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# Achieving economic and socially sustainable climate-smart farming

Eileen Wall

SRUC, Edinburgh and ClimateXChange

# Ruminant animal methane emissions vs system (food chain) GHG emissions

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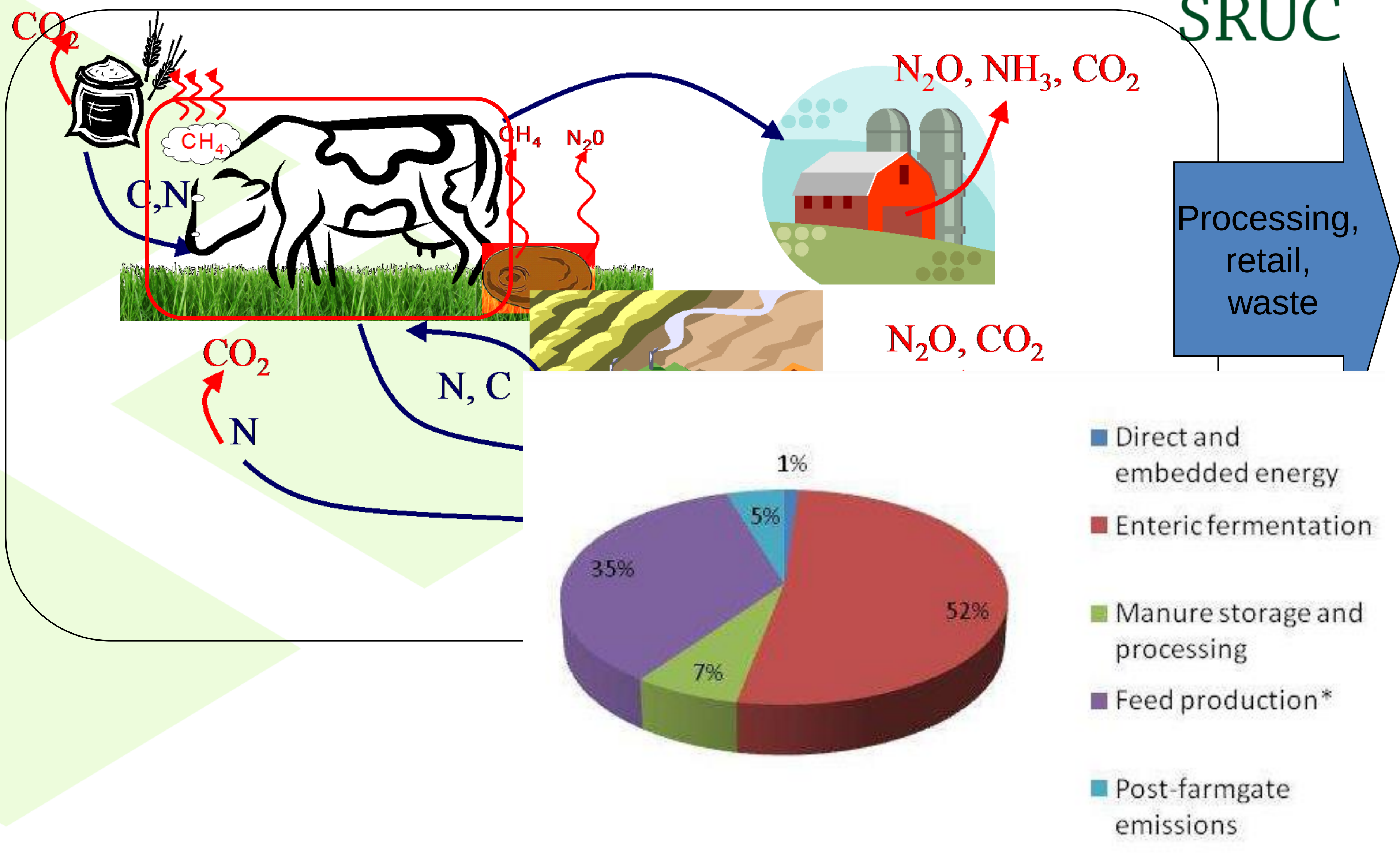
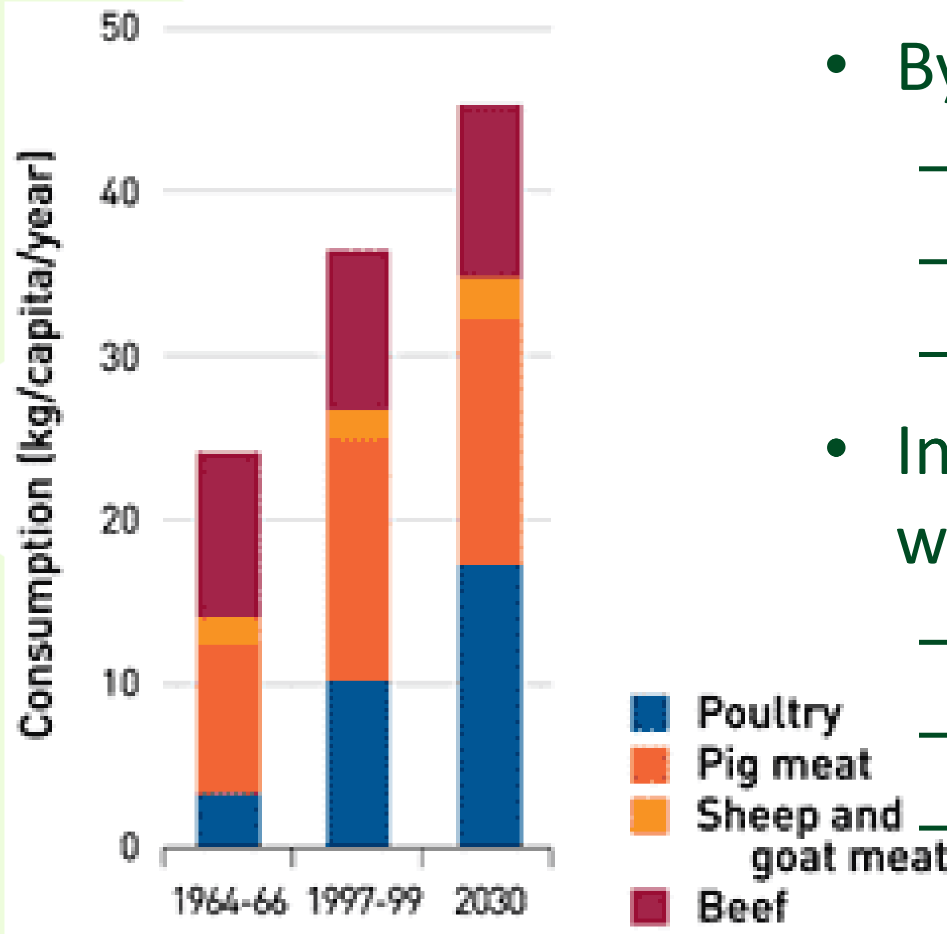


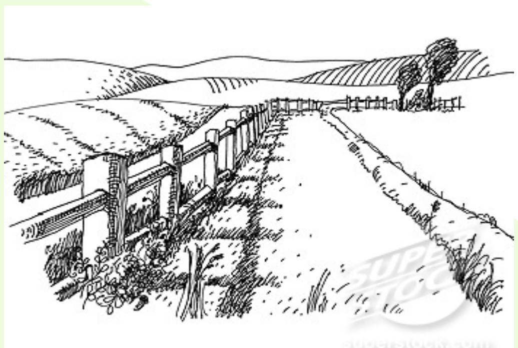
# Consumption patterns and demand for livestock



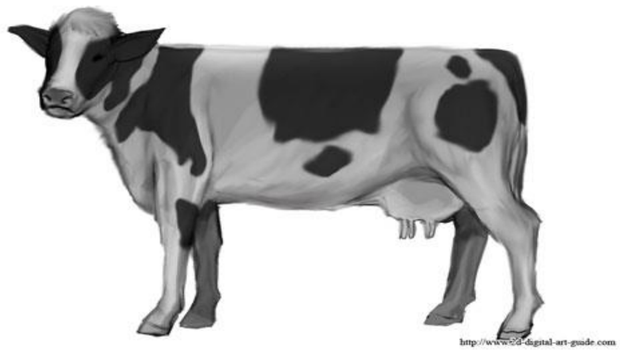

- By 2030 more:
  - 360m cattle & buffaloes[24%]
  - 560m sheep & goats[32%]
  - 190m pigs[22%]
- Increasing productivity is the way to go
  - Developing vs Developed
  - 163 vs 284 kg beef
  - 1.1 vs 5.9 tonnes/yr milk

# Mitigation options for ruminant systems

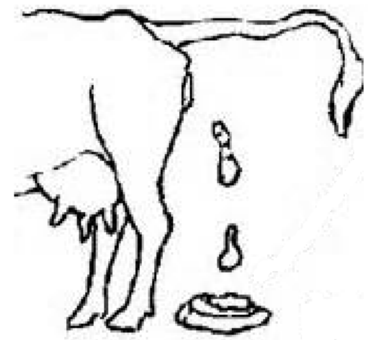
## Within the farm gate:



Crops and grassland:
$N_2O$, $CH_4$, Soil carbon




Animal:
$CH_4$



Manure/slurry:
$N_2O$, $CH_4$

Grazing management: reduced stocking rate, no grazing

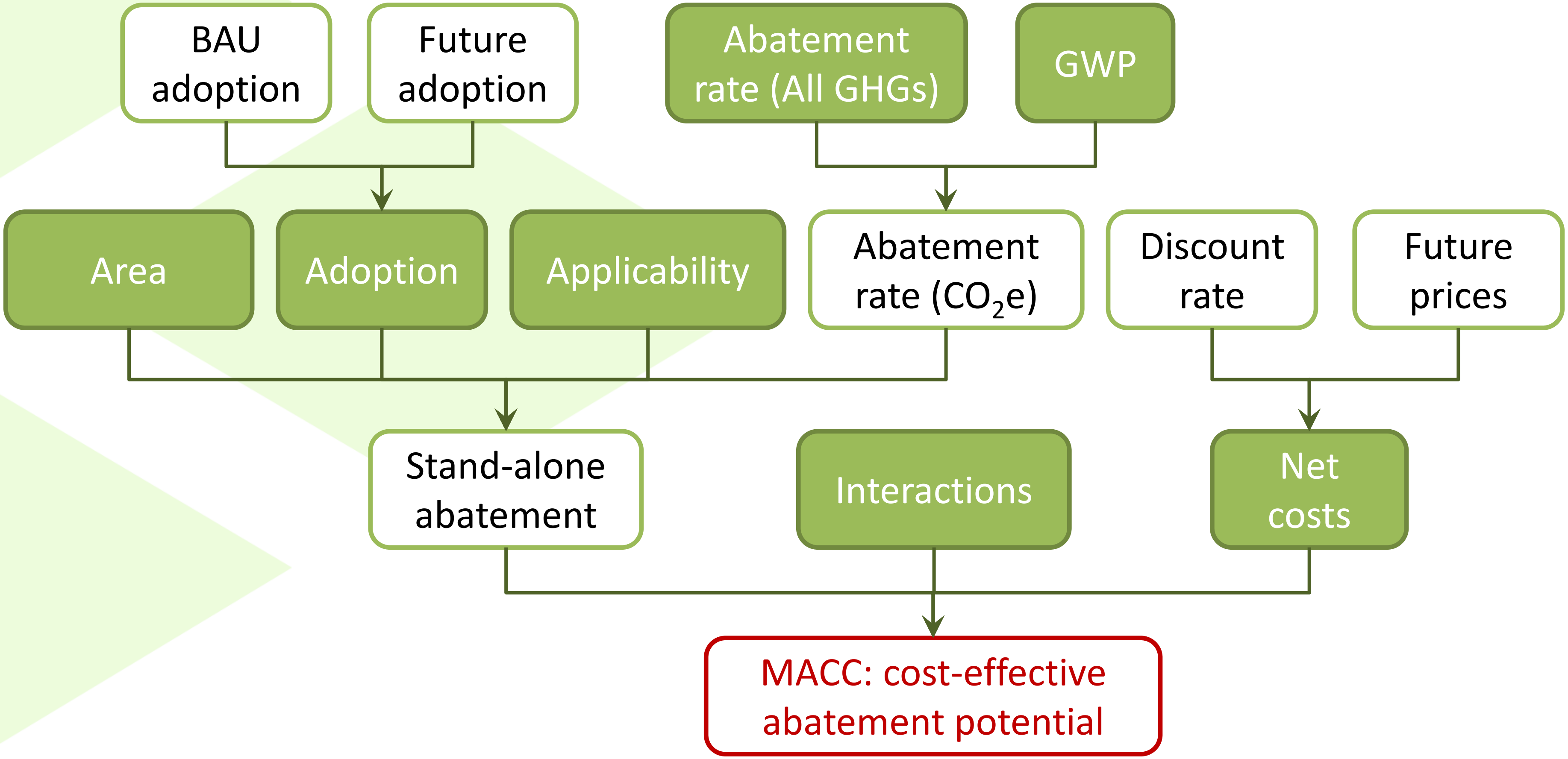
Crop management: Cover crops, optimal fertilisation, reduced tillage

Feed additives (e.g., probiotics, lipids, tannins..); changes to diets

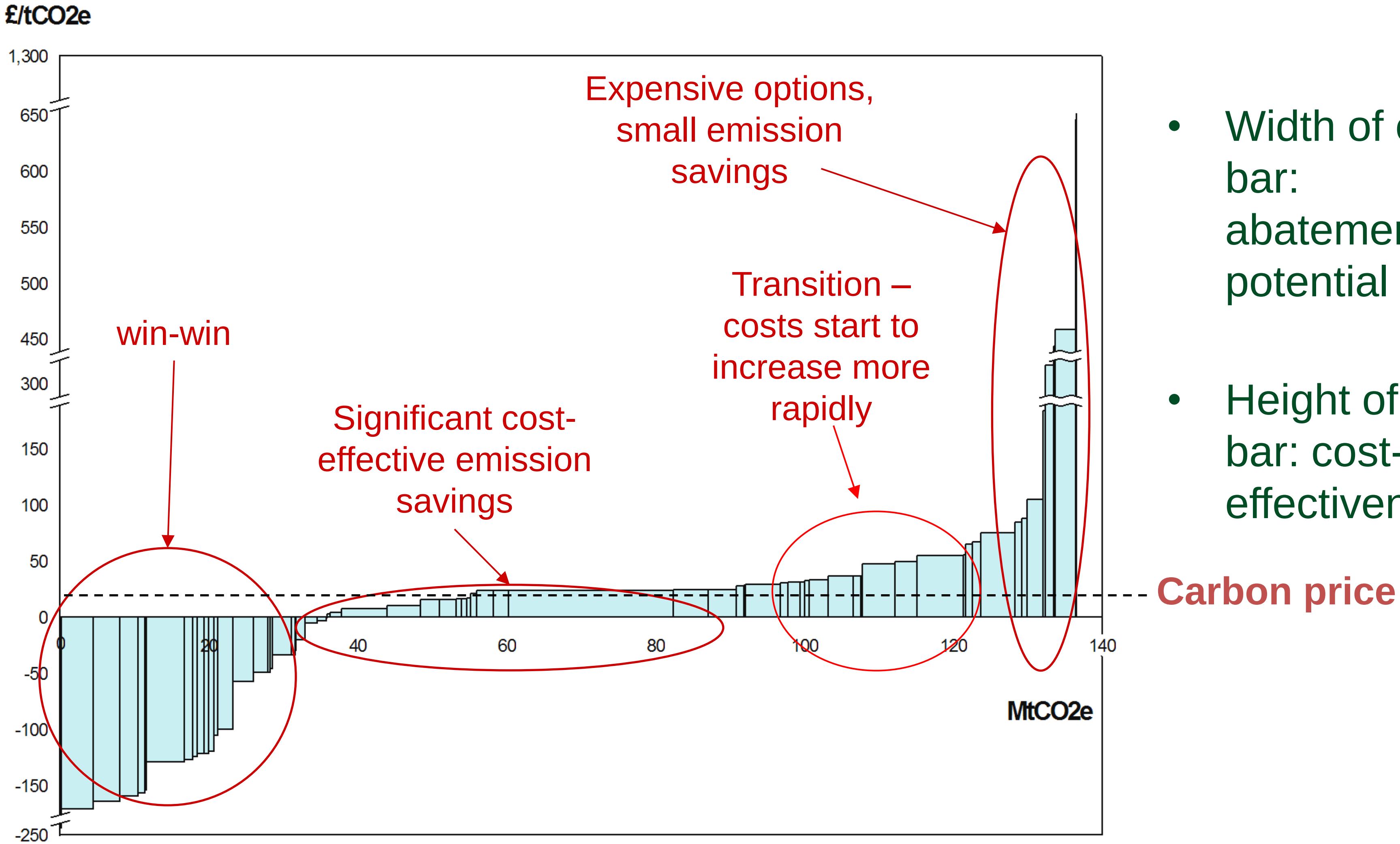
Genetic Improvement: production, system and feed efficiency in beef and dairy

Manure management: anaerobic digestion; slurry management

# What information do we need to examine mitigation potential

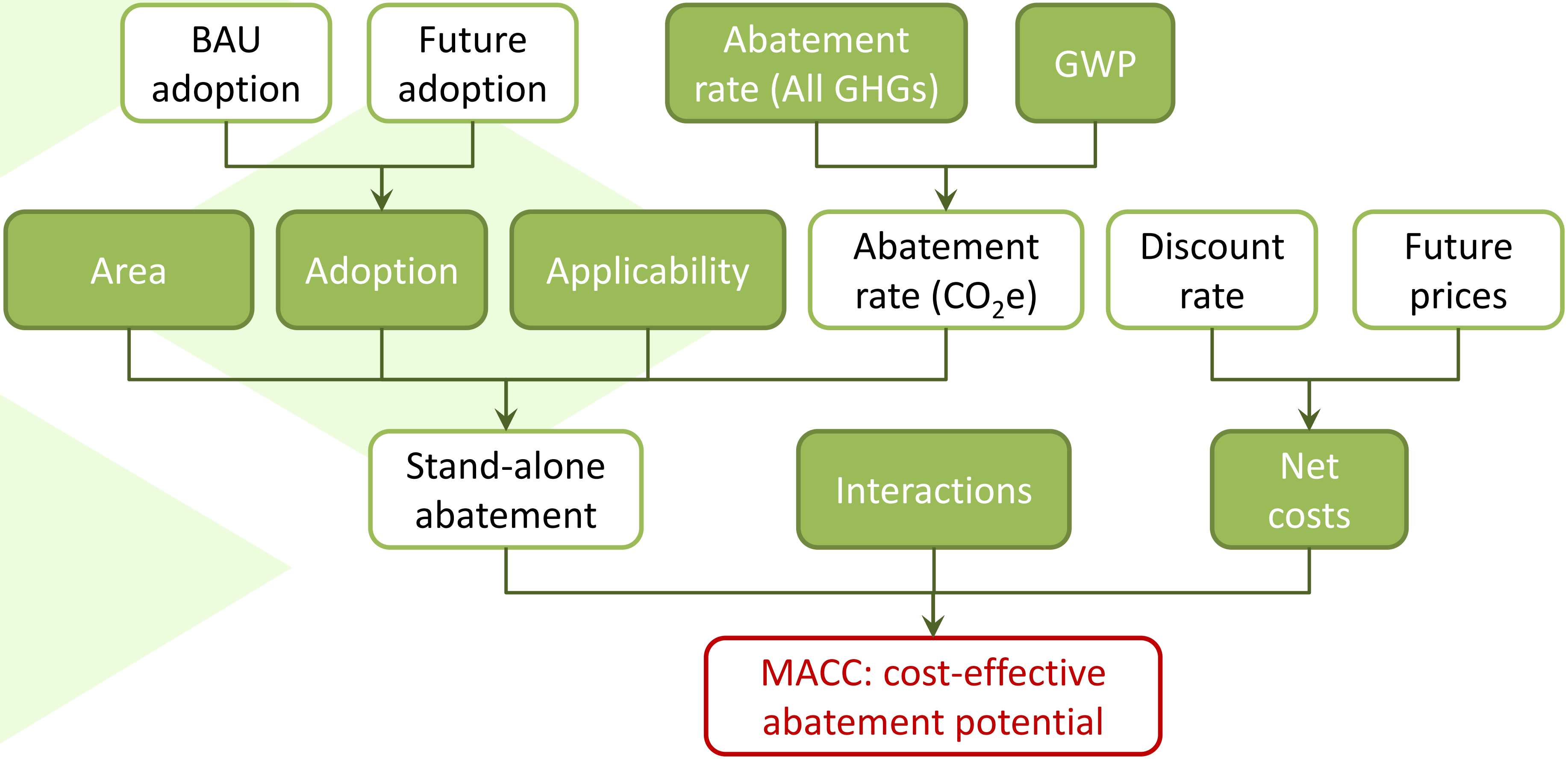


# Marginal Abatement Cost Curves




- Width of each bar: abatement potential
- Height of each bar: cost-effectiveness

# What information do we need to examine mitigation potential of GENETICS



# What information do we need to examine mitigation potential of GENETICS

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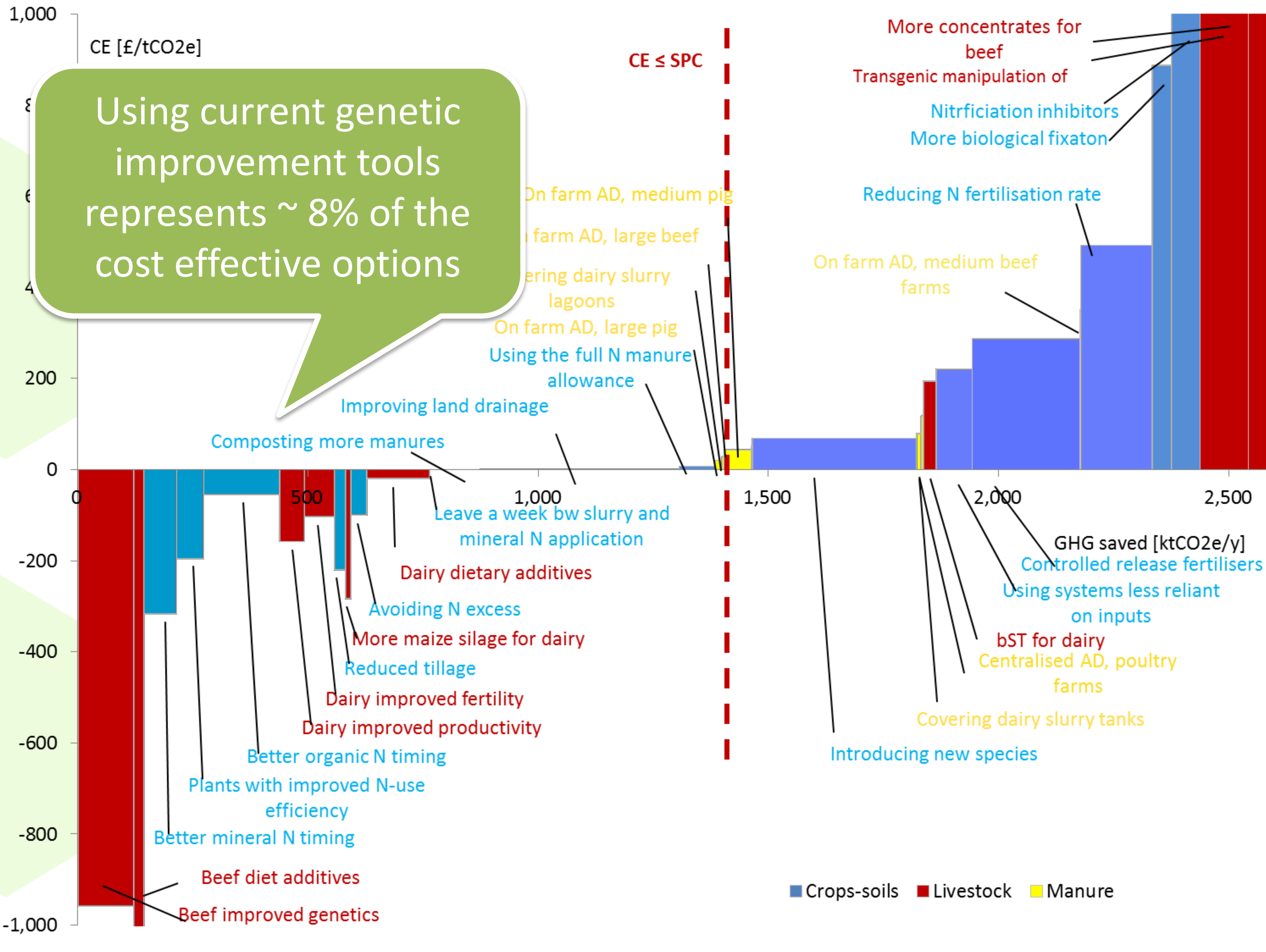
| | Dairy | Beef |
|---|---|---|
| Business as usual | Widespread uptake of national breeding goal genetic improvement | Low penetration of genetic improved stock into production population |
| Mitigation tools | 1. System efficiency<br>2. Environmental efficiency<br>3. Genomics | 1. Increase penetration rate<br>2. Improve accuracy of selection<br>3. Select for feed efficiency<br>4. Genomics |
| Area and applicability | All dairy farms | Increasing proportions of national beef |
| Abatement rates | • Expected change in population based on different breeding goals, traits and genomics estimated (selection index theory)<br>• Impact on system wide GHG calculated using IPCC and PAS2050 Carbon Calculator | |
| Mitigation option costs | Development of new systems of recording and genetic improvement, trade-offs from moving away from economic optimum | |
| Mitigation benefits | Profitability within a farm - Estimated per unit product and total emissions | |

# Expected responses for different breeding goals in dairy

| | ⇩ GHG | ⇧ System Efficiency |
|---|---|---|
| Economic (£/cow/yr) | ⇧3.21 | ⇧6.80 |
| GHG (kg CO2e/cow) | ⇩64.1 | ⇩45.3 |

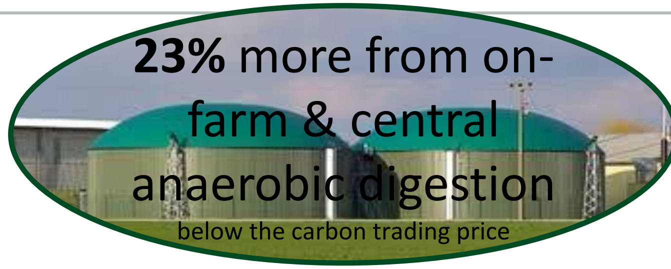
- Both options make money and reduce GHGs
  - Selecting for maximum GHG savings reduces profitability but increases GHG savings
    - unfavourable relationship of cow fitness
  - System efficiency (improving survival/fertility) but lower GHG savings

Wall et al, 2010. *Animal*, 4, 366-376

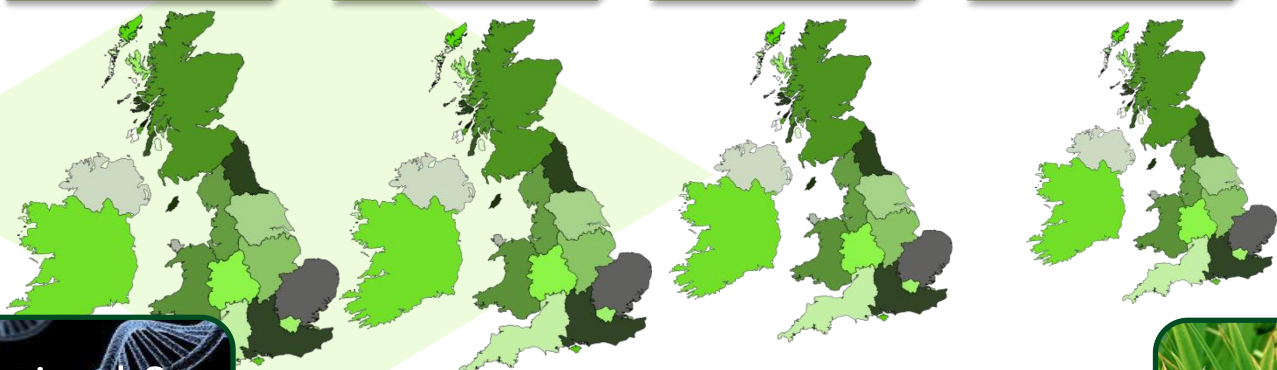


Using current genetic improvement tools represents ~ 8% of the cost effective options
CE [£/tCO2e]
CE ≤ SPC
GHG saved [ktCO2e/y]
More concentrates for beef
Transgenic manipulation of
Nitrficiation inhibitors
More biological fixaton
On farm AD, medium pig
farm AD, large beef
ering dairy slurry lagoons
On farm AD, large pig
Using the full N manure allowance
Improving land drainage
Composting more manures
Reducing N fertilisation rate
On farm AD, medium beef farms
Leave a week bw slurry and mineral N application
Dairy dietary additives
Avoiding N excess
More maize silage for dairy
Reduced tillage
Dairy improved fertility
Dairy improved productivity
Better organic N timing
Plants with improved N-use efficiency
Better mineral N timing
Beef diet additives
Beef improved genetics
Controlled release fertilisers
Using systems less reliant on inputs
bST for dairy
Centralised AD, poultry farms
Covering dairy slurry tanks
Introducing new species
Crops-soils
Livestock
Manure

# GHG mitigation for UK agriculture




2005 = 24.25 $MtCO_2eq$ → 2012 ↓6% → 2017 ↓15% → 2022 ↓25%





**59%** is cost-effective

(£1.3 mill/ $MtCO_2eq$ mitigated)



Wall et al, 2010. *Animal*, 4, 366-376
MacLeod et al, 2011. *Agricultural Systems* 103, 198-209
Moran & Wall, 2011. *Animal Frontiers* 1, 19-25
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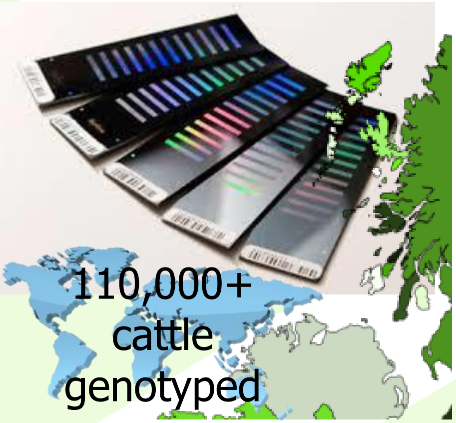
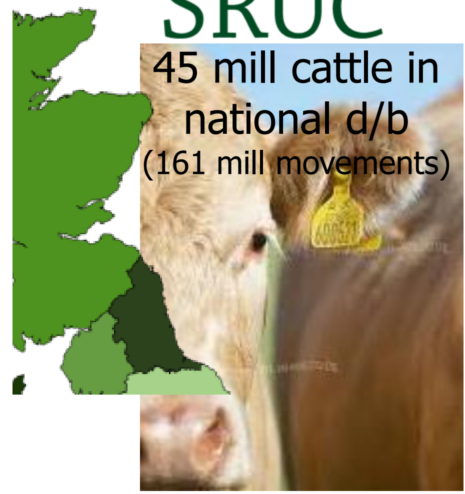
# Step changes in beef genetic improvement



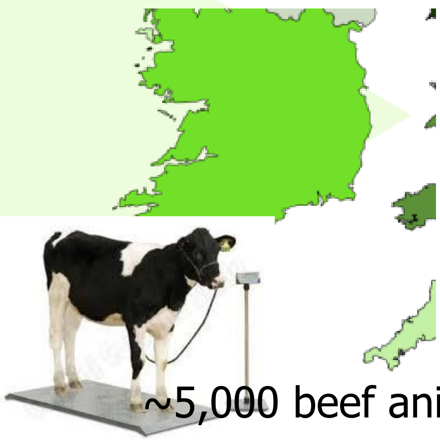



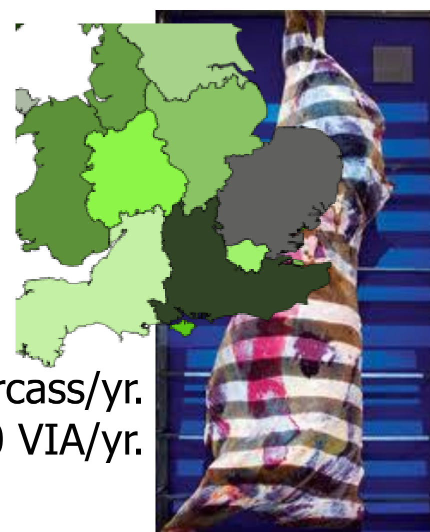

Increases the accuracy of the selection decision
(55 > 86% in beef)

75% ↑ in farm profitability
(£54 million to beef farmers)

Release land for ecosystems services?
(1.5% of beef grazing)

73% more ↓ in $CO_2$ emissions from beef
(1.25 Mt $CO_2$ eq from beef)




Moore et al, WCGALP, 2014.

# Value of adding genomics

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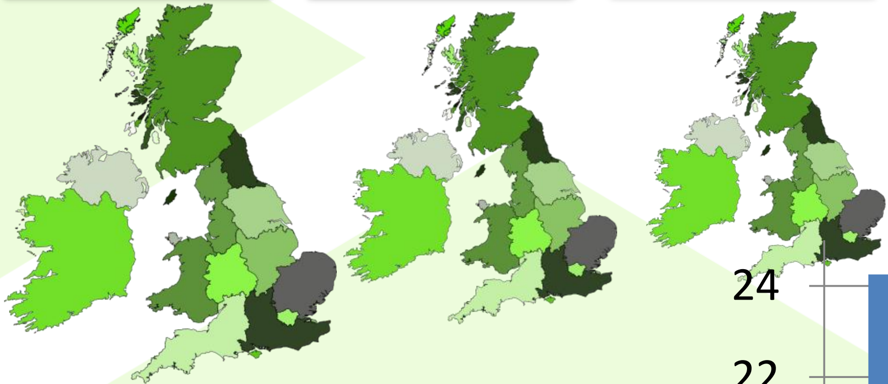
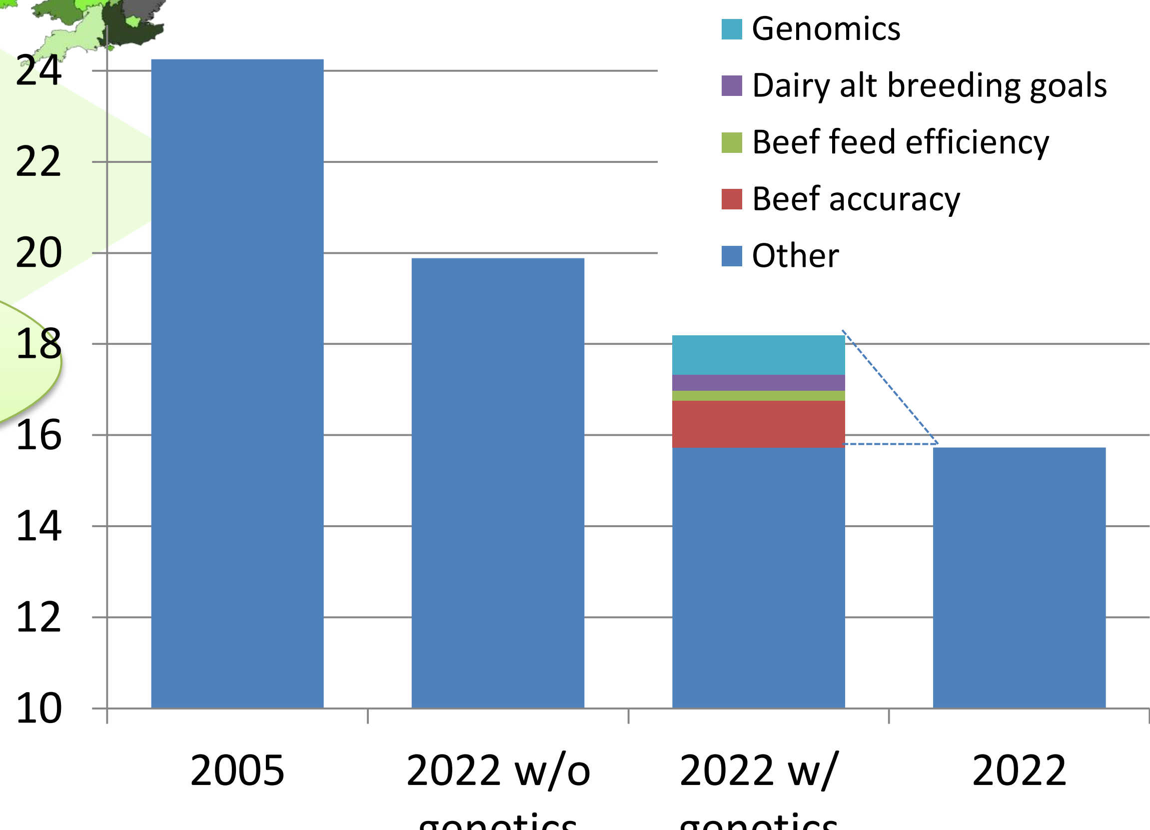
- Adding genomic information to beef improves current economic response
  - 14 - 21% improvement
- Adding novel traits to goal (target for genomics) improves it further
  - 29 - 45% across beef breeds
- Large training populations for novel traits
  - Including feed efficiency!
- The value propsition for genotyping to cover the range of breeds and systems

# GHG mitigation potential from genetics

**2005 = 24.25 $MtCO_2eq$** → **2022 ↓25%** → **2022 ↓32%**

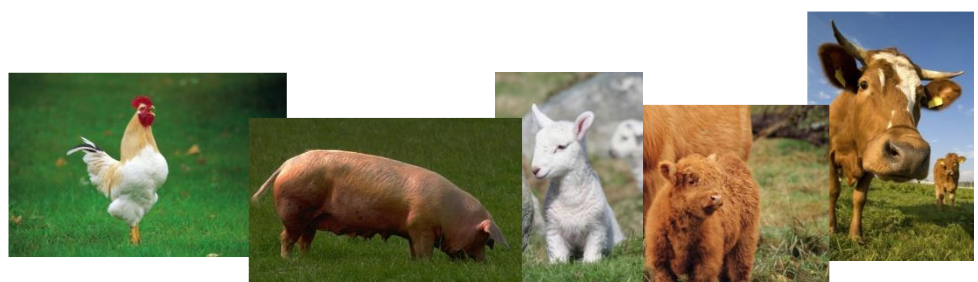


**70%** is cost-effective
(£1.25 mill/ $MtCO_2eq$ mitigated)



# GHG Summary – Genetic Improvement

- Genetic improvement , manure mgmt and nutrition are the main cost-effective options for the livestock sector that will reduce methane emissions
- Applying cost-effective livestock tools could reduce **UK agriculture** emissions by ~20% by the 2020s
  - Livestock genetics ~ 35%
- Increasing rates of genetic improvement in all efficiency sinks with known tools increases GHG savings by 1.45
  - Makes money for the industry (£1.25 mill/mt $CO_2$e)



# GHG mitigation for UK agriculture

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**23%** more from on-farm & central anaerobic digestion
below the carbon trading price

2005 = 24.25 $MtCO_2eq$ → 2012 ↓6% → 2017 ↓[illegible]% → 2022 ↓25%

EMISSIONS INTENSITY

**17%** > animal & plant breeding

**47%** > manure & nutrient mgmt

**59%** is cost-effective
(£1.3 mill/ $MtCO_2eq$ mitigated)

**19%** > ruminant nutrition options

**15%** > afforestation

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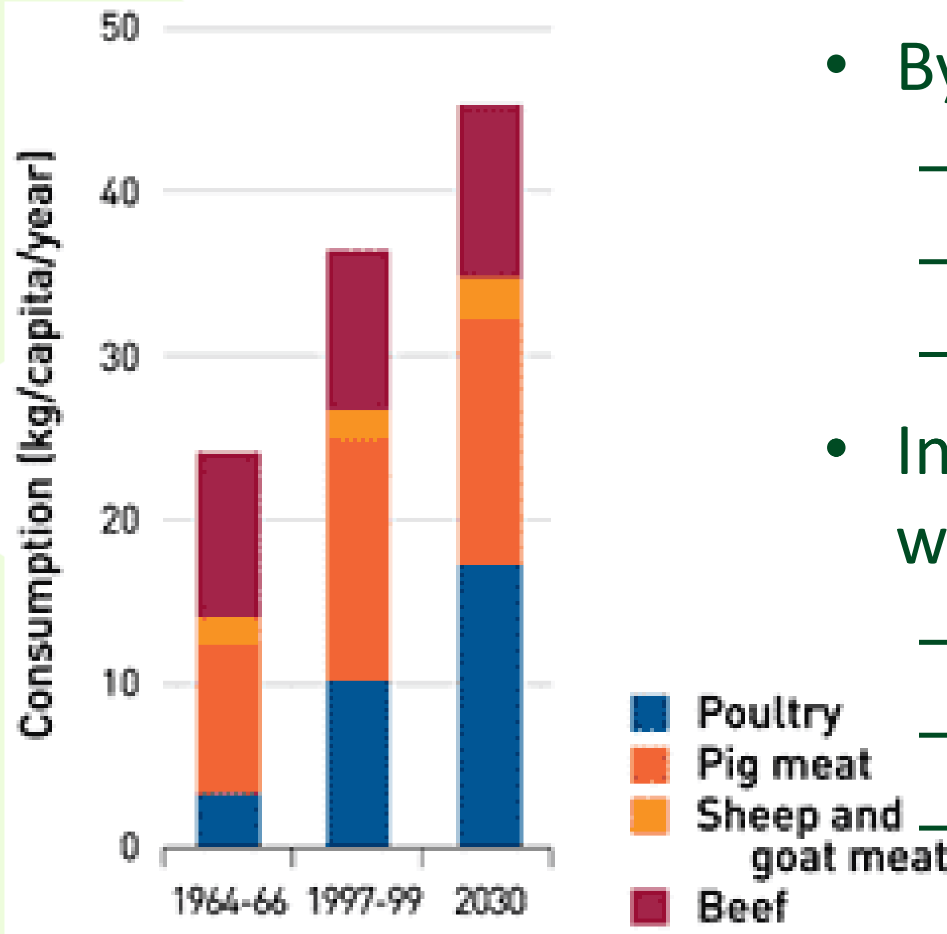


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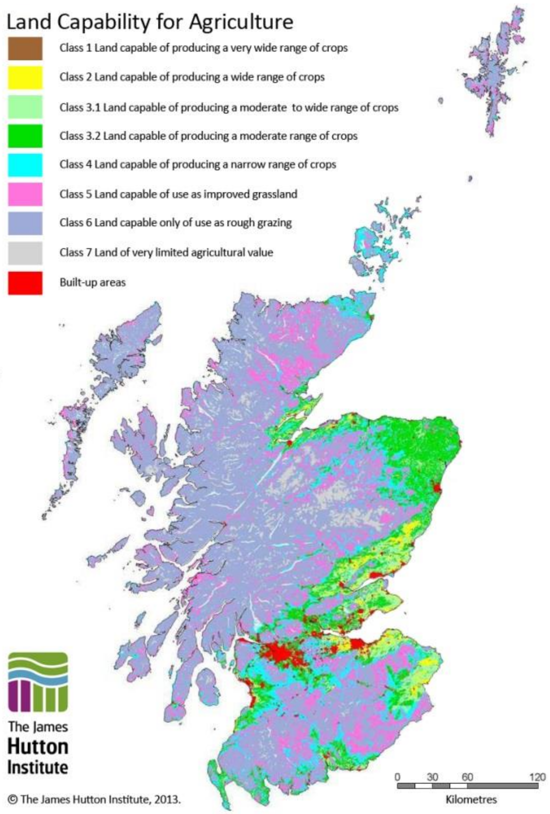
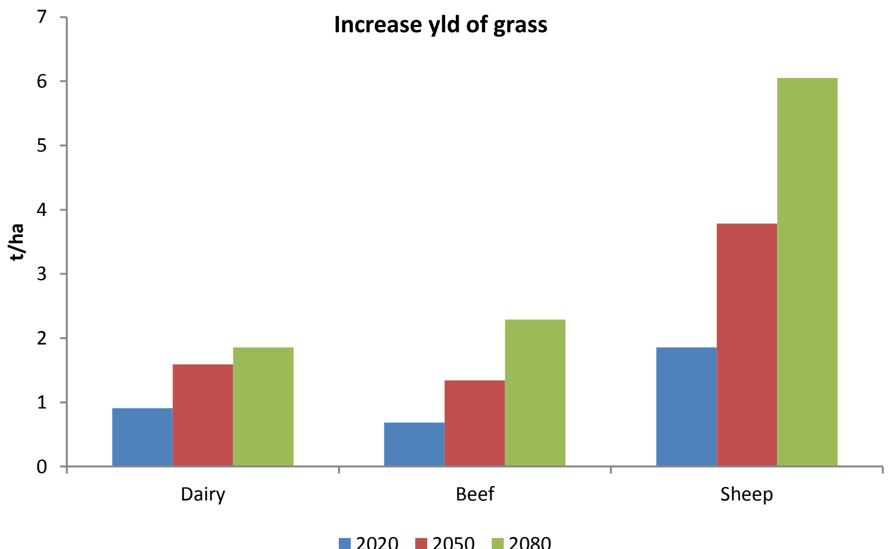
# Total GHG mitigation potential from genetics with support

- Predicted favourable impact of climate change on land capability and grass/fodder yld
  - Big regional differences
- New crops/grasses of higher nutritive value
  - Higher value of by-products
- Sustainable intensification
  - Land sharing vs. land sparing



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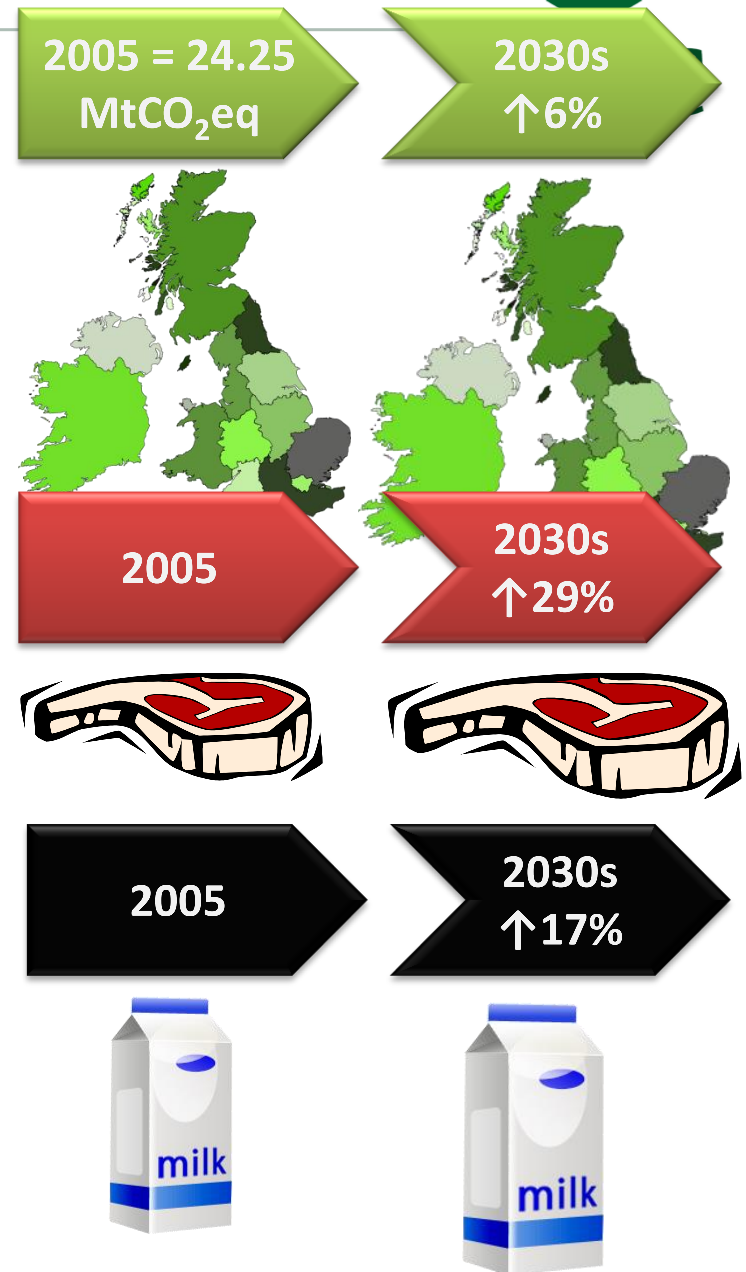

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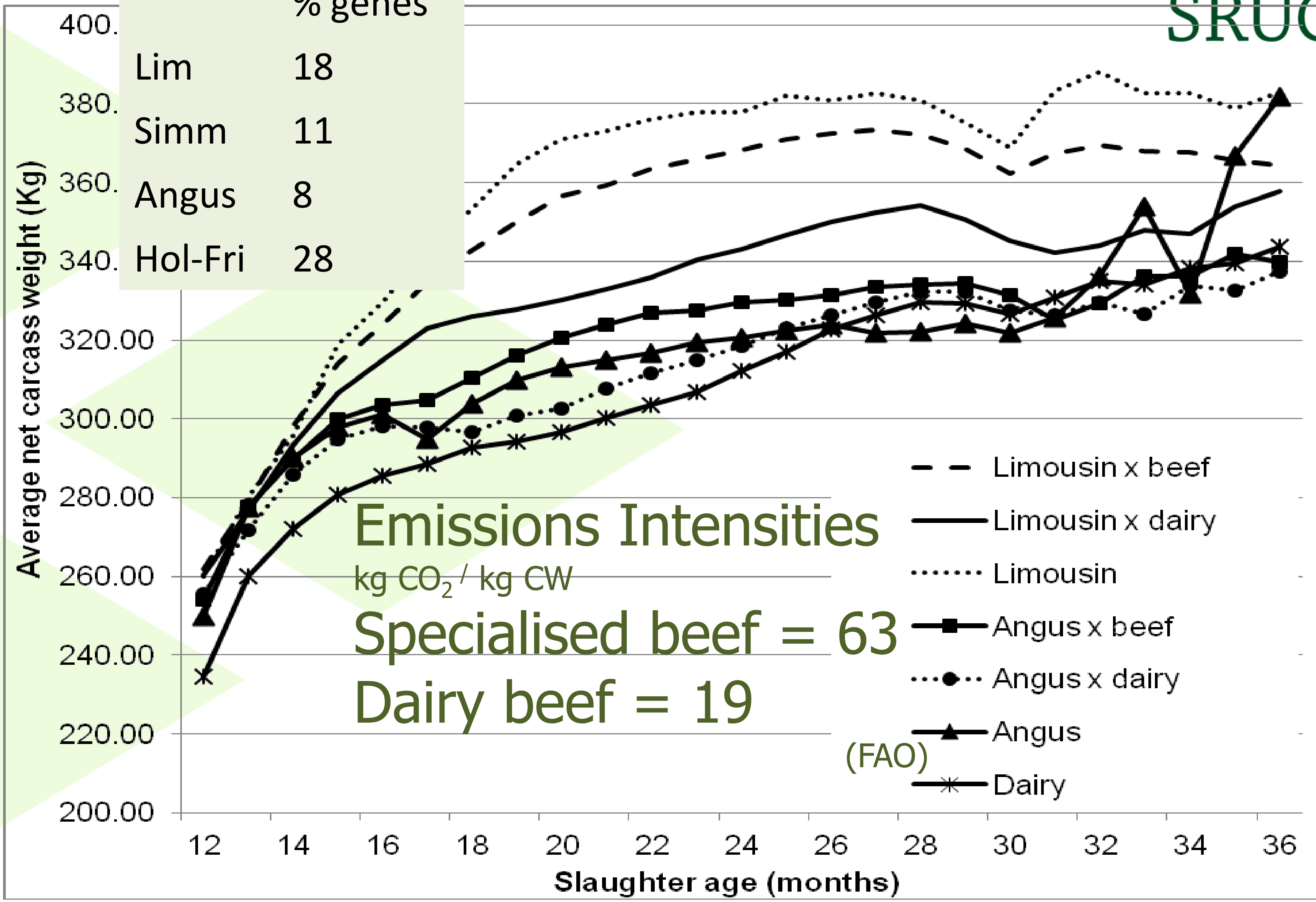
# Beef ....dairy beef




| | % genes |
|---|---|
| Lim | 18 |
| Simm | 11 |
| Angus | 8 |
| Hol-Fri | 28 |

Emissions Intensities

kg $CO_2$ / kg CW

Specialised beef = 63

Dairy beef = 19

(FAO)

# Genetic correlations between dairy and beef traits

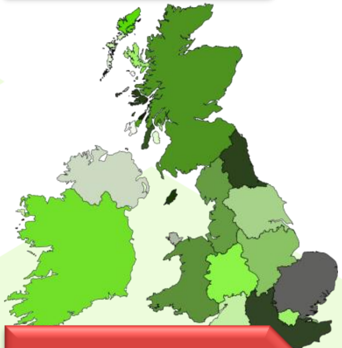
**Higher milk production = less desirable carcass conformation**

| | [illegible] | CCON (1-15) | CFAT (1-15) |
|---|---|---|---|
| Milk (305d, kg) | 0.22 (0.0[illegible] | -0.40 (0.060) | -0.34 (0.062) |
| Fat (305d, kg) | 0.23 (0.064) | -0.33 (0.062) | -0.33 (0.062) |
| Protein (305d, kg) | 0.33 (0.062) | -0.26 (0.064) | -0.23 (0.064) |
| LS (lactation) | -0.07 (0.070) | 0.05 (0.070) | 0.06 (0.070) |
| SCC | -0.05 (0.067) | 0.07 (0.067) | 0.05 (0.067) |
| CI (days) | -0.04 (0.068) | -0.31 (0.064) | -0.25 (0.066) |
| NR (0/1) | -0.16 (0.06[illegible] | 0.10 (0.068) | 0.23 (0.066) |

**Better carcass conformation = better dairy fertility**

# More product from same feed resource and less total GHGs

2005 = 24.25 $MtCO_2eq$



2005

2005


2030s ↑6%

2030s ↑29%

2030s ↑17%


2030s ↓2-5%

2030s ↑37%

2030s ↑29%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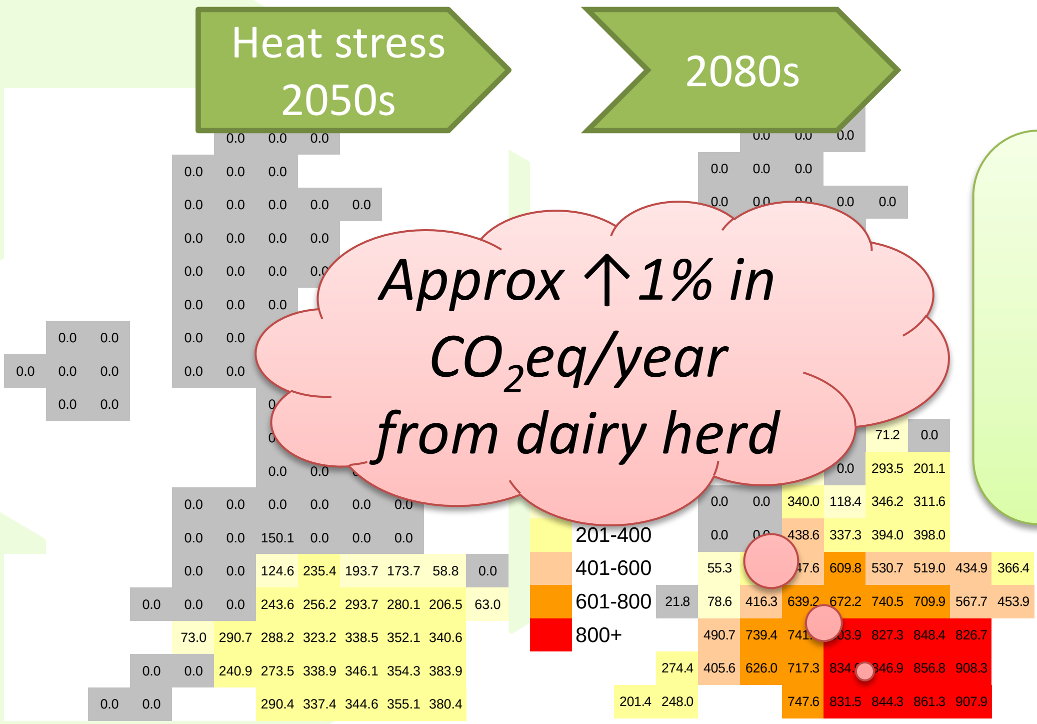
# Costs of climate/stress resilience




## By 2080s

- 10% decline in fertility (cycling)
- 0.3 % mortality young animals
- Costs of£80mill/annum
- Additional costs of heat wave (potentially £15.4 million per event)

# We should consider and quantify for …

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- Wider land use > competition and cooperation
  - Identifying the GHG reduction options across systems within a region/country and across the globe
  - Wider economy drivers and interactions > Carbon trading in agriculture vs. elsewhere, food security
- Consequences of a changing climate (economic & wider)
  - Breeding for future systems and/or environmental envelopes?
  - Non-linear breeding goals incorporating risk?
  - Management options to overcome?

# Conclusions

- Socio-economic framework helps to track impact of genetic change on livestock system and the multiple goals they deliver
  - Help value the wider social benefit genetic improvement
  - And/or value the trade-offs
- Appropriate genetic improvement is a sustainable tool to deliver multiple end-user priorities
- We need more information to quantify additional benefits (or costs) of selecting for multiple breeding goals

# Acknowledgements


- FUNDERS: Defra, Scottish Govt, DECC, Eblex, DairyCo, EU…..
- COLLABORATORS: Davina Hill, Vera Eory, Michael MacLeod, Dominic Moran, Frank Kozlowski, Kairsty Topp, Bob Rees (SRUC), Yvette deHaas (WUR), Peter Amer (Abacus Bio), Anthony Lamb (Cambridge), Cameron Luddemann (Uof Melbourne)

# EAAP 2016

**67th Annual Meeting of the European Federation of Animal Science**

**Belfast 29 August – 1 Sept 2016**

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