MM24 and MM50: Low Emission Livestock Housing

Category

Livestock management: housing and manure management

Overview

Emissions from livestock housing include CH_4 emissions from enteric fermentation and manure (during storage in the house) and N_2O and NH_3 (and thus indirect N_2O) from manure and the surface of the house. Several approaches exist to minimise these emissions or even to capture them before they leave the house. Aspects of the housing design (e.g. ventilation, temperature, cleaning, manure collection and storage, positioning of the feeders) have significant impact on what proportion of the N and volatile solids excreted by the animals transforms into reactive N compounds (NH_3 and N_2O) and CH_4, respectively. Enteric CH_4 emissions are not affected by these factors.

Besides optimising the housing design to reduce the rate NH_3 and CH_4 are formed, end-of-pipe solutions (air scrubbers and biofilters) can capture NH_3 (and hydrogen sulphide and odour). An efficient solution for CH_4 is yet to be developed; the existing technologies can remove CH_4 from covered slurry stores but do not yet work well in livestock houses where the CH_4 concentration is much lower (Melse and van der Werf 2005, Van der Heyden *et al.* 2015).

The housing designs used on pig and poultry farms varies significantly, partially due to the different needs of the animal types (e.g. gestating sows *vs* fatteners, broilers *vs* layers), but also due to preferences of the farmer regarding manure management (liquid or solid systems), engineering solutions (e.g. frame and roofing of the building), feeding system (wet or dry), ventilation options.

There is also a large variety in the technologies which reduce NH_3 emissions (Anon. 2014, ADAS 2004). The 'Best Available Techniques (BAT) reference document for the intensive rearing of poultry and pigs' describes in detail technologies to reduce NH_3 and odour emissions (Santonja *et al.* 2017). This is a document supporting the compliance rules with the Industrial Emissions Directive[1] for large pig and poultry operations. The 34 Best Available Techniques suggest alternative solutions, for example BAT 30 describes 16 housing design solutions to reduce NH_3 emissions from pig buildings (see examples on Figure 1).

[1] http://ec.europa.eu/environment/industry/stationary/ied/legislation.htm

1. A vacuum system for frequent slurry removal (in case of a fully or partly slatted floor).	All pigs	May not be generally applicable to existing plants due to technical and/or economic considerations.
2. Slanted walls in the manure channel (in case of a fully or partly slatted floor).	All pigs	
3. A scraper for frequent slurry removal (in case of a fully or partly slatted floor).	All pigs	
4. Frequent slurry removal by flushing (in case of a fully or partly slatted floor).	All pigs	May not be generally applicable to existing plants due to technical and/or economic considerations. When the liquid fraction of the slurry is used for flushing, this technique may not be applicable to farms located close to sensitive receptors due to odour peaks during flushing.
5. Reduced manure pit (in case of a partly slatted floor).	Mating and gestating sows	May not be generally applicable to existing plants due to technical and/or economic considerations.
	Fattening pigs	
6. Full litter system (in case of a solid concrete floor).	Mating and gestating sows	Solid manure systems are not applicable to new plants unless it can be justified for animal welfare reasons. May not be applicable to naturally ventilated plants located in warm climates and to existing plants with forced ventilation for weaners and fattening pigs. BAT 30.a7 may require large space availability.
	Weaners	
	Fattening pigs	
7. Kennel / hut housing (in case of a partly slatted floor).	Mating and gestating sows	
	Weaners	
	Fattening pigs	

Figure 1 Example of technologies to reduce NH_3 emissions from pig houses (Santonja et al. 2017)

Technologies aiming to reduce NH_3 emissions have an effect on GHG emissions too (Blanes-Vidal *et al.* 2008, Brink *et al.* 2005, Eory *et al.* 2015). These effects can be synergistic, for example adding more straw to litter-based systems reduces both NH_3 and N_2O emissions, and reducing the temperature of the slurry pit reduces both NH_3 and CH_4 emissions. Sometimes reducing NH_3 emissions can increase GHGs, air scrubbers to remove NH_3 from the air of the building can increase N_2O emissions, and retaining more N in the slurry can increase N_2O emission from manure spreading unless low emission application methods are used.

Furthermore, reducing NH_3 emissions have a small synergistic effect on N_2O mitigation since on average 1% of NH_3 emissions are converted into N_2O (IPCC 2006). Agriculture was responsible of 245 kt NH_3 emissions in 2017 (Misselbrook and Ghilespy 2019), which results in 945 kt CO_2e indirect N_2O emissions. Pig and poultry housing NH_3 emissions were 23 kt in the same year (equivalent of 88.7 kt CO_2e indirect N_2O) (Table 1).

Table 1 NH_3 emissions from agriculture in 2017 (Misselbrook and Ghilespy 2019)

Source	NH_3 emission (kt NH_3)	Indirect N_2O emission (kt CO_2e)
Total ruminants and horses	126.6	488.2

Source	NH_3 emission (kt NH_3)	Indirect N_2O emission (kt CO_2e)
Total pigs	18.6	71.7
Of which housing	10.1	39.0
Total poultry	37.7	145.4
Of which housing	12.9	49.7
Fertiliser, sewage sludge, digestate	61.9	238.7
Total agriculture	**244.9**	**944.4**

This mitigation measure considers pig and poultry housing technologies, specifically:

- Wider compliance with BAT technology requirements (MM22)
- Chemical air scrubbers for NH_3 removal (MM50)

Mitigation summary

Table 2 Effects on emissions

GHG categories	Effect*	Notes
Enteric CH_4		
Manure CH_4	-	
Manure N_2O	Indirect N_2O: – Direct N_2O: +/-	
Soil N_2O: applied N	+	Unless low-NH_3-emission spreading technology used
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	-	Fertiliser production
Post-farm emissions		
Substitution of higher C products		
Production increases by more than the emissions		
	Rating	
Confidence in mitigation effect	Moderate	
Cost-effectiveness**	High	(if monetary value of NH_3 mitigation is not included)
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

Table 3 Likely effects on the abatement potential of other measures

Measure	Impact
	-
	-

Inclusion in other marginal abatement cost curves

Table 4 Past assessment of the measure

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

What does the measure entail?

The measure requires improvements in the housing design, retrofits where possible, but mostly adopting the solutions when new livestock houses are constructed.

Abatement rate

Table 5 Data from literature on abatement

Measure	Abatement	Value	Country	Reference
Animal housing adaptations - slurry based pig houses	Housing NH_3	-35%	Europe	(Brink *et al.* 2001, Brink *et al.* 2005)
	Manure CH_4	-10%		
	N_2O spreading	+900%		
Animal housing adaptations – laying hen houses	Housing NH_3	-70%	Europe	(Brink *et al.* 2001, Brink *et al.* 2005)
	Manure CH_4	-90%		
	N_2O spreading	+900%		
BAT housing	Housing NH_3	-30%	UK	(Misselbrook *et al.* 2016)
Reduced slatted area for pig buildings	Housing NH_3	-30%	UK	(Webb *et al.* 2006)
Flush slurry channels in pig buildings	Housing NH_3	-60%	UK	(Webb *et al.* 2006)
Frequent removal of slurry from beneath-slatted storage in pig housing	NH_3 housing	-25%	UK	(ADAS 2017)
	NH_3 storage	+2%		
	NH_3 spreading	+2%		
	Energy use	+2%		
Frequent removal of slurry from pig houses with vacuum system	NH_3 housing	-25%	UK	(Misselbrook and Ghilespy 2019)
	N_2O	0%		
	CH_4	0%		

Measure	Abatement	Value	Country	Reference
More frequent manure removal from laying hen housing with belt clean systems	NH_3 housing	-10%	UK	(ADAS 2017)
	NH_3 storage	+2%		
	NH_3 spreading	+2%		
	Energy use	+2%		
Air drying of manure on laying hen manure belt systems	NH_3 housing	-30%	UK	(Misselbrook and Ghilespy 2019)
	N_2O	Not conclusive		
	CH_4	Not conclusive		
Changing from deep pit to belt cleaned layer hen cages	Housing NH_3	-60% TAN-NH_3 EF*: deep pit: 35.6% belt: 14.5%	UK	(Misselbrook and Ghilespy 2019)
Air filter: 1-stage chemical washer	Housing NH_3	-80%	German y	(Wagner *et al.* 2015)
Chemical air scrubbers	Housing NH_3	-30% - -100% in 10 studies reviewed	The Netherla nds	(Van der Heyden *et al.* 2015)
Acid air scrubbers	NH_3 housing	-80%	UK	(Misselbrook and Ghilespy 2019)
	N_2O	0%		
	CH_4	0%		
Chemical air scrubbers	Housing $_{NH3}$	-70% - -90%	-	(Anon. 2014)
Install air-scrubbers or biotrickling filters to mechanically ventilated pig housing	NH_3 housing	-25%	UK	(ADAS 2017)
	Energy use	+10%		

* Emission factor for NH_3 emissions expressed as a percentage of total ammoniacal N content of the excreta

Cost

Table 6 Data from literature on costs

Measure	Value	Country	Reference
Animal housing adaptations - slurry based pig houses	€0.2 – €206 head^{-1} year^{-1}	Europe	(Brink *et al.* 2001, Brink *et al.* 2005)
Animal housing adaptations – laying hen houses	€0.2 – 206 head^{-1} year^{-1}	Europe	(Brink *et al.* 2001, Brink *et al.* 2005)
Reduced slatted area for pig buildings	£13.1 animal place^{-1}	UK	(Webb *et al.* 2006)
Flush slurry channels in pig buildings	£7.05 animal place^{-1}	UK	(Webb *et al.* 2006)

Measure	Value	Country	Reference
Frequent removal of slurry from beneath-slatted storage in pig housing	Capital cost £2.62 m^{-3} managed excreta	UK	(ADAS 2017)
More frequent manure removal from laying hen housing with belt clean systems	Operating cost: £0.03 m^{-3} managed excreta	UK	(ADAS 2017)
Air filter: 1-stage chemical washer	€26.8 animal place^{-1} year^{-1}	Germany	(Wagner *et al.* 2015)
Install air-scrubbers or biotrickling filters to mechanically ventilated pig housing	Capital cost £8.43 m^{-3} managed excreta Operating cost: £5.33 m^{-3} managed excreta	UK	(ADAS 2017)

Applicability

The technologies are applicable to housed pig in slurry based systems and caged layer hens.

Current uptake and maximum additional future uptake

As mentioned in the Overview, the Industrial Emissions Directive requires that pig and poultry farms above a certain threshold (Table 7) apply Best Available Techniques on their farms, including livestock building technologies used. These regulations came into force in 2008 and the target date for all large farms to achieve these standards was set as 2020[2].

Table 7 Proportion (%) of livestock kept on holdings above the IPPC threshold (Misselbrook et al. 2016)

	E	W	S	NI	UK
Pigs					
Sows	29	0	23	27	28
Fatteners (>20 kg)	40	0	53	49	42
Poultry					
Layers	67	49	74	54	66
Broilers	95	98	94	67	92

Based on this regulation we can assume that by 2020 all farms above the threshold will have reduced their NH_3 emissions using the principles described in the regulation (which includes e.g. reduced slatted area in pig houses and frequent removal of slurry as well as laying hen housing with manure belt with forced air drying (Environment Agency 2010)). The future uptake could be 100%.

[2] https://www.gov.uk/government/publications/intensive-farming-introduction-and-chapters

No information source on air scrubber adoption was identified. Air scrubbers are not a requirement in the BAT technologies, therefore, based on their high costs it is assumed that their adoption rate is negligible. The future uptake is assumed to be 30%.

Assumptions used in the MACC

Parameter	Change in value	Notes
NH_3 reduction by BAT housing	-30%	
NH_3 reduction by air scrubbers	-80%	
Maximum future uptake of BAT	1	
Maximum future uptake of air scrubbers	0.3	
Additional capital costs of BAT housing	Pigs: £10 head^{-1}, 15 years lifetime Poultry: £0.2 head^{-1}, 15 years lifetime	
Cost of air scrubber	Pigs: Capital cost £16 head^{-1}, 10 years lifetime, operating cost: £10 head^{-1} year^{-1} Poultry: Capital cost £0.32 head^{-1}, 10 years lifetime, operating cost: £0.2 head^{-1} year^{-1}	Based on (ADAS 2017)

Wider effects

Table 8 Wider effects of the measure

Aspect	Effect	Reference
Positive effects		
Off-farm GHG		
Production		
Adaptation		
Environment	Reduced NH_3 emissions	
Negative effects		
Off-farm GHG		
Production		
Adaptation		
Environment		

Identified implementation challenges and barriers

Table 9 Potential barriers of the measure

Barrier to uptake	Reference
Cost	
Other key risks/uncertainties	**Reference**

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