MM26: Increased uptake of cattle genetic improvement practices using the current breeding goal and using genomic tools

MM27: Using a new, lower emissions intensity breeding goal in cattle breeding, using genomic tools

MM28: Genetic modification of cattle for low methane emissions

MM29: Increased uptake of current cattle breeding practices to reduce EI

Category
Livestock management: Animal breeding, genetics and herd structure

Overview
26. Increased uptake of cattle genetic improvement practices using the current breeding goal, using genomic tools). This entails farmers collecting performance information on the individual animals and genetic testing, and feeding back these information to breeding goal development (genomic tools) and also incorporating enteric CH_4 emission in the breeding goal.

27. Using genomics to identify cattle genetic effects that produce lower emissions intensity (e.g. improved performance or rumen microbiomes with lower rates of methanogenesis), enabling lower EI to be included in cattle breeding goals.

28. Genetic modification of cattle to reduce enteric methane emissions.

29. Reduction in EI achieved through the use of conventional production-focused breeding goals and methods (i.e. not genomic or genetic engineering).

Mitigation summary

Effect on GHG categories*	Rating	Notes
Enteric CH_4	-	
Manure CH_4	-	Via reduction in FCR
Manure N_2O	-	“”
Soil N_2O: applied N	-	“”
Soil N_2O: grazing	-	“”
Energy CO_2: fieldwork	-	“”
Energy CO_2: other	-	“”
CO_2 liming and urea		
CO_2 sequestration below ground		
CO_2 sequestration above ground		
Pre-farm emissions		
Post-farm emissions		
Substitution of higher C products		
Production increases by more than the emissions	-	
Confidence in mitigation effect	high	
Cost-effectiveness**	low	
Confidence in cost-effectiveness	high	

*   ”-“ GHG reduction, “+”: GHG increase, “ ”: no significant effect

** low: =< £0/tCO_2e, moderate: £0/tCO_2e< >SCC, high: >SCC

Related measures and potential synergies

Measure	Impact on other measures
Manure measures	Reduced VSx and Nx per kg of output so reduced effect of manure measures
Animal health	Reduction in cattle EI, so reduced effect of health measures. Also potential direct health effects of genetic improvement.
Multi use of cows (milk, calves and meat)	Potentially complex interactions.
3NOP	AR reduced, cost increased

Inclusion in other marginal abatement cost curves

UK 2008	UK 2010	UK 2015	Ireland 2012	France 2013	France 2019
Yes	Yes	Yes	Yes	No	?

What does the measure entail?

Many production and fitness traits have been shown to have a genetic component and have scope to be improved via genetic selection. Current broader breeding goals that select on both production and fitness traits can help to mitigate GHGs from livestock systems per unit of output, due to a combination of lower feed intake, higher yield and fewer non-productive animals in the herd. GHG emissions can be reduced if the output is kept constant (i.e. if rebound effects are avoided). The reduction in dairy cattle numbers in the past two decades in the UK was accompanied by an increase in milk production and a decrease in enteric CH_4 emissions from dairy cattle (Brown et al. 2016, Brown et al. 2018). Similarly, increased growth rate enables beef animals to reach slaughter age quicker, reducing their lifetime emissions. Garnsworthy (2004) estimated, using modelling, that if cow fertility was restored to 1995 levels (from the 2003 level) that methane emissions from the dairy industry could be reduced by 10-15%.

So far, improvement in cattle production and efficiency using the current breeding goals has been happening. However, the uptake of using better genetic material is only around 20-25% in the dairy herd, and still lower in the beef herd (Defra 2018). An increased uptake will lead to further improvements in efficiency. Though it is expected that the efficiency is going to continue to increase without further policy intervention, a more widespread and therefore larger increase in milk yield and growth rate can be expected from increased adoption of the best available genetic material. Measure 29 (Increased uptake of cattle genetic improvement practices using the current breeding goal) is representing this mitigation.

Genetic improvement in the national herd can be enhanced by using genomic tools (measure 26: Increased uptake of cattle genetic improvement practices using the current breeding goal, using genomic tools). This entails farmers collecting performance information on the individual animals and genetic testing, and feeding back these information to breeding goal development (genomic tools) and also incorporating enteric CH_4 emission in the breeding goal.

Literature suggests that the genetics of mammals have an influence on the micro-organisms present in the gut (Hegarty and McEwan, 2010). It is possible to select sheep for high or low CH_4 emissions, as CH_4 production is heritable to some extent (Pinares-Patiño et al. 2013); selection for low emission causes changes in the animal's nutritional physiology (Goopy et al. 2014). Studies indicate potential genetic selection for low CH_4 emission for dairy cattle too (de Haas et al. 2011, Roehe et al. 2016). Inclusion of low enteric CH_4 emission in the breeding goal (measure 27: Using a new, lower emissions intensity breeding goal in cattle breeding, using genomic tools) could reduce CH_4 emissions from cattle, though might limit the productivity and fitness improvements to some extent.

Measure 28: Genetic modification of cattle to reduce enteric methane emissions
is a mitigation measure which is speculative at the moment, assuming that genetic modification could be found which reduces enteric CH_4 emissions.

The breeding measures as modelled in the MACC cannot be applied to the same animals as MM26 assumes MM29 is implemented (and includes those effects), and both MM27 and MM28 includes both MM29 and MM26. However, they could still be applied in parallel within the national herd.

Assumptions used in the MACC

Abatement rate

<u>Measure 26: Increased uptake of cattle genetic improvement practices using the current breeding goal and using genomic tools</u>
Dairy
Milk yield: +0.9%/year
Milk protein: +0.9% (of % value)/year
Cow fertility: +0.38% (of % value)/year
Enteric CH4 conversion factor (Ym): no change

Beef
Live-weight: +0.25 %/year
Growth rate: +0.25 % (of % value)/year
Cow fertility: +0.25 % (of % value)/year
Enteric CH4 conversion factor (Ym): no change

<u>Measure 27: Using a new, lower emissions intensity breeding goal in cattle breeding, using genomic tools</u>
Dairy
Milk yield: +0.75%/year
Milk protein: +0.75% (of % value)/year
Cow fertility: +0.3% (of % value)/year
Enteric CH4 conversion factor (Ym): -0.15% (of % value)/year

Beef
Live-weight: +0.25 %/year
Growth rate: +0.25 % (of % value)/year
Cow fertility: +0.25 % (of % value)/year
Enteric CH4 conversion factor (Ym): -0.15% (of % value)/year

<u>Measure 28: Genetic modification of cattle for low methane emissions</u>
Dairy
Milk yield: +0.75%/year
Milk protein: +0.75% (of % value)/year
Cow fertility: +0.3% (of % value)/year

Enteric CH_4 conversion factor (Ym): -0.4% (of % value)/year

Beef
Live-weight: +0.25 %/year
Growth rate: +0.25 % (of % value)/year
Cow fertility: +0.25 % (of % value)/year
Enteric CH_4 conversion factor (Ym): -0.4% (of % value)/year

<u>Measure 29: Increased uptake of current cattle breeding practices to reduce EI</u>
Dairy
Milk yield: +0.6%/year
Milk protein: +0.6% (of % value)/year
Cow fertility: +0.25% (of % value)/year
Enteric CH_4 conversion factor (Ym): no change

Costs

<u>Measure 26: Increased uptake of cattle genetic improvement practices using the current breeding goal and using genomic tools</u>
Dairy
£0.5 million research investment in the UK, lifetime 20 years
Genomic tools recurring cost: £0.25 million every 5 years
Genomic testing cost: £20/bull, serving 500 cows

Beef:
£1.5 million research investment in the UK, lifetime 20 years
Genomic tools recurring cost: £0.25 million every 5 years
Genomic testing cost: £20/bull, serving 100 cows

<u>Measure 27: Using a new, lower emissions intensity breeding goal in cattle breeding, using genomic tools</u>
Dairy
£2.5 million research investment in the UK, lifetime 20 years
Genomic tools recurring cost: £0.5 million every 5 years
Genomic testing cost: £20/bull, serving 500 cows

Beef:
£2.5 million research investment in the UK, lifetime 20 years
Genomic tools recurring cost: £0.5 million every 5 years
Genomic testing cost: £20/bull, serving 100 cows

<u>Measure 28: Genetic modification of cattle for low methane emissions</u>
Dairy
£5 million research investment in the UK, lifetime 20 years
Genomic tools recurring cost: £0.5 million every 5 years
Genomic testing cost: £20/bull, serving 1000 cows

Beef:
£10 million research investment in the UK, lifetime 20 years
Genomic tools recurring cost: £0.5 million every 5 years
Genomic testing cost: £20/bull, serving 1000 cows

<u>Measure 29: Increased uptake of current cattle breeding practices to reduce EI</u>
Dairy

no additional cost

Beef
no additional cost

Costs/savings of the operation (figures in brackets are savings)

Costs/savings	**Total cost**	**Source**
Increased meat/milk output		
Reduced feed (for same ouput)		
R&D	See above	
Tool development	See above	
Genomic testing	See above	

The cost-effectiveness is categorised as being low.

Applicability and current uptake

The current uptake of all these measures are assumed to be zero as these are additional improvements achievable over the improvements already happening in the dairy and beef herds (i.e. in the business as usual future). The applicability of the measures were assumed as follows.

<u>Measure 26: Use of current breeding practices to reduce EI</u>
Dairy cows =0.9
All beef cattle = 0.2

<u>Measure 27: Breeding for lower EI with genomics</u>
Dairy cows = 0.45
All beef cattle = 0.2

<u>Measure 28: Genetic modification of cattle for low methane emissions</u>
Dairy cows =0.45
All beef cattle = 0.1

<u>Measure 29: Increased uptake of current cattle breeding practices to reduce EI</u>
Dairy cows =0.9
All beef cattle = 0.0

Ancillary effects
Increased dairy cow milk yield means that fewer cows are required to produce the same volume of milk, and may lead to a reduction in the amount of beef produced by the dairy herd. Keeping beef production constant will therefore require an increase in the amount of (higher EI) suckler beef produced (see also Fiche 38: Dual purpose cattle. Use of AI/sexed semen could be used to optimise beef from dairy herd.

Ancillary effects of the operation

Positive effects		**Source**
Off-farm GHG		
Production		
Adaptation		

Environment	Reduced nutrient excretion per unit of meat/milk output > reduced losses to air/water.	
Off-farm GHG	Induced increase in suckler beef production.	
Production		
Adaptation		
Environment		

Identified implementation challenges and barriers

Potential barriers to uptake and key risks/uncertainties

Barrier to uptake	Source
Moving towards higher producing animals may have knock-on effects on essential fitness traits. Any reduction in EI via breeding for increased milk yield may be negated if it impacts on other aspects of physical performance.	MacLeod et al. (2019)
Other key risks/uncertainties	
There is the risk that some genetic improvements may not be permanent. Rumen microbes adapt to dietary changes to restore the status quo so prolonged effects may be difficult to achieve.	MacLeod et al. (2019)

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