NIRAS

Danish Ministry of the Environment
Environmental Protection Agency

ASSESSMENT OF BAT IN LIVESTOCK REGULATION IN DENMARK

- From adjusted system analysis to BAT conclusions in practice

1 Introduction

During the last two years the Danish EPA has conducted standardized BAT-assessments for the most prevailing combinations of types and sizes of livestock farms in Denmark. The BAT-conclusions include quantitative BAT-emission limit values for ammonia and phosphorous emission together with qualitative BAT-assessments for nitrate leaching and the consumption of water and energy. The emission limit values apply to the installation - in this case the farm - and it is left to the farmer to decide which techniques or technologies he wishes to apply on the installation in order to comply with these emission limit values.

The standardized BAT-assessments are formulated as guidelines to the competent authorities, and are published on the Danish EPA's homepage together with technical and economical documentation.

2 General system considerations

The IPPC Directive/IED Directive and ECM BREF document (Economics and Cross-media Effects) call for whole-system assessments including an evaluation of the environmental cross media effects and the economic viability, or as it is prescribed in the definition of BAT in the directives - taking into consideration the costs and advantages. In the Danish BAT-assessment a systematic three-step methodology was adopted, in which it was attempted to apply a technical and economic system analysis in practice, supplemented with necessary work-arounds and pragmatic assessments where data quality or data availability was judged to be inadequate.

2.1 Direct and indirect environmental effects

The direct environmental effects included in the assessment followed the effects addressed in the current BREF-document (NH_3 emission, P-emission, Nitrate leaching, odour, noise and dust). In addition, consumption of energy and water was included indirectly as input factors for the economic analysis related to the evaluated technologies.

As greenhouse gasses are not addressed as a relevant direct effect in the current BREF-document, these emissions are not included in the analysis as a direct effect. These emissions were, however, attempted included as indirect effects in the economic considerations if they could be quantified sufficiently.

2.2 Selection of reference systems

For each group of livestock a reference system was chosen, based on the feeding practice and housing and storage systems that farmers would most likely choose if no environmental demands should be achieved. The environmental effects and economic costs of different alternative techniques are then quantified in comparison with this system.

3 Initial BAT-evaluation of direct environmental effects

Initially, the emissions of odour, noise and dust were assessed as local effects not suitable for determination of BAT emission limit values at national scale. These effects should instead be handled on a local scale applying locale scale regulatory demands.

Consumption of water and energy was included in the quantitative BAT-assessment as an operating cost in line with e.g. maintenance cost influencing evaluation of total costs of applying different techniques for reduction of i.e. NH_3-emission.

Nitrate leaching and emission of ammonia due to field application was evaluated using a qualitative approach. It was assessed that measures adopted in Danish legislation in order to reduce field emission of nitrate and ammonia comply with, and go further than, the techniques addressed in the current BREF. It was therefore concluded, that emission levels of nitrate and ammonia from field application obtainable by using BAT are met with measures implemented in the legislation.

Hereafter, the only environmental effects left for quantitative BAT-assessment are the ammonia and phosphorous emission from the farm, defined as the combined housing and storage emissions.

4 Method for quantitative BAT-assessment

The following stepwise methodology was applied:

1. Evaluation of single techniques having documented reducing effects on emission of ammonia and phosphorous from housing and/or storage facilities. Calculation of emission reduction cost and increased production cost of the technique.
2. Evaluation of total effects on farm scale from combinations of techniques, as in step 1. Calculation of emission reduction cost and increased production cost of several techniques in combination.
3. BAT-conclusions determining emission limits obtainable with BAT regarding ammonia and phosphorous at farm level (housing and storage facilities as a whole). The final conclusion was based on two economic evaluation criteria described in the next section, supplemented with a necessary political process determining the acceptable economic burden of the agricultural sector.

5 Economic evaluation criteria

When considering whether a certain technology has a BAT-potential there are two main evaluation criteria:

- Cost of emission reduction (expressed as DKr pr. kg reduced emission of e.g. ammonia)
- Increased production costs (expressed as DKr pr. produced animal)

The cost of emission reduction expresses the cost effectiveness of the technology for society as a whole.

The increased production costs express how a certain technology affects the economy of the agricultural sector as a whole.

5.1 Calculating costs and emissions

Both costs and emissions were evaluated against the reference system in order to uncover all additional effects associated with the technology.

The costs can be split into:
- Investment costs
- Operating costs

The investment costs were converted into annual costs using the lifetime of the technology and the discount rate. Investment costs are obtained by asking producers and manufactures of the investigated technologies as well as agricultural experts.

The operating costs were calculated by obtaining the increased (or reduced) consumption of e.g. electricity, water and maintenance related to the technology and multiplying the quantity by unit prices. Unit prices can be obtained via authorised price forecasts e.g. for energy or via actual market prices if authorised price forecasts are not obtainable.

The annual cost of investment and the operating costs are added to get the total costs, which are calculated for different farm sizes

In order to calculate the cost of reduction the total costs of the technology were divided by the reduced emissions by the technology. The reduced emissions of e.g. ammonia can consist of both the reduction in the stable, in the storage of manure and in the field.

In order to calculate the increased production costs of the farmers the total costs of the technology was divided by the number of produced animals for the different farm sizes. It is common that cost of reduction and increased production cost are decreasing relative to the farm size due to economics of scale.

6. An example – production of finishers in slurry based housing systems

Step 0 - Choice of reference system

If Danish farmers producing finishers were to choose feeding practice and housing system based on economic considerations only, they would most likely choose a fully slatted floor system producing slurry, which is transported to a slurry tank. According to Danish legislation, the slurry tank should have a floating cover of either natural crust or straw material. This practice is therefore assumed to be applied. In addition, the farmer would most likely use diets with a larger degree of production certainty, i.e. with more protein and phosphorous than the environmentally best practice. The estimated emissions of ammonia and phosphorous from this system are therefore defined as “the reference emissions”.

Step 1 – evaluation of single techniques

The following techniques were judged to have a sufficiently documented reduction effects on emissions of ammonia or phosphorous from housing and/or storage facilities – compared with the reference system.

Feeding practice:
- Optimized feeding practice related to nitrogen – 3 levels of crude protein
- Optimized feeding practice related to phosphorous – 3 levels of P-content

Housing systems:
- Two varieties of partly-slatted floor (25-49 % and 50-75 % solid floor)

Add-on techniques in the stable:
- Cooling slurry in canals (different cooling effects, i.e. 10, 20, 30, 40 w/m^2)
- Acidification of slurry in the canals
- Air cleaning with acid (treatment of 20, 60 and 100 % of air-exhaustion)
- Air cleaning - biological (treatment of 20, 60 and 100 % of air-exhaustion)

Add on- technique for the slurry tank:
- Rigid cover

Table 1 Example of calculated costs of a single technology (biological aircleaner, taking all of the air exhaustion)

Farm size ("Nitrogen units", DE)	**250**	**500**	**750**
NH_3 reduction,kg N/year	3.417	6.834	10.251
Investments cost, DKR	1.144.688	2.289.375	3.434.063
Investment cost as annual cost, DKR	148.242	296.485	444.727
Operating cost (water, electricity, maintenance)	144.572	267.194	387.766
Savings from reduced need for fertilizer	-7.688	-15.377	-23.065
Total annual cost	285.126	548.302	809.428
Increased production cost per animal, DKR/pig	32	30	30
Emission reduction cost DKR/kg N	83	80	79

Step 2 - evaluation of relevant combinations of techniques – an example

The ammonia emission of a number of relevant combinations of techniques was estimated together with the economic costs relative to the chosen reference system (Fully slatted floor, natural crust on slurry tank and standard feeding) (table 2).

Table 2 Relevant combinations of techniques and technologies with documented reducing effect on emission of ammonia from housing and storage facilities for production of finishers (32-107 kg) in slurry based housing systems. The economic costs were calculated for different farm sizes presented in the Danish “nitrogen unit”, DE (1 DE approximately represent 100 kg N from manure applied to the field from a given animal type, i.e. for finishers 1 DE represents the annual production of 36 finishers, 32-107 kg)

Combinations of techniques and technologies	**NH_3-emission (Housing+storage) kg NH_3-N per prod. Finisher, annuallly**	**Extra costs incl. the value of potentially saved N-fertilizer: DKr pr. produced finisher**			**DKr pr. kg reducet NH3-N emission**		
		250 DE	**500 DE**	**750 DE**	**250 DE**	**500 DE**	**750 DE**
Reference system	0.47	0	0	0	0	0	0
25-49 % solid floor	0.39	4	4	4	48	48	48
50-75 % solid floor	0.31	5	5	5	33	33	33
Fully slatted floor + close cover on slurry tank	0.45	2	2	1	19	19	10
25-49 % solid floor + close cover on slurry tank	0.37	6	6	5	60	60	49
50-75 % solid floor + close cover on slurry tank	0.29	7	7	6	41	41	35
25-49 % solid floor + diet with 153 g protein pr. FU	0.39	4	4	4	47	47	47
50-75 % solid floor + diet with 153 g protein pr. FU	0.30	5	5	5	31	31	31
Fully slatted floor + diet with 147 g protein pr. FU	0.43	2	2	2	32	32	32
25-49 % solid floor + diet with 147 g protein pr. FU	0.35	5	5	5	37	37	37
50-75 % solid floor + diet with 147 g protein pr. FU	0.27	7	7	7	34	34	34
Fully slatted floor + diet with 141,5 g protein pr. FU	0.39	5	5	5	50	50	50
25-49 % solid floor + diet with 141,5 g protein pr. FU	0.32	9	9	9	53	53	53
50-75 % solid floor + diet with 141,5 g protein pr. FU	0.25	10	10	10	44	44	44
25-49 % solid floor + cooling 10 W/m2 with **full** utilization of heat surplus	0.36	3	2	2	24	15	15
50-75 % solid floor + cooling 10 W/m2 with **full** utilization of heat surplus	0.29	5	5	5	28	28	28
25-49 % solid floor + cooling 10 W/m2 with **no** utilization of heat surplus	0.36	10	10	10	93	93	93
50-75 % solid floor + cooling 10 W/m2 with **no** utilization of heat surplus	0.29	9	9	9	52	52	52
Fully slatted floor + diet with 147 g protein pr. FU + close cover on slurry tank	0.41	4	4	3	50	50	36
25-49 % solid floor + diet with 147 g protein pr. FU + close cover on slurry tank	0.33	7	7	6	45	45	38
50-75 % solid floor + diet with 147 g protein pr. FU + close cover on slurry tank	0.25	9	9	8	39	39	35
Fully slatted floor + diet with 141 g protein pr. FU + close cover on slurry tank	0.37	7	7	6	59	59	51
25-49 % solid floor + diet with 141 g protein pr. FU + close cover on slurry tank	0.30	11	11	10	58	58	52
50-75 % solid floor + diet with 141 g protein pr. FU + close cover on slurry tank	0.23	12	12	11	48	48	44
Fully slatted floor + slurry acidification	0.15	23	13	9	50	28	20
25-49 % solid floor + slurry acidification	0.13	27	17	13	55	34	26
50-75 % solid floor + slurry acidification	0.10	28	18	14	55	35	27
Fully slatted floor + chemical aircleaner (20% of air exhaustion)	0.24	9	7	7	43	33	33
25-49 % solid floor + chemical aircleaner (20% of air exhaustion)	0.23	13	11	11	57	48	48
Fully slatted floor + chemical aircleaner (60% of air exhaustion)	0.13	20	19	18	65	62	59
25-49 % solid floor + chemical aircleaner (60% of air exhaustion)	0.13	24	23	22	75	72	69
Fully slatted floor + chemical aircleaner (100% of air exhaustion)	0.09	31	30	29	90	87	84
25-49 % solid floor + chemical aircleaner (100% of air exhaustion)	0.08	35	34	33	98	95	92
Fully slatted floor + biological aircleaner (20% of air exhaustion)	0.20	9	7	7	36	28	28
Fully slatted floor + biological aircleaner (60% of air exhaustion)	0.12	20	19	18	63	60	57
Fully slatted floor + biological aircleaner (100% of air exhaustion)	0.10	32	30	30	83	80	79

Step 3 - BAT assessment and conclusion
The overall ambition of the BAT-assessment will always be to reach the lowest obtainable emission levels in order to achieve a high general level of protection of the environment as a whole. This may, however, be considered too expensive either from a socio economic point of view (only little environmental effect compared with the costs), or it may be considered too costly for the agricultural sector as a whole.

The socio economic criteria can be evaluated objectively by quantifying the damage cost from emission of i.e. ammonia and comparing these with the costs of reducing ammonia. This is however only possible if the damage cost has been quantified, which can be difficult and was not the case for ammonia during the Danish project.

The acceptable economic burden for the sector is not a given number and will therefore often be negotiated as part of a political process.

The economic maximum limits assessed as acceptable in Denmark for evaluation of BAT for finishers were -

- Max. 100 DKr/ kg reduced NH_3-N emission
- Approximately no extra costs for reducing P emission
- And max. 8 DKr per produced finisher in increased production costs for the sector