



University of
Nottingham

UK | CHINA | MALAYSIA

Dairy nutrition research at Nottingham

Phil Garnsworthy

Professor of Dairy Science

The University of Nottingham, UK



The Big Issues with Livestock

- Global demand for animal products is increasing
- Competition for land to grow animal feed versus human food
- Pressure on the environment
- Reduced margins
- Need more efficient use of resources

Our Aim: To increase production efficiency whilst reducing environmental impact



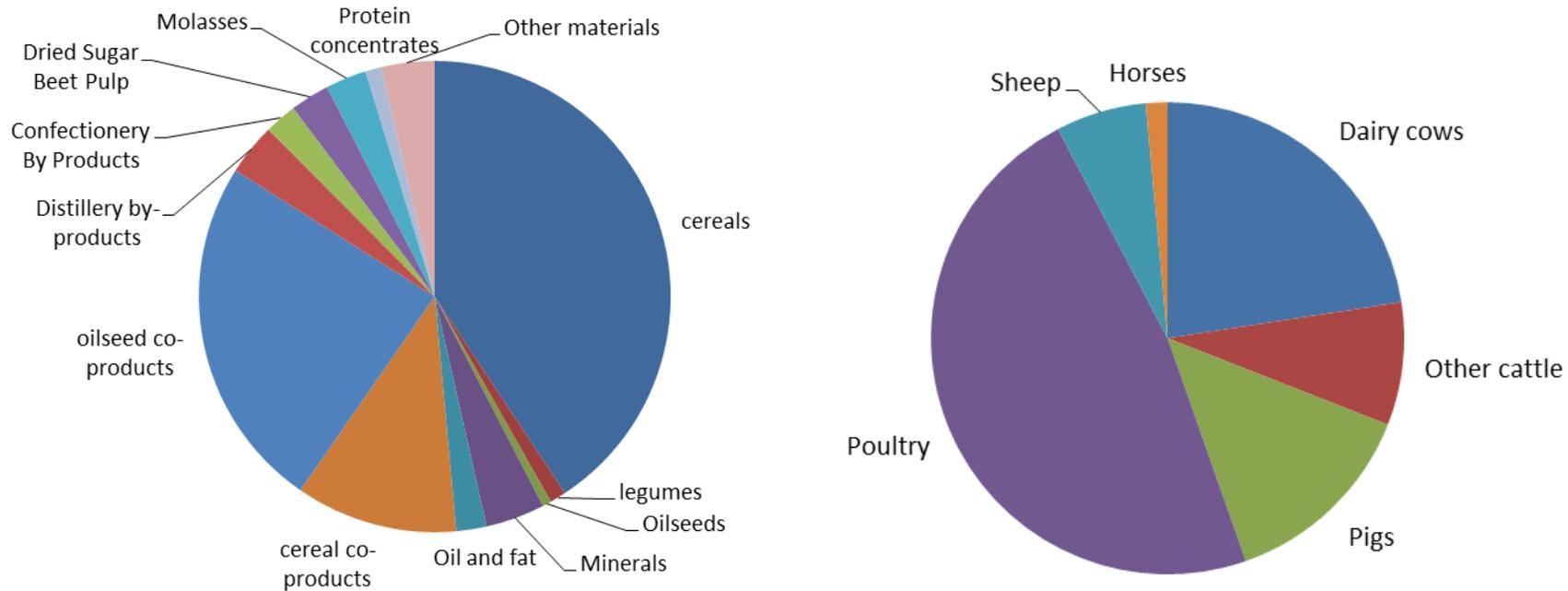
- UK Land Utilisation
30% crops, 40% grass, 30% marginal
- Ruminants can use grass and by-products
Beet pulp, distillers grains, wheatfeed, rapemeal

	Efficiency (%)			
	Total		Human Edible	
	Energy	Protein	Energy	Protein
Pigs & Poultry	15-28	20-30		
Beef & Lamb	2-10	3-10		
Milk	24	20		

Adapted from Wilkinson (2011)



Raw materials in manufactured feeds (UK)

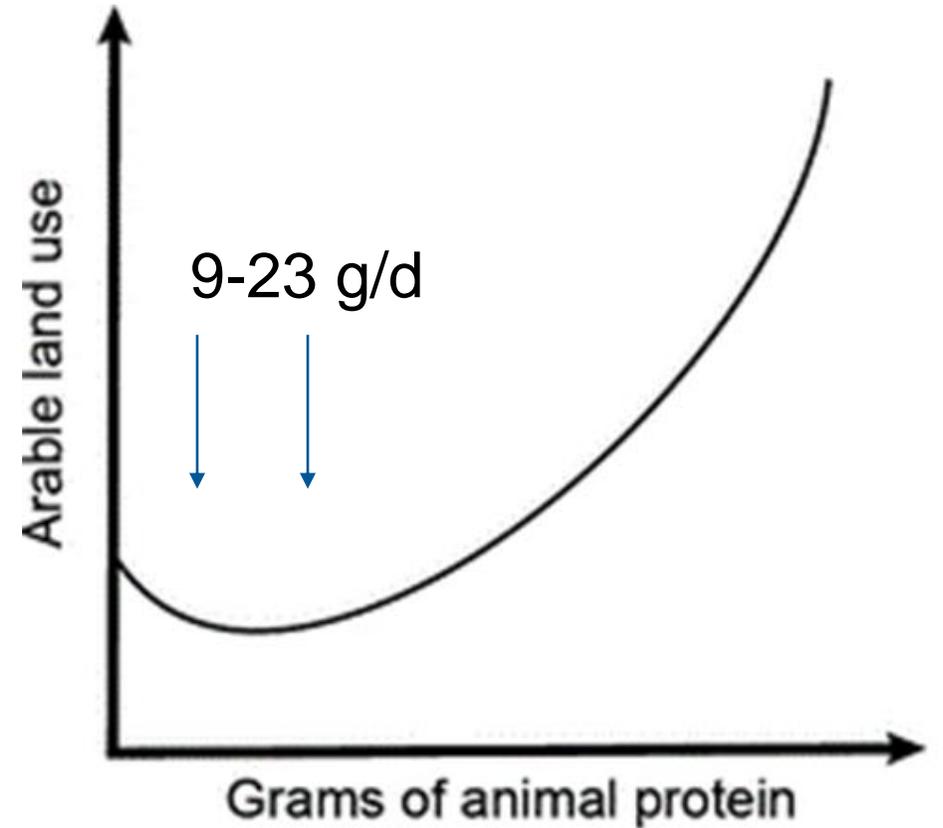
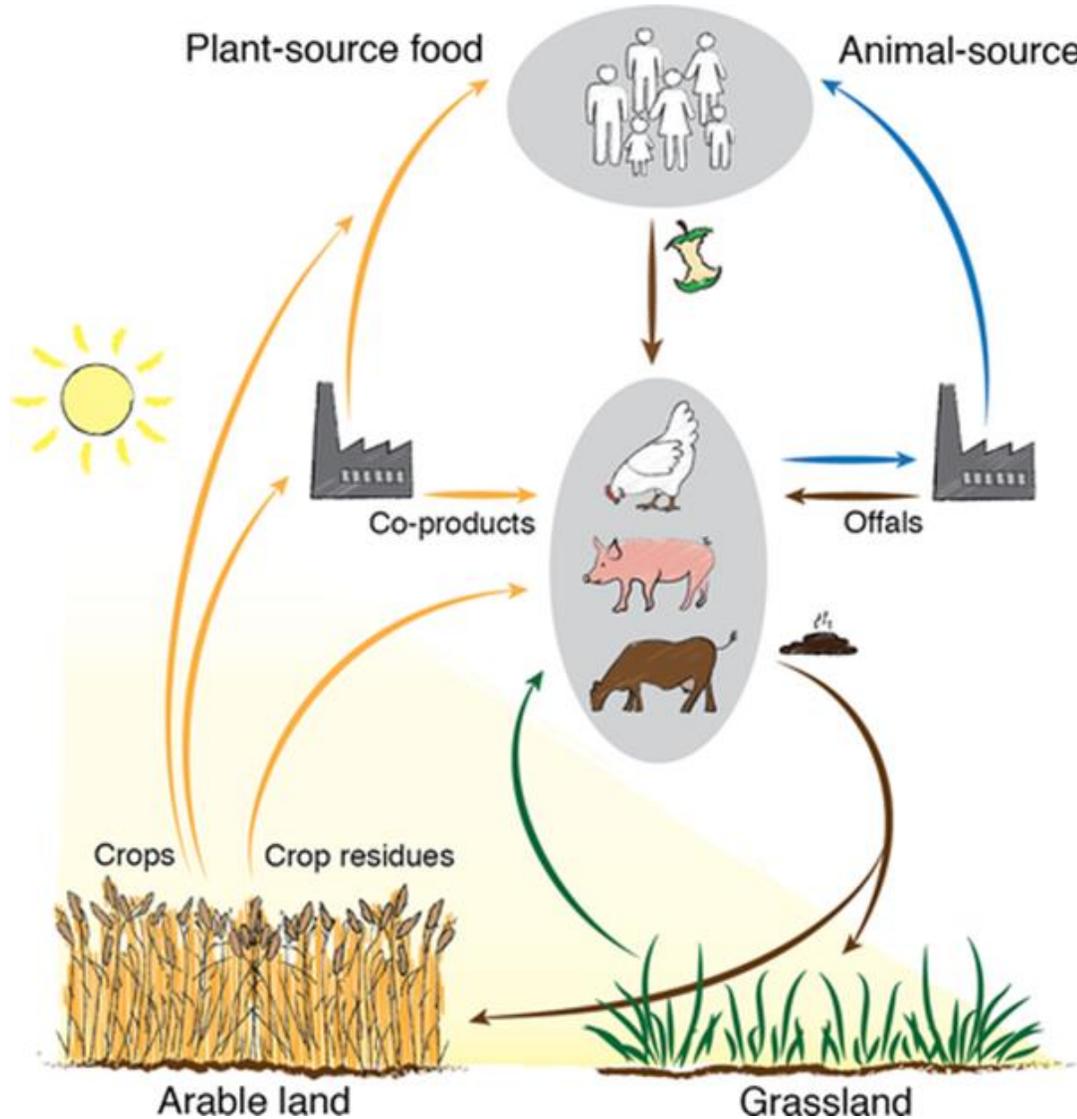


Defra stats 2010-2017

- 50% products, 50% co-products
- Cereals and soya meal main ingredients
- Poultry, pigs, dairy cows main species

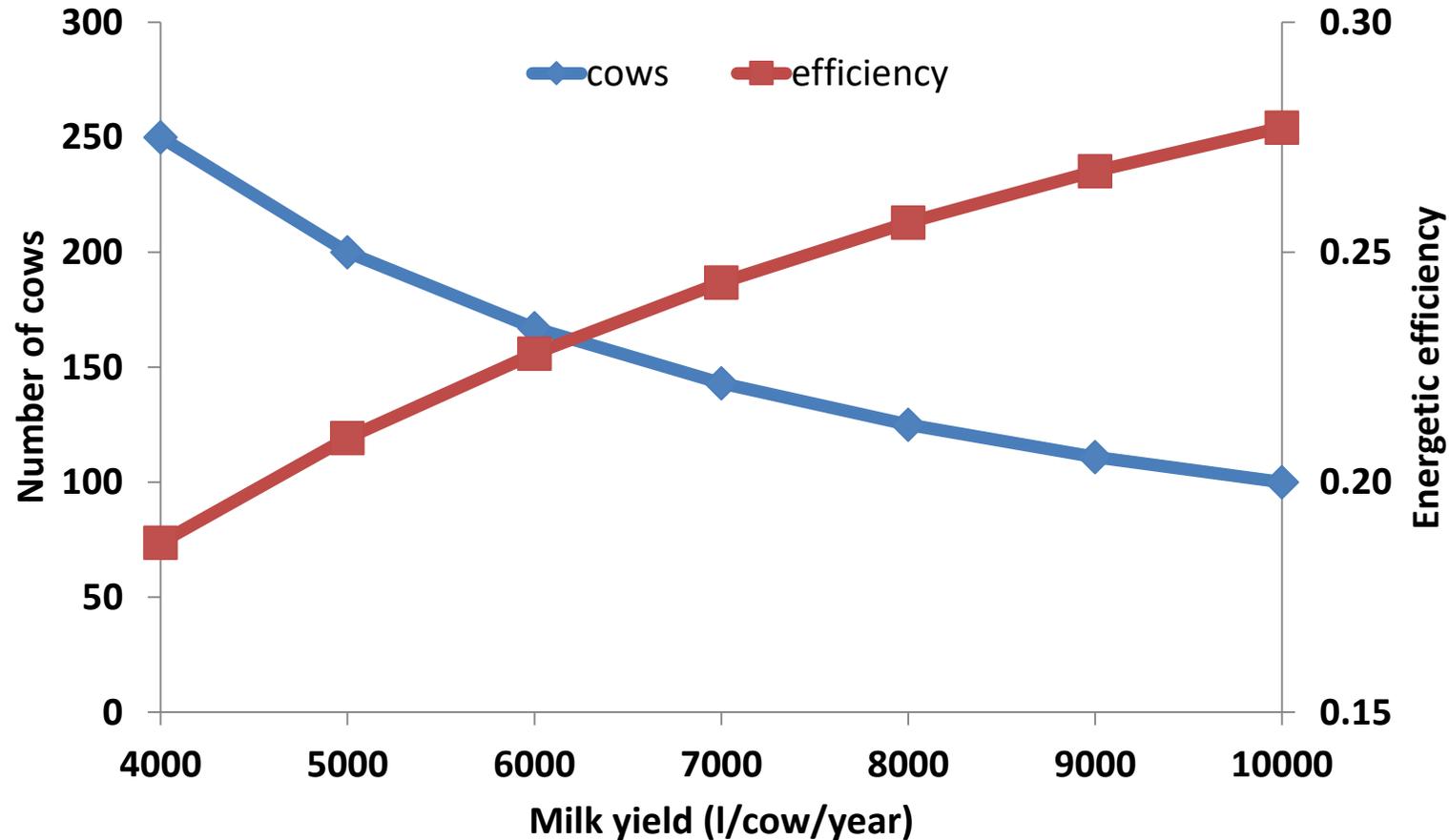


Feeding animals on grass and leftovers



Milk yield and efficiency of dairy herds

Milk yield and energetic efficiency (per million litres)



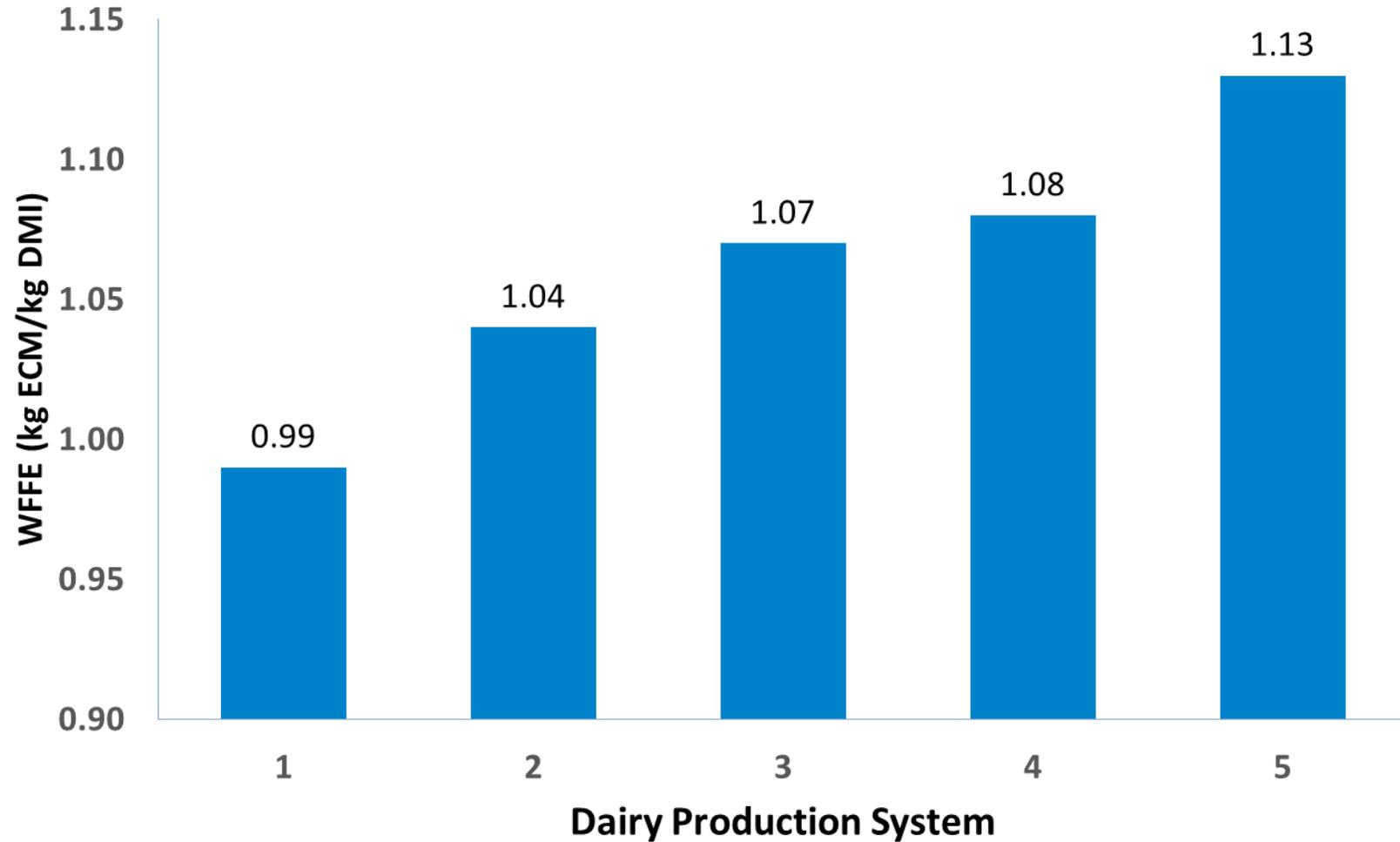
Whole farm feed efficiency - systems

Descriptor	Dairy Production System				
	1	2	3	4	5
Calving pattern	Spring	Block / All year	Block / All year	All year	All year
Grazing days	> 274 days	183 to 274 days	91 to 182 days	0 to 90 days	Housed
Feeding approach	Limited supplements	More use of supplements	Mixed ration supplements	Mostly mixed ration	All mixed ration





Whole farm feed efficiency



Grazing months

>9

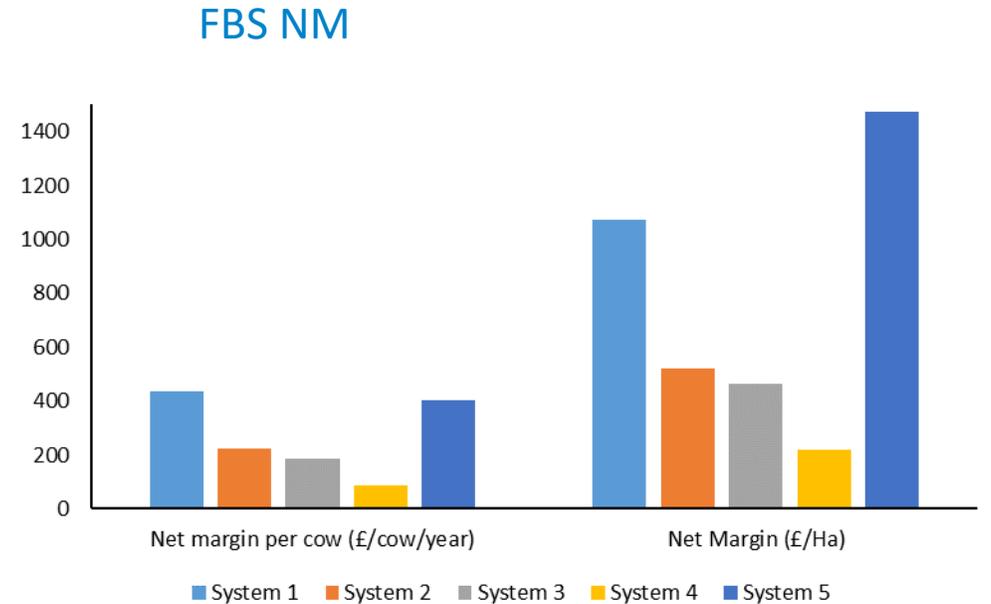
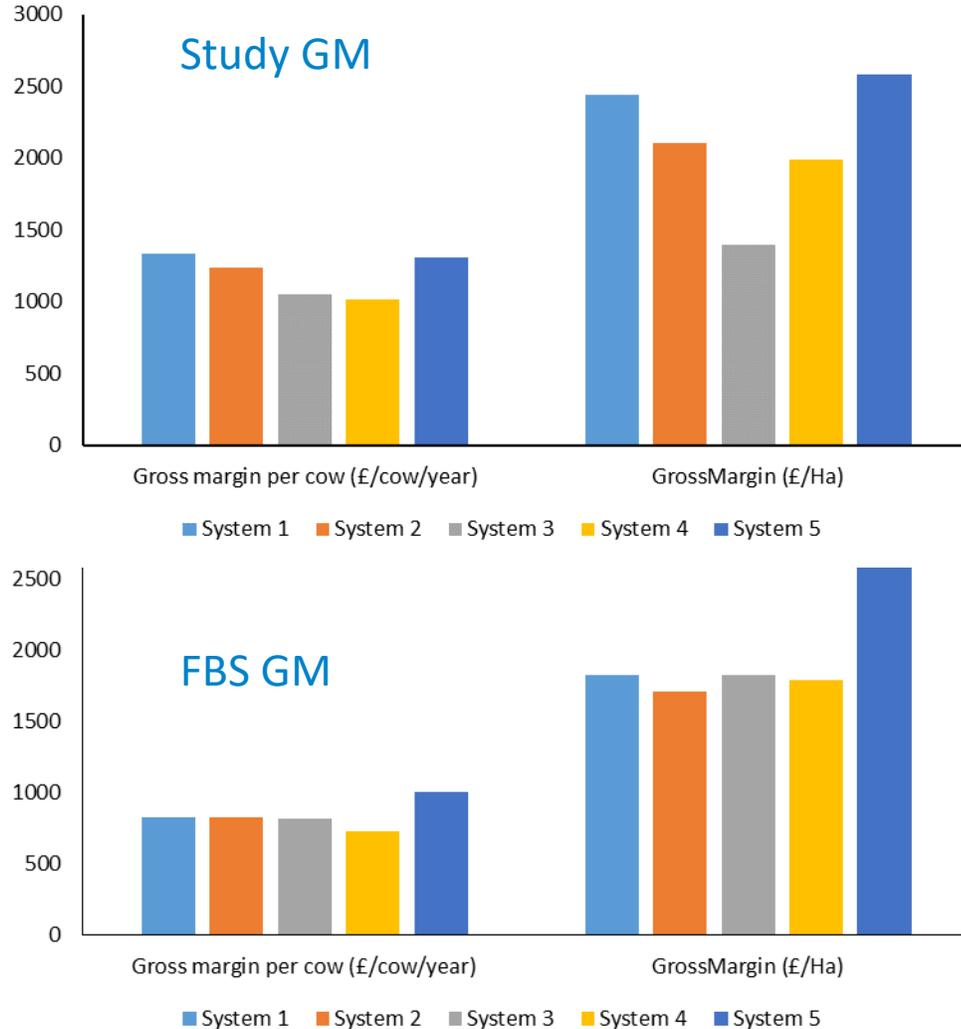
6-9

3-6

<3

0

Whole farm feed efficiency - margins



Reminder: Preliminary Data



Drivers of WFFE within systems

- Milk yield per hectare
- Stocking rate
- Grass and forage quality
- Proportion of feed for replacements

Number of replacements

Fertility culls

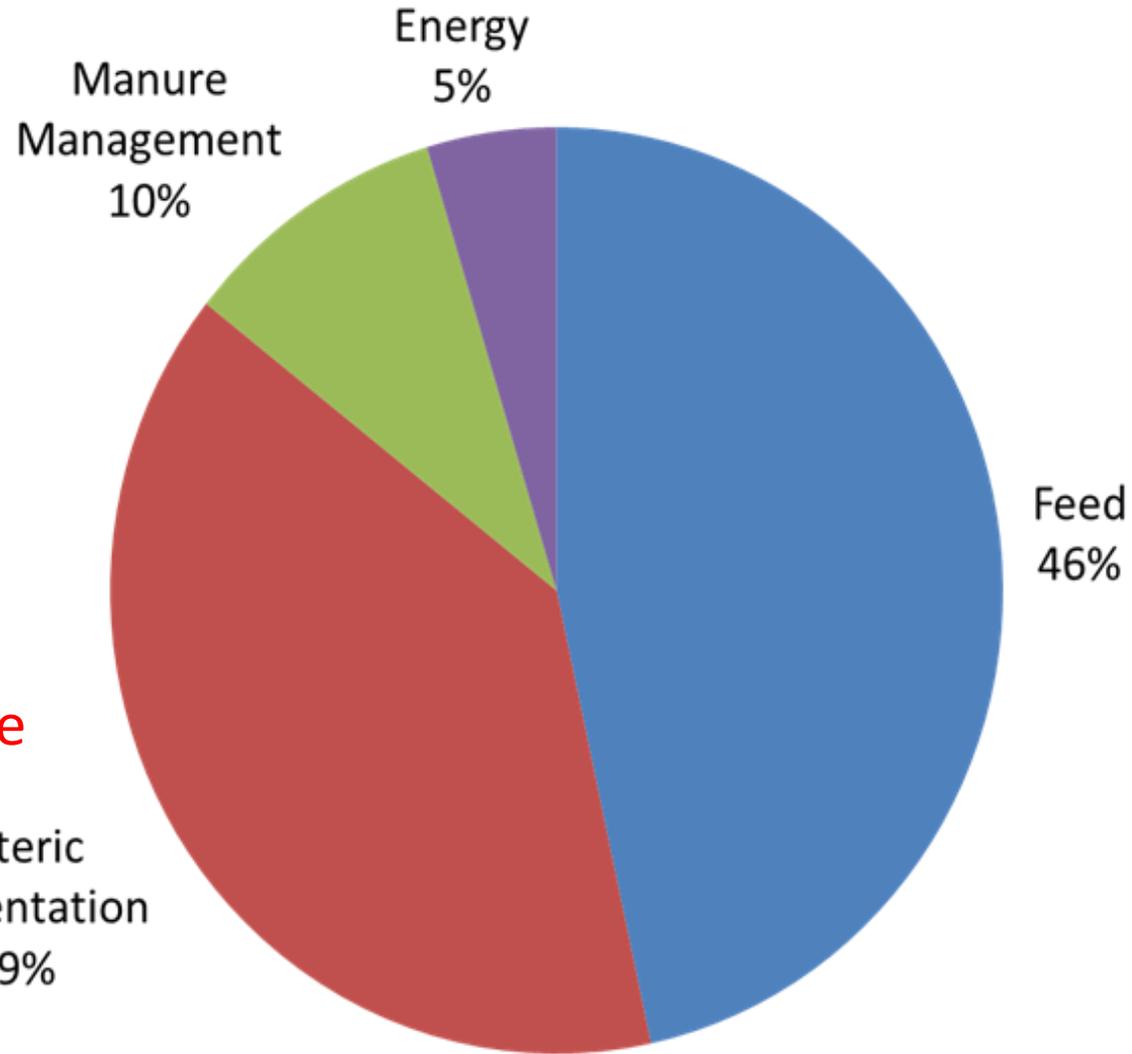
Health

Longevity

Factors are not independent

Neutral responses can mask interactions

Dairy GHG emissions



Feed Carbon Footprint

Rumen Methane





Feed Carbon Footprint

Feed CFP (g CO₂e/kg DM) of ingredients

	CFP	LUC	Total
Grazing	329	69	398
Grass silage	304	78	382
Maize silage	163	90	252
Wheat	424	165	589
Sugar beet pulp	322	0	322
Soya bean meal	633	437	1070
Rapeseed meal	534	166	700



FeedPrint Database:

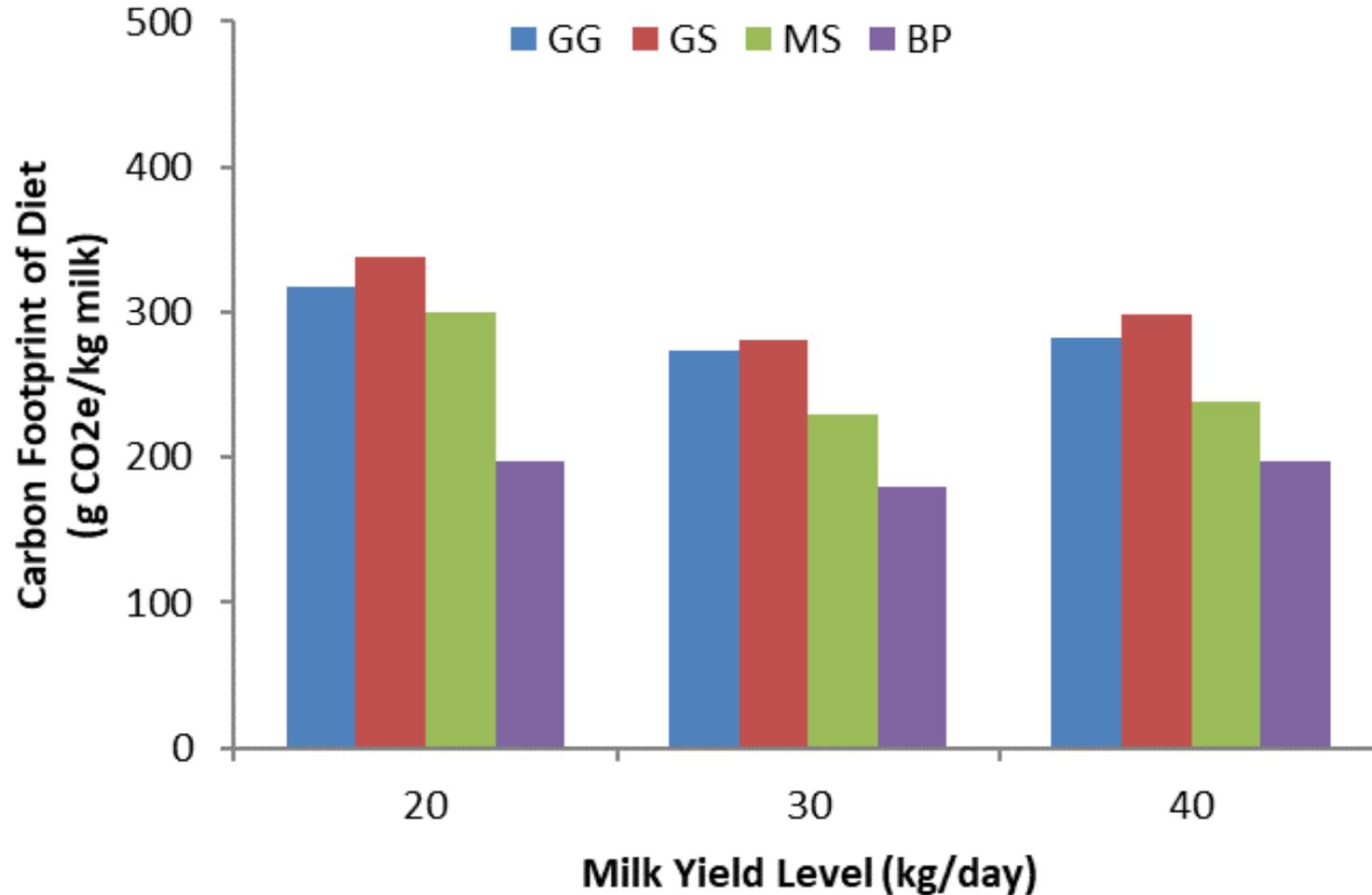
Vellinga et al. 2012

Wageningen UR

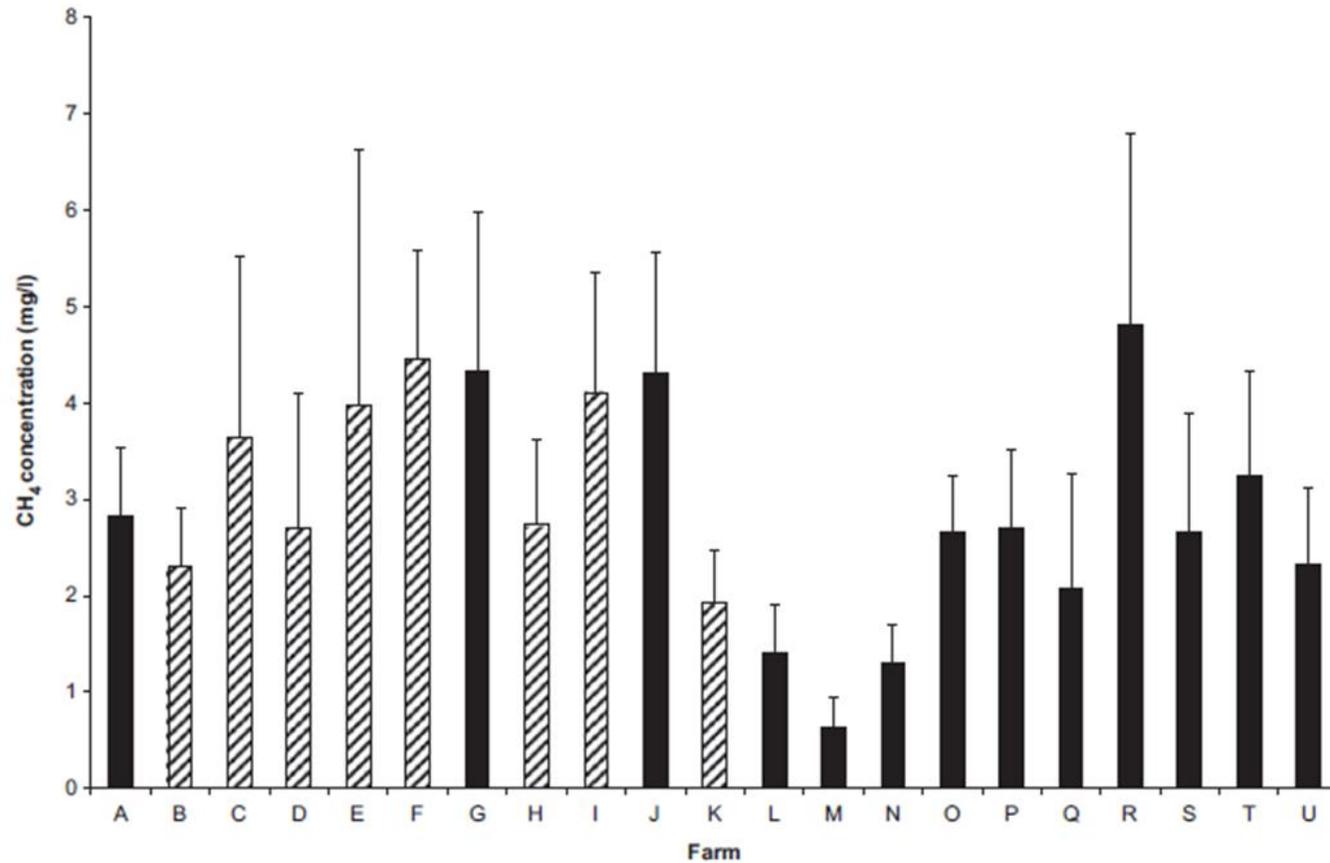
Wilkinson & Garnsworthy (2017) J Agric Sci 155, 334-347

Feed CFP of least-cost diets

Diets based on
Grazed Grass
Grass silage
Maize silage
By-products



Variation in methane on commercial dairy farms



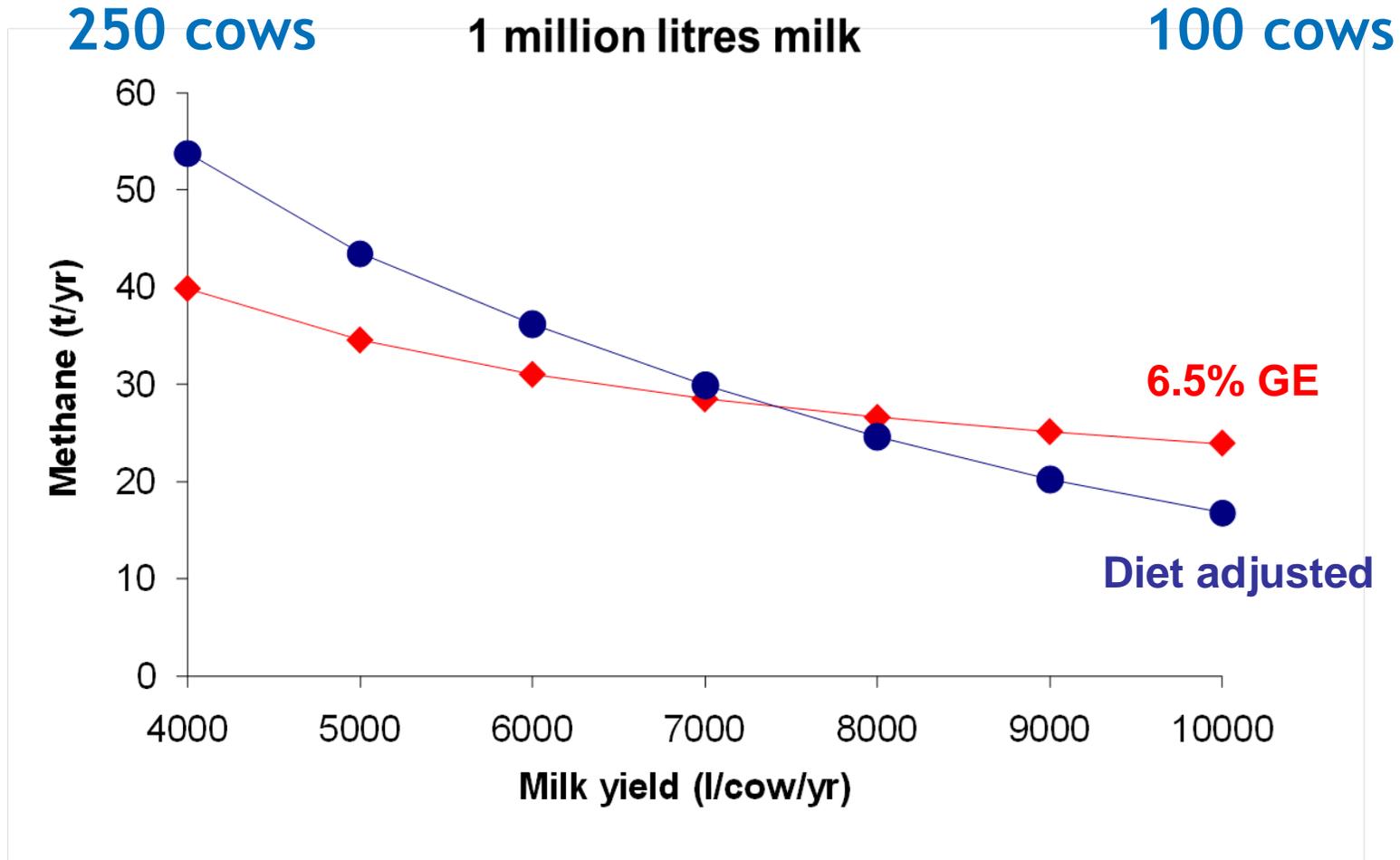
- 2,000 cows, 21 farms
- Variation between and within farms
- Due to diet, milk yield and individual cow



Silage type influences methane

	Silage type		
	Grass Early Cut	Grass Late Cut	Maize
DM Digestibility	0.76	0.72	0.71
DMI (kg/d)	17.6	16.0	16.9
EC milk yield (kg/d)	24.8	21.8	26.0
Rumen acetate %	61	60	55
Rumen propionate %	23	22	27
Methane (L/d)	539	542	495
Methane (L/kg DMI)	29	32	26
Methane (% GEI)	6.4	6.9	5.6

Methane and Milk Yield

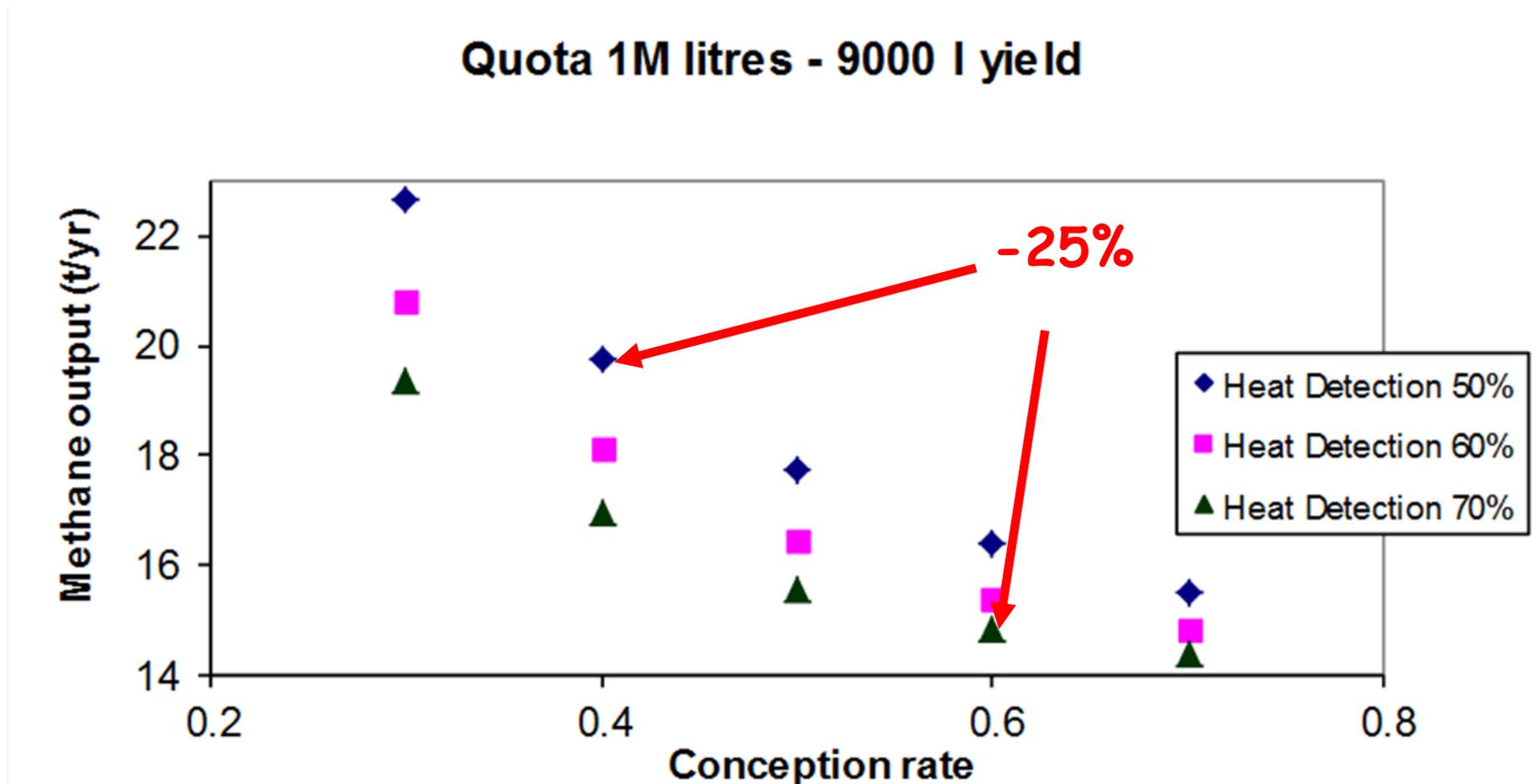


Higher milk yield reduces methane by diluting maintenance and needing fewer replacements

But, higher milk yield may reduce fertility, leading to more replacements

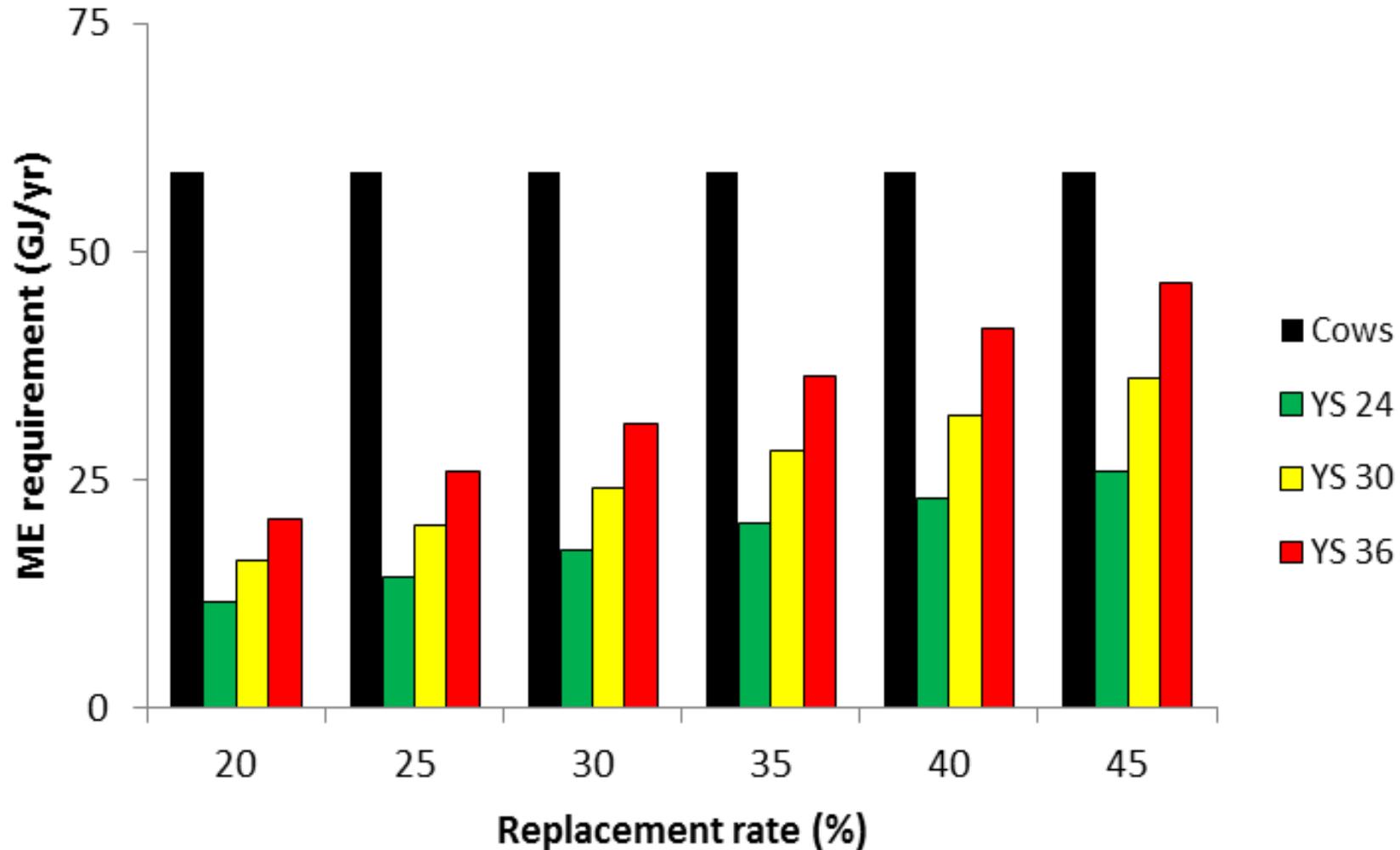


Fertility affects methane per herd



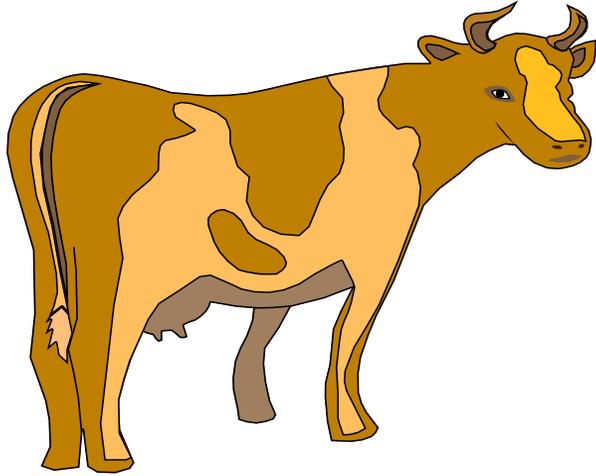


Replacement rate, age at first calving and energy requirements



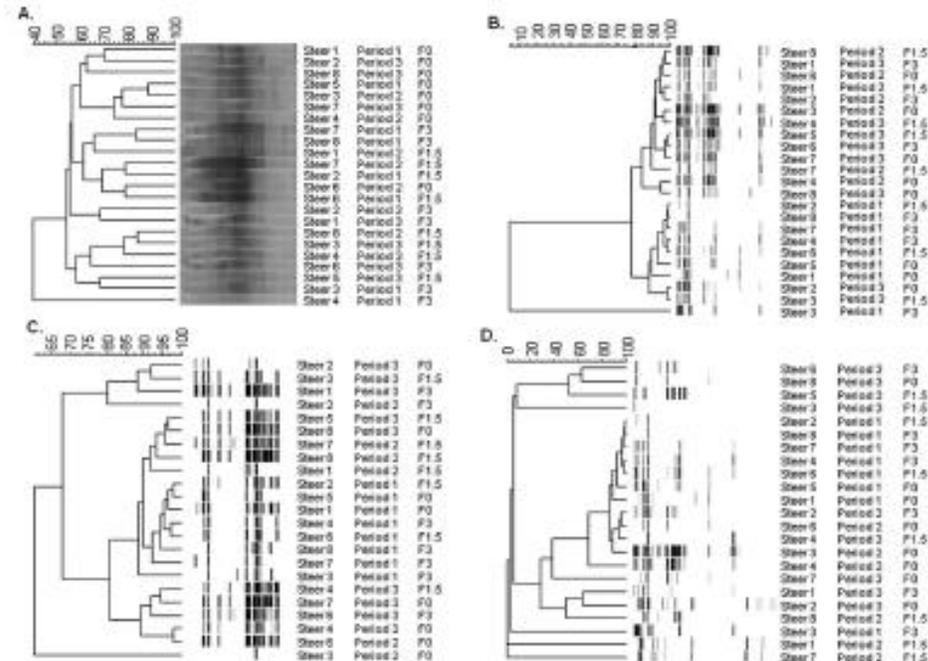
Feed energy required for heifers ranges from 16 to 44% of total feed energy for herd

Feed energy \equiv
Diet CFP
Methane
N excretion
P excretion
Profit



Measured CH₄ and sampled 1,000 cows

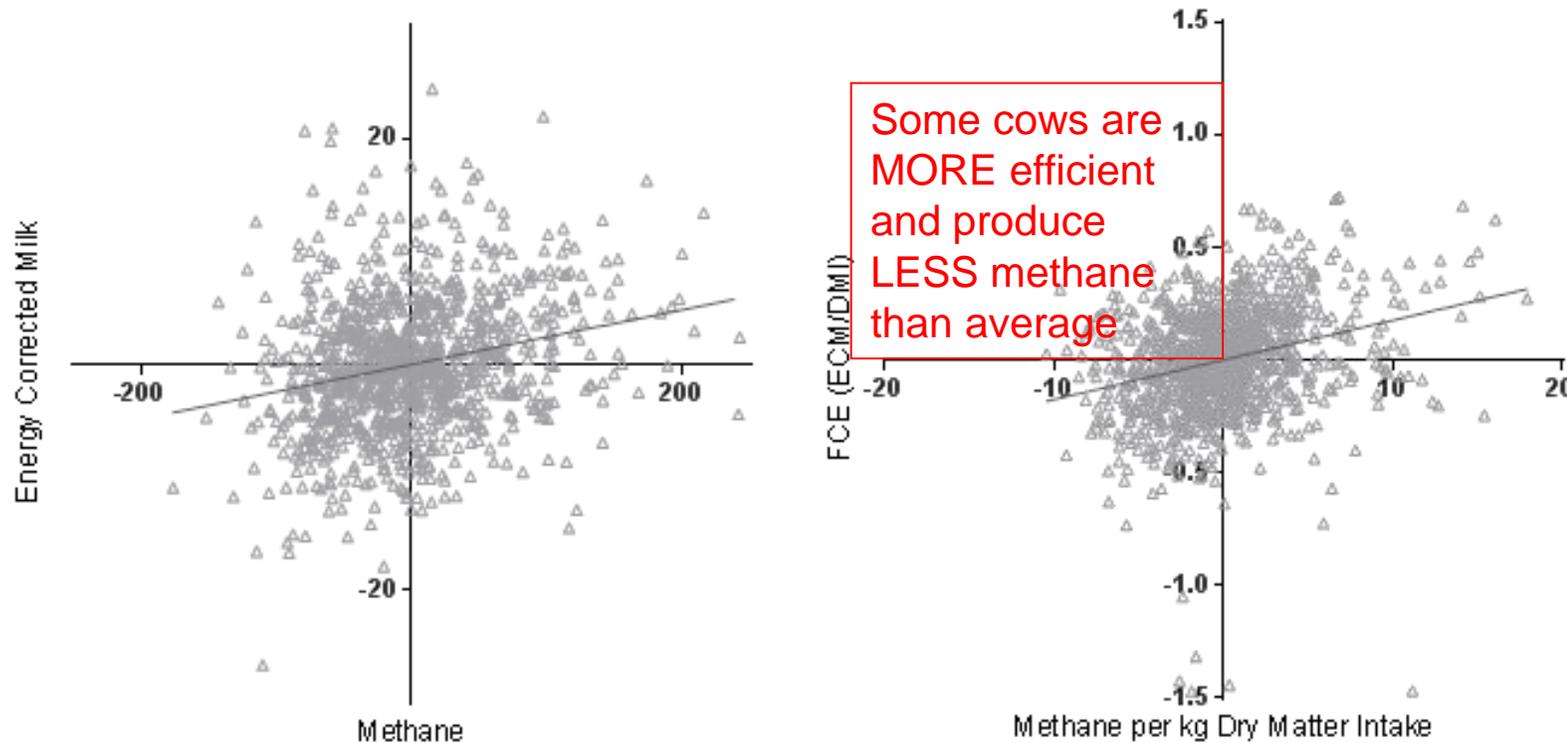
Linking the cow genome to the rumen microbiome, feed efficiency and impact





Should we breed for low methane?

Methane is related to milk yield and feed efficiency

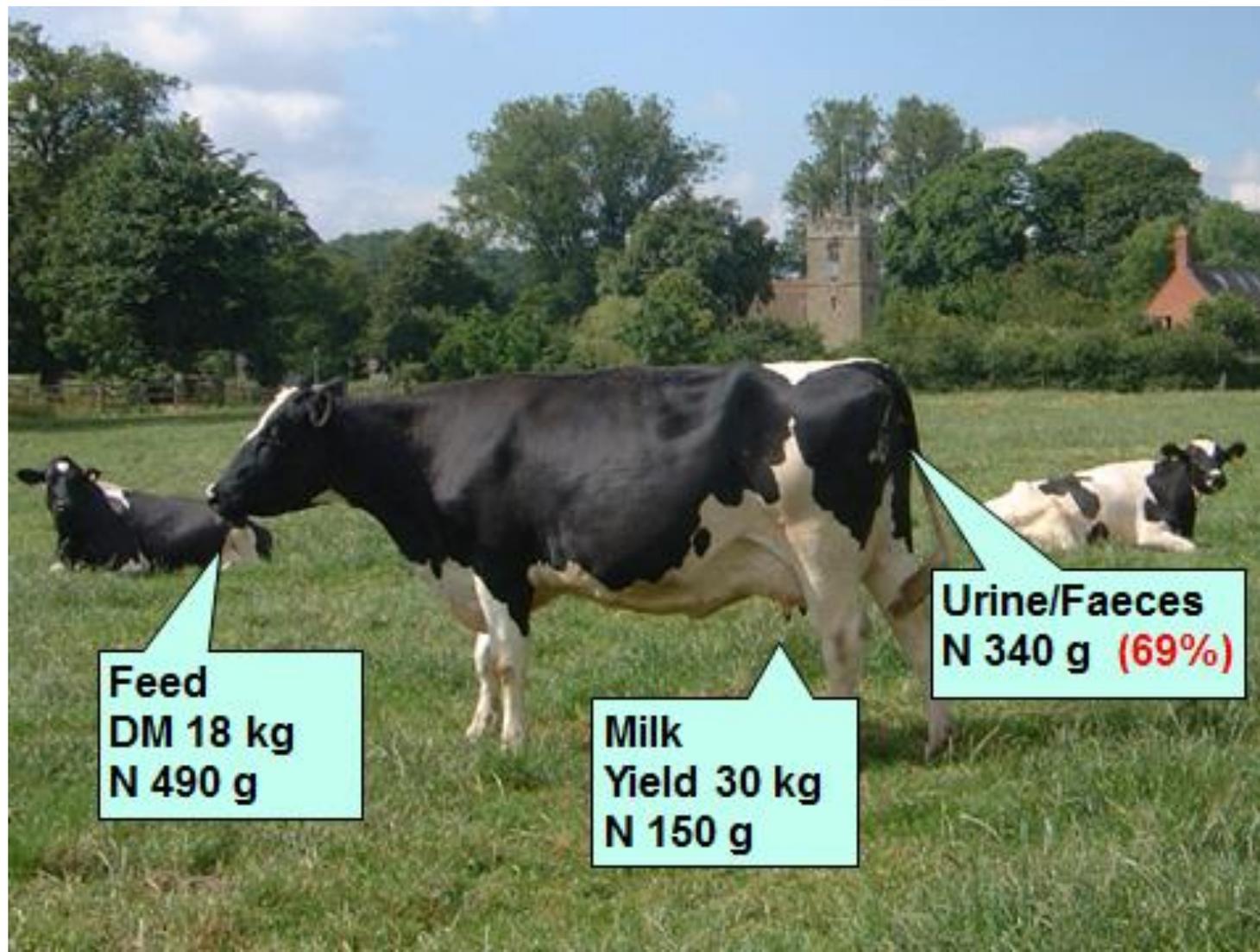


Reducing methane does NOT increase milk yield
High emitters generally digest forage more efficiently
Lower methane should not be the only breeding goal



Nitrogen excretion

Daily N Input & Output for an Average Dairy Cow





Protein Sources in Dairy Diets

g/kg DM	CP	dg	RDP	UDP	RDP:MCP
Grazed grass	214	0.72	154	60	1.7
Grass silage	135	0.74	100	35	1.2
Maize silage	87	0.70	61	26	0.6
Wheat	130	0.67	87	43	0.8
Beet Pulp	124	0.49	61	63	0.5
Soya meal	540	0.58	314	226	5.1
Rape meal	373	0.55	207	166	3.4
DDGS	348	0.60	208	140	2.6



Balancing rumen protein and carbohydrates reduces nitrogen excretion

Three diets for cows yielding 40 litres of milk per day
Based on grass and/or maize silages
Equal metabolisable energy and protein intakes

	Grass	Grass/Maize	Maize
ME (MJ/d)	268	268	268
MP (g/d)	2338	2325	2324
Starch % of DM	4	16	25
RDP:MCP ratio	2.07	1.49	1.00
N excretion (g/d)	577	-19% 469	-38% 357
N Efficiency (%)	25	30	37



Conclusions

To improve efficiency and lower environmental impact:

- Improve grass and forage quality
- Better utilisation of grass and forage
- Choose feeds with lower carbon footprint
- Maximise use of by-products
- Balance rumen fermentable carbohydrate and protein supply
- Increase stocking rate and/or milk per cow
- Manage feed to reduce wastage
- Maximise fertility & health to reduce animal wastage

- Yield, Efficiency, Emissions, and Profit are all linked

Thank you for your attention

