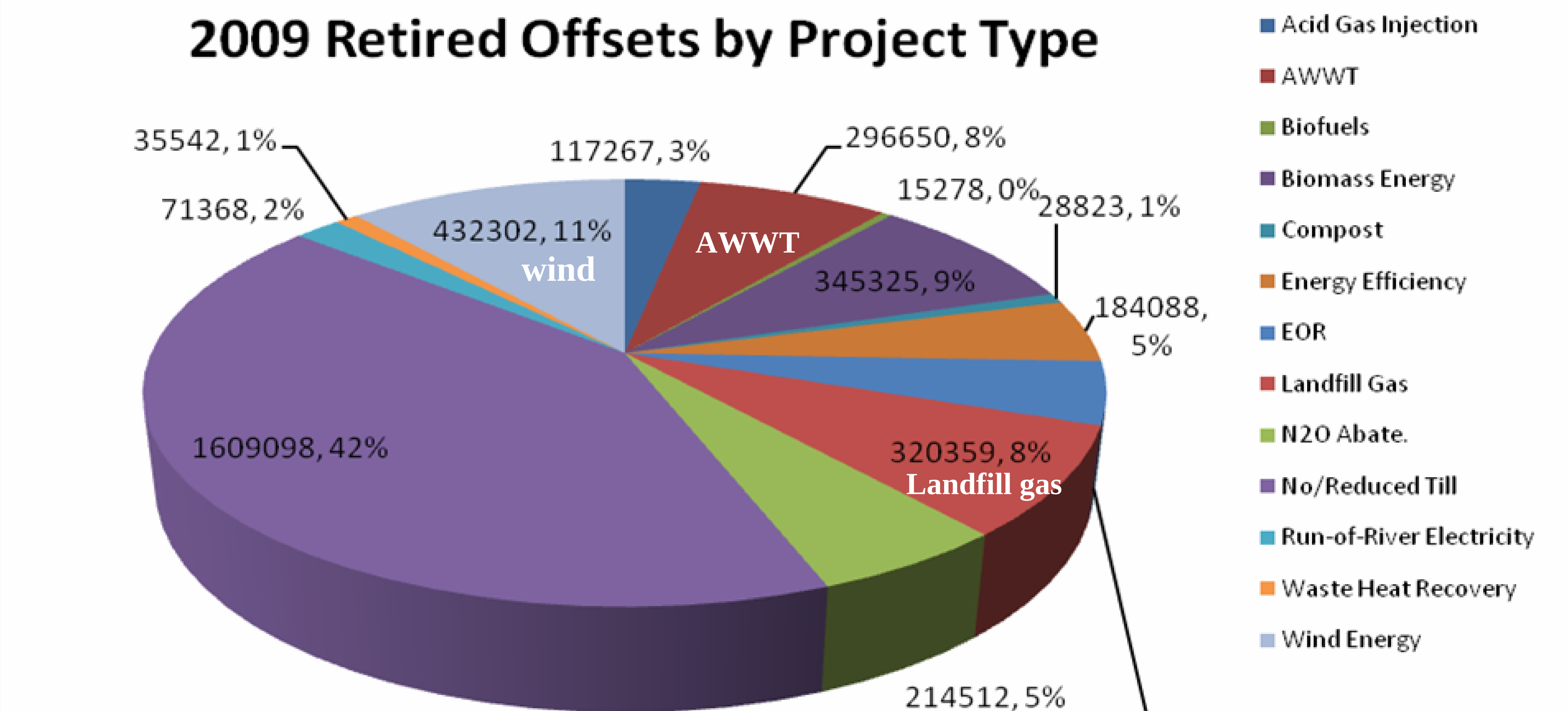
Offset Demand Increases, 2007 to 2009





SGER, Specific Gas Emitters Regulation; CCEM, Climate Change Emission Management
EPCs, Emission Performance Credits

No Till largest 2009 Offset Project type



AWWT, Anaerobic Waste Water Treatment
EOR, Enhanced Oil Recovery

Credits from Ag totals 3.2 mt CO_2e worth >$35 million

Alberta Offset System Activity	2007	2008	2009	Total
No. of Projects	7	25	26	58
Tillage Management	3	10	15	28
Other Types of Projects	4	15	11	30
Total Registered (tCO_2e)	1,555,037	3,471,495	4,432,124	9,458,656
Total Retired (submitted for compliance)	986,700	2,845,763	3,828,232	7,660,695
Agriculture tonnes registered (tCO_2e)	558,714	1,000,976	1,654,084	3,213,774
Agriculture tonnes retired	202,210	821,836	1,584,108	2,608,154

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?

Freedom To Create. Spirit To Achieve.

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_2e) 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

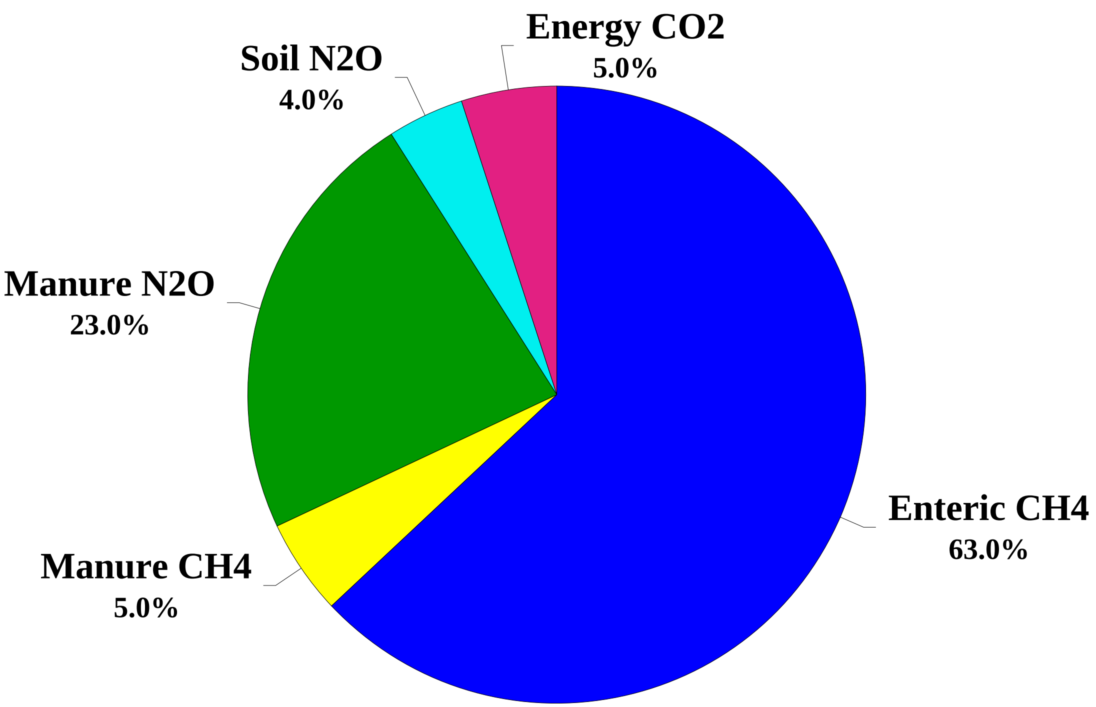
Eq. 10.23 & 10.24 (IPCC 2006)
DMI, DOF, TDN or DE of ration
Defaults for UE, ASH of manure, etc

3. Manure N_2O direct

Eq. 10.32, 10.25 &10.26 (IPCC 2006)
DMI, CP of ration, NE
Defaults for NR or 7%

4. Soil N_2O

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

= SUM (N cattle x DOF x DMI x GE_{diet} x (EF/100)/EC),

GE_{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

EF = default 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

EC = conversion factor of energy to methane or 55.65 MJ/kg CH_4

BASELINE vs. PROJECT

calculated on actual pen-average mid-point weights and DMI

Table 1. Diet ingredients and composition for FEEDLOT 1.

Diet Ingredients and composition[z]	Baseline Diets (No Oil)				Project Diets (Oil Added)			
	1	2	3	4	1	2	3	4
Days on diet	14	7	7	94-146	14	7	7	94-146
Barley grain	50.3	62.5	74.9	87.0	46.3	58.5	70.9	83.0
Barley Silage	23.4	17.1	6.8	4.4	23.4	17.1	6.8	4.4
Corn Silage	21.8	15.9	13.9	4.1	21.8	15.9	13.9	4.1
Canola oil	0.0	0.0	0.0	0.0	4.0	4.0	4.0	4.0
Supplement	4.5	4.5	4.4	4.5	4.5	4.5	4.4	4.5
Dry matter, %	53.6	59.9	67.4	78.0	65.0	60.1	67.6	78.4
NEm, Mcal/kg DM	1.71	1.83	1.87	1.95	1.81	1.89	1.96	2.04
NEg, Mcal/kg DM	1.09	1.20	1.23	1.30	1.17	1.23	1.30	1.37
Crude Protein, %	12.5	12.2	12.9	13.3	11.9	12.2	12.4	12.8
Cost, $/kg DM[y]	0.132	0.140	0.145	0.150	0.151	0.166	0.172	0.175

Production parameters for feedlot steers under BASELINE and PROJECT conditions

						BASELINE	PROJECT
Diet	DOF	N	Wt in, kg	Wt out, kg	ADG kg/day	DMI kg/day	DMI kg/day
1	14	117	392	411	1.32	9.60	9.41
2	7	117	411	421	1.40	9.80	9.51
3	7	117	421	431	1.47	9.81	9.49
4	130	117	431	631	1.54	11.41	11.00

BASELINE EF, kg CH4/hd/period

=[((9.60 kg/day x 18.45 MJ/kg DM) * (6.5/100))/55.65] x 14d = 2.90 kg/hd

PROJECT EF, kg CH_4/hd/period

=[((9.41 kg/day x 19.10 MJ/kg DM) * (5.2/100))/55.65] x 14d = 2.35 kg/hd

The Size of the Prize

Alberta's potential – 223,856 to 302,769 t CO_2e/yr
Worth \$2.2 to \$3.0 million/yr in carbon credits (@ \$10/t CO_2e)

However,

At \$800-900/t for edible oils, the cost of mitigation would be very high at ~ \$0.27 to 0.30/kg CO_2e, while the benefit in carbon credits would only be worth \$0.01/kg CO_2e

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**

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 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_2O, kg/hd/period

4. Direct manure storage N_2O, kg/hd/period

5. Indirect volatilization N_2O, kg/hd/period (NH_3 & NO_x)

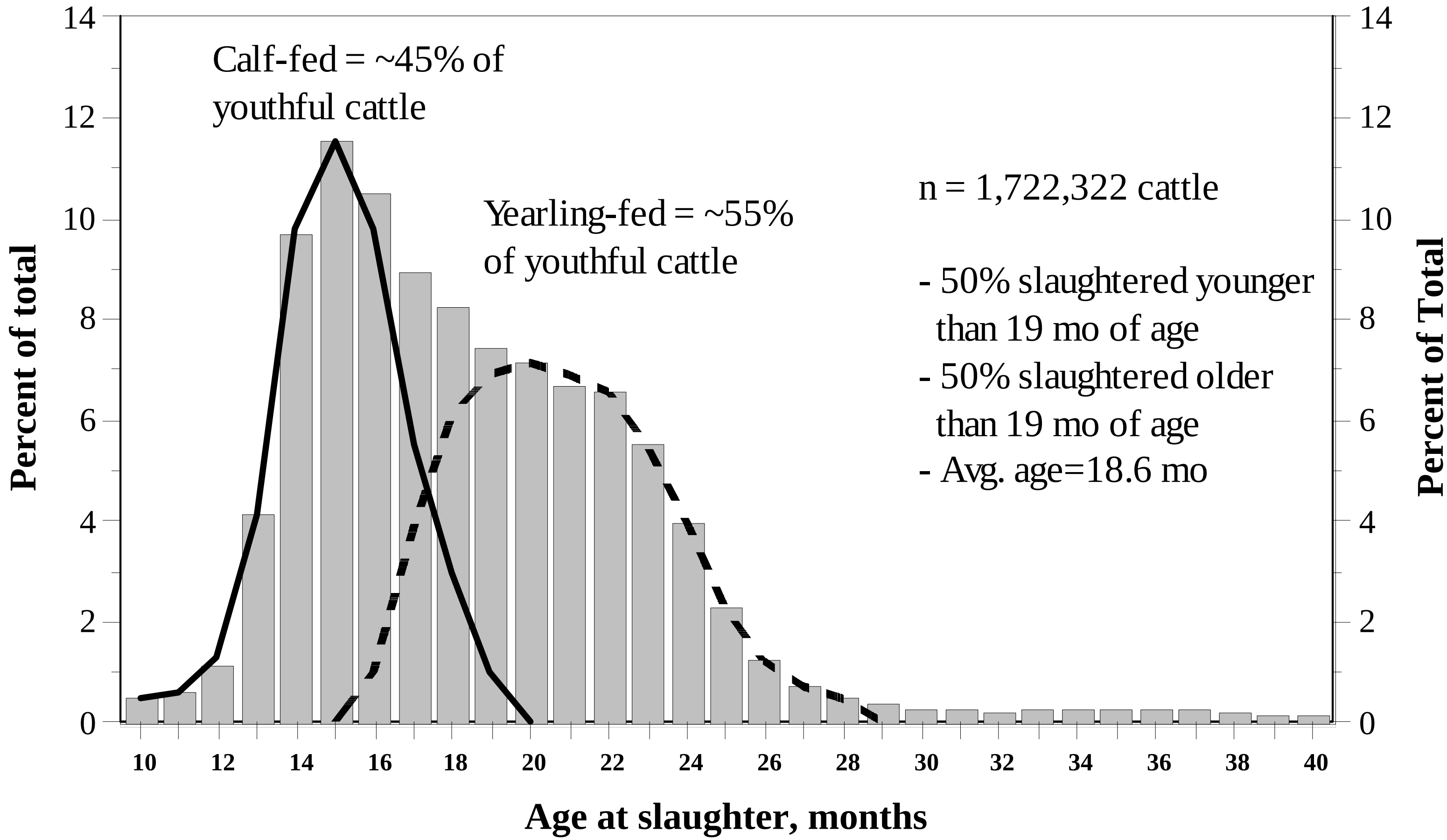
6. Indirect manure leaching N_2O, kg/hd/period

$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 CH_4, manure and N_2O

Source: CCIA database as of June 1, 2009

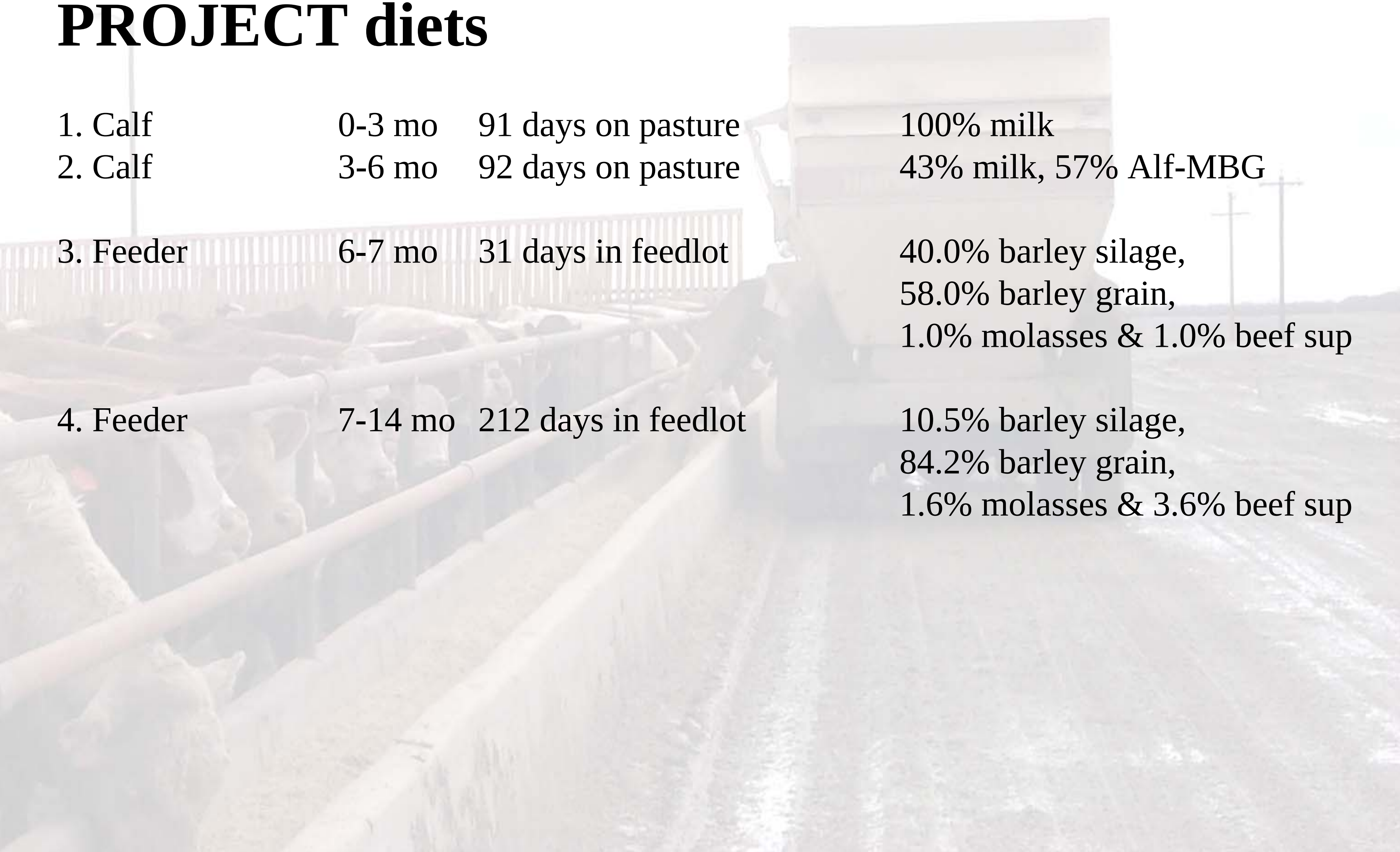


Age at slaughter may be over-estimated by 0.5-1 months as some producers register birth date for a group of calves as the date of first born. This only affect the average birth date slightly as most (75-79%) calves are born in the first 42 days of the calving season (Alberta Cow-Calf Audit 2001).

BASELINE diets

1. Calf	0-3 months	91 days on pasture	100% milk
2. Calf	3-6 mo	92 days on pasture	43% milk, 57% Alf-MBG
3. Calf	6-9 mo	92 days on pasture	100% Alf-MBG
4. Feeder	9-12.6 mo	104 days in feedlot	35%barley silage, 40% barley grain; 23% hay 1% molasses & 1% beef sup
5. Feeder	13-16 mo	92 days on pasture	100% Alf-MBG
6. Feeder	16-18 mo	75 days in feedlot	10.5% barley silage, 84.2% barley grain, 1.6% molasses & 3.6% beef sup

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

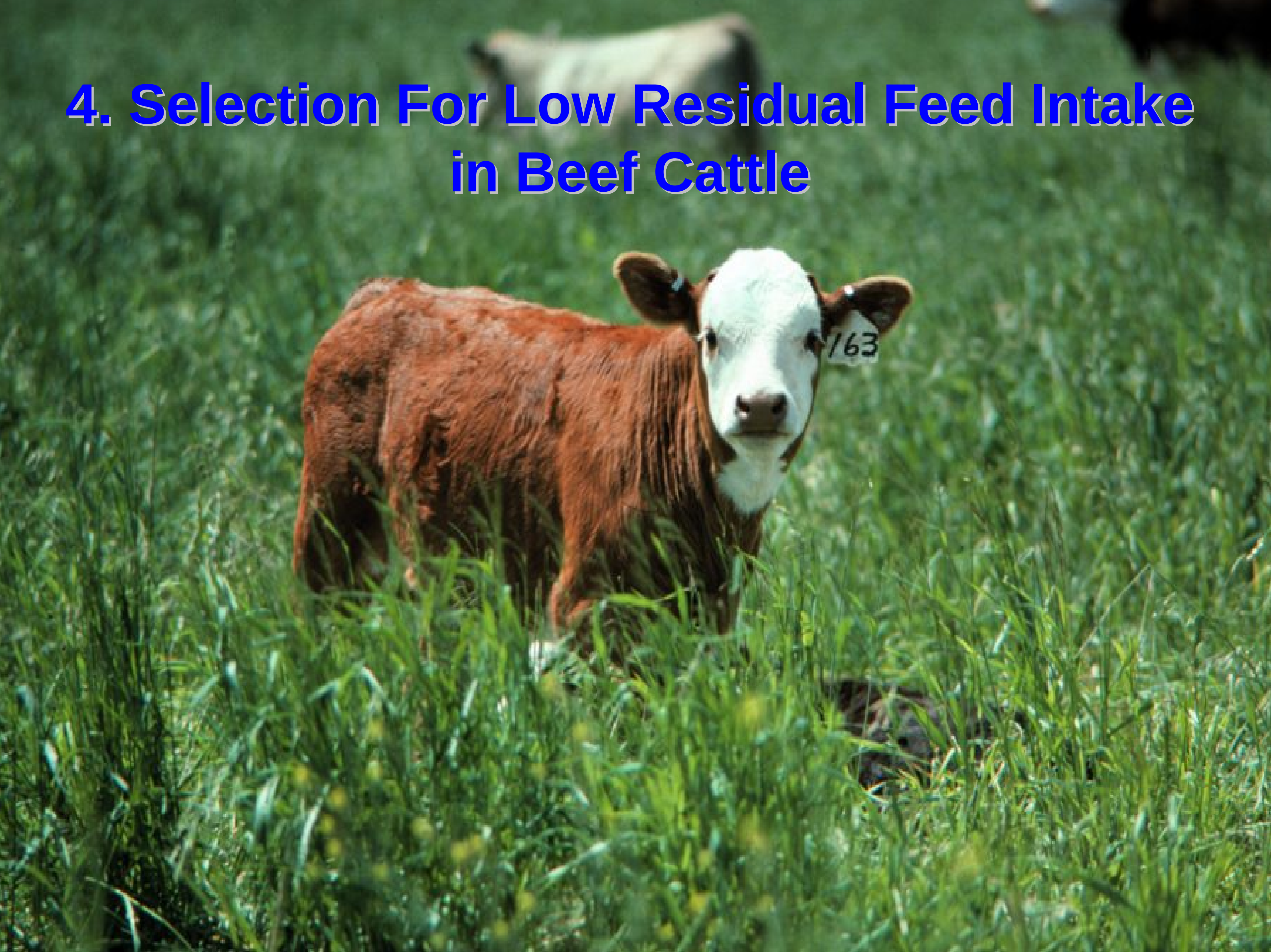
The Size of the Prize
Reducing age at slaughter by 1-4 months

$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_2e/yr
Worth $6.81 to $27.3 million/yr in carbon credits (@ $10/t CO_2e)

4. Selection For Low Residual Feed Intake in Beef Cattle

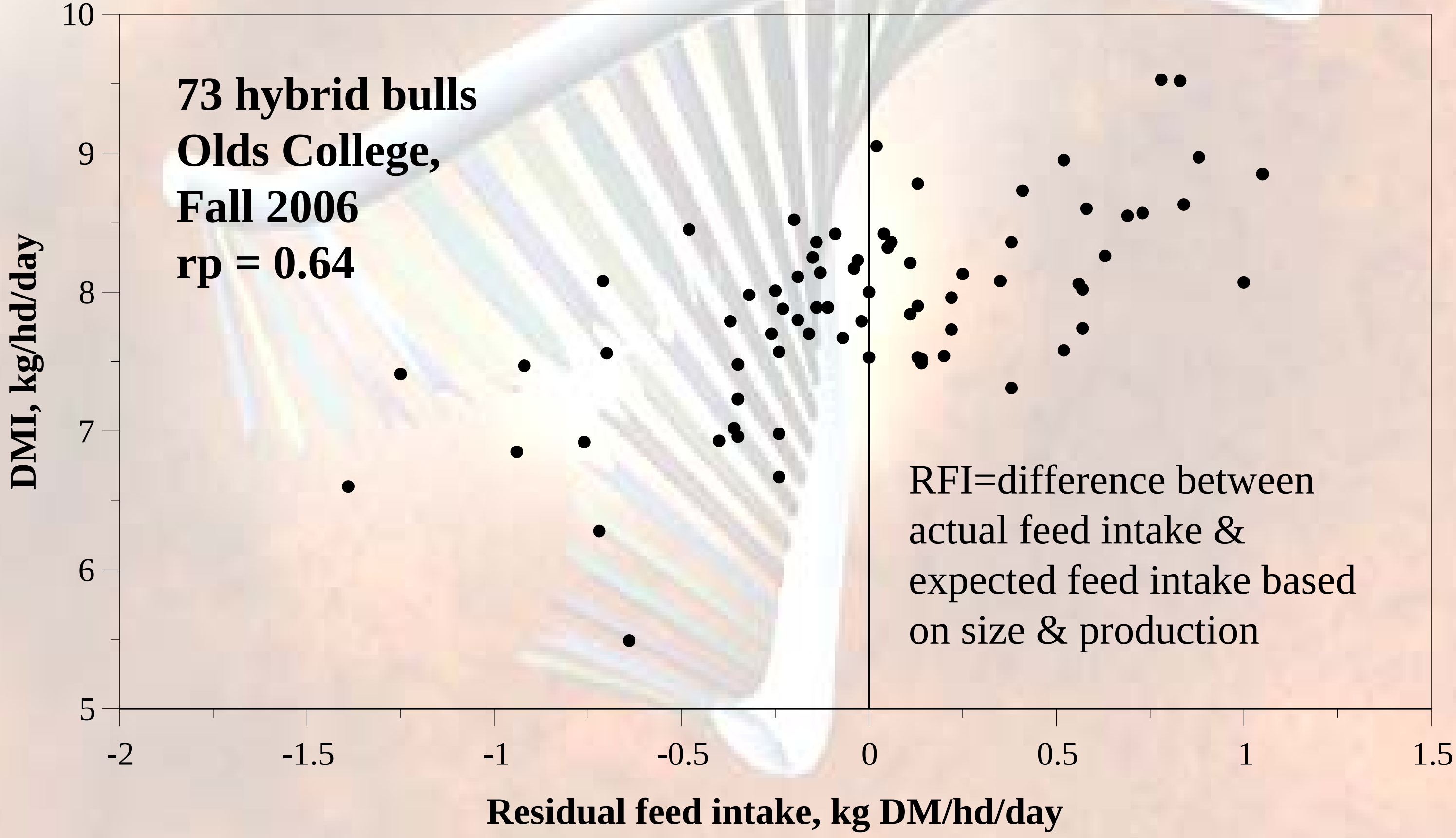


4. Selection for improved efficiency of feed utilization; LOW Residual Feed Intake (RFI)

Mechanism (s):

1. Reduces feed intake at equal body size & ADG

rp = 0.60-0.72; rg = 0.69-0.79 (Arthur et al. 2001; Basarab et al. 2003;Herd et al. 2002)



Mechanisms, independent of intake, are related to metabolizability and animal variation in NEm, HIF & host mediated methanogenesis

$$MEI = RE + HP$$

$$HP = NE_m + HIF$$

Lower NEm
-lower visceral organ wt
(40-50% of daily HP)
-protein turnover
-ion pumping
-protein leakage
- leptin, IGF1, UCPs, ATP synthase, NPY

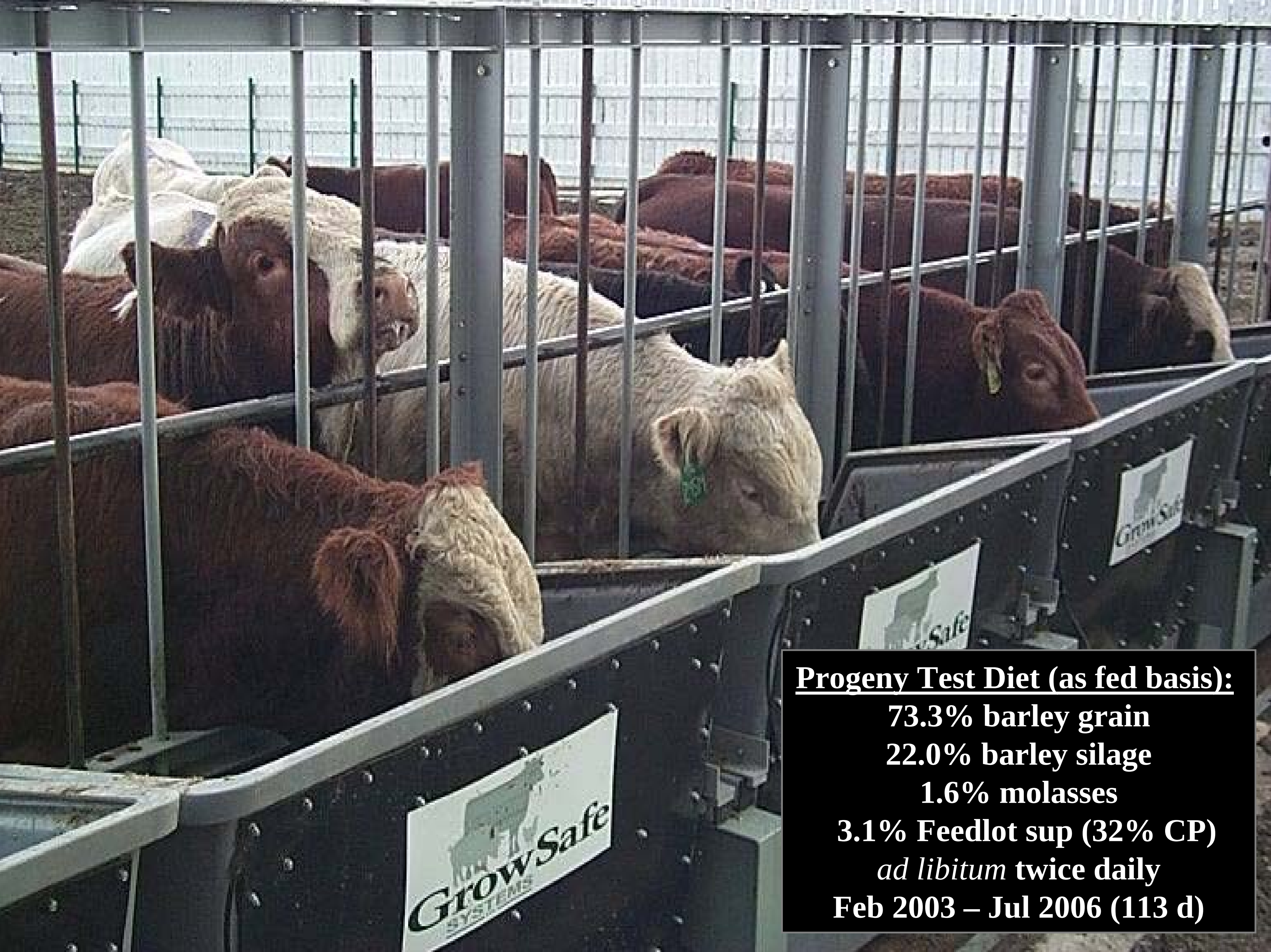
In LOW RFI:

$$MEI = \uparrow RE + \downarrow HP$$

Increased apparent digestability
-ruminal retention time
-feeding behavior
-saliva production

$$\downarrow HP = \downarrow NE_m + \downarrow HIF$$

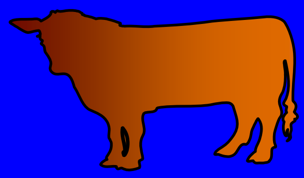
decreased HIF at lower levels of DMI (Ferrell and Jenkins 1998)


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)
GrowSafe
SYSTEMS

Estimated Breeding value

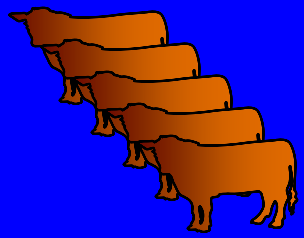
A Simple Example

-1.25 kg DM / d

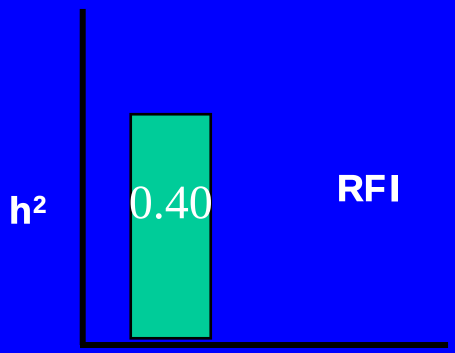


individual

0.0 kg DM / d



contemporary group average



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 kg DM/day

BASELINE (EBV=0 or ?) vs. PROJECT (EBV=-0.5 kd 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

<u>FOR SIRES</u>:

- 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_2O, kg/hd/period

4. Direct manure storage N_2O, kg/hd/period

5. Indirect volatilization N_2O, kg/hd/period (NH_3 & NO_x)

6. Indirect manure leaching N_2O, kg/hd/period

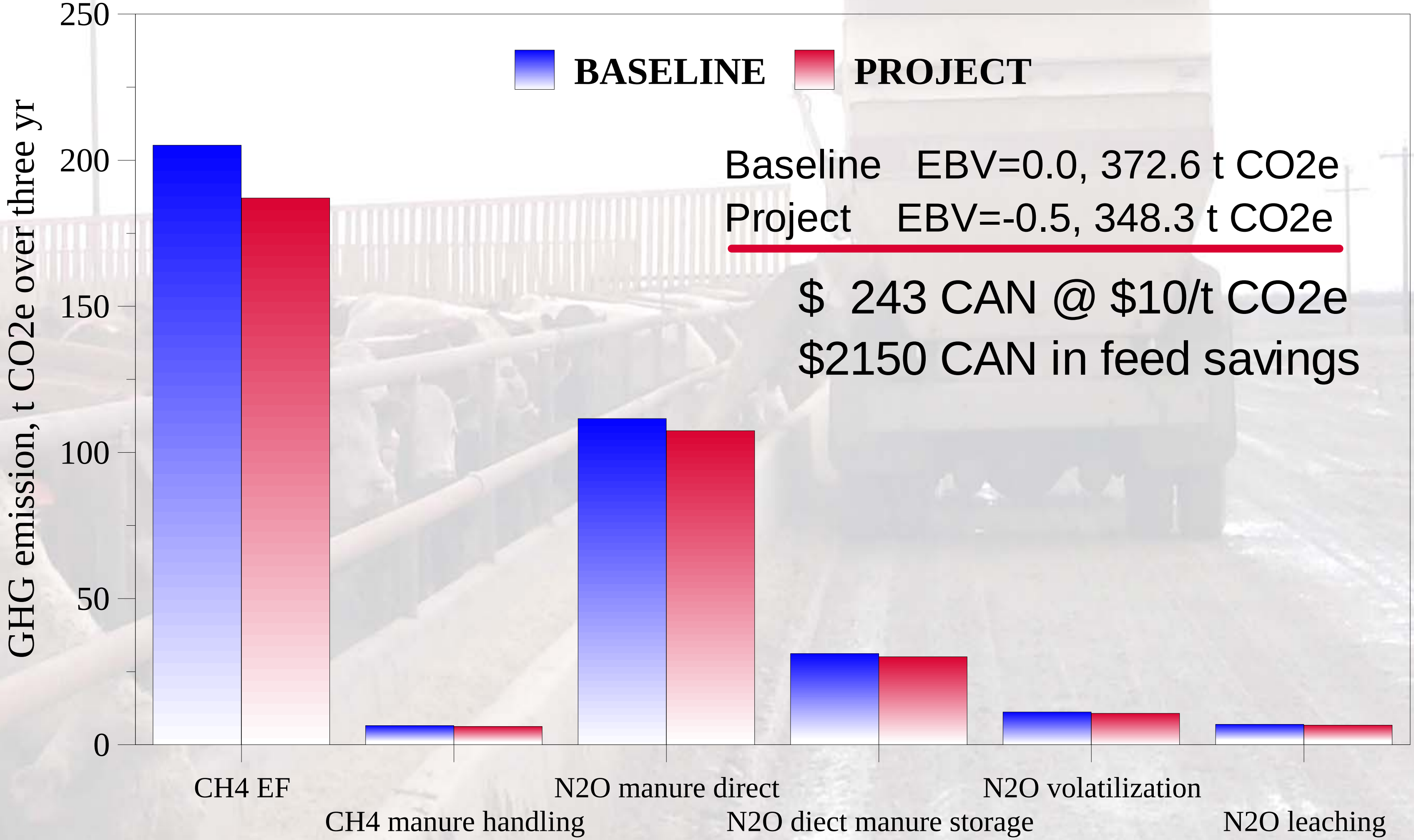
Conversion of CH_4 to CO_2e = x 21

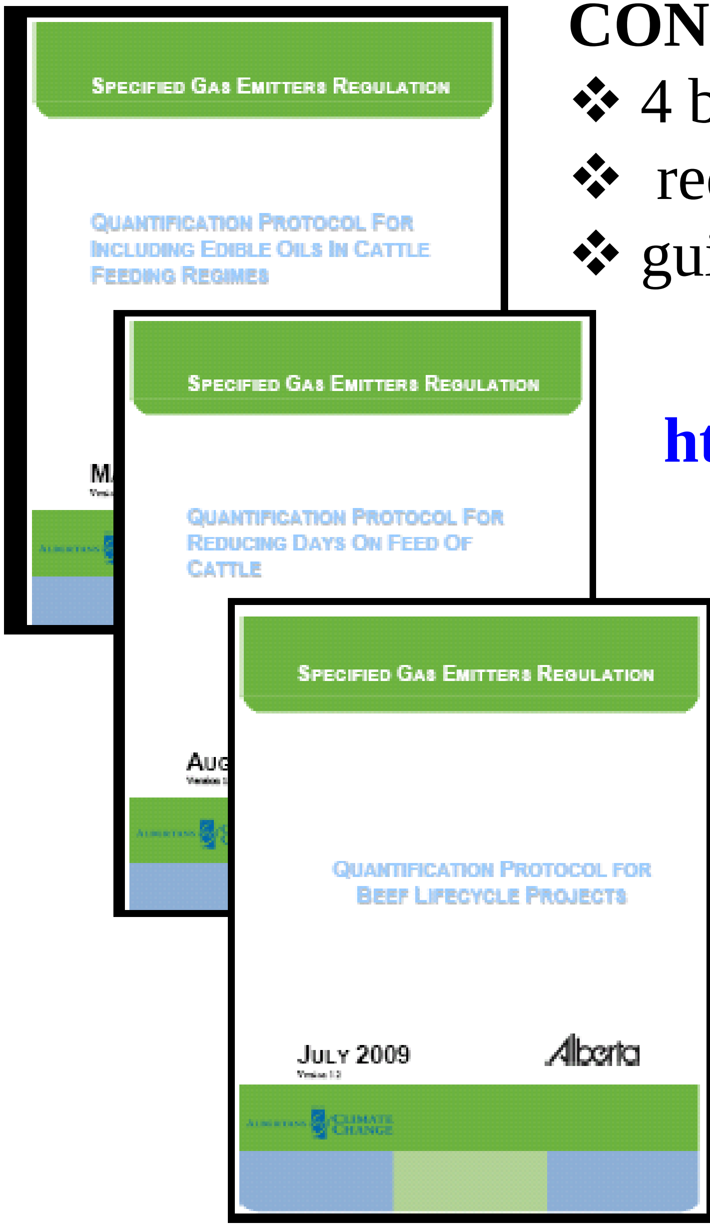
Conversion of N_20 to CO_2e = x 310

Adjusted for carcass weight (kg CO_2e/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





CONCLUSION

- 4 beef cattle protocols developed
- reduce GHG by 0.02-1.0 t CO_2e/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