



Efficient Cows – Less Methane

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**Tools for Building Better Cows
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**Western
Forage/Beef
Group**



**Agriculture and
Agri-Food Canada**

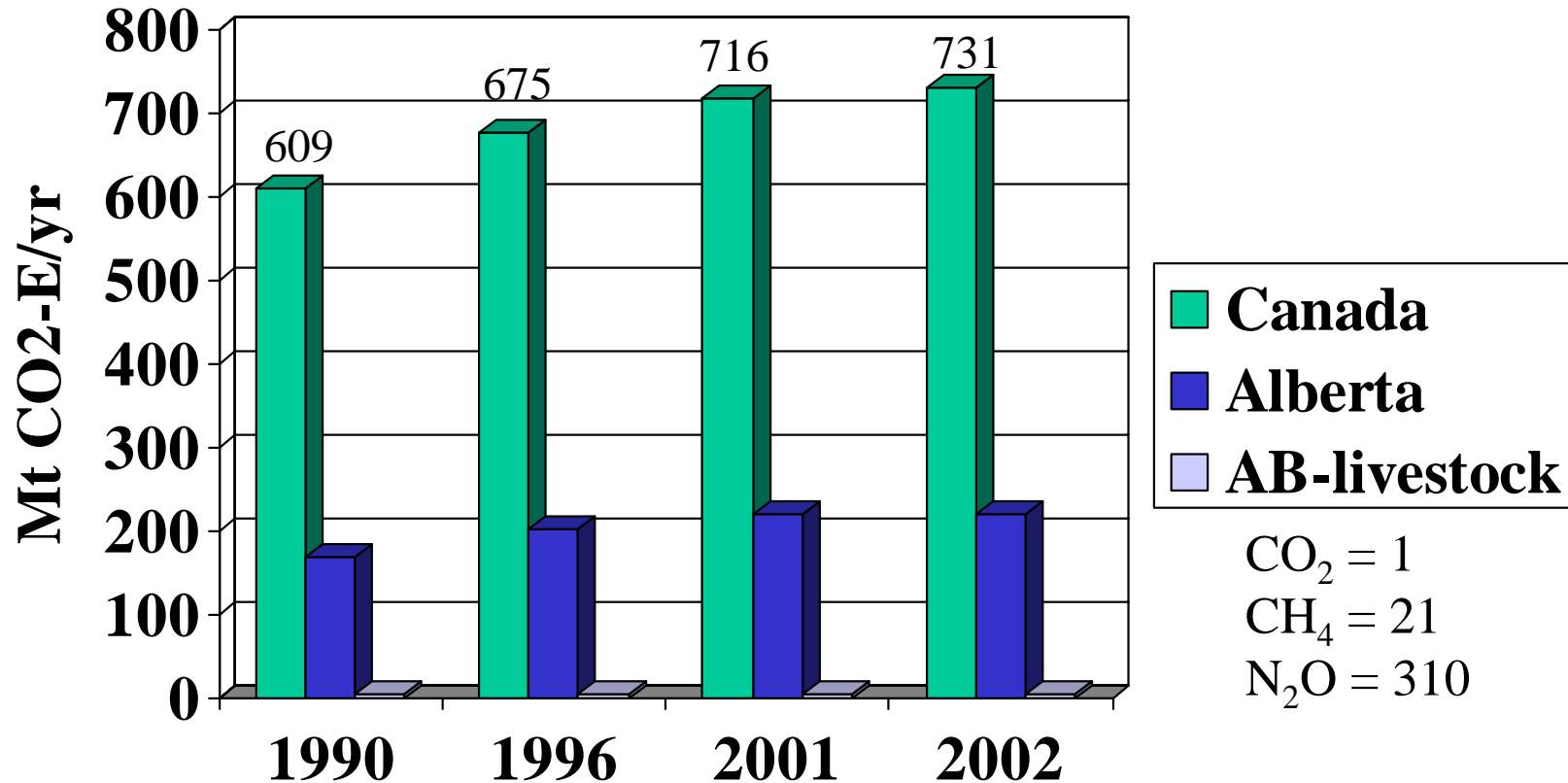
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Alberta

**AGRICULTURE, FOOD AND
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Canada's Greenhouse Gas Emissions from 1990 to 2002 (IPCC Tier 1; Env. Canada, 2005)

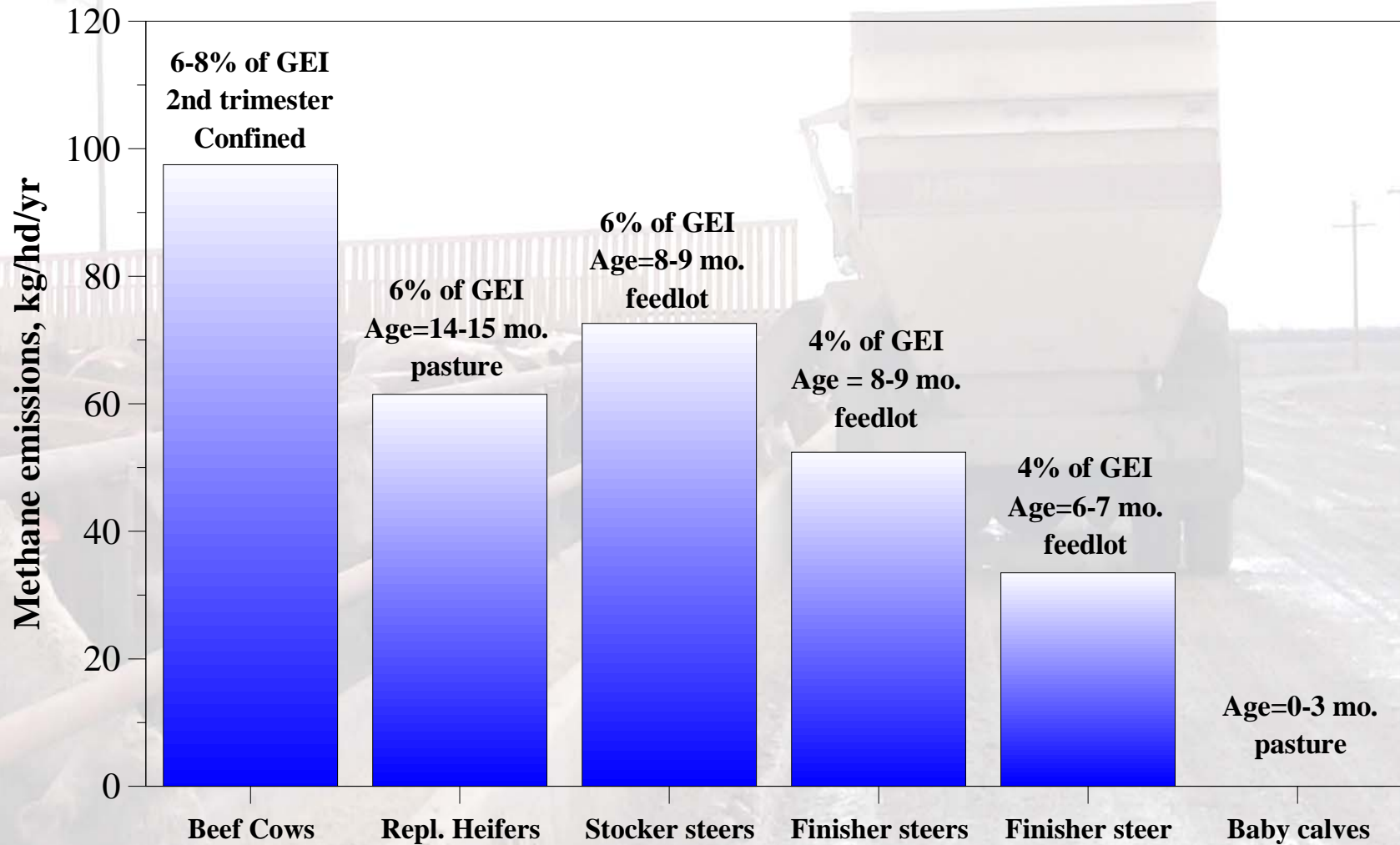


20% increase from 1990 to 2002;

98% of the increase is from the energy sector

Canada 2002 figure represents ~2% of total global GHG emissions

Methane emissions in various categories of beef cattle (Basarab et al. 2005)





Maintenance requirements of beef cattle is largely unchanged over last 100 years *(Johnson, Ferrell and Jenkins, 2003)*

Selection for growth & size: increased NEm, body size, production costs, methane & manure

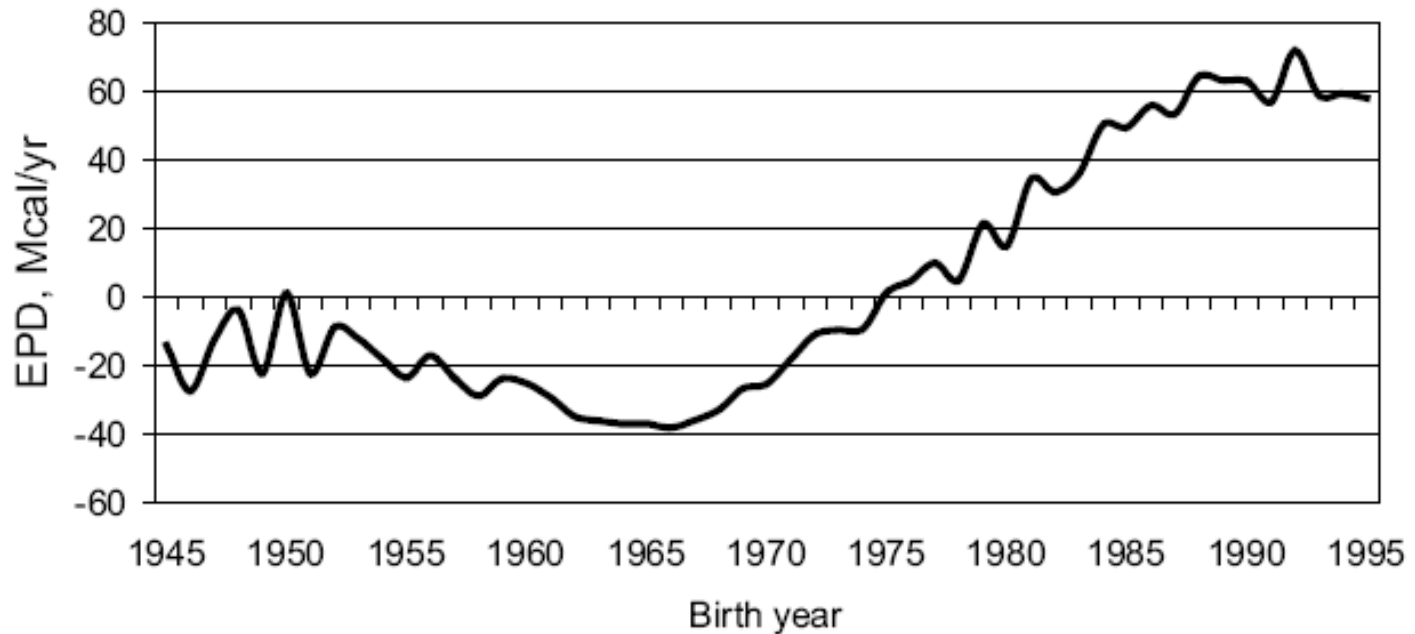



Figure 1. Average EPD (Mcal/yr) for mature cow maintenance energy requirements by birth year in Red Angus cattle (Evans et al., 2002).


Feed Efficiency in Beef Cattle: Why?



>50% of total feed intake is used solely for body maintenance of adult and slaughter animals (*Dickerson 1970*)



65-75% of the total dietary energy cost in breeding cows is required for maintenance (*Ferrell & Jenkins 1985; NRC 1996*)



5% improvement in feed efficiency has an economic impact 4X greater than a 5% improvement in ADG
(*Gibb & McAllister 1999*)

Energetic Efficiency in growing beef cattle

1. **Feed Intake**

2. **Feed Conversion Ratio: DMI/ADG**

3. **Partial Efficiency of growth: $ADG / (\text{avg. DMI} - \text{expected DMI}_m)$**

efficiency of growth after removing FI for maintenance

4. **Relative Growth Rate: $100 \times [\log \text{ end wt} - \log \text{ start wt}] / \text{days on test}$**

Growth relative to instantaneous body size

5. **Kleiber Ratio: $ADG / \text{avg test period LWT}^{0.75}$**

weight gain per unit of metabolic body weight

kg calf/mating
opportunity;
kg calf/Mcal energy
intake

**All measures are related to body size, growth
and composition of gain**

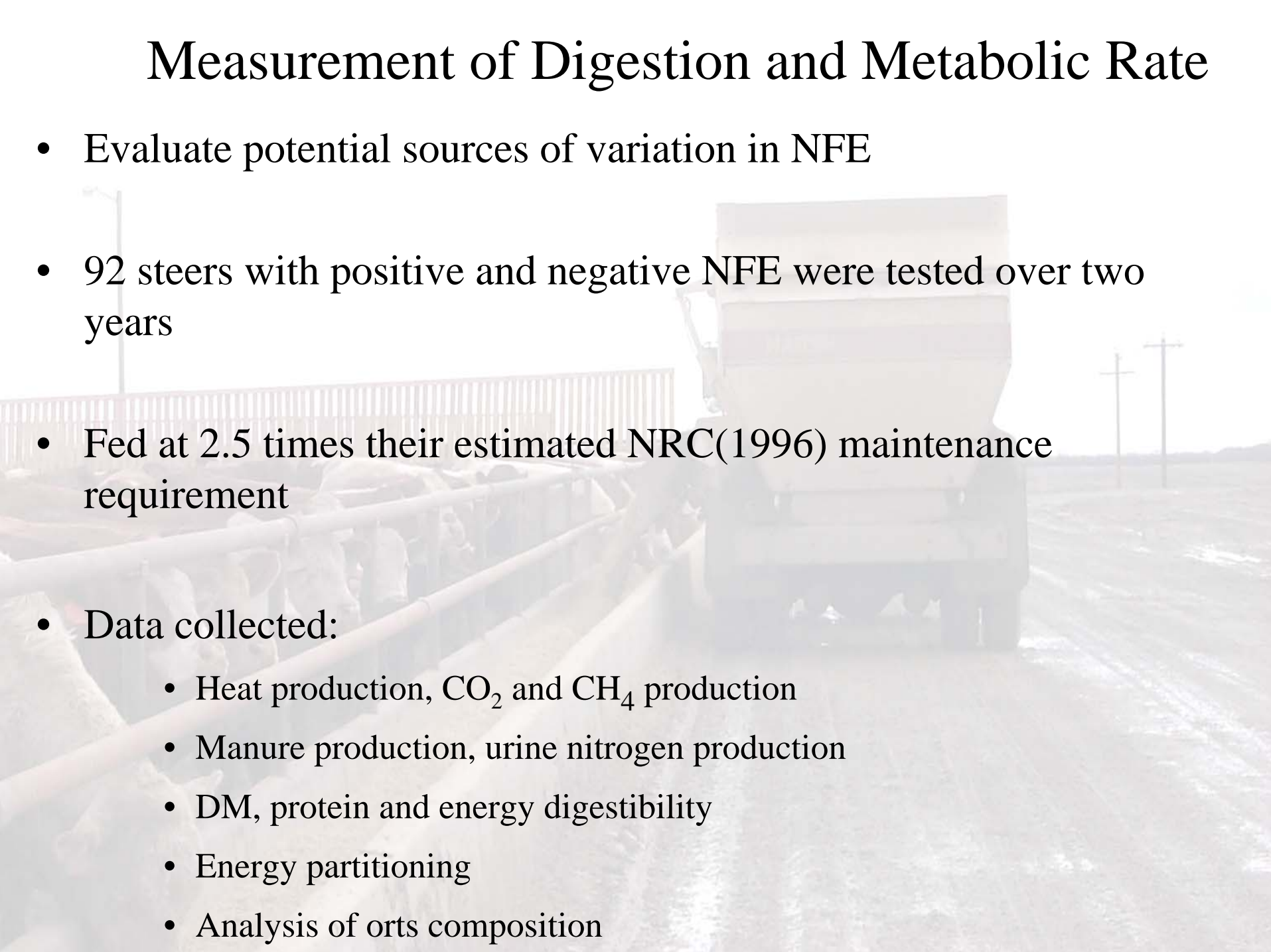
Net Feed Efficiency - NFE

- Also called Residual Feed Intake
 - The difference between animal's actual feed intake and its expected requirements for maintenance and production (growth in beef cattle or milk in dairy cattle) over a specific test period.
- Independent of body size and growth
 - Moderately heritable
 - Relatively easy to measure with available technology

University of Alberta GrowSafe® System



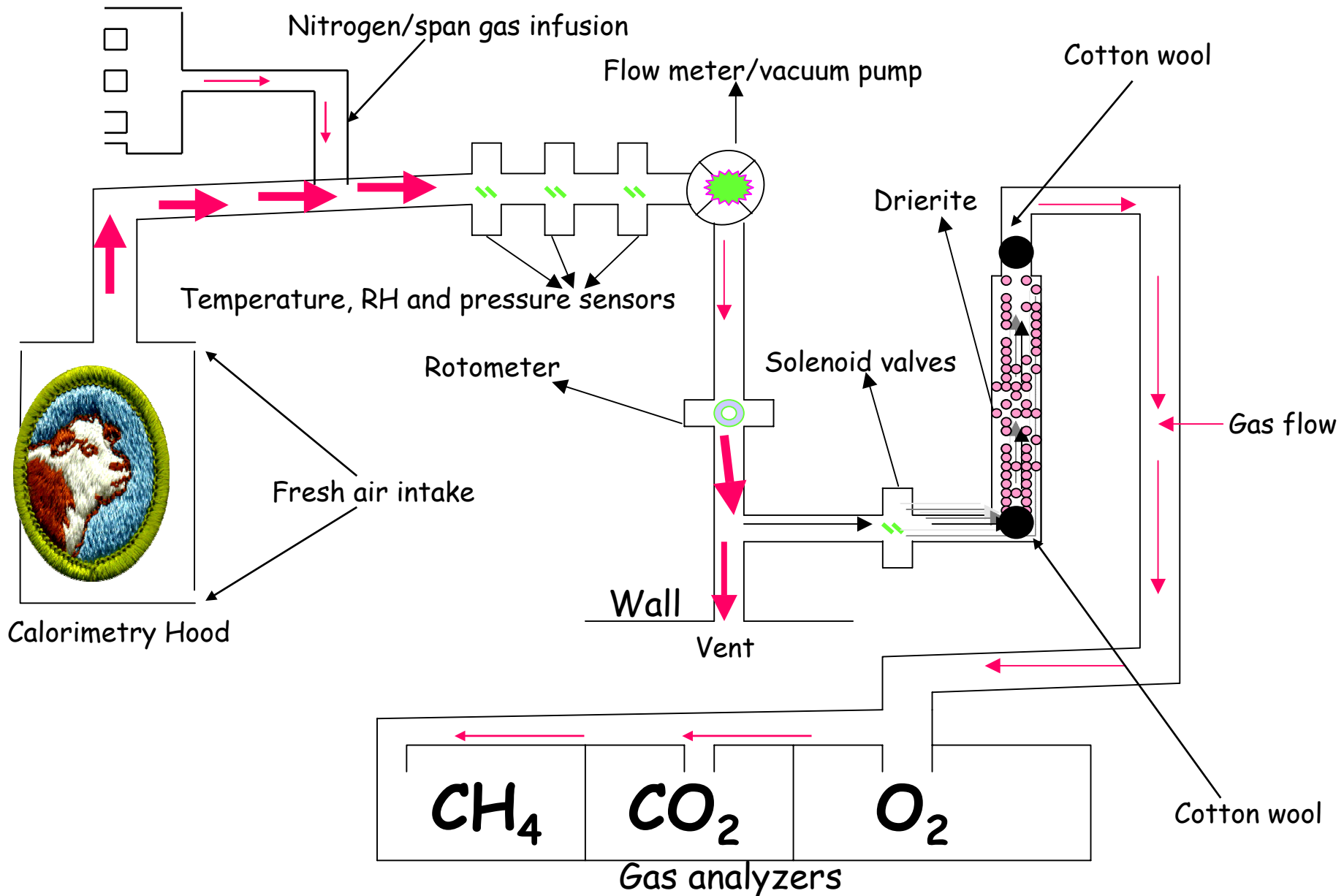
Measurement of Digestion and Metabolic Rate

- Evaluate potential sources of variation in NFE
 - 92 steers with positive and negative NFE were tested over two years
 - Fed at 2.5 times their estimated NRC(1996) maintenance requirement
 - Data collected:
 - Heat production, CO₂ and CH₄ production
 - Manure production, urine nitrogen production
 - DM, protein and energy digestibility
 - Energy partitioning
 - Analysis of orts composition
- 

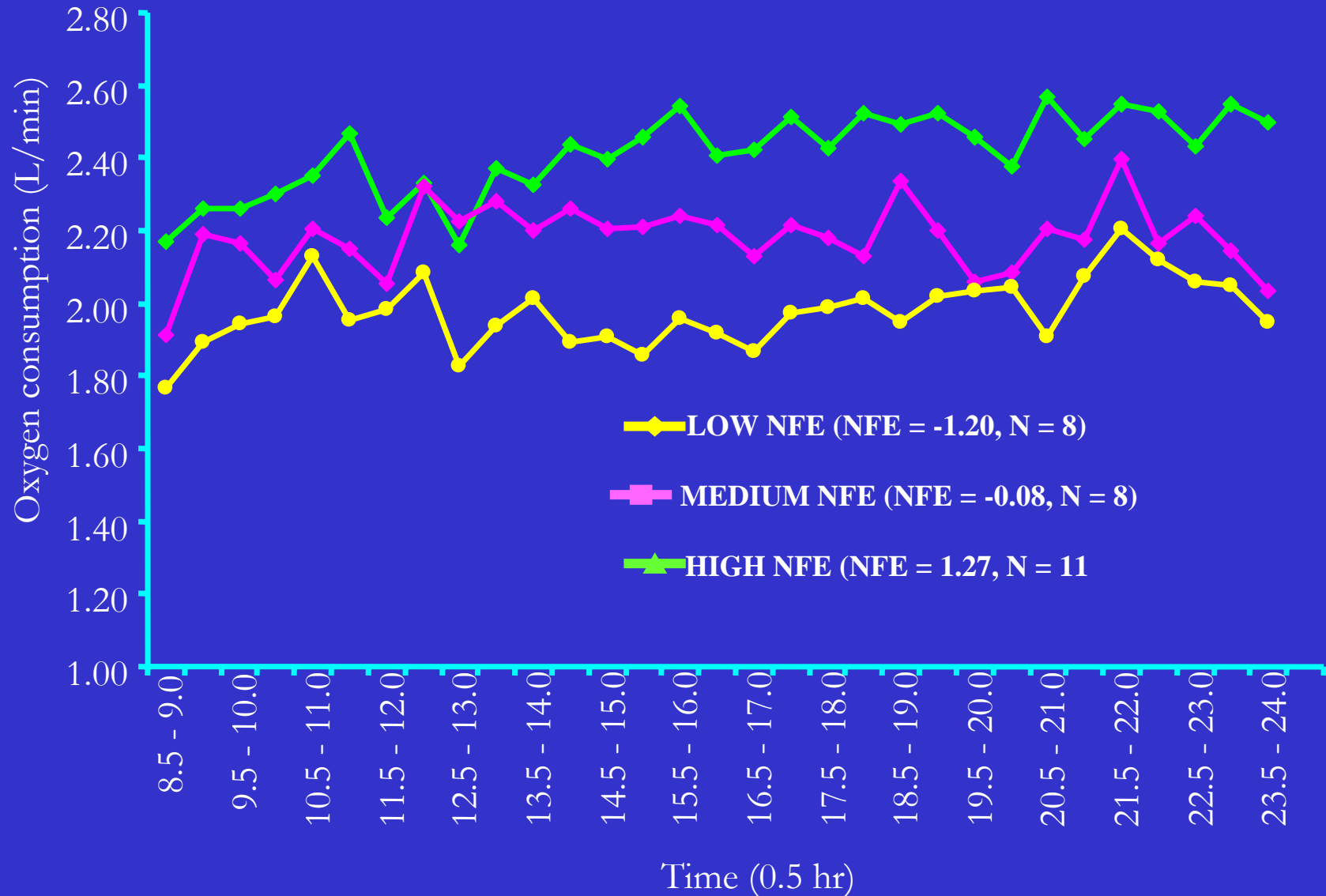
Steers in Respiratory Calorimetry Hoods



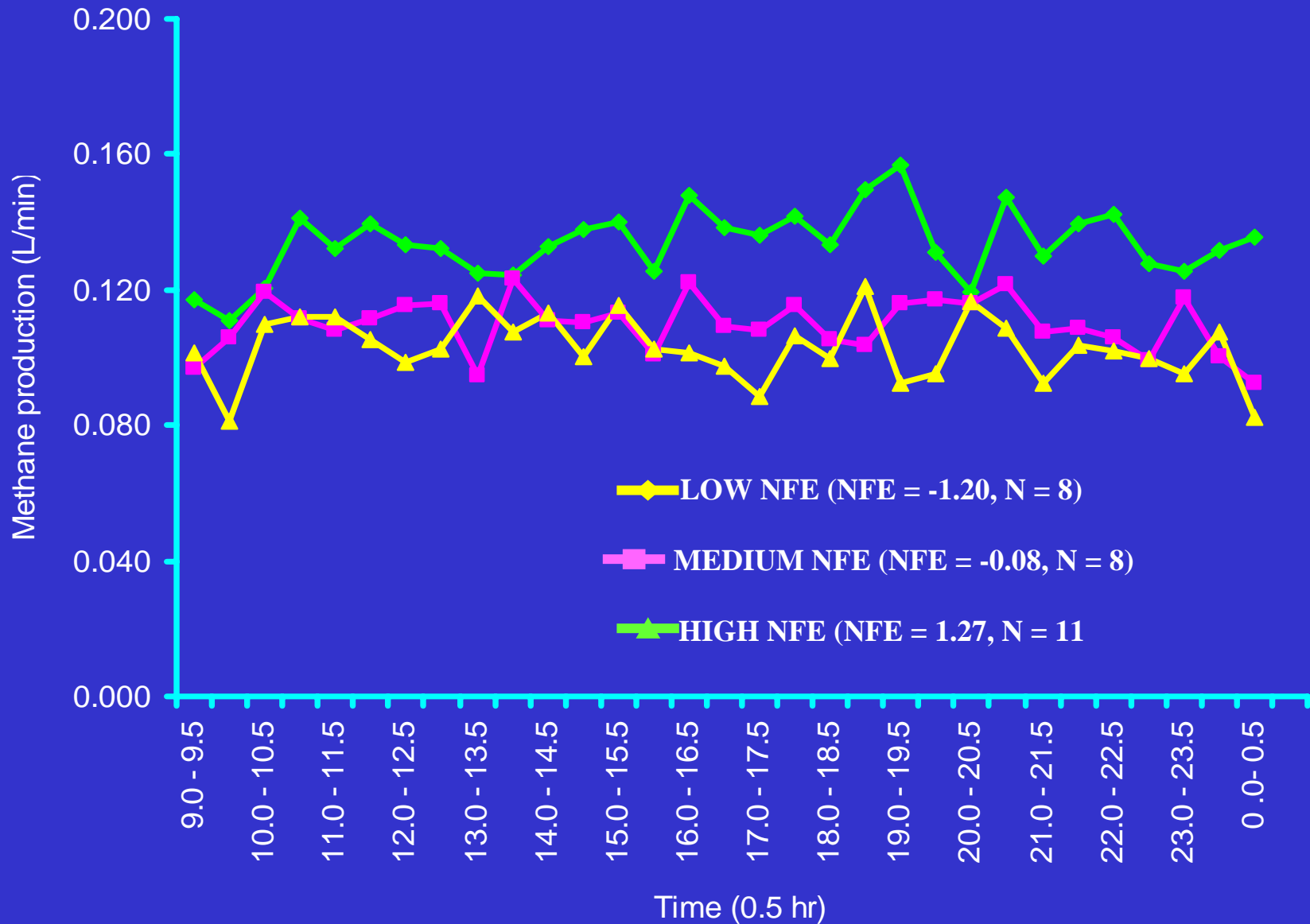
Diagrammatic impression of the indirect calorimetry system



Relationship of NFE with the rate of oxygen consumption of beef cattle



Relationship of NFE with methane production of beef cattle



Relationship of NFE with daily dietary energy partitioning in beef cattle

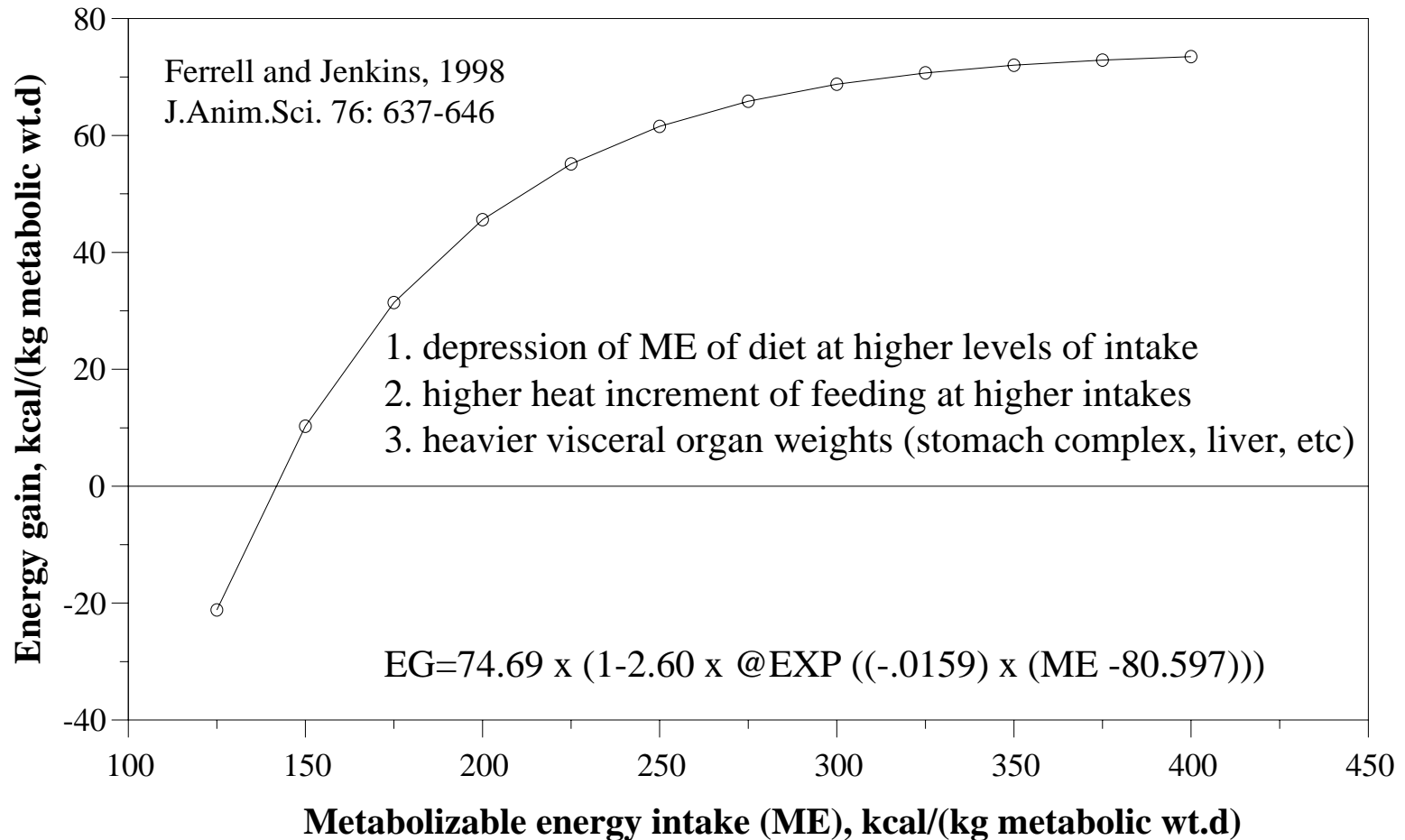
Traits	NFE groups			<i>P</i> value
	High	Medium	Low	
Number of steers	31	26	33	
Intake energy, kcal/kg ^{0.75}	384.8 ± 7.9	382.2 ± 6.3	387.9 ± 6.0	0.39
Fecal energy, kcal/kg ^{0.75}	104.4 ± 4.9	96.0 ± 6.4	88.2 ± 6.7	0.16
Digestible energy, kcal/kg ^{0.75}	265.2 ± 5.2	288.1 ± 7.1	293.8 ± 6.8	0.05
Methane energy, kcal/kg ^{0.75}	16.1 ± 1.0	15.9 ± 1.2	12.09 ± 1.3	0.04
Urinary energy, kcal/kg ^{0.75}	10.9 ± 0.6	9.4 ± 0.8	10.0 ± 0.8	0.35
Metabolizable energy, kcal/kg ^{0.75}	238.5 ± 5.4	248.7 ± 7.1	265.7 ± 7.4	0.02
Heat production, kcal/kg ^{0.75}	163.9 ± 4.2	143.0 ± 5.5	129.3 ± 5.46	<0.001
Retained energy, kcal/kg ^{0.75}	75.3 ± 7.2	104.3 ± 9.5	135.2 ± 9.8	<0.001

NFE and methane emission in beef cattle

Traits	NFE groups			<i>P</i> value
	High	Medium	Low	
Number of steers	31	26	33	
Methane energy, kcal/d	1742 ± 11.0	1717 ± 11.0	1303 ± 13	0.04
Methane liters, L/d	182 ± 3.1	179 ± 2.6	136 ± 2.8	0.04

25.3% reduction

Relationship of energy gain (EG) and metabolizable energy intake (MEI)



Genetic Gain and Methane Reduction

Selected heifer = -2.00 kg as fed/day
Herd average = 0.00 kg as fed/day
-2.00 kg as fed/day

Selected bull = -2.00 kg as fed/day
Herd average = 0.00 kg as fed/day
= -2.00 kg as fed/day

Expected progeny performance=
0.40 x ((-2.00 + -2.00)/2) = -0.8 kg as fed/day

Reduction in methane emissions in yearling steers in feedlot

HIGH NFE = 10 kg DM/hd/day x 18.45 MJ/kg DM = 184.5 MJ/hd/day

184.5 MJ/hd/day x 0.04 = 7.38 MJ/hd/day lost as methane

7.38 MJ/hd/day \div 0.0555606 MJ/g CH₄ = 132.8 g CH₄/day (48.8 kg CH₄/yr)






LOW NFE = (9.2 x 18.45 x 0.04)/0.0555606 = 122.2 g CH₄/day (44.6 kg CH₄/yr)

8.6% reduction

Simple scenario in Alberta

- **Projection of 494,765 tons in 2008-2012 versus 294,778 tons of methane per year in 1990**
- **“Implementation of selection for low NFE bulls and cows could eliminate about 125,000 tons of methane from the projected figures of 494,765 tons for 2008-2012”**
(25.3%)*Nkrumah et al. 2005*

Management practices that mitigate against methane emissions from beef cattle

-  **Selection for Net Feed Efficiency (Alford et al. 2005)**
Individual herd – 16% in year 25 vs. year 1 of selection
Australia – 3.1% in year 25 vs. year 1 (cumulative=11.9 Mt CO₂-E over 25 yr or \$178.5 million); max. 30% adoption rate.
-  **Dietary grain level/days to finish – 30% to 2.4x**
-  **Feeding of ionophores (e.g., monensin) – 0-30%**
-  **Feeding edible oils (canola, sunflower or soybean) – 20%**
-  **Forage management - 25-50%**

Method 2: IPCC Tier 2 (IPCC 2000)

- **Cattle category; body weight; ADG; DE of diet**
- **IPCC Tier 2 equations calculated GEI**
- **Energy lost as methane was 6% of GEI for all cattle categories except those fed diets containing 90% or more concentrates (4%).**
- **GEI x methane loss factor = energy lost as methane (MJ/day)**
- **Energy lost as methane (MJ/day) \div 0.0555606 MJ/g CH₄ = g CH₄/day**
- **GEI converted to DMI by dividing GEI by 18.45 MJ/kg DM**

Yearly enteric methane emission factors for different categories of beef cattle

Category	IPCC Tier 2 % of GEI	IPCC Tier 2* % of GEI	Reference
1. Beef cows, confined	6.0%	6.9%	Boadi & Wittenberg 2002
2. Beef cows, pasture	6.0%	8.7-9.5%	McCaughey et al. 1999
3. Beef bulls, confined	6.0%	5.9-6.9%	Okine et al. 1989
4. Beef bulls, pasture	6.0%	8.7-9.5%	Boadi & Wittenberg 2002 McCaughey et al. 1997
5. Repl. heifers & stockers on pasture	6.0%	4.5-5.8%	McCaughey et al. 1997; Boadi et al. 2002
6. Repl. Heifers confined	6.0%	6.7-6.9%	Boadi & Wittenberg 2002
7. Stocker heifers & steers in feedlot	6.0%	6.7-7.3%	Beauchemin & McGinn 2005 Boadi & Wittenberg 2002
8. Heifers & steers, feedlot; >70% grain	4.0%	4.0%	Beauchemin & McGinn 2005
9. Baby calves, 0-3 months	6.0%	0.0%	Ominski et al. 2005

INTRODUCTION

- General problems with one-sided selection for faster growth and higher body weight
- Increase in mature body size and hence large-size breeding animals with increased maintenance requirements, which become expensive to manage.
 - Higher production costs, less efficient usage of feed resources.
 - Potentially higher manure and green house gases emission with associated environmental problems.

INTRODUCTION

- Lack of interest in Feed Efficiency research in the past
 - Accurate measurement of feed intake of cattle is usually time consuming and difficult.
 - A very expensive process to collect data on relatively large numbers of cattle, which also have a long generation interval.
 - Sophisticated technology and equipment required to record feed intake accurately.

INTRODUCTION

Recent interests in feed efficiency research

- Centralized and automated individual feeding systems for relatively large numbers
- Available technology:
 - Facilities with capacity for the quick, accurate and efficient estimation of feed intake and animal performance.