MM37: Increased Milking Frequency via Robotic Milking

Category
Livestock management: Structural and management changes

Overview
The use of robotic milking parlours allows cows to choose milked when they want to be milked which typically increases milking frequency from twice a day to nearer three times per day. Increased milking frequency removes milk from the udder thereby stimulating further milk production. It has been argued that:

"Three times a day milking increases milk yield, and increases N use efficiency through a dilution of animal energy and N maintenance requirements (Dunlap et al., 2000). Increasing milking frequency can also increase the efficiency of utilisation of amino acids for milk production by reducing the turnover of milk and constitutive proteins in the mammary gland (Bequette et al., 1998). Effects such as these which increase the efficiency of incorporation of dietary N into milk naturally reduce excretion and the effects this has on subsequent N2O emissions and related NO3 leaching and NH3 volatilisation." Moorby et al. (2007, p46).

Mitigation summary

Effect on GHG categories*	Rating	Notes
Enteric CH_4		
Manure CH_4		
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	Moderate	
Cost-effectiveness**	Low-moderate	
Confidence in cost-effectiveness	Moderate	

* "-" 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**

32 Precision feeding	
Breeding measures (26-29)	
38: Shift from specialised dairy cattle to dual purpose breeds	

Inclusion in other marginal abatement cost curves

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

**Discussed under precision livestock farming, one of the 2050 measures*

What does the measure entail?

Increasing the rate of dairy cow milk secretion through the use of robotic milking parlours. This entails purchase of a robotic milker (typically costing £50-80k per 60 cows) and changes to stock management (e.g. keeping cattle closer to the milking parlour).

Abatement rate

Moorby et al. (2007) reported that increasing milking frequency from twice to three times a day increases milk yield, which increases nutrient use efficiency (NUE) and decreases N excretion, and therefore direct and indirect N2O per unit of milk secreted (Table1).

Table 1 Effects of increased milking frequency (Moorby et al. 2007)

Parameter	Units	Control	Milking 3x a day	Difference
Milk yield	kg/day	29.1	32.3	11%
N intake	g/day	470	500	6%
N excretion	g/day	313	329	5%
NUE*	%	33%	34%	2%

*Nutrient use efficiency: ((N intake – N excretion) / N intake) x 100

Sitkowska et al. (2015) reported increases in daily milk yield of 8% and 15% in the year after switching from conventional to robotic milking. Salfer et al. (2017) assumed an increase in milk yield of 9% when switching from a conventional parlour milking twice a day to a robotic system.

Estimate of abatement potential and cost-effectiveness

In order to compare specialised dairy and dual purpose cattle, an illustrative calculation has been done for a 60 cow and 120 cow dairy with conventional milking and robotic milking (Table 2).

The GHG emissions and production were quantified using the Scottish Agricultural Emission Model (SAEM, MacLeod et al., 2017), a model based on GLEAM, the Global Livestock Environmental Assessment Model, which was developed by the UN-FAO (FAO, 2017, 2018; MacLeod et al., 2018).

The analysis assumes that using a robotic milker increases the milk yield per cow by 10% (based on Moorby et al. 2007, and Heyden 2015), and that the robotic milker costs £75k (for 60 cows) or £125k (for 120 cows). The increase in milk yield leads to a 5% reduction in the EI of milk, and increases the gross margin per farm by 3-4% (although the gross margin per litre of milk decreases by 4-5%). This analysis is intended to be illustrative, as it does not fully reflect the differences between a conventional and robotic system. In practice the situation is more complex, and changing to the robotic milking system may involve changes in other parameters, such as: cow rations, activity levels, milk fat and protein content, manure management and animal health. The analysis should also include the emissions arising from the manufacture and maintenance of the robotic milker, and the maintenance costs, and the value of the reduced labour.

More detailed analysis is required to determine under which circumstances switching to a robotic milker is likely to be commercially viable. As Salfer et al. (2017) have noted "Milk production and labor assumptions between the systems greatly affect the profitability projections. More research is needed to understand the economics of how these systems perform with different herd sizes and management practices."

Table 2 Illustrative calculation of the effect of robotic milking on a 60 cow and 120 cow dairy herd

						Difference	
Input assumptions		60-Conv.	60-Robotic	120-Conv.	120-Robotic	60 cow	120 cows
Number of adult females	#	60	60	120	120	0%	0%
Age at first calving	years	2.3	2.3	2.3	2.3	0%	0%
Fertility rate adult females	% of AF's giving birth	89%	89%	89%	89%	0%	0%
Adult female replacement rate	% of AF's replaced each year	25%	25%	25%	25%	0%	0%
Milk yield	kg milk/year	8021	8823	8021	8823	0%	0%
Results							
Meat, carcass weights	kg/farm/year	15398	15398	30797	30797	0%	0%
Milk sold standard	kg/farm/year	430286	473315	860572	946630	0%	0%
EI of milk	kg CO2eq / kg milk	1.25	1.19	1.25	1.19	-5%	-5%
Financial appraisal							
Variable costs							
Feed	£	35114	35908	70228	71817	2%	2%
Other	£	17662	17662	35325	35325	0%	0%
Output							
Milk	£	124094	136504	248189	273008	10%	10%
Meat	£	84245	84245	168491	168491	0%	0%
Purchase cost of robotic milker	£	0	75000	0	125000		
Annual repayment*	£/year	0	6750	0	11250		
Gross margin	£/farm per year	155564	160428	311127	323107	3%	4%
Gross margin	£ per litre	0.22	0.21	0.22	0.22	-5%	-4%

** Assuming: 15 year lifespan, nominal resale value at 15 years (FWI 2019), first robot £75k, second robot £50k. Interest rate 4%.*

Cost-effectiveness

“Milking robots are currently expensive, and although labour is reduced a change in skills is required by the farmer. Increased milking frequency would mean more cow movements, to the point that robotic milking systems require animals to be kept close to the machines at all times (i.e. housed year round).” Moorby et al. (2007, p47).

Table 3. Costs/savings of the operation (figures in brackets are savings)

Costs/savings	**Total cost**	**Source**
Increased milk production	Milk yield per cow up by ~10%	Moorby et al. (2007) Heyden (2015)
Reduced labour	From no savings up to 29% savings in labour costs	Salfer et al. (2017)
Increased energy consumption	Not known	
Purchase of unit	€120,000 (60-70 cow) €200,000 (120-140 cow) €80,000 (60 cow unit)	Irish Independent (2016) DairyGlobal (2018)
Maintenance of unit	Not known	

A preliminary financial appraisal was undertaken (table2). The results indicate that switching to robotic milking increase the farm gross margin of a 60 cow dairy herd by 3%, while decreasing the gross margin per litre of milk produced (including the cost of the robotic milker) by 5%. The financial performance is improved for a larger herd (120 cow) with two robotic milkers (farm gross margin increases by 4%, while gross margin per litre decreases by 4%). This is because the second unit is assumed to be cheaper to install (£50k compared to £75k for the first unit): “The first robot is the most expensive to fit because it is like the mothership, featuring the main vacuum and cleaning system that is actually capable of supplying a second unit, if desired, as the herd grows.” Irish Independent (2016).

The cost-effectiveness is categorised as being low-moderate.

Applicability, current uptake and potential additional maximum uptake

“Three times daily milking is possible by most dairy farmers, and robotic milking systems offer the potential for even higher milking frequencies.” Moorby et al. (2007).

In 2018 around 22% of dairy farms in Denmark were using robotic parlours (DairyGlobal 2018)

Heyden (2015): “5% of UK farms already use robotic milking, according to Liz Snaith of the Royal Association of British Dairy Farmers. But they also constitute about 30% of all new milking systems being purchased.”

Salfer et al. (2017) noted that “production increases of 5 to 10% compared to milking 2X, but production decreased 5 to 10% compared to milking 3X”.

Assumptions used in the MACC

- Maximum additional uptake is 50%
- 5% reduction in the EI of milk produced in robotic milkers, i.e. an overall reduction in milk EI of 2.5%
- Assume a low-moderate CE, i.e. £10/tCO2e

Ancillary effects

"Increased milking frequency, particularly in high genetic merit dairy cows, may have a benefit in terms of udder health (Dahl et al., 2004)." Moorby et al. (2007)

Effects on milk quality – are milk solids maintained? Wikipedia suggests they decrease with increased frequency of milking. And some evidence that bacteria count increases.

Table 4. Ancillary effects of the operation

Positive effects		**Source**
Off-farm GHG		
Production	Improved udder health in high genetic merit cows Improved farmer quality of life	Dahl et al. (2004) Molfino et al. (2014)
Adaptation		
Environment	Increases NUE and decreases Nx per kg of milk secreted > reduced leaching and volatilisation	
Negative effects		
Off-farm GHG		
Production		
Adaptation		
Environment		

Identified implementation challenges and barriers

"The capital cost of setting up a greenfield site robotic Dairy unit can potentially be grant funded under the recently announced RDPE funding. However, the potential variance in profitability (5ppl) in one year on a 240-cow robotic Dairy unit could virtually wipe out the grant funding income if technical performance/ milk price was to fall. This highlights the relative risk and reward of investing in robotics purely on the basis of grant funding." AKC (2018)

"The fact that each machine is typically capable of milking 50 or 60 cows a day also makes robots quite a "lumpy" investment, explains Ohnstad, in that farmers have to increase their herd by those large increments to justify their investment." Heyden (2015)

Sitkowska et al. (2015) showed that cows introduced to AMS quickly adapt to the new way of milking, and farmers with milking robots can precisely track many parameters related to the milking performance of their cows. Milk yield, milking frequency, intermilking interval, teat-cup attachment success rate and the length of the milking procedure are only some parameters that can be analysed with the use of robots. In addition to AMS changing the efficiency by which cows are milked by selecting cows that adapt best, or are genetically more efficient in AMS characteristics, then the cows themselves would be selected differently and genotype change.

Table 5 Potential barriers to uptake and key risks/uncertainties

Barrier to uptake	**Source**
Capital cost	
Scale required to ensure short payback period	
Other key risks/uncertainties	

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