Overview of GHG Emissions Quantification Science in Beef Cattle

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Alberta

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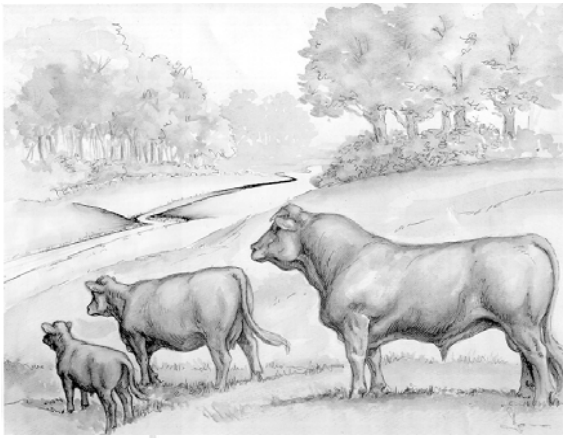
Western Forage/Beef Group

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Alberta Bovine Genomics



Enteric methane emissions from beef cattle can be calculated as follows:

IPCC 2006 Tier 1 for beef cattle (Table 10A.2, page 10.73)

Mature females	=	*76 kg CH_4/yr*
Mature males	=	*81 kg CH_4/yr*
Calves on milk	=	*0 kg CH_4/yr*
Calves on forage	=	*48 kg CH_4/yr*
Growing heifers/steers	=	*55 kg CH_4/yr*
Replacements/growing	=	*66 kg CH_4/yr*
Feedlot cattle	=	*33 kg CH4 /yr*

We know that enteric CH_4 emissions are affected by:

animal type, diet, physiological status, gender, weight, growth rate, activity level, age, climate, etc

Inventory of beef cattle on farms in Alberta for 2006

1. Beef cows	2,035,841	3 categories
2. Calves, < 1 yr	2,050,773	17 categories
3. Breeding bulls, ≥ 1 yr	109,753	3 categories
4. Beef heifers, breeding, ≥ 1 yr	275,683	5 categories
5. Beef heifers, market, ≥ 1 yr	805,829	3 categories
6. Beef steers, ≥ 1 yr	974,559	3 categories

Numbers based on May 16, 2006 census data, Statistics Canada.

http://www.statcan.gc.ca/pub/95-629-x/2007000/4123855-eng.htm

Method 2: IPCC Tier 2 (IPCC 2006)

- **Cattle category; diet composition, body weight; ADG; DE of diet; DMI; carcass wt & yield**
- **IPCC Tier 2 equations calculated DMI or from NRC or actual DMI**
- **GEI = DMI x 18.45 MJ/kg/DM**
- **Energy lost as methane was 6.5% of GEI for all cattle categories except those fed diets containing 90% or more concentrates (3.5-4.0%).**

- **GEI x methane emission factor = energy lost as methane (MJ/day)**
- **Energy lost as methane (MJ/day) ÷ 0.05565 MJ/g CH_4 = g CH_4/day**

Eq. 1: Methane from enteric fermentation (kg/hd)

EF cattle = ∑(No. of Cattle x DOF x DMI x
18.45 x (EF/100)/0.05565)

EF = 4.0% for diets ≥ 90% concentrates, no edible oil
6.5% for diets <90% concentrates, no edible oil

Eq. 2: Daily volatile solids excreted (manure/urine), kg/hd

VS = [(DMI x 18.45 x (1-(TDN/100))) + (UE x
DMI x 18.45)] x ((1-(ASH/100))/18.45)

VS = UE = urinary energy; 0.04 for diets <85% conc.; 0.02 for diets >85% conc.
ASH = ash content of manure; 8% for forage based diets; 2% for grain based diets

Eq. 3: CH_4 from manure handling, storage & application (kg CH_4/hd) =

$\sum$ (No. of Cattle x DOF x VS x Bo x θ methane x (MCF/100))

Bo = max. CH_4 producing capacity of manure or 0.19 m^3 CH_4/kg VS excreted
θ methane = density of methane at normal temp (20°C) & pressure (2 atm) or 0.67 m^3/kg
MCF = CH_4 conversion factor for each manure mgmt system; 1.0% for pasture; 2.0% for solid storage

Eq. 4: Nitrogen excreted (kg N/hd/day) =

$NE = DMI \times (CP/100)/CF_{protein} \times (1\text{-}NR)$

CP = crude protein content of the diet, $CF_{protein}$ = 6.25 kg feed protein/kg N
NR = fraction of N intake retained by the animal or 0.07 kg N retained/kg N consumed.

Eq. 5:Direct N_2O from manure (kg N_2O/hd) =

$\sum$ (No. of Cattle x DOF x NE x CF_{manure} x (44/22))

CF = conversion factor of N excreted N_2O-N; 0.02 kg N_2O-N/kg N excreted
44/22 = conversion factor of N_2O-N emissions to N_2O emissions

Eq. 6: Direct N_2O from manure storage (kg N_2O/hd) =

$\sum$ (No. of Cattle x DOF x NE x MS x EF storage) x (44/22))

MS = fraction of N excreted for each cattle group managed in a particular manure mgmt system and is set at 0.8
EF storage = emission factor for direct N_2O emissions from manure mgmt system and is set at 0.007 kg N_2O-N/kg N excreted

Eq. 7:Indirect N_2O from volatilization (kg N_2O/hd) =

$\sum$ (No. of Cattle x DOF x NE x MS x EF volatilization x (44/22))

MS = fraction of N excreted that is managed in a particular manure mgmt system and is set at 0.2
EF volatilization = percent of managed manure N that volatilizes as NH_3 and NO_x in the manure mgmt system and is set at 0.01 kg N_2O-N/kg N excreted

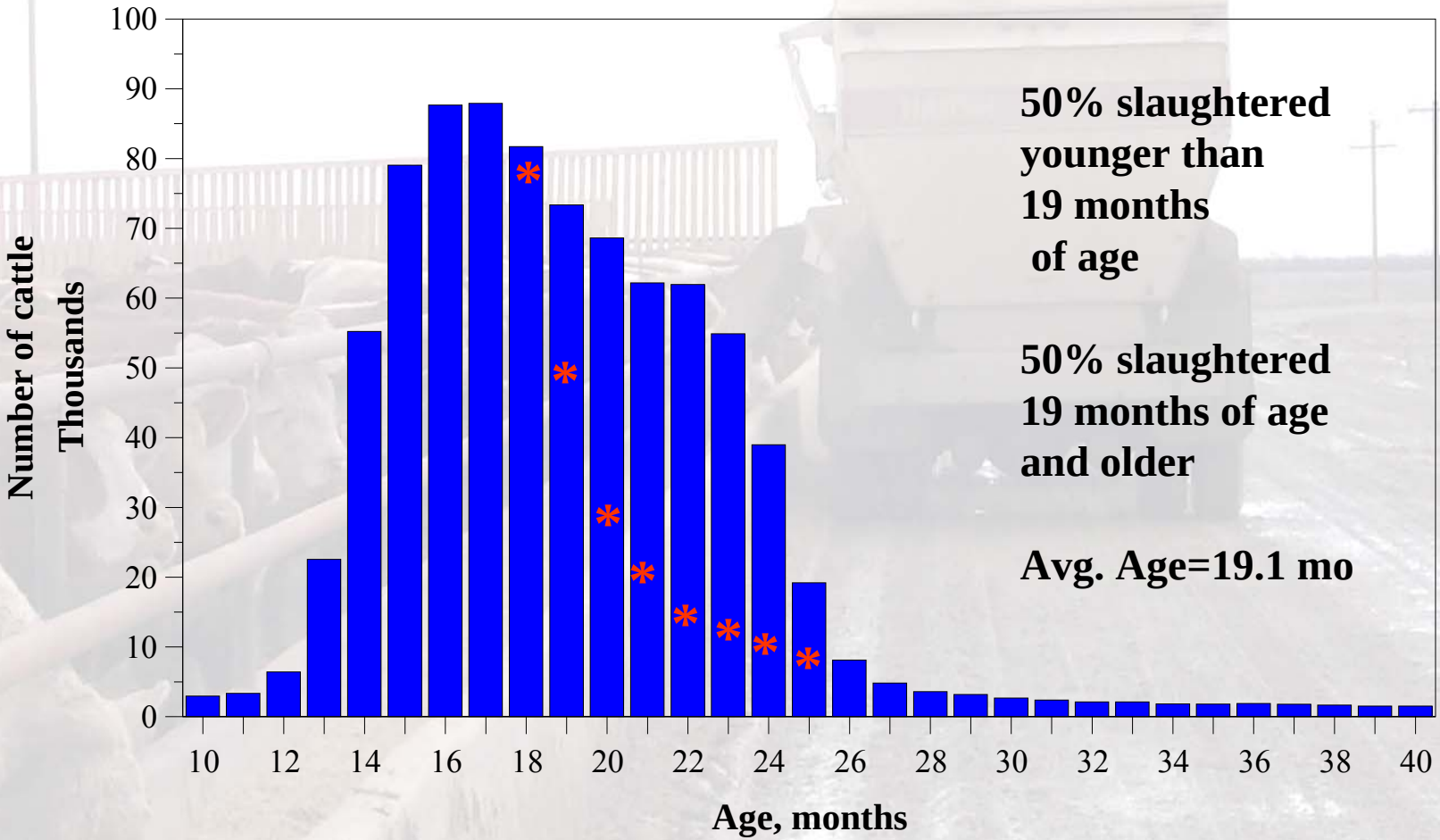
Eq. 8: Indirect N_2O from leaching (kg N_2O/hd) =

$\sum$ (No. of Cattle x DOF x NE x MS x EF leaching) x (44/22))

MS = fraction of N excreted for each cattle group managed in a particular manure mgmt system and is set at 0.1
EF leaching = percent of managed manure N due to runoff and leaching during solid and liquid storage of manure and is set at 0.0125 kg N_2O-N/kg N excreted

Example: Reducing Age at Slaughter

Retired Cattle by Age as of May 1, 2008
CCIA database (n=847,182)



BASELINE (18 mo of age) **VS. PROJECT** (14 mo of age)

- 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

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

GHG Sources: Baseline (18 mo) vs. Project (14 mo)

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)

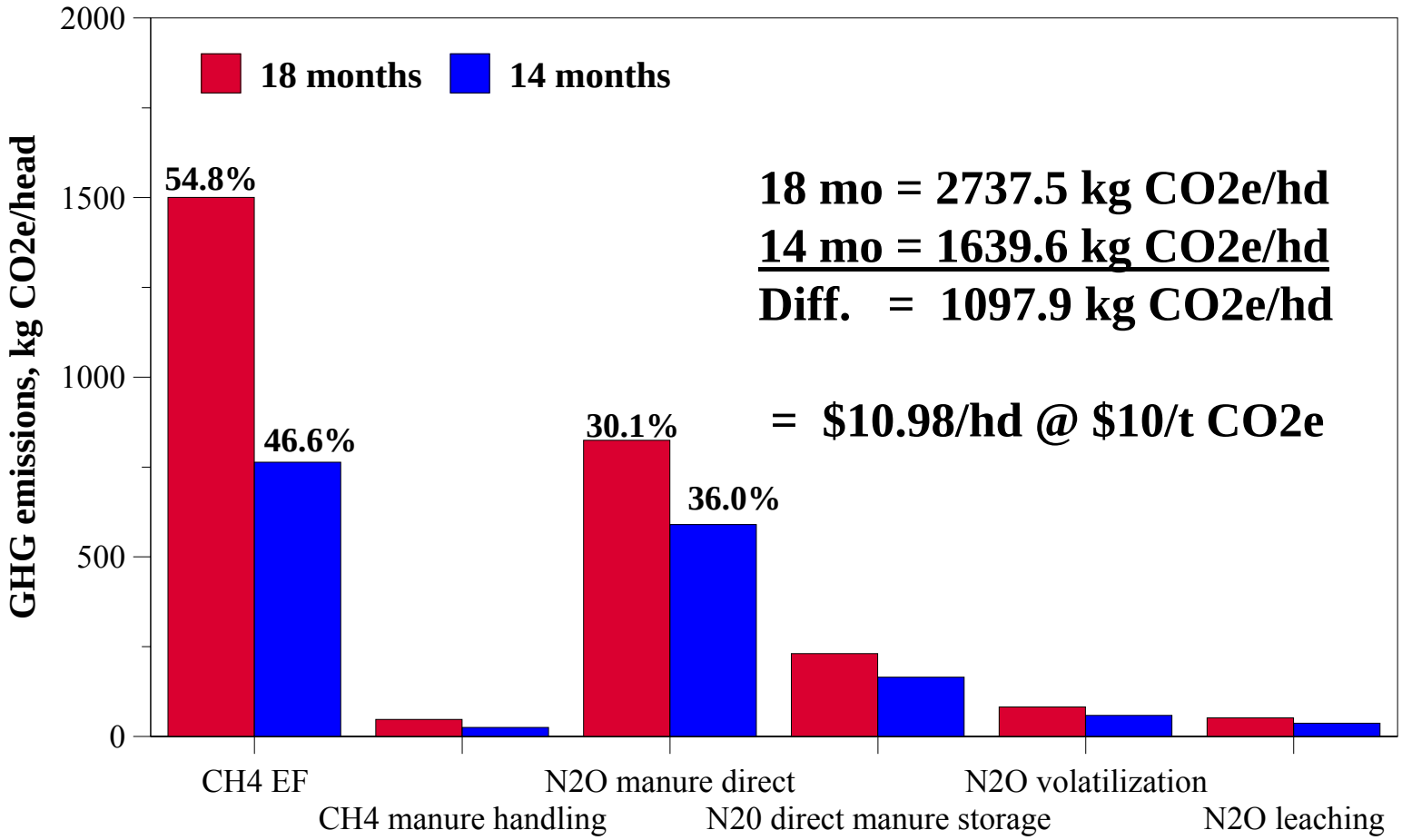
6. Indirect manure leaching N_2O, kg/hd/period

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)

Greenhouse gas (GHG) emission from harvesting youthful beef cattle at 18 vs. 14 months of age



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

$2.75 to $11/hd or about $2.75/mo reduction

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

Alberta's potential – 0.64 to 2.58 million t CO_2e/yr
Worth $6.4 to $25.8 million/yr in carbon credits (@ $10/t CO_2e)