Key indicators of the environmental impact of broiler growing

Louise Manning

Working Paper

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Working Paper No 2005/No1

Louise Manning, Royal Agricultural College, Stroud Road, Cirencester Gloucestershire, GL7 6AS

Corresponding Author

Louise Manning
l.manning@btinternet.com

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Abstract

Seeking to comply with environmental legislation such as Integrated Pollution Prevention and Control (IPPC); EU Waste Incineration and Animal By-products Regulations whilst remaining globally competitive is one of the major issues facing broiler production in the UK. This paper reviews how the environmental impact of broiler production can be quantitatively measured. Case study data has been collected from a commercial broiler site and has been compared with current industry benchmarking figures. The results indicate general compliance with benchmarking figures but the study concludes that to benchmark the environmental performance of different broiler production systems we may need to relate environmental performance indicators to floor area (m^2) or kilograms (kg) of liveweight produced rather than nominal bird places.

Key words

IPPC, environmental, benchmarking, BAT, resources

1. Introduction

Within the poultry meat supply chain, the IPPC Directive (96/61/EC) needs to be implemented in factories, feed mills, hatcheries, breeder, rearing, laying and broiler production sites, once the individual installation is over the relevant threshold of either tonnage produced or number of bird places. IPPC is a regulatory system that uses an integrated approach to control certain industrial activities. The term "integrated" means it addresses the combined environmental impact on air, water and soil in one rather than several pieces of legislation. The influence of IPPC legislation on all stages of the supply chain has been analysed during this study, but this paper focuses specifically on key indicators for broiler growing. IPPC addresses many of the potential environmental impacts from the site such as resource use (including water, energy and animal feed), housing design, litter, dust noise and odour management and emergency planning.

To gain a permit to operate under these regulations, broiler site operators must comply with the requirements set out under the Standard Farming Installation Rules and Guidance (SFIR, 2003) drawn up by the Environment Agency (EA) in England and Wales, the Scottish Environment Protection Agency (SEPA) and the Northern Ireland Environment and Heritage Service (NIEHS) respectively. These regulations were made under the Pollution Prevention and Control Act 1999 and The Pollution Prevention and Control (England and Wales) Regulations 2000 No. 1973, which implemented the European Community (EC) Directive 96/ 61/EC on IPPC ('the IPPC Directive'). UK IPPC legislation affects all installations with over 40,000 bird places. It is the nominal number of bird places rather than the current stocking density that is addressed by the legislation. All new installations with over 40,000 bird places need to comply with IPPC legislation as well as existing sites where there is an addition where the change is deemed to be "substantial". All other sites have until 2007 to obtain a permit. The SFIR (2003) have been developed to minimise the environmental impact of an intensive livestock installation especially with regard to phosphorous and nitrogen.

There are a number of internal audits required under IPPC and this study will analyse the benchmarking figures for these audits including water and energy use. The benchmarking figures used come from a variety of sources including the "Opportunities for saving money by reducing waste on your farm" (DEFRA, 2004) and "Reference Document on Best Available Techniques for Intensive Rearing of Poultry and Pigs (2003) otherwise known in this paper as "IPPC BREF". The European IPPC Bureau exists to catalyse an exchange of technical information on best available techniques under the IPPC Directive 96/61/EC and to create reference documents (BREFs) which must be taken into account when the competent authorities of Member States determine conditions for IPPC permits The BREFs provide information about what may be technically and economically available to an industry in order to improve their environmental performance. Data has been collected from a case study broiler site for years 2000 – 2004 and these figures have been analysed and compared to published figures including those from IPPC BREF. The case study site is a four house 6022 m^2 site established in 1995 with a current nominal 115,000 bird places. The birds are sexed rather than "as hatched" and in each house the birds are placed in two pens. The pullets are thinned at around 38 days and final clearance is around 52 days.

Best Available Techniques or BAT is defined in Article 2 (11) of the IPPC Directive 96/61/EC as "the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole". BAT is therefore the "best" management techniques with regard to reducing wastage and emissions and thus the environmental impact of the site. BAT covers areas such as water and electricity use, training and management of the unit, manure storage and spreading techniques, carcase disposal, animal nutrition, waste management, and housing design. Environmental impact has been defined as "any change to the environment whether adverse or beneficial, totally or partly resulting from an organisation's activities, products or services." (EN ISO 14001:1996).

Table 1: Key environmental issues (adapted from IPPC BREF, 2003)

Major on-farm activity	Consumption	Potential Emission
Housing of animals	Energy, bedding, feed, water	Air emissions (ammonia or carbon dioxide), odour, noise, dust, litter
Storage of feed and feed additives	Energy	Dust
Storage of litter in separate facility		Air emissions (ammonia), odour, emissions to soil
Storage of waste other than litter		Emissions to soil, groundwater, odour
Storage of carcases		Odour
Unloading and loading of birds	Energy	Noise
Application of litter on land	Energy	Air emissions, antibiotics, odour, emissions to soil groundwater and surface water of N, P, K etc, noise
Treatment of waste water	Additives, Energy	Odour, waste water
Incineration of carcases	Energy	Air emissions, odour
Cleaning of houses	Energy, water, cleaning chemical	Air emissions (ammonia), dust, odour, noise, waste water.

Poultry farms can impact on the environment in many ways both through their use of water, energy and raw materials and their potential to produce waste and pollute. Activities carried out on intensive farming installations could have an environmental impact on both a local and national scale (Table 1) including acidification (NH_3, SO_2, NO_2), eutrophication (N, P), greenhouse effects (CO_2, CH_4, N_2O), local disturbance (odour, dust and noise) and desiccation through groundwater use (IPPC BREF, 2003). Ammonia has been considered as a key air pollutant and the United Nations Economic Commission for Europe (UNECE) Protocol to the 1999 convention on long-range trans-boundary air pollution and the EU Emissions Ceilings Directive 2001, which came into UK law in November 2002, commit the UK to achieving a reduction in ammonia emissions to an annual ceiling of 297kt by 2010 (SFIR, 2003).

2. The interaction between bird welfare and environmental impact

Bird welfare and environmental impact management are key business drivers, which may at times have an opposite effect i.e. what may be in the best interests of bird welfare, may not always be in the best interest of reducing an installation's environmental impact. Environmental impact will also vary between routine, abnormal and emergency situations. Abnormal situations could, for example, include a subclinical disease challenge, poor litter quality, or feed variability. Emergency situations are incidents which could cause high bird mortality including a disease challenge, mechanical breakdown or equipment failure, water supply failure or power loss, or an incident of heat stress. The emergency situation, which would represent the greatest environmental impact, would be an outbreak of a notifiable disease such as Newcastle Disease or Avian Influenza as this would lead to movement restrictions, high bird losses through either mortality or culling and the commercial and environmental effects would be significant as the UK Foot and Mouth Disease outbreak demonstrated (Manning *et al., 2005)*. With the introduction of the Animal By-products Regulations 2003, on-farm burial is no longer an acceptable means of disposal and mortalities would have to be rendered first before land-fill unless approved by the State Veterinary Service (SVS).

2.1 Bird place efficiency

Within an integrated supply chain, operators of a poultry installation are contracted to obtain chicks and feed from a designated source. Initial chick health and disease status, and feed suitability and consistency have a significant influence on bird health, welfare and the environmental impact of the installation (Behnke and McCoy, 1992). These factors are largely outside the control of the operator as are the effects of external weather conditions. Poor litter quality increases the incidence of contact dermatitis such as foot pad dermatitis, hockburn or skin lesions (Ekstrand, 1993). Improving litter quality, by increasing ventilation and heating will improve bird health and welfare, but will cause a greater emission of ammonia and increased usage of fossil fuels (liquid petroleum gas (LPG), oil and electricity). There is a market led and potentially legislative requirement to improve performance with regard to foot pad dermatitis, hock burn and skin lesions and to reduce the stocking density of birds.

For some resources the quantity used is related to house area rather than bird number such as bedding, volume of cleaning chemical or wash water. As stocking density reduces, it will result in increased resource usage per bird. The quantity of cleaning chemical used is also a factor of the growing programme (age of birds at slaughter).

Some production systems consist of six crop cycles a year, whilst others are based on seven cycles i.e. the birds are slaughtered at a younger age. This will therefore affect the frequency of terminal hygiene programme and resource usage per bird. Increased stocking density will require ventilation systems to effectively manage increasing heat, humidity, carbon dioxide and ammonia levels per m^2. (industry accepted calculations are based on metre squared of the floor surface area). However, as bird numbers are reduced, the ventilation rates are reduced pro rata to match the kg of liveweight in the house. The heat generated by the birds is also reduced so it may require further energy to maintain temperature profiles. In the UK, the Farm Animal Welfare Council (FAWC) recommended a maximum stocking density of 34 kg/m^2 (Defra, 2002). Broilers reared under the British Farm Standard Scheme Assured Chicken Production (ACP, 2004) can be stocked up to 38 kg/m^2. The maximum stocking density in Australia is 40 kg/m^2. (AUS, 2002) and the stocking density defined in the IPPC BREF (2003) is 18 to 24 birds/m2. This study has evaluated the conversion factor for two weight ranges (Table 2). The case study site has been analysed over 30 crop cycles in 2000 –2004 (Table 3) and the last year where both placement and depletion stocking density have reduced. The data demonstrates compliance with IPPC BREF (2003).

Table 2: Conversion between kg/m^2 and birds/ m^2 for two weight ranges

Stocking density kg/m^2	No of birds/ m^2 (1.85 – 2.15 kg)	No of birds/m^2 (1.74 – 3.63 kg)
38	17 – 20	11 – 22
34	16 – 19	10 – 20
30	14 – 16	8 – 17

Table 3: Bird placement on case study site

	Birds placed	Birds placed 2004	Birds slaughtered	Birds slaughtered 2004
Crop cycles analysed (number)	30	6	30	6
Mean birds/ m^2	19.58 (SD 0.91)	18.69 (SD 0.30)	18.83 (SD 0.80)	18.03 (SD 0.27)
Average weight (kg) (*thinning process)	-	-	2.68 (SD 0.12)	2.72 (SD 0.06)
IPPC BREF (2003) birds/m^2	18 – 24	18 – 24	18 – 24	18 - 24

Optimum environmental performance requires the most efficient use of resources and the minimisation of waste so there are environmental, welfare and economic benefits to birds that are healthy, and growing at optimum rates. One of the major impacts on bird welfare (and performance) is late mortality either due to disease or leg problems. Environmentally, the natural resources (inputs) have been lost and there is the resultant environmental impact of the disposal of carcases. Bird performance is measured as Feed Conversion Rate (FCR) and/or European Production Efficiency Factor (EPEF).

$$\text{EPEF} = \frac{\text{Liveability X Liveweight in Kg x 100}}{\text{Age in Days x FCR}}$$

Data has been collected from the case study site in 2000 - 2004 (Table 4) and been analysed against IPPC BREF (2003) data on bird performance (Table 5). The case study site complies with the IPPC BREF data excepting that the feeding level range is 0.41 Kg/bird/cycle higher than the IPPC BREF figures this is probably due to the age of the birds at depletion and the growth rates achieved on the case study site.

Table 4: Average Performance figures for case study site (2000 – 2004)

	All Years	2004
Crop cycles analysed (number)	30	6
FCR	1.92 (SD 0.07)	1.83 (SD 0.06)
Average weight (kg)	2.68 (SD 0.12)	2.72 (SD 0.06)
Feed (kg/bird/cycle)	4.91 (SD 0.33)	4.87 (SD 0.15)
EPEF	288 (SD 24)	319 (SD 21)
Weight (kg/m^2/yr)	-	33.13

Table 5: BAT Performance Data comparison with case study site

	Production Cycle (Days)	Weight (Kg)	Feed Conversion Rate (FCR)	Weight (Kg/ m^2/yr)	Feeding Level range (Kg/bird/cycle)	Kg/ bird place/ year
Broilers (1)	39 – 45	1.85 – 2.15	1.85	30 – 37	-	-
Broilers (2)	35 – 55	-	1.73 – 2.1	-	3.3 – 4.5	22 - 29
Case Study Site 2000 - 2004	39 – 53	2.68 (SD 0.12)	1.92 (SD 0.07)	33.13	4.91 (SD 0.33)	Nominal = 28.8 Actual = 29.4

(1) IPPC BREF - Source Portugal, 1999. "Overview of intensive farming in Portugal"; Netherlands (2001) Comments on the second draft of the ILF BREF; Germany (2001) Comments on the 2nd draft BREF") ((2) LNV (1994) "Handboek voor de pluimveehouderij", 90-800999-4-5.; Italy (1999) "Italian Contribution to BATs Reference Document (BREF) (draft June 1999); NFU, (2001) "Comments UK NFU to first draft", Portugal (2001) "Comments Portugal to first draft")

Table 6: Nominal vs. Actual Bird places (2000 – 2004)

	Nominal bird places	Actual bird places
Year 1	120 000	117 780
Year 2	120 000	121 670
Year 3	120 000	117 000
Year 4	115 000	114 640
Year 5	115 000	113 020

Table 6 demonstrates the change in nominal and actual bird place over the five years of the study. Between Year 1 and Year 5 there was a steady reduction in the number of birds placed.

2.2 Energy Usage

The major factor that affects energy usage is the external temperature and the cycles of external temperature compared with bird age. High external temperatures when the chicks are placed means that less fuel will be used. High external temperatures at the end of the crop will lead to higher electricity usage due to maximising the ventilation, but less fuel usage. The energy usage on the case study site in the years 2000 – 2004 has been determined (Table 7). The data demonstrates that the electricity usage has varied per bird over the five year period. The major difference has been gas usage and analysis of management practices identified that reductions in 2002 and 2003 could have been due to a change in the temperature profile. The temperature profile used an initial temperature of brooding (2 °C lower), and the rate of reduction of the temperature was altered depending on breed of bird and age of breeder hen and chick behaviour. The initial brooding temperature was raised again in 2004. In 2004, more energy was used as the ventilation profile was changed as a result of a need to improve litter quality. The variation in electricity usage was assessed over four crops in 2002 and 2004 (Table 8) and demonstrated the impact of summer ventilation on increasing electricity usage. The figures of the case study site are well within the benchmarking figures provided by Defra (2004) for 2000 - 2003, but higher for 2004. The impact of external temperature on electricity usage has not been assessed.

Table 7: Figures from case study unit comparing energy efficiency (2000 – 2004).

Year	**2000**	**2001**	**2002**	**2003**	**2004**
Total Space (m^2)	6022	6022	6022	6022	6022
Total Birds per year	706635	730009	702007	687814	678126
Birds/m2	19.6	20.2	19.4	19.0	18.7
Electricity (K Wh/yr)	186579	195288	206474	194766	217806
Electricity (KWh/bird)	0.26	0.27	0.29	0.28	0.32
Electricity (KWh/1000 birds)	260	270	290	280	320
Gas (K Wh/yr)	1319404	1321340	972589	1140290	1345512
Gas (KWh/bird)	1.84	1.81	1.39	1.66	1.98
Gas (KWh/1000 bird)	1840	1810	1390	1660	1980
Total Energy (KWh)	1505983	1516628	1179063	1335056	1563318
Total Weight (Kg)	1758102	1933713	1783517	1792519	1754071
Average Weight of slaughtered bird (Kg)	2.63	2.78	2.63	2.70	2.70
Total (KWh/bird place) (see Table 6)	**12.6**	**12.6**	**9.8**	**11.6**	**13.6**
Total (KWh/1000 birds)	**2100**	**2080**	**1680**	**1940**	**2300**
Total (KWh/bird)	**2.10**	**2.08**	**1.68**	**1.94**	**2.30**
Total (KWh/bird/day)	**0.04**	**0.04**	**0.03**	**0.04**	**0.04**
Total (KWh/kg)	**0.86**	**0.78**	**0.66**	**0.74**	**0.89**
Total (KWh/m^2)	**250**	**252**	**196**	**222**	**260**

Table 8: Electricity usage on case study site for two benchmark years.

Crop start/end date	**Jul 02 – Sep 02**	**Sep 02 – Nov 02**	**Dec 02 – Jan 03**	**Feb 03 – Mar 03**	**Annual 2002**	**Defra (2004)**
Usage (kWh/ 1000 birds	365	195	220	248	260	250 - 300
Crop start/end date	**Aug 04 – Oct 04**	**Oct 04 - Dec 04**	**Dec 04 – Feb 05**	**Feb 05 – Apr 05**	**Annual 2004**	**Defra (2004)**
Usage (kWh/ 1000 birds	354	297	280	272	321	250 - 300

The EU's aim is to achieve the Kyoto Protocol objectives to reduce greenhouse gas emissions by 8% by 2008-2012 compared to 1990 levels. In the longer term by 2020 it will be necessary to reduce these emissions by 20 to 40% by means of an effective international agreement. (SCADPlus, 2001) The proposed target is to reduce greenhouse gas emissions by an average of 1% per year over 1990 levels up to 2020. The poultry meat sector is subject to the Climate Change Levy. The poultry industry is required to demonstrate an improved performance with regard to carbon dioxide emission and managing the use of fossil fuels. The daily energy consumption on the case study site was compared with benchmarking figures (Table 9).

Table 9: Indicative levels of daily energy consumption on case study site.

Unit Size	**Energy use (KWh/bird/day)**	**Production Time (days)**	**Energy use (KWh/bird sold)**
Broilers up to 200,000 sold/year (Peirson, 1999)	0.05 – 0.18	42	2.12 – 7.37
Broilers over 200,000 sold/year (Peirson, 1999)	0.03 – 0.046	42	1.36 – 1.93
Case study (700,000 birds/year)	0.03 - 0.04	52	1.68 – 2.31

The benchmarking figures demonstrate the improved energy efficiency on larger sites and that production time and age of birds will impact on energy use i.e. the longer the crop length the more energy utilised per bird. Further study is currently being undertaken to compare energy usage between sites growing on both 42 and 52 day crop cycles.

2.3 Water Consumption

Water intake will depend on a number of factors including breed and age, bird health and well-being, feed composition, water temperature, water quality and drinking system used. The increased use of nipple drinkers has led to better management of water (Berg, 1998) and is a BAT requirement (IPPC BREF 2003, SFIR, 2003). The water consumed by the birds was analysed over two time periods in 2002 and 2004 and compared to benchmarking figures (Table 10 and 11). The Defra benchmarking figures would appear to be a factor of ten lower than the other benchmarking figures and the case study site. The data from the case study site complies with IPPC BREF figures. The water utilized in cleaning has also been analysed on the case study site (Table 12) and meets IPPC BREF. Effective terminal hygiene is critical to bird health and poor control of terminal hygiene such as incorrect chemical dilution has both environmental issues and health and welfare implications.

Table 10: Benchmarking data for drinking water consumption

	Defra (2004)	IPPC BREF (2003)	AUS (2000)
Water consumption (L/head per day/1000)	15 –30		180 - 320
Water consumption (L/head per cycle) 42 days	0.63 – 1.26	4.5 – 11	7.6 – 13.4
Water consumption (L/head per cycle) 52 days	0.78 – 1.56	4.5 - 11	9.4 - 16.6
Annual water consumption (L/bird place per year)	3.8 – 9.4	40 - 70	44 - 100

Table 11: Drinking water consumption on case study site for two benchmark years.

Crop start/end date	**Jul 02 – Sep 02**	**Sep 02 – Nov 02**	**Dec 02 – Jan 03**	**Feb 03 – Mar 03**	**Annual 2002**	**IPPC BREF (2003)**
Usage (kWh/ 1000 birds	7.7	7.3	7.4	7.4	7.6	4.5 - 11
Crop start/end date	**Aug 04 – Oct 04**	**Oct 04 - Dec 04**	**Dec 04 – Feb 05**	**Feb 05 – Apr 05**	**Annual 2004**	**IPPC BREF (2003)**
Usage (kWh/ 1000 birds	8.4	7.9	8.0	7.9	8.1	4.5 - 11

Table 12: Benchmarking water use for terminal hygiene for case study site

	IPPC BREF (2003)	Case Study Site 2002	Case Study Site 2004
Water use m^3 per m^2 per cycle	0.002 – 0.020	0.005 – 0.010	0.005 – 0.008
Cycles per year	6	6	6
Water use m^3 per m^2 per year	0.012 – 0.120	0.030 – 0.06	0.030 – 0.032

2.4 Disposal of carcases

Carcases in the UK must be disposed of in compliance with the Animal By-Products Regulation 2003. They cannot be buried on the farm other than in accordance with a dated and agreed Emergency Plan under the direction of the SVS (SFIR, 2003). The average mortality was analysed for the case study site between 2000 and 2004 (Table 13) and compared to the total mortality benchmark figure (DEFRA, 2004) which is three times higher than the average figure for the case study site.

Table 13: Case study site mortalities (2000 – 2004)

Parameter	Case Study Site 2000 - 2004	Case Study Site 2004	Defra (2004)
Crop cycles analysed (number)	30	6	
Mean mortality (%)	3.31 (SD 1.13)	3.10 (SD 0.95)	10.00

The Waste Incineration Directive 2000/76/EC aims to reduce emissions to air, water and land from the incineration of non-hazardous wastes. When the Directive was negotiated, it was recognised that the controls were too onerous to permit the continued use of small animal carcase incinerators, thus there is an exemption for incinerators which burn only animal carcases, on the understanding that appropriate controls would be included in the Animal By-Products Regulation. The controls that apply to animal carcase incinerators are set out in Annex 1v of the EU Animal By-Products Regulation. All operations must meet basic hygiene and technical standards i.e. animal by-products are handled and stored safely; incinerators reduce animal-by-products to dry ash and operate to the required temperature (850°C) and the ash is disposed of properly and records kept.

2.5 Feed composition

Diets need to be formulated to minimise the amount of nitrogen excreted by the broilers over the growing cycle by ensuring that the diets are tailored to the needs of the birds optimising crude protein input and feed utilisation. By lowering the levels of excreted nitrogen this will reduce ammonia emissions to air and levels of nitrogen in litter (SFIR, 2003). Indeed as already demonstrated in this paper excess levels of excreted nitrogen have been linked to increased incidence of skin dermatitis in birds (Ekstrand, 1993 and Estevez 2002) Lower phosphorus levels in rations fed to the birds will reduce phosphorus excretion and so reduce phosphorus levels in the litter. The feed additive phytase, an enzyme that enhances animal uptake of phosphorous contained in animal feed offers a cost effective way to minimise the losses of P in manure from poultry (EPA, 2001).

Table 14: Indicative crude protein levels in BAT-feeds for broilers (EPA, 1996)

Phases	Crude protein content (% in feed)	Total Phosphorous content (% in feed)
Starter	20-22	0.65-0.75
Grower	19-21	0.60-0.70
Finisher	18-20	0.57-0.67
	Adequately balanced and optimum digestible amino acid supply	Adequate digestible phosphorous by using highly digestible inorganic feed phosphates and/or phytase

IPPC BREF (2003) feed standards are defined (Table 14) and the broiler feed standard for the case study site is compared with benchmarking figures (Table 15). The nitrogen levels of the feed on the case study site comply with benchmarking figures for nitrogen content.

2.6 Ammonia emissions

One of the key factors that will identify the environmental impact of broiler installations is the potential ammonia emissions (IPPC, 2002). Table 16 compares the ammonia calculations and the bird place thresholds from three benchmarking sources. These figures for broiler production, especially the IPPC BREF (2003), show a large range. This in part is due to whether the installation is also using the poultry litter as a nutrient source for arable crop production. The IPPC Permit application form (IPPC, 2002) contains a table of ammonia and dust emissions, which relates to the activities on each installation. The factors for broiler production have been collated (Table 17) and demonstrates that calculations will need to be made for individual installations based on the specific activities undertaken.

Table 15: Appraisal of protein levels the feed on the case study farm.

Current protein level (Crude Protein =N*6.25) total content	Broiler Feed Standard (IPPC BREF 2003)	Ross 42-45 Day Birds (1999)	Broiler Feed used on Case Study Site (2002)
% feed 1	24 – 20	24 – 22	21.2 – 22.3
% feed 2	22 – 19	22 – 20	19.8
% feed 3	21 – 17	20 – 18	19.3

(Source IPPC BREF (2003) - BREF FEFANA (2001) "Comments on draft 2 ILF BREF" with reference for amino acids to references as, Mack et al 1999; Gruber 1999 and IPC Livestock Barneveld College (1998) "Broiler Nutrition", LNV (1994) "Handboek voor de pluimveehouderij" 90-800999-4-5; Netherlands (2001) "Comments Netherlands to First Draft)

Table 16: Comparison of Bird Places and Ammonia Emissions (kg/bird place/yr)

Livestock Category	IPPC (2002)	AUS (2002)	IPPC BREF (2003)	Bird Places UK IPPC (2002)	Bird Places AUS (2002)
Layers	0.1 - 0.2	0.17 – 0.305	0.01 – 0.386	40000	58800 -59900
Breeder hens to POL	0.1	0.269		40000	37200
Breeder hens from POL	0.1	0.598		40000	16700
Broilers	0.1	0.167	0.005 – 0.315	40000	59900

Table 17: Table of ammonia emissions factors for broilers (IPPC, 2002)

Category	Emissions (kg/yr)
Ammonia	
Housing	0.1 x number of bird places
Litter/Manure Storage	0.2 x floor area of store m2
Land spreading on operator controlled land (broadcast)	7.8 x amount of litter spread in t/yr
Land spreading on operator controlled land (broadcast and ploughed in within 24 hrs)	0.8 x amount of litter spread in t/yr
Dust	
Broilers	0.1 x number of bird places

2.7 Waste Minimisation

An inventory must be maintained detailing the quantities and relevant environmental characteristics of raw materials used (SFIR, 2003). A waste minimisation audit must also be undertaken within eighteen months of the effective permit date. This includes analysis of the usage of veterinary medicines, carcasses, feed waste, oil and lubricants, scrap metal, tyres and packaging.

3. Summary,

Following literature review, this paper has identified key indicators of the environmental impact of broiler production. The study has also compared published benchmarking figures with data from a commercial broiler site. The results demonstrate that the case study site complies with IPPC benchmarking figures for FCR (but not total feed consumption because the benchmarking figures are for the production of younger birds); energy usage in (kWh/bird/day) but not in (kWh/bird) sold for the same reason; water consumption in (L/bird/cycle) and water use for cleaning (m^3 per m^2); mortality levels (%) and protein levels in the feed (%). The legislation and the benchmarking figures tend to relate resource usage to nominal numbers of birds and it has been shown that a reduction in stocking density (bird numbers) will impact on the measurement of environmental impact and resource usage. Table 18 identifies the difference in variance which is measured using a range of the benchmarking criteria and demonstrates a significant range in variance values depending on the benchmarking figure used.

Table 18: Figures from case study unit comparing benchmarking parameters.

Year	**2002**	**2003**	**Variance 2002/2003 (%)**	**2004**	**Variance 2002/2004 (%)**
Total Space (m^2)	6022	6022		6022	
Total Birds per year	702007	687814	- 2.0	678126	- 3.4
Birds/m2	19.4	19.0	- 2.1	18.7	- 3.6
Electricity (K Wh/yr)	206474	194766		217806	
Electricity (KWh/bird)	0.29	0.28	- 3.4	0.32	+ 10.3
Electricity (KWh/1000 birds)	290	280		320	
Gas (K Wh/yr)	972589	1140290		1345512	
Gas (KWh/bird)	1.39	1.66	+ 19.4	1.98	+ 42.4
Total Energy (KWh)	1179063	1335056	+ 13.2	1563318	+ 32.6
Total Weight (Kg)	1783517	1792519	+ 0.5	1754071	- 1.7
Average Weight of slaughtered bird (Kg)	2.63	2.70	+ 2.7	2.70	+ 2.7
Total (KWh/bird place) (115,000 birds)	**9.8**	**11.6**	**+ 18.4**	**13.6**	**+ 38.8**
Total (KWh/bird)	**1.68**	**1.94**	**+ 15.5**	**2.31**	**+ 37.5**
Total (KWh/bird/day)	**0.03**	**0.04**	**+ 16.6**	**0.04**	**+ 38.8**
Total (KWh/kg)	**0.66**	**0.74**	**+ 12.1**	**0.89**	**+ 34.8**
Total (KWh/m^2)	**196**	**222**	**+ 13.3**	**260**	**+ 32.7**
Measure variance			**12.1 – 18.4**		**32.7 – 38.8**

Therefore in order to measure a poultry installation's environmental impact and also to compare poultry installations growing birds to a different production standard nominal birdplace may not be the best performance measure. When comparing broiler production systems with different stocking densities and bird age it may be more important to determine efficiency in terms of liveweight (kg) or floor area (m^2) rather than per bird or nominal bird place and relate to a time variant either per day or per week. The authors are currently extending their research to benchmark a series of commercial sites producing to differing broiler production systems to identify which are the most suitable benchmarking parameters to objectively quantify the environmental impact of broiler meat production.

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