une University of New England

MEAT & LIVESTOCK AUSTRALIA

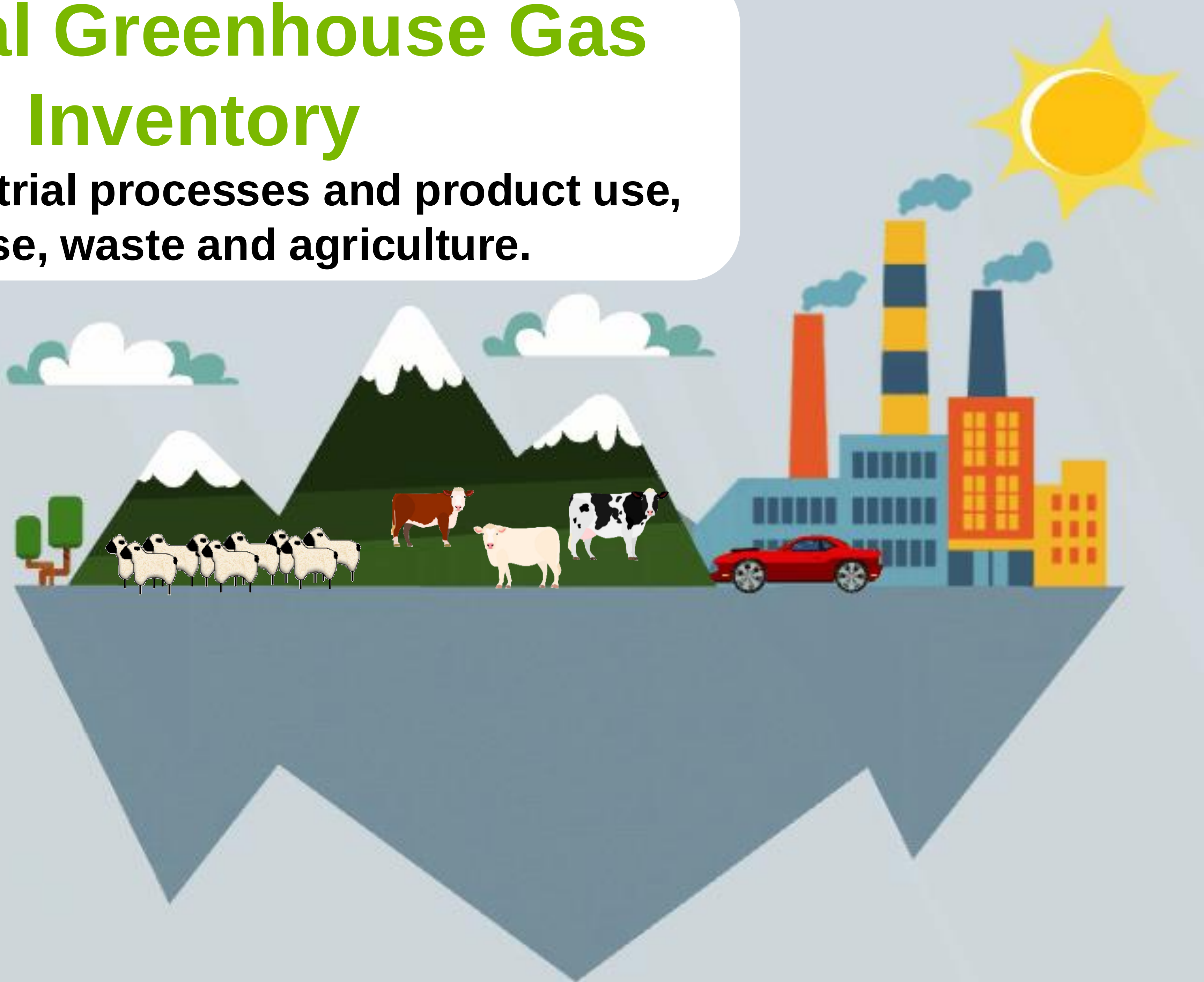
B.FLT.5013

Assessment of the Australian Feedlot Enteric Methane Inventory Equation

Assoc Prof Fran Cowley & Dr Amelia de Almeida

National Greenhouse Gas Inventory

Energy, industrial processes and product use, land use, waste and agriculture.



National Greenhouse Gas Inventory

Quarterly Update: Year to December 2023

Total emissions

432.9 Mt CO_2-e

Down 0.5%

Emissions change on the year to June 2005

29.0% ▼

Transport up 3.4 Mt CO_2-e (3.6%)	Agriculture up 0.5 Mt CO_2-e (0.7%)	Stationary energy down 0.8 Mt CO_2-e (0.8%)
Electricity down 4.4 Mt CO_2-e (2.8%)	Fugitive emissions down 1.0 Mt CO_2-e (2.1%)	Industrial processes down 0.2 Mt CO_2-e (0.6%)

Change in electricity generation in the NEM

Renewables	Coal	Gas
13% ▲	3% ▼	28% ▼

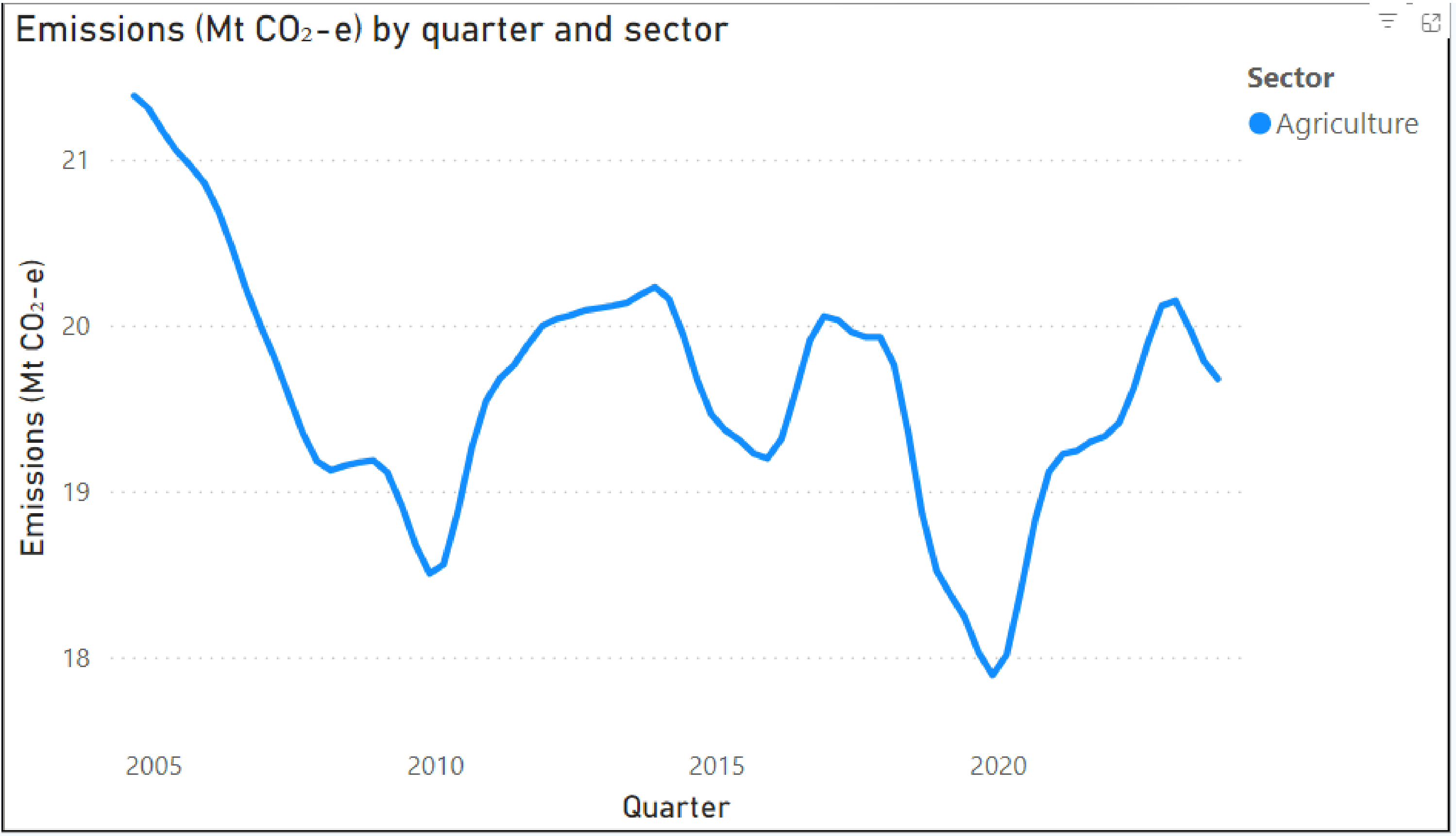
Australia is 35% of the way through the Paris Agreement target period and has used 35% of the emissions budget to 2030

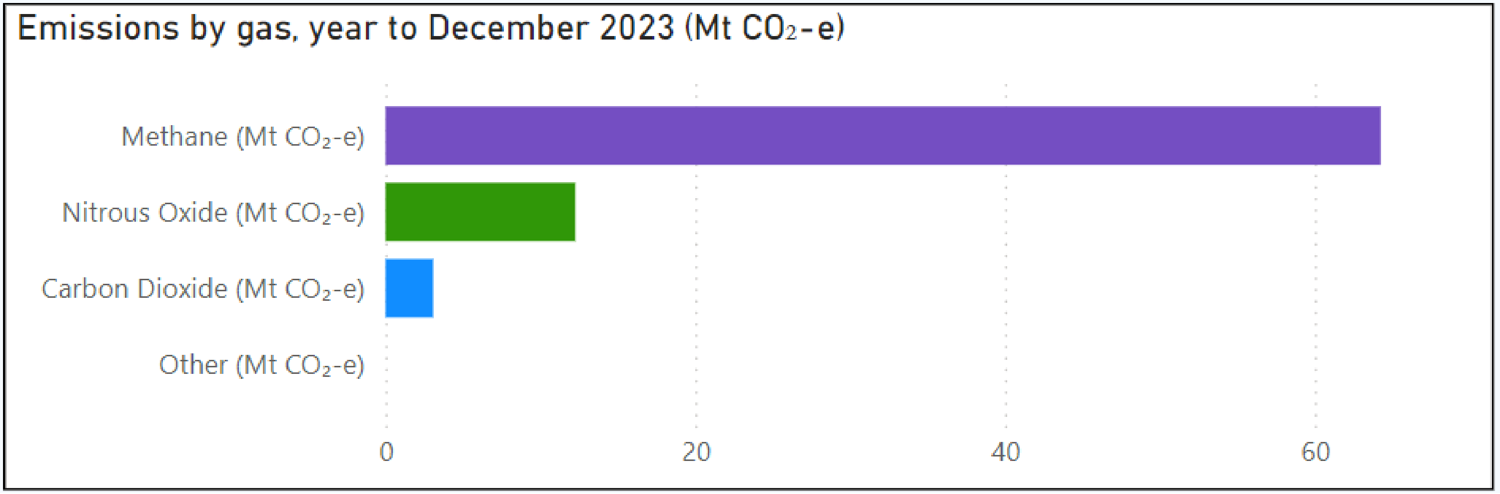
Emissions intensity of the economy

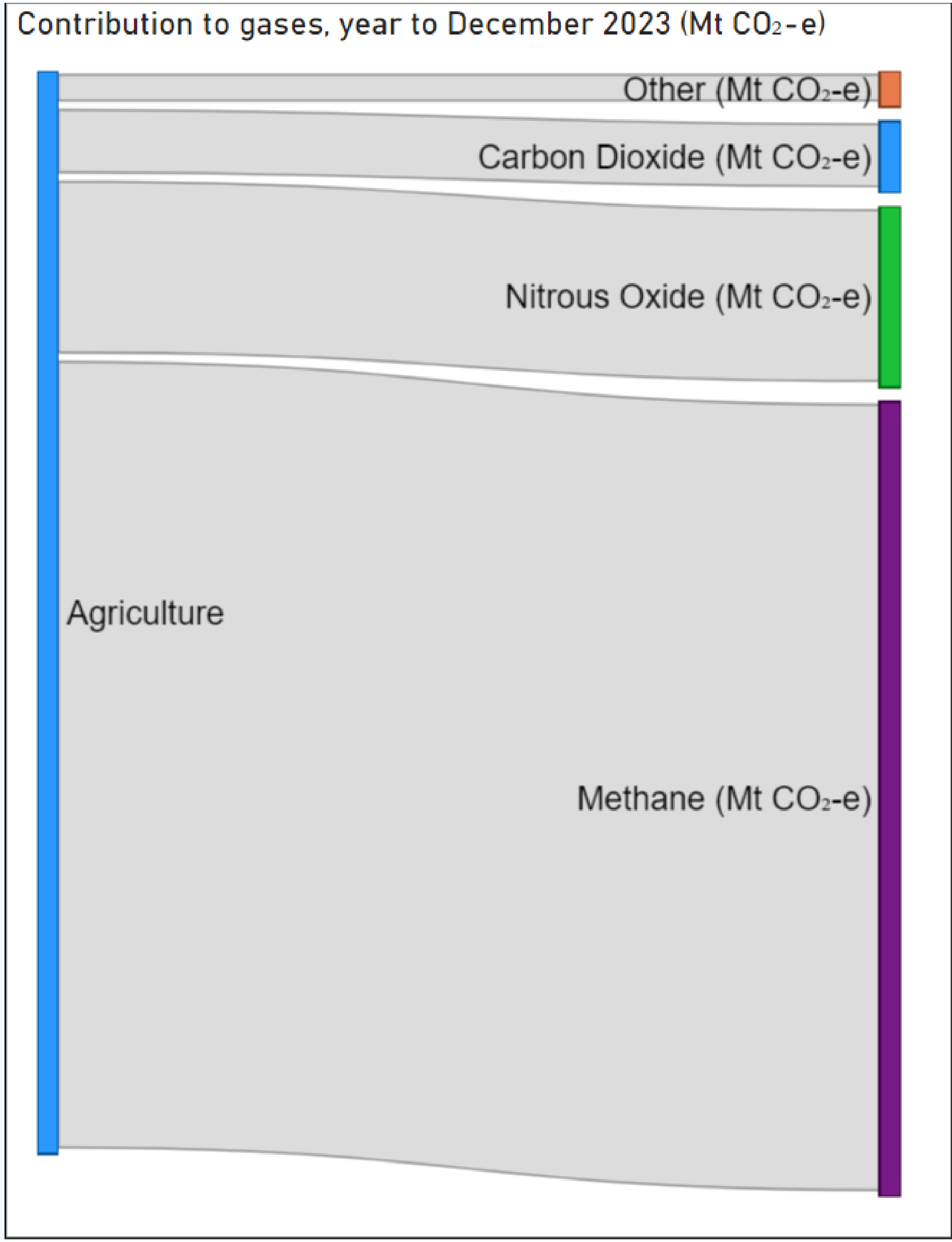
55.9% ▼

on June 2005

Countries and regions that have joined Global Methane Agreements

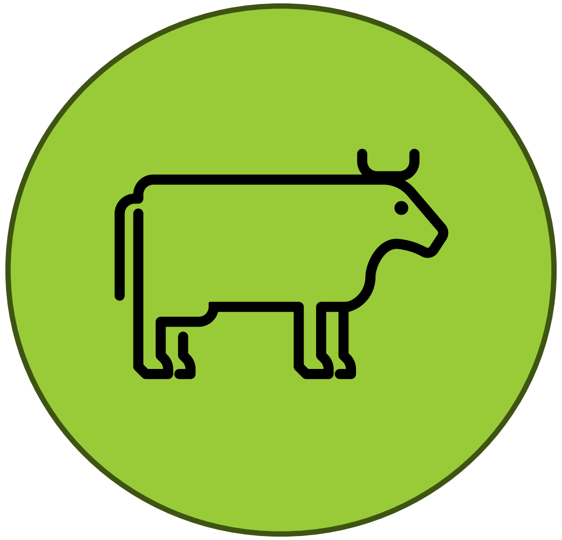

Emissions (Mt CO₂-e) by quarter and sector
Sector
Agriculture
21
20
19
18
Emissions (Mt CO₂-e)
2005
2010
2015
2020
Quarter


Emissions by gas, year to December 2023 (Mt CO₂-e)
Methane (Mt CO₂-e)
Nitrous Oxide (Mt CO₂-e)
Carbon Dioxide (Mt CO₂-e)
Other (Mt CO₂-e)
0
20
40
60


Contribution to gases, year to December 2023 (Mt CO₂-e)
Other (Mt CO₂-e)
Carbon Dioxide (Mt CO₂-e)
Nitrous Oxide (Mt CO₂-e)
Agriculture
Methane (Mt CO₂-e)

Where do feedlot emissions come from?

- Enteric methane



- Methane from manure
- Nitrous oxide from manure

Measuring methane on-farm?

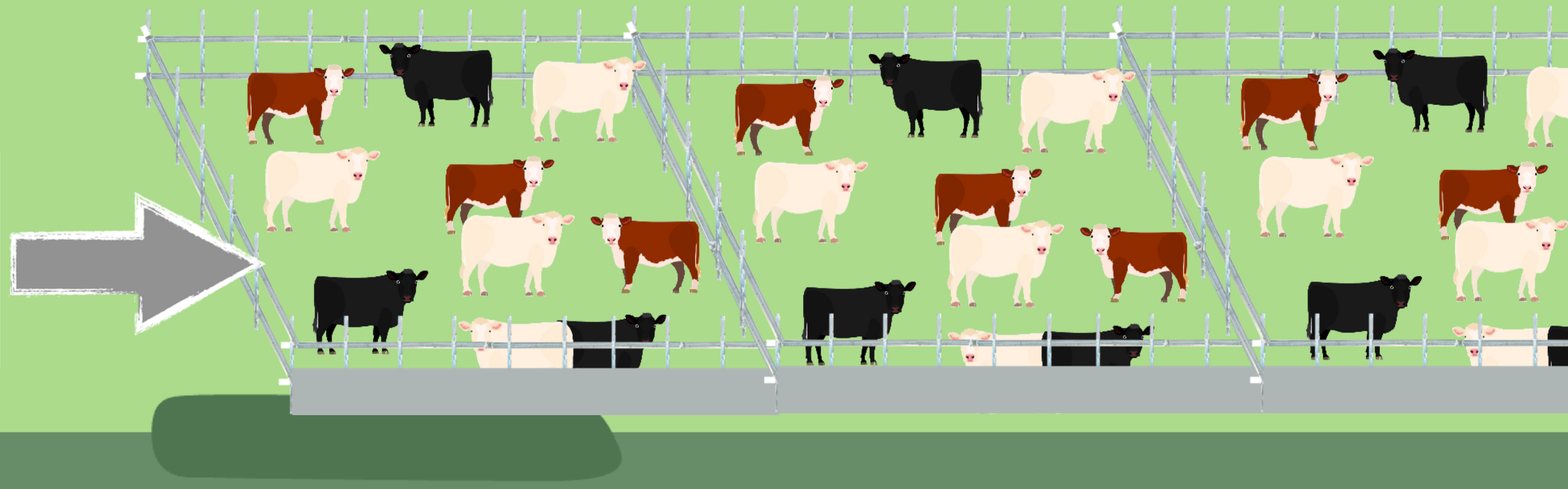
3 Tiers of National Inventory methodologies for enteric methane

- **Tier 1**: default global emissions factor per head
- **Tier 2**: Country-specific emissions factors and equations
- **Tier 3**: Continuous, direct field measurement

Current Australian Tier 2 method

Intake: IPCC (2019)

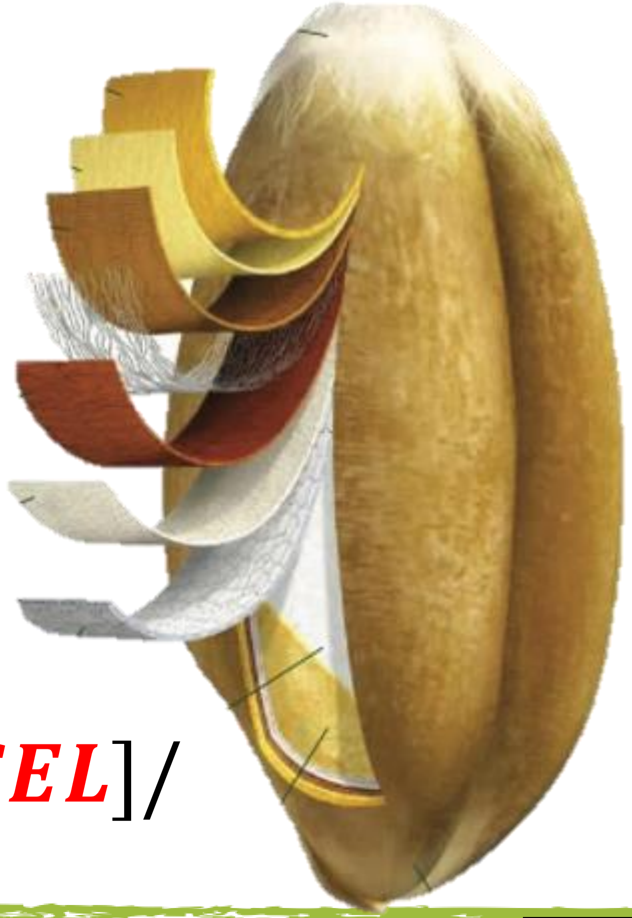
CH_4: Moe & Tyrrell (1979)



Current Australian Tier 2 method

- Predicts methane emissions from diet content of :
  - Cell wall carbohydrates
    - Cellulose, Hemicellulose
  - Starches and non-fibre carbohydrates
- Equation developed by Moe & Tyrell (1979)
  - US dairy cattle data

- $\boldsymbol{CH_4} = [3.406 + 0.510 \times \boldsymbol{SR} + 1.736 \times \boldsymbol{HC} + 2.648 \times \boldsymbol{CEL}]/0.05522$



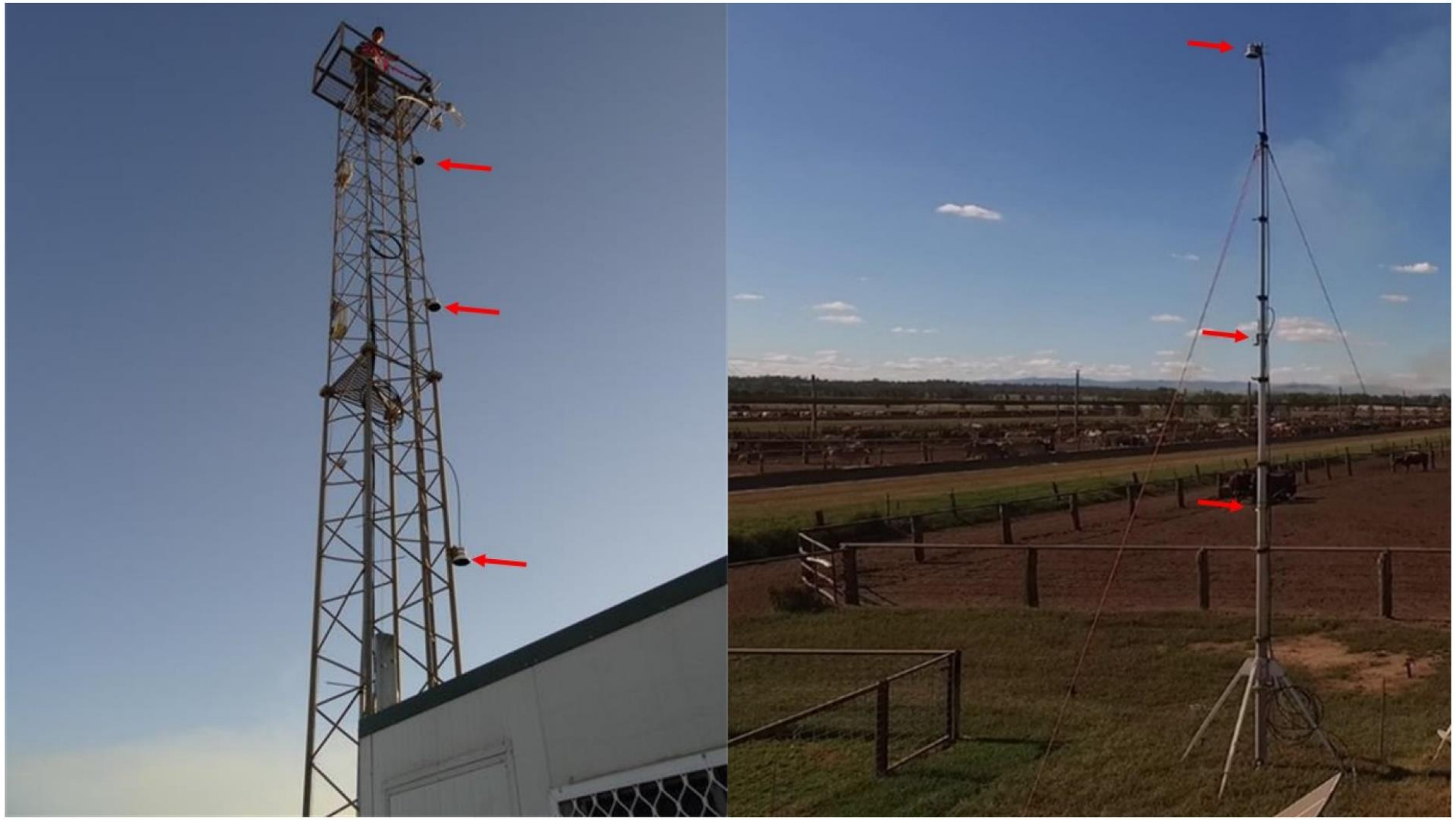
atmosphere

MDPI

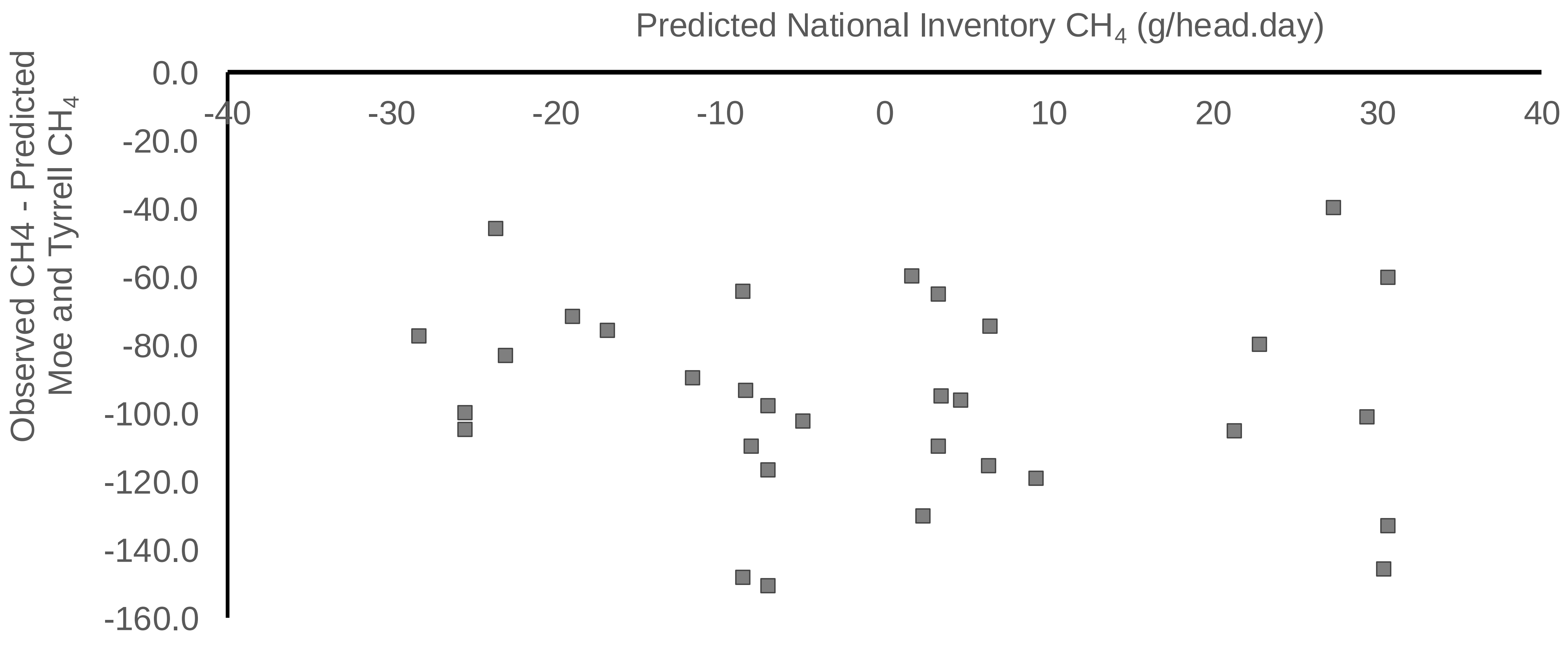
Article

Measurement of Long-Term CH_4 Emissions and Emission Factors from Beef Feedlots in Australia

Mei Bai [1,*], Trevor Coates [2], Julian Hill [3], Thomas K. Flesch [4], David W. T. Griffith [5], Matthew Van der Saag [6], Des Rinehart [6] and Deli Chen [1]



2022: Early modelling exercises…

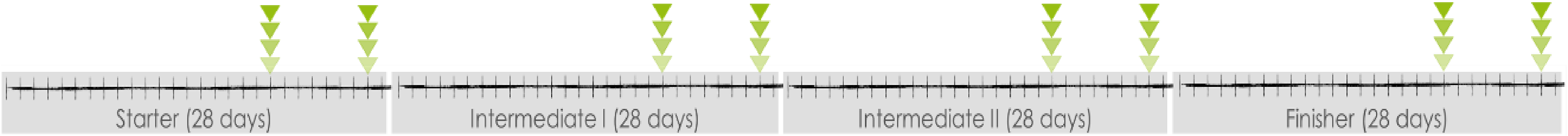


Validating prediction methodologies

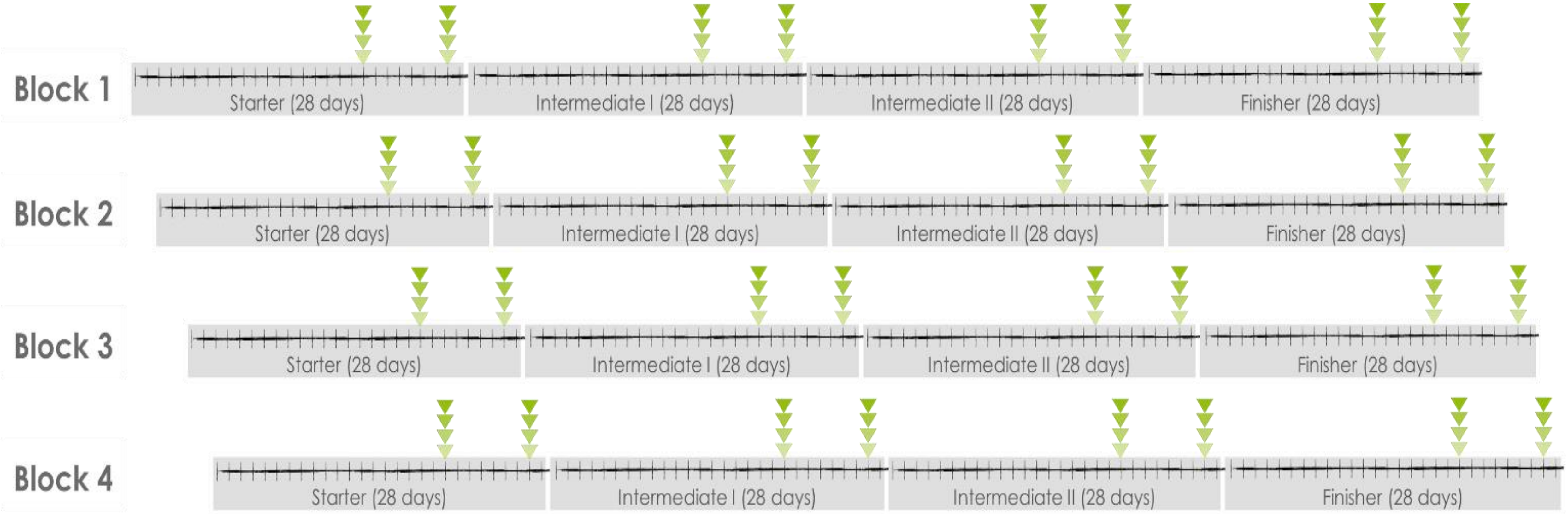
- Historical database of gold-standard methane studies using Australian diets
- *In vivo* matrix study
  - – 4 Levels of NDF
  - – 4 levels of total fat (ether extract)

Total NDF %	Fat level (DMB,10 steers per fat level)				Period
	3 %	4.3 %	5.6 %	7 %	
35 %	Starter/no fat	Starter/Low fat	Starter/Medium fat	Starter/High fat	28d
30 %	T1/no fat	T1/Low fat	T1/Medium fat	T1/High fat	28d
25 %	T2/no fat	T2/Low fat	T2/Medium fat	T2/High fat	28d
20 %	Finisher/no fat	Finisher/Low fat	Finisher/Medium fat	Finisher/High fat	28d

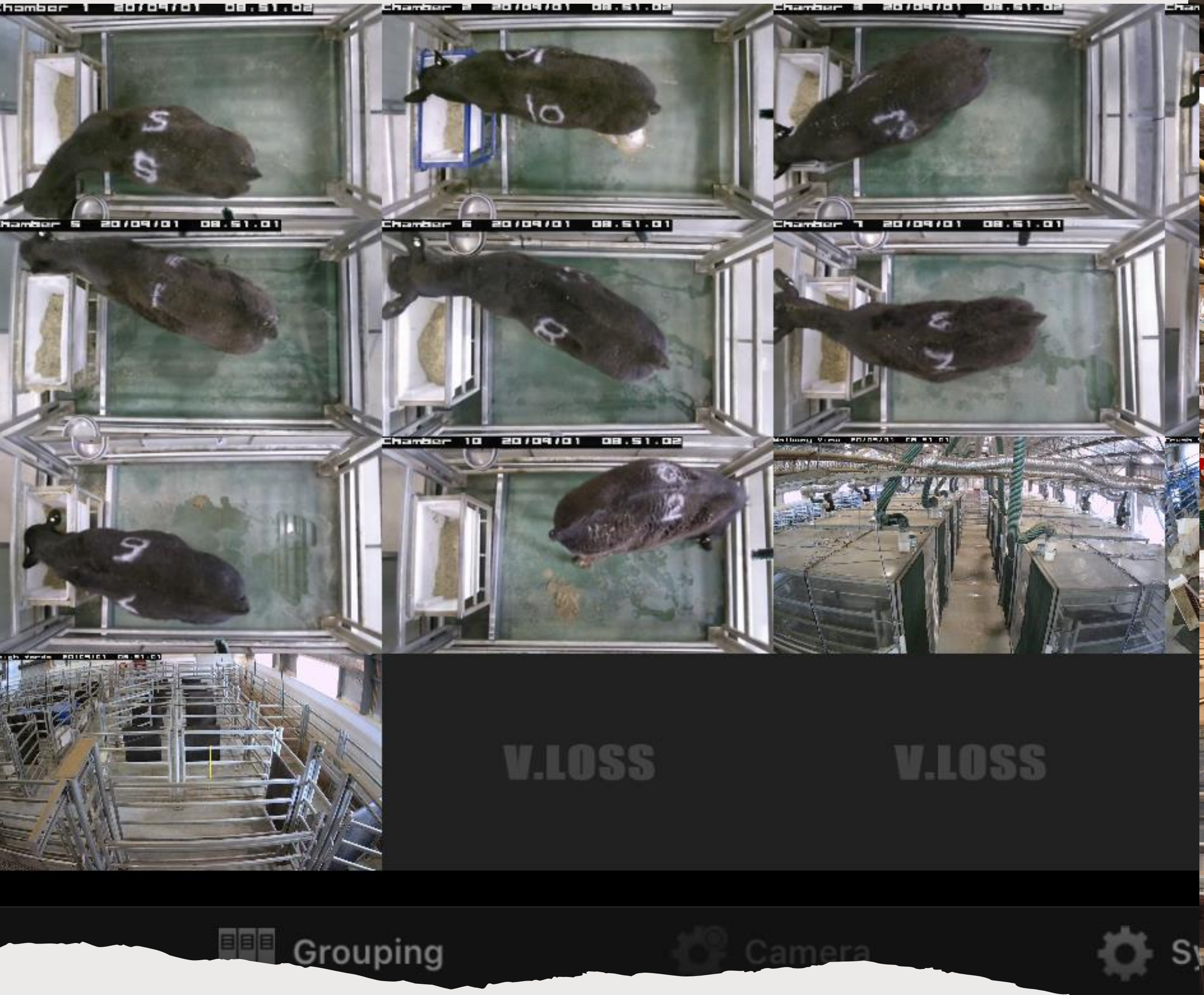
In vivo study



In vivo study



une University of New England

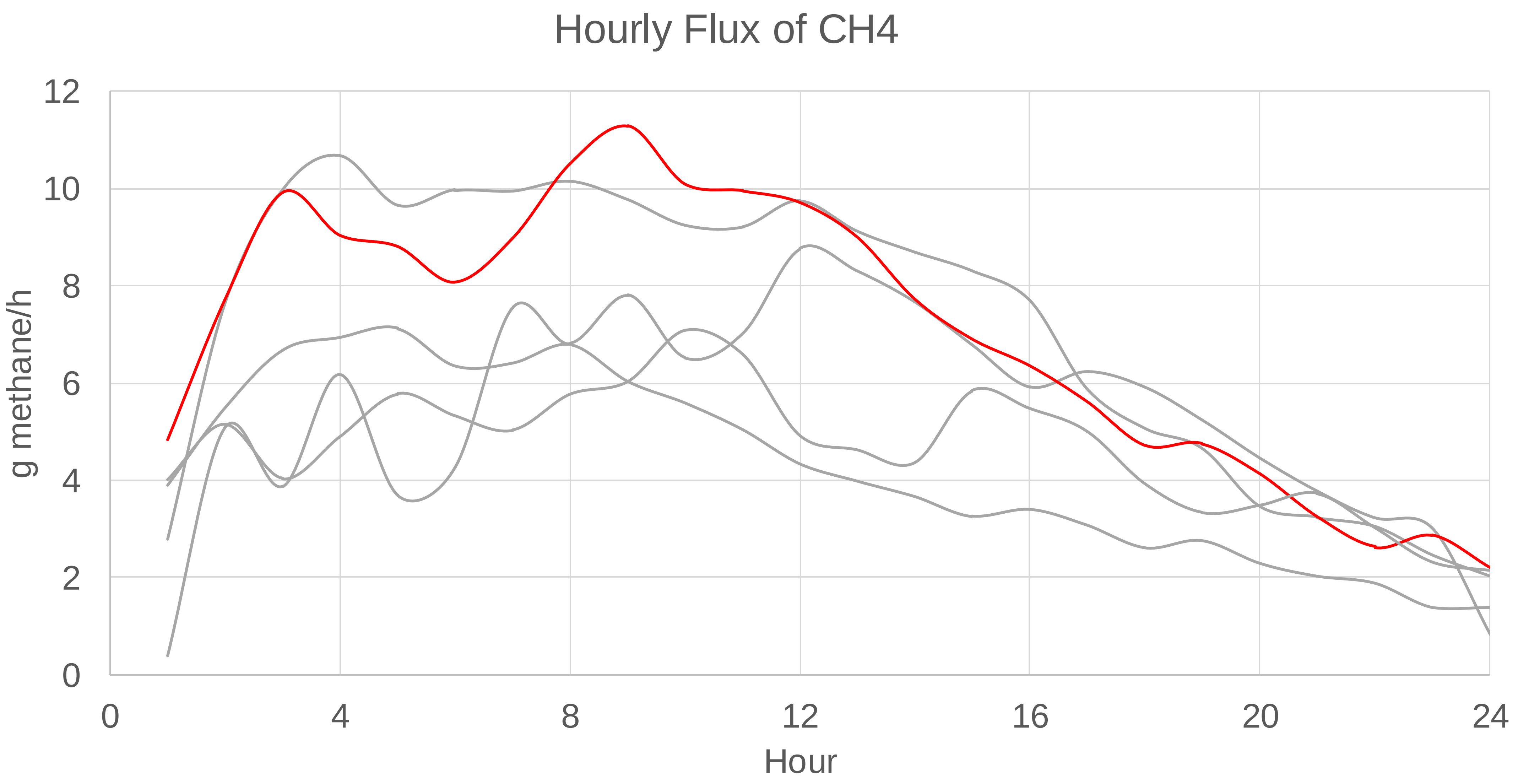


UNE Livestock Emissions Research

World’s largest methane research facility


TRT
336
20


Emissions monitored in open circuit respiration chambers

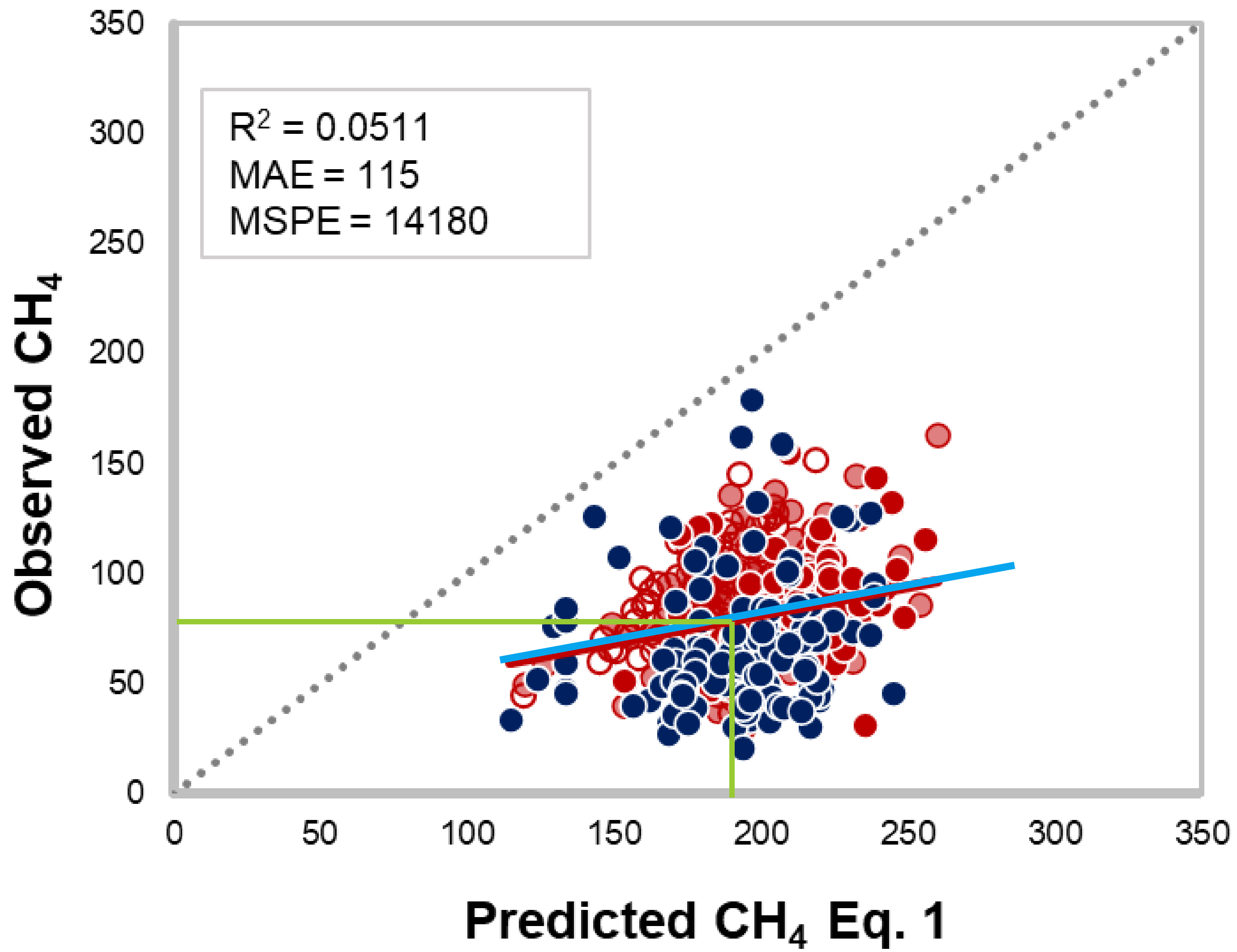

Hourly Flux of CH4
g methane/h
0
2
4
6
8
10
12
0
4
8
12
16
20
24
Hour

Database composition

- 4 MLA-funded studies
- 384 individual records from 53 feedlot cattle
- Analysed 26 different barley-based diets
- 25 mg/kg DM of monensin

Fit of current equation to observed CH_4 emissions

- Current equation estimates CH4 from feedlot cattle on <u>average</u> to be 2.44 × observed emissions (‘*mean bias*’)

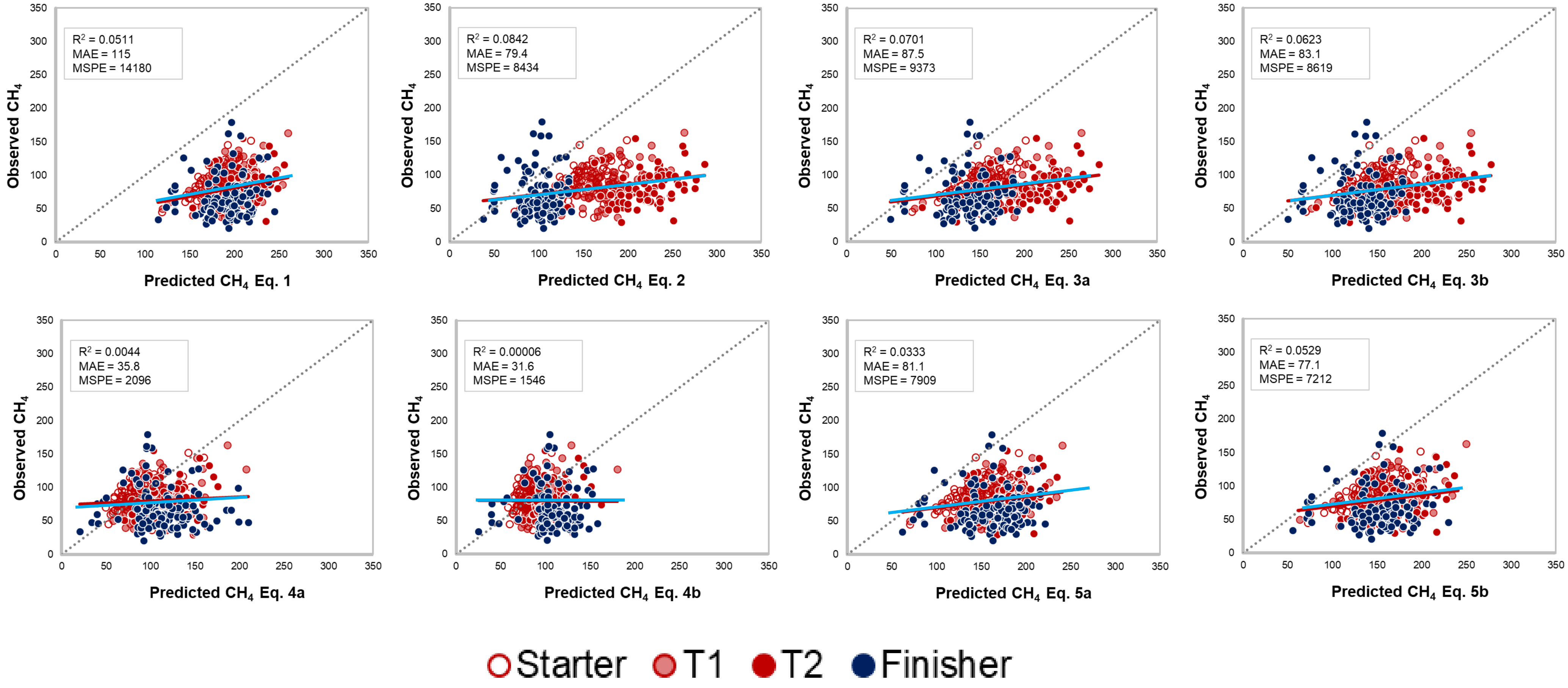


Equations Assessment

Evaluated literature equations used to predict feedlot cattle CH_4 production (g/d)

Equation	Description
Moe and Tyrrell (1979)	$CH_4 = [3.406 + 0.510 \times SR + 1.736 \times HC + 2.648 \times CEL]/0.05522$ **(Current Inventory Method)**
IPCC (2006)	$CH_4 = [(\frac{Y_m}{100}) \times GEI)]/0.05565$
IPCC (2019)	$CH_4 = (MY \times DMI)$
IPCC (2019)	$CH_4 = [(\frac{Y_m}{100}) \times GEI)]/0.05565$

Other alternative equations were also validated…



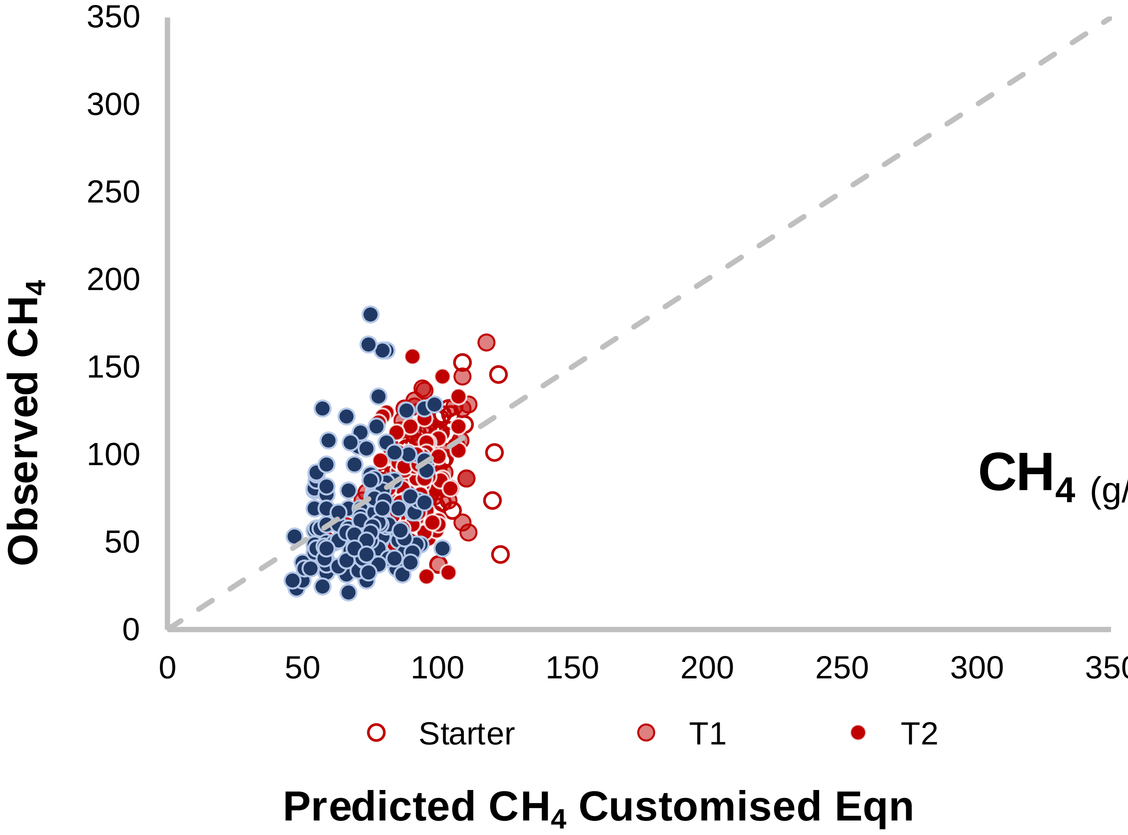
New equation: inputs analysed

- Dry matter intake/d
- Body weight
- Gross energy content of diet
- Crude protein content of diet
- Fat intake/d
- Fat content of diet
- NDF intake/d
- NDF content of diet
- Hemicellulose intake/d
- Cellulose intake/d
- ADF intake/d
- Soluble residues intake/d
- Starch intake/d

New equation: inputs available

- Dry matter intake/d
- Body weight
- Gross energy content of diet
- Crude protein content of diet
- Fat intake/d
- Fat content of diet
- NDF intake/d
- NDF content of diet
- Hemicellulose intake/d
- Cellulose intake/d
- ADF intake/d
- Soluble residues intake/d
- Starch intake/d

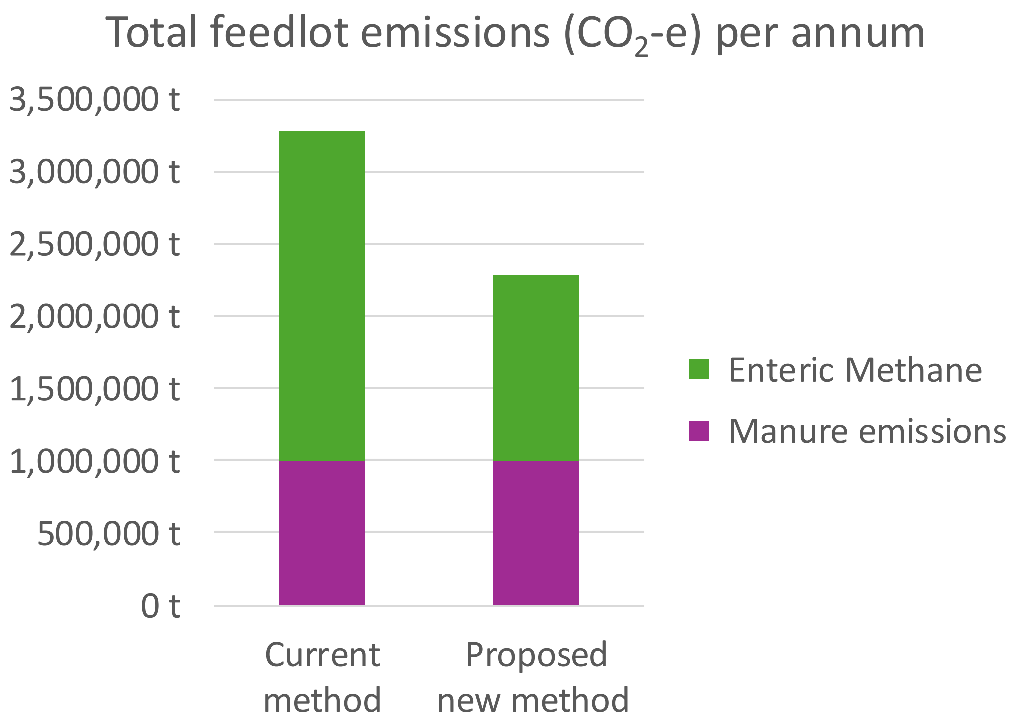
Australian-specific emission factor



n = 384
$P < 0.05$
RMSE = 22.2 g/d
$r^2 = 0.91$

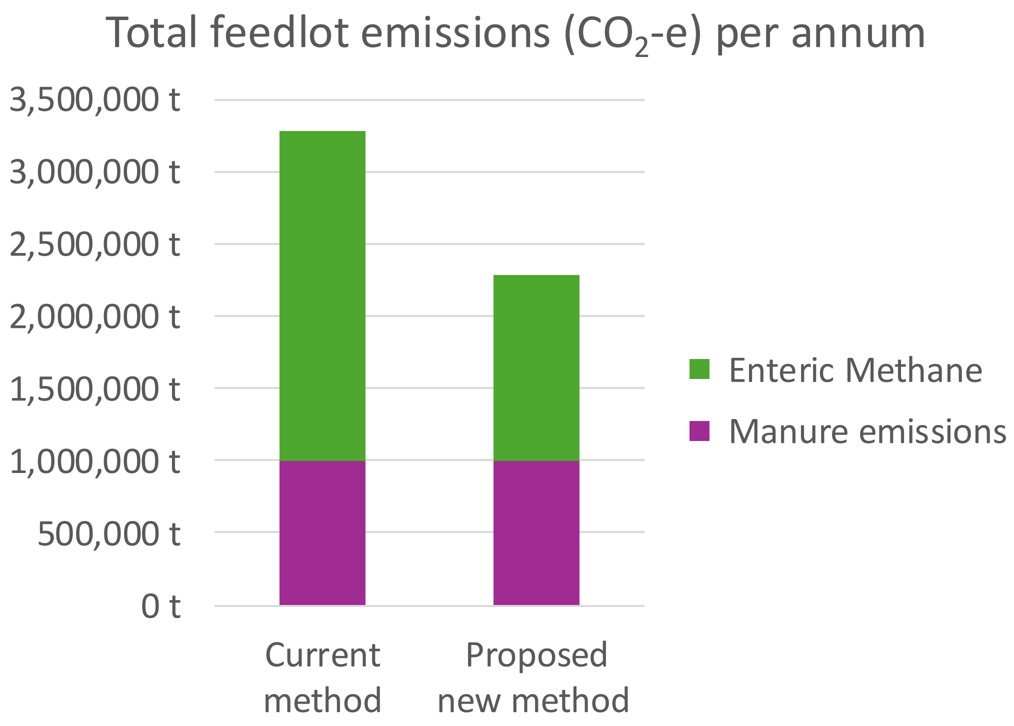
$$CH_{4\ (g/d)} = 5.1 \times \mathbf{DMI} - 4.0 \times \mathbf{Fat\%} + 2.3 \times \mathbf{NDF\%}$$

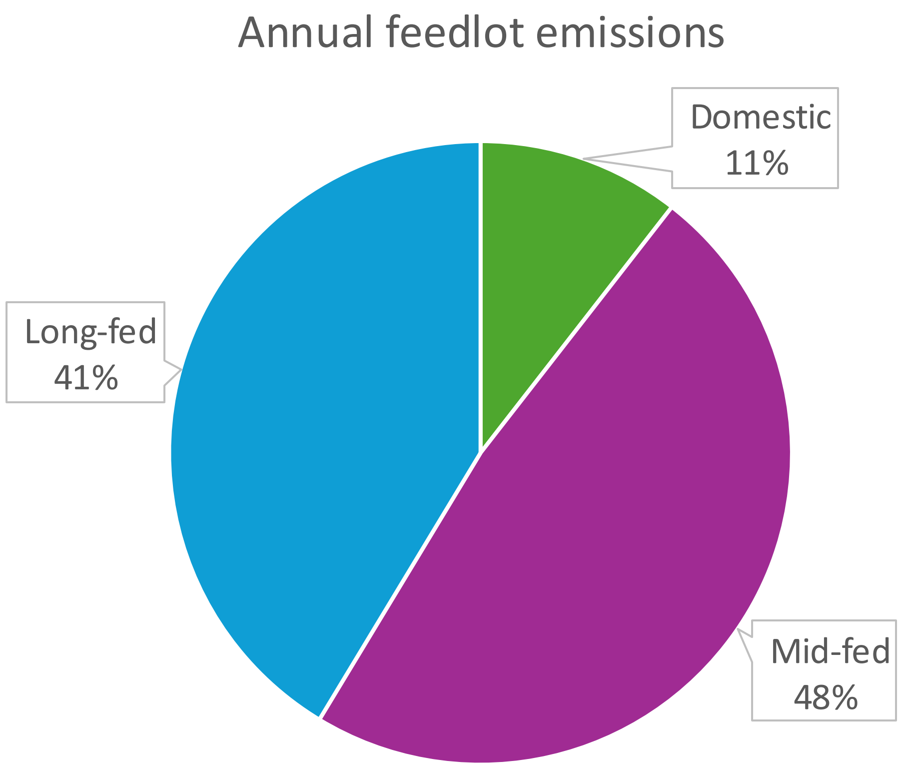
Implications for Emissions from Lot-fed Cattle



- Previous IPCC reporting
  - = 2.28 Mt CO2e/year
- Using the new equation
  - = 1.13 Mt CO_2e/year
  - 43.4% lower

Implications for Emissions from Lot-fed Cattle





Next steps

- Submission to the Department of Climate Change, Energy, the Environment and Water
- Change Australia’s Tier 2 methodology
- Collect data from feedlot nutritionists on fat and NDF content of domestic- mid- and long-fed cattle
- Retrospectively update emissions from Australian grainfed beef cattle

mla
MEAT & LIVESTOCK AUSTRALIA

une
University of New England

Ruminant Research Group

1. *In vivo* study

Item	Diet			
	Starter	T1	T2	Finisher
Ingredient, % DM				
Tempered Barley	**36.7 - 53.7**	**53.0**	**67.8 - 69.5**	**80.1 - 85.7**
Oaten hay	16.3 - 26.5	16.3 - 19.1	8.7 - 11.0	2.2 - 3.8
Mill run	5.3 - 11.1	3.0 - 11.1	0.0 - 5.7	-
Wheat straw	7.80-11.4	7.8 - 9.1	4.2 - 5.2	-
Whole cottonseed	6.7 - 8.0	6.7	6.7 - 6.9	6.90
Molasses	2.6	2.6	2.6	2.70
Vegetable Oil	0.0 - 3.9	0.0 - 4.1	0.0 - 4.1	0.0 - 2.5
Mineral Supplement	2.5	2.5	2.5	2.0
Monensin (ppm)	**25.0**	**25.0**	**25.0**	**25.0**
Chemical Composition (DM-basis)				
Moisture, % DM	19.4	19.8	19.5	19.1
Organic Matter, % DM	93.1	93.6	95.0	95.8
Ash, % DM	6.9	6.4	5.0	4.2
Crude Protein, % DM	11.6	11.2	10.9	11.4
Fat, % DM	**3.0 - 6.4**	**3.0 - 6.7**	**3.2 - 6.5**	**3.4 - 7.1**
NDF, % DM	**34.4**	**29.8**	**24.7**	**19.4**
ADF, % DM	16.6	13.6	10.9	7.80
Lignin, %DM	2.32	1.79	1.59	1.18
Starch, % DM	21.0	29.3	41.1	45.5
GE, MJ/kg DM	18.0	18.1	19.2	19.4
ME, MJ/kg DM	10.5	11.7	12.8	13.6
Roughage % DM	**35.1**	**29.3**	**18.1**	**6.21**

Methane measurements

- d 20, 27, 48, 55, 76, 83, 104, and 111

2. Equations Assessment

Summary statistics of all data included in the evaluation database

Item	N	Mean	SD	Minimum	Maximum
Dry matter intake (kg/d)	384	9.1	2.1	3.5	14.1
Body weight (kg)	384	412	71.0	163	737
Diet composition (% of DM)					
Crude protein	25	11.6	0.9	10.5	14.6
Ether extract	25	4.9	1.3	3.0	7.3
Neutral detergent fiber	25	27.1	5.7	18.9	44.2
Acid detergent fiber	25	11.9	3.4	7.3	19.9
GE (MJ/kg DM)	25	18.1	0.3	17.4	19.5
Hemicellulose	25	15.2	3.0	11.4	29.3
Cellulose	25	10.2	3.1	5.4	16.8
Starch	25	34.9	9.63	20.0	51.0
CH_4 emissions					
CH_4 production (g/d)	384	79.9	27.5	20.9	179
CH_4 yield (g/kg DMI)	384	9.3	3.74	1.97	21.1
Y_m (% of GE intake)	384	2.9	1.2	0.6	6.6

une
University of New England