Emission estimations for the commercial chicken, non-chicken and layer industries within New Zealand

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From the:
Poultry Industry Association of New Zealand (Inc).

and the

Egg Producers Federation of New Zealand (Inc).

Executive Summary

As of 2010, New Zealand currently has a Tier 1 approach to determining emission from all commercially grown poultry meat and chicken eggs. The default emission factors (tonnes CO_2) assigned to a generalized poultry category (i.e. that which includes broilers, broiler breeding stock, layer hens, pullet chicks, turkey, ducks and non-chicken breeding stocks) are 0.8 per tonne of carcass weight as well as 0.033 per thousand eggs (MAF 2010).

Thus the intent of this submission is to improve the current level of emission estimations for the both the broiler and layer hen industries in New Zealand by providing New Zealand specific information on (i) flock size, (ii) feed intake and digestibility of feed and (iii) nitrogen excretion from broiler and layer hens. The methods employed in this submission contain a combination of default and industry specific data which is encouraged by the Intergovernmental Panel on Climate Change, i.e. IPCC (IPCC, 1996, 2006), and is considered a Tier 2 approach towards determining or estimating the total amount of emissions generated by the commercial poultry and layer hen industries.

It is suggested that the current flock size data gathered for the broiler and non-chicken flock sizes are overestimated and an average annual flock size calculation to determine the annual flock size is proposed, which is similar to the IPCC 2006 equation suggested to calculate average annual populations (IPCC, 2006).

Industry data on gross intake and digestibility of feed have been collected to demonstrate that based off of the current IPCC 1996 methodology used to estimate the methane excretion factor for broilers and layer hens, the current default methane excretion factor of 0.117 kg CH_4/bird/year is an overestimate of the actual excretion rate for poultry in New Zealand. Based off of industry data, it is proposed that the methane excretion factor for broilers and layer hens should be 0.018 kg CH_4/bird/year and 0.011 kg CH_4/bird/year, respectively.

Industry data on nitrogen excretion rates from both broiler and layer hen birds have also been collected to demonstrate that the current default nitrogen excretion factor of 0.6 kg N/bird/year is overestimated. Based off of industry data, it is proposed that the nitrogen excretion factor for broilers and layer hens should be 0.39 kg N/bird/year and 0.32 kg N/bird/year, respectively.

Because the commercial diets of turkeys, ducks and broiler chickens are similar in dietary content, the poultry industry would expect that the daily emissions generated from these birds would be very similar. It is proposed the main difference between chicken and either turkey

or duck production is that turkeys and ducks are generally grown for a longer number of days which will have a greater influence on the total amount of emissions being generated on a per annum basis. Thus, it was assumed that the methane excretion and nitrogen excretion factors developed for broilers would be similar to the excretion factors for those of turkeys and ducks within New Zealand.

Based on the proposed new flock size, methane and nitrogen excretion factors, the total amount of CO_2 equivalent emissions were subsequentially determined and emission factors were developed based off of the total tonnage of meat produced or eggs produced from the 2007-2009 calendar years. The newly proposed factors for the broilers, layer hens, turkey and ducks are 0.23 ± 0.01 per tone of broiler carcass weight, 0.013 ± 0.001 per 1,000 eggs produced, 0.017 ± 0.00 per tone of turkey carcass weight and 0.18 ± 0.01 per tone of duck carcass weight.

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1 Introduction

The New Zealand Emissions Trading Scheme (NZ ETS) was created by the Climate Change Response Act 2002 (the Act). The Emissions Trading Scheme includes greenhouse gases from agricultural, horticultural, and arable production. For the poultry industry, the gases of concern are methane (CH_4) and nitrous oxide (N_2O) from agricultural sources.

The New Zealand Emissions Trading Scheme operates as a self reporting system, where participants open an account with the New Zealand Emission Unit Register, monitor emissions and report them on an annual basis.

Sectors are staggered into the New Zealand Emissions Trading Scheme. The agricultural industry will enter the scheme on 1 January 2015. However, voluntary reporting begins in 2011 and mandatory reporting begins in 2012. The agriculture sector will not be required to fully pay for their emissions, as it will receive a 90% allocation of the total 2005 emissions in the 2015 calendar year. This will be gradually phased out, reducing the amount allocated by 1.3% per annum from 2016 to 2030.

For the broiler and non-chicken meat industries, the default point of obligation is at the processing level (i.e. where slaughtered animals are processed for meat) and is based on the tonnage of chicken meat produced. For the layer industry, the point of obligation is placed at the farm level where eggs are generally produced and packaged for trade (based on the number of eggs sold). The points of obligation in the broiler, non-chicken meat and layer hen industries will also be required to cover downstream emissions, such as those from contractors who remove waste.

Emissions from the poultry industry are a result of methane production from enteric fermentation and nitrous oxide production from manure management systems. Significant quantities of both are emitted from poultry litter. However, these are small compared to other livestock production systems and, as such; poultry is defined as a non-key source category.

The emissions from poultry manure depend on the waste management system used. When manure is stored in a system that promotes anaerobic fermentation, such as lagoons and tanks, methane is the main emission. However, when manure is handled as a solid, such as in stacks or when spread on pastures, decomposition tends to be aerobic resulting in lower levels of methane but higher amounts of nitrous oxide. In New Zealand, there are 2 manure management systems that are the most commonly used in the poultry industry, the application of manure to pasture and manure and litter turned into compost (Brooks, personnel communication, 2010), where it is estimated that the majority of the manure/litter is eventually spread onto pastures whilst a significantly smaller proportion of the remaining litter is utilized in compost systems (Michael Brooks, personnel communications, 2010). Mitigation strategies for the poultry industry include balancing dietary nutrient levels to result in minimal faecal waste, the minimization of feed and water wastes, efficient removal of litter, filtering of air through sheds, and the drying of manure. Feed ingredients and composition for both the broiler and layer industries is controlled to help achieve maximum production. In many of the larger companies within New Zealand, nutritional and dietary information are monitored for this purpose.

This report puts forward New Zealand specific excretion factors for poultry in New Zealand and also estimates the total amount of emissions generated for the 2008 calendar year, so that emission factors for the broiler, non-chicken meat and layer hen industries in New Zealand can then be subsequentially determined. As of 2010, New Zealand currently has a Tier 1 approach to determining emission from all commercially grown poultry meat and chicken eggs. The default emission factors (tonnes CO_2) assigned to a generalized poultry category (i.e. that which includes broilers, broiler breeding stock, layer hens, pullet chicks, turkey, ducks and non-chicken breeding stocks) are 0.8 per tonne of carcass weight as well as 0.033 per thousand eggs (MAF 2010). Based off of 2008 data and a fixed New Zealand amount of NZ$ 25 per tonne of CO_2 emissions (MAF 2010), this translates into approximately $2.8 million NZD for the production of chicken meat and $798 thousand NZD for the production of eggs across both the broiler and layer hen industries in New Zealand (respectively; please see the Appendix for a review of the potential costs associated with the ETS for the broiler and layer industries from 2005-2009). Thus the intent of this submission is to improve the current level of emission estimations for the both the broiler and layer hen industries in New Zealand by providing New Zealand specific information on (i) flock size, (ii) feed intake and digestibility of feed and (iii) nitrogen excretion from boilers and layer hens. The methods employed in this submission contain a combination of default and industry specific data which is encouraged by the Intergovernmental Panel on Climate Change, i.e. IPCC (IPCC, 1996, 2006), and is considered a Tier 2 approach towards determining or estimating the total amount of emissions generated by the commercial poultry and layer hen industries.

2 General Industry Background

The broiler (meat chickens) and layer hen industries represent in excess of 99% of the total size of the poultry industry in New Zealand. These two industries are closely linked together through the companies that import breeding stock from major international breeding companies.

Chicken meat production in New Zealand is based on two quality stock imports in the form of fertile hatching eggs; the Ross bird and the Cobb bird. The two breeds that make up New Zealand's commercial layer flock are the Hyline (both brown hens and white hens) and the Shaver (brown hens only in New Zealand). Fertile breeding eggs are imported for hatching by the industry every two to three years by two major livestock breeding companies. Strict quarantine regulations protect the 'unique and superior health' status of the New Zealand poultry flock. Among these regulations is a prohibition on the importation of live birds, fresh and frozen poultry and commercial table eggs.

Fertile hatching eggs of the great-grand parent generations are sent by airfreight in sealed containers to New Zealand and then transported directly to quarantine farms and hatcheries under Ministry of Agriculture and Forestry (MAF) supervision. The imported fertile hatching eggs are hatched at company owned quarantine farms under MAF supervision. MAF import health standards and quarantine supervision combined with careful industry bio-security, has enabled New Zealand poultry to remain free from a number of serious exotic diseases such as Highly Pathogenic Avian Influenza, Newcastle Disease and Infectious Bursal Disease.

The Poultry Industry Association of New Zealand (PIANZ) represents poultry processors in New Zealand. Membership is open to all poultry (excluding ratite) processors operating in New Zealand and membership is voluntary. Currently, PIANZ represents in excess of 99% of New Zealand's poultry meat (excluding ratites) production. The Egg Producers Federation of New Zealand (EPFNZ) represents all egg producers in New Zealand. Membership of the EPFNZ is mandatory under the Commodities Levies (Eggs) Order 2004, for all persons who purchase 100 or more laying hen chicks per calendar year.

2.1 THE DISTRIBUTION OF COMMERCIAL MEAT CHICKEN AND EGG PRODUCTION OPERATIONS IN NEW ZEALAND:

The majority of commercial poultry production in New Zealand is concentrated around major cities in New Zealand such as: Auckland, New Plymouth, Palmerston North, Christchurch and Dunedin. The commercial broiler industry consists of hatcheries, breeding and broiler meat chicken farms and processing facilities. The layer hen industry consists of the same hatcheries, as well as rearing facilities and layer hen farms. The majority of egg operations are also concentrated around major cities in New Zealand, with smaller-scale operations scattered across both the North and South Islands.

2.2 THE NEW ZEALAND MEAT CHICKEN/BROILER INDUSTRY:

The New Zealand broiler industry is currently dominated by four large poultry meat producers. These are Tegel Foods Ltd., Inghams Enterprises (New Zealand), Pty. Ltd., P. H. Van den Brink Ltd. and Turks Poultry Farm Ltd. (Cooper-Blanks, 1999; Brooks, personal communication, 2010). There are seven major processing facilities scattered throughout New Zealand, with five located in the North Island and the remaining two located in the South Island.

Table 1 summarizes the total number of broiler birds produced and the total tonnage of meat produced by PIANZ for the 2005-2009 calendar years (PIANZ, 2010). The average dressed weight of broiler birds at slaughter has increased from 1.69 kg/bird in 2002 to 1.74 kg/bird in 2009 (Brooks, personal communication, 2010).

Table 1: Yearly summaries of total chicken production from 2005-2009 (PIANZ, 2010)

Year	Total number of Birds Processed	Tonnage of Chicken Meat Produced
2005	88,766,000	154,982
2006	83,214,000	144,634
2007	85,023,000	144,167
2008	81,007,000	142,167
2009	78,634,000	136,680

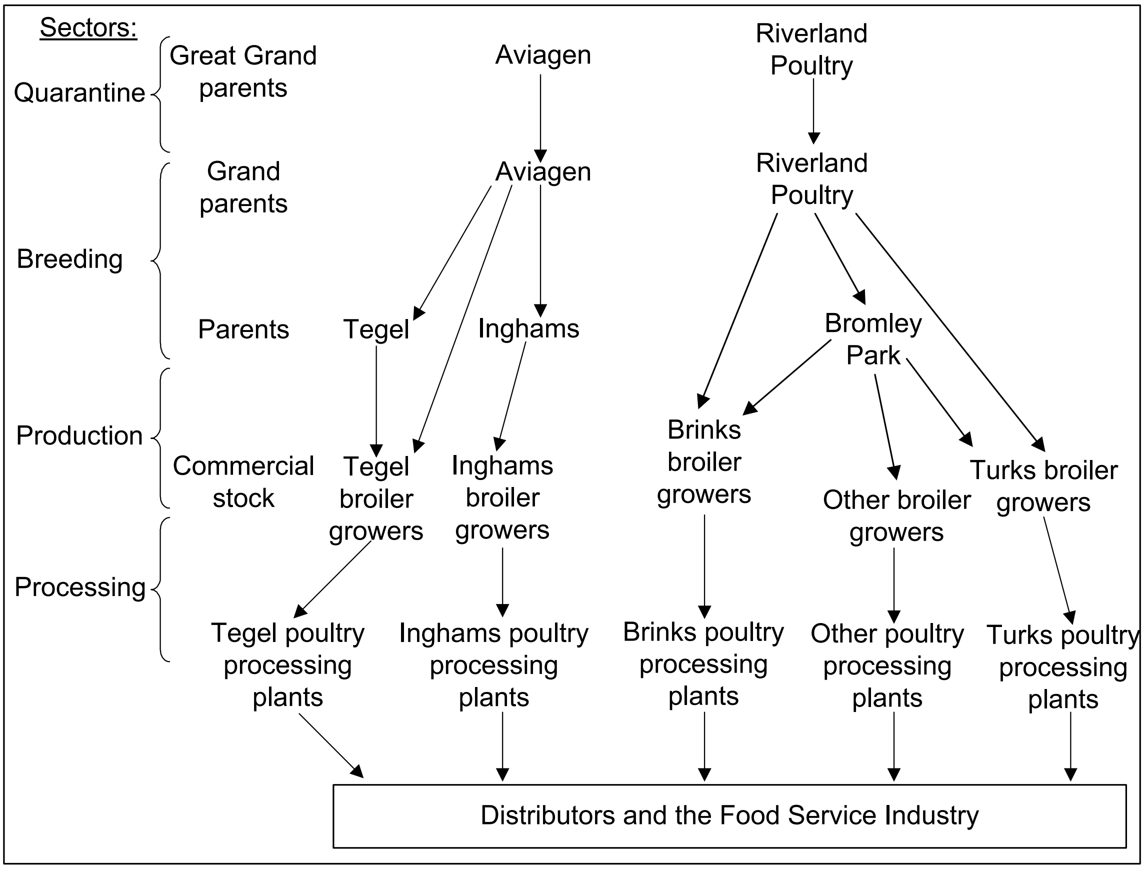
Three companies operate commercial hatcheries in New Zealand. The first is the Bromley Park Hatcheries Group, an independent company producing both commercial layer and broiler chicks. They are located in Tuakau, Christchurch (Barnard, personal communication, 2005) and in Waitakere. The Waitakere hatchery only produces broiler chicks for meat production (Granshaw, personal communication, 2010).

The second company is Gold Coast Commercial, which is owned by Tegel Foods. They have locations in Auckland, Christchurch and New Plymouth. All hatcheries produce broiler chickens for meat production, however, the hatchery located in New Plymouth also produces layer hens for egg production (Clarke, personal communication, 2010). The day-old broiler chicks hatched in these facilities are then distributed to the broiler growers. Birds are usually harvested between 31 and 42 days of age (Chrystal, personal communication, 2010; Jones, personal communication, 2010). However, the average number of days that chickens are grown for is 37 (Chrystal, personal communication, 2010).

The third and final company that owns a commercial hatchery in New Zealand is Aviagen, located in New Plymouth. Aviagen only hatch day-old breeder broiler chickens, which are then distributed to other growers to produce broiler birds (Marks, personal communication, 2010). The current structure of the New Zealand broiler industry is illustrated in Figure 1.

Both Riverland Poultry and Aviagen export fertile eggs/ to other countries for meat production, but for simplicity, these sectors are not included in Figure 1.

Figure 1: The current structure of the New Zealand broiler industry as of May 2010



The New Zealand broiler and laying industries are internationally renowned for their high biological performance. Average live weight gains and feed conversion ratios achieved on New Zealand broiler and laying farms are often better than the expected breed standard. This improved performance is attributable to a combination of factors, including high levels of animal husbandry and on-farm management, good climatic conditions for production and, in particular, high levels of on-farm biosecurity and freedom from diseases such as Newcastle Disease, Highly Pathogenic Avian Influenza, and IBD.

2.3 THE NEW ZEALAND LAYER HEN INDUSTRY:

According to Statistics New Zealand, the number of layer hen chicks placed in 2009 was 3,321,059 (see Table 2). Table 2 summarizes the estimated number of layer hens in lay and the total number of eggs produced (in dozens) from 2005 to 2009 (Statistics New Zealand, 2010b).

Table 2: Total numbers of layer hens in production (or lay) from 2005-2009

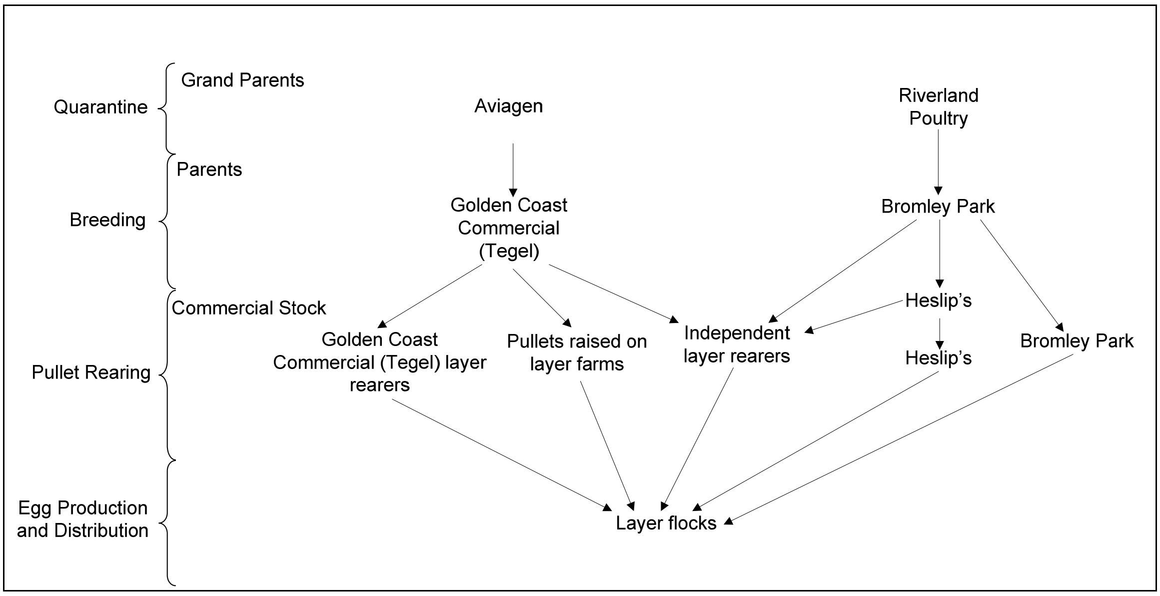
Year	Number of Birds in Lay	Total Number of Eggs Produced (Dozens)
2005	3,348,916	77,933,181
2006	3,011,425	69,780,113
2007	2,994,202	69,341,843
2008	3,405,415	76,635,716
2009	3,321,059	78,575,736

During 2002 and 2003, 92% of layer hens in New Zealand were housed in cages, 6% were free range and 2% of hens were housed in barn production systems (International Egg Commission (IEC), 2002; IEC, 2003). Currently, the EPFNZ estimates that 87% of laying hens are housed in cages, 10% are in free range systems and 3% are in barn systems (EPFNZ, 2010a). The main geographical regions of egg production in New Zealand include Auckland, Waikato, Manawatu-Wanganui, Canterbury and Dunedin (EPFNZ, 2010b).

The New Zealand layer industry is currently dominated by Mainland Poultry and the Independent Egg Producers co-operative, who together account for over 80% of the cage egg production, equating to over 65-70% of total egg production (Brooks, personal communication, 2009). Mainland Poultry also operates the largest free range poultry farm in New Zealand (Brooks, personal communication, 2009). In contrast, over 75% of barn eggs are produced by the two main producers, Benniks Poultry Farm (Brooks, personal communication, 2009) and Henergy Eggs (Christensen, personal communication, 2008).

There are currently three commercial hatchery companies in New Zealand that produce layer hens for egg production. Bromley Park Hatcheries, Golden Coast Commercial and Heslip's Hatcheries hatch commercial layer chicks (Barnard, personal communication, 2005; Clarke, personal communication, 2005). The day-old chicks hatched in these facilities are distributed to the either independent pullet rearers or to integrated layer farms, where chicks are reared on farm. At point of lay, when birds are beginning egg production, the birds are transferred to the laying sheds where they are housed until the end of their commercial life. The current structure of the New Zealand layer industry is illustrated in figure 2.

Figure 2: The current structure of the New Zealand commercial layer industry as of April 2010



Both Golden Coast Commercial and Bromley Park export fertile eggs/hatching chicks to other countries, but for simplicity, these sectors are not included in Figure 2.

2.4 MEAT CHICKEN PRODUCTION OF BROILER BIRDS:

Chicken meat in New Zealand is grown for production according to the Animal Welfare (Boiler Chickens: Fully Housed) Code of Welfare 2003 (MAF, 2003). These represent the minimum welfare standards that broiler companies are legally required to provide for animals which are either bred or grown for production purposes. The majority of the meat chicken grown in New Zealand, i.e. 97% of all broiler birds, are produced in barns production systems, whilst the remaining 3% of all of meat chicken produced in New Zealand is grown in free range production systems. The major difference between these two production systems is that a free range raised broiler bird is given the opportunity (choice) to be able to range on pasture. Both of the barns utilized in these production systems are lined with litter and bedding materials that are replaced when the broiler birds are removed from their respective sheds for slaughter.

In the context of emissions produced from chickens, the minimum welfare standards are important as these will heavily influence the duration over which chicken processing companies grow their broiler chicken flocks. Generally speaking, the longer broiler chickens are kept alive, the larger the total amount of emissions will be generated. With regards to the growing time frames or the number of days that chickens are alive, this will be the influenced by Minimum Welfare standard No. 5 (Stocking Densities). Minimum Standard No. 5– (Stocking Densities) states the following (MAF, 2003):

> *"(a) Placements of broiler chicks in individual broiler sheds must be scheduled so that the planned maximum stocking density does not exceed 38 kg of live weight of broiler chickens per m^2."*

In New Zealand, broiler chickens are grown up to a range of sizes for meat production. It is these growing time-frames that will significantly influence the amount of emissions that are generated from these birds during their growing life. Broiler chickens are typically grown to different live weights within the same shed, with the shed population being reduced at certain times (called cuts) so that both Minimum Standard No. 5 can be effectively achieved.

2.5 EGG PRODUCTION FROM LAYER HENS:

Layer hens that are housed to produce table eggs in New Zealand are managed according to the Animal Welfare (Layer Hens) Code of Welfare 2005 (MAF, 2005). As previously explained there are 3 major types of layer hen production systems in New Zealand (i.e. caged, barn, and free range production systems). Layer hens typically are reared in their respective production system up until 18 weeks of age, when they are then transferred into productions sheds and begin to produce table eggs. Layer hens are typically in production sheds until 78 weeks of age (i.e. one year and 6 months). As with Broiler birds grown for meat production, layer hens housed in sheds according to the minimum stocking densities for cage, barn or free range productions systems. The minimum stocking density for cage operations are 500 cm^2/bird, the minimum stocking density for barn operations can range between a minimum of 1428 cm^2/birds to a maximum of 7 birds/m^2 and the minimum stocking density for houses for free-range operations can range between a minimum of 1000 cm^2/bird to a maximum of 10 birds/m^2. With a combination of good animal husbandry and flock management, stocking densities will influence the number of birds stocked in a given shed and, in turn, will affect the actual number of eggs being produced.

2.6 COMMERCIAL NON-CHICKEN MEAT INDUSTRY IN NEW ZEALAND:

Other types of commercially produced poultry in New Zealand are turkey and duck meat. Both turkey and meat production is small relative to the commercial broiler industry in New Zealand and encompass less than 0.25% of the total broiler industry. Turkey meat operations are located only in the South Island whereas duck meat operations are geographically spread across New Zealand with operations located in both the North and South Island (Brooks, personnel communication, 2010). Currently, Statistics New Zealand reports the flock sizes for commercially grown turkeys and ducks under the 'other poultry' category, which combines both the turkey and duck flock sizes in New Zealand. The following table summarizes the flock sizes for 'other poultry' for the 2007 – 2009 calendar years.

Table 3: Flocks sizes of other poultry in New Zealand from 2007-2009

Year	Total Number of Turkeys and Ducks (i.e. Other Poultry)
2007	168,181
2008	206,653
2009	200,891

Both turkeys and ducks are grown and slaughtered in accordance with the Animal Welfare (Commercial Slaughter) Code of Welfare, a Code issued under the Animal Welfare Act 1999 (MAF, 2010). Turkeys are generally grown between 90-100 days, or an average of 95 days in a calendar year (Chrystal, Crozier, Dick, personnel communications, 2010) whereas ducks are generally grown for an average of 43 days within a calendar year (Dick, Houston, personnel communications, 2010). Approximately 83% of the total turkey population grown for meat production and all of the commercial duck population grown for meat production are grown in barn systems. The remaining proportion of turkeys are produced in free range systems which basically consist of barns that allow the bird excess to the outdoors (for ranging purposes) and are similar to the free range systems described for the broiler industry. The barns utilized in these production systems are lined with litter and bedding materials that are replaced when the broiler birds are removed from their respective sheds for slaughter.

3 Annual Average Populations of poultry grown in New Zealand

The following sections will explain how the flock sizes within the poultry industry in New Zealand are determined and will discuss proposed alternatives to better determine some of these annual average flock sizes.

3.1 NEW ZEALAND MEAT CHICKEN/BROILER INDUSTRY:

3.1.1 Broiler Production

Statistics New Zealand currently determines the meat chicken/broiler industry's annual flock size through a modelling formula which considers the ratio of the total amount of poultry of type (species) '$_i$' processed (plus poultry of type '$_i$' mortality) produced in New Zealand to the number of growing cycles (i.e. rotations) within a calendar year (Chou, personnel communication, 2009). Equation 1 illustrates the equation used to estimate the current annual flock size for New Zealand.

$$Annual\ Flock\ Size = \frac{Annual\ Number\ of\ Poultry\ of\ type\ '_i\ '\ Processed}{(1-X_i)*(1-Y_i)*(1-Z_i)*R_i}$$

(equation 1)

Where:

X_b is the condemned ratio of broilers.

Y_b is the ratio of broilers that are dead on arrival to processing plants.

Z_b is the ratio of the broilers lost while still in sheds during growing.

R_b is the average number of broiler growing cycles (per annum).

According to Statistics New Zealand for 2008, X, Y and Z (i.e. the ratio estimators for broiler bird mortality) were 0.00106, 0.00099 and 0.03034; respectfully, whilst the number of broiler cycles were 6.0821 for broiler production (Chou, personnel communication, 2010). According to 2008 data, this was the equivalent to an annual average population of 14,642,773 broiler birds (Statistics New Zealand, 2009). However, this equation does not take into consideration the variable amount of downtime between cycles which can vary between 7 to 14 days (Chou, personnel communications 2010; Brooks, personnel communications, 2010). Thus, an annual average flock size of the New Zealand broiler flock can be more accurately determined by taking the average number of days that broilers are alive for (‘Days Alive’ in equation 2) multiplied by the ratio of the Annual Number of Poultry of type (species) ‘$_i$’ Processed, i.e. the number of broilers processed (including the number of birds that are lost from a combination of mortality and those which are condemned) to the number of days in a calendar year. This approximation would better represent the average annual flock size in New Zealand (see equation 2) and is also consistent with Equation 10.1 from the 2006 IPCC (International Panel on Climate Change) Guidelines for National Greenhouse Gas Inventories to determine the annual average population (IPCC, 2006).

$$\text{Average Annual Flock Size} = \text{Days Alive} * \frac{\left(\dfrac{\text{Annual Number of Poultry of type '}_i\text{' Processed}}{(1-X_i)*(1-Y_i)*(1-Z_i)}\right)}{365}$$

(equation 2)

Where:

‘Days Alive’ is the average number of days that broiler birds are grown for.

365 is the number of calendar days in a year.

X_b is the condemned ratio of broilers.

Y_b is the ratio of broilers that are dead on arrival to processing plants.

Z_b is the ratio of the broilers lost while still in sheds during growing.

R_b is the average number of broiler growing cycles (per annum).

In order to determine the number of days that the birds are grown for, i.e. ‘Days Alive’, a typical growing schedule can identify the day when the poultry birds are removed from the shed for slaughter (PIANZ, 2010). When approximately 50% or half of the entire proportion of birds are removed from a shed, the time will correspond to the average number of days that the particular type of poultry is alive for and can be substituted as the variable for ‘Days Alive’ from equation 2.

Table 4 represents a summation of the growing schedule for the entire broiler bird/meat chicken industry. Please note that sheds begin to become depopulated as early as 31 days, corresponding to a total of 19% of the broiler population and as late as 48 days, corresponding to 6% of the broiler population (PIANZ, 2010). More importantly, more than 50% of the entire broiler flock in New Zealand is removed from the shed in 37 days. Thus 37 days is seen as an appropriate average value to represent the number of days that broiler chickens are alive for in the commercial broiler industry.

Table 4: Total proportion of broiler birds removed from sheds for slaughter

days	% of birds	% of flock
31	19.3%	
32	18.9%	
33		
34		
35	1.8%	
36		
37	**17.0%**	**57.0%**
38	2.9%	
39		
40	7.3%	
41		
42	24.7%	
43	1.2%	
44		
45		
46	0.6%	
47		
48	6.3%	

Thus, from equation 2 the meat chicken/broiler industry in 2008 grew a total of 8,485,993 broilers in the 2008 calendar year. Compared to the Statistics New Zealand's estimation, this amounts to a difference of 6,156,780 broiler birds. The reason for this difference is because the equation in equation 1 does not reflect the true annual population of an animal population which are grown for production in a period of time that is less than a calendar year and is reflective of an equation that takes into consideration the maximum number of days alive (of a typical broiler bird) as well as the downtime (or 'off' production time) as opposed to the average number of days and thus, this would over-estimate the broiler flock size rather then an average number of days alive.

3.1.2 Broiler Breeding Stock

Statistics New Zealand Meat currently determines the Broiler Chicken breeding flock size through an identical modelling equation used to estimate the annual flock size for broiler birds grown for the production of chicken meat. Thus, for the broiler breeding stock ($_{bs}$) the following morality ratio estimators and number of rotations for the 2008 calendar year:

X_{bs} is the condemned ratio of breeding stock (0.00121).
Y_{bs} is the ratio of breeding stock that are dead on arrival to processing plants (0.00087).
Z_{bs} is the ratio of the breeding stock lost while still in sheds (0.09652).

R_{bs} is the average number of breeding stock growing cycles per annum (0.8355).

The commercial breeding stock in New Zealand remains static throughout an entire calendar year to ensure that genetic lines of meat chickens are successfully produced for chicken meat production in New Zealand (i.e. the average number of breeding stock growing cycles is typically equivalent to or less than 1 per year). Thus, the current flock size reported by Statistics New Zealand is representative of the average annual breeding flock size. For the 2008 calendar year, the breeding stock flock size in New Zealand was 772,273 birds.

3.2 NEW ZEALAND LAYER HEN INDUSTRY:

3.2.1 Hens for Egg Production

The New Zealand layer hen industry's annual flock size is currently determined through the surveying performed by Statistics New Zealand, where the total surveyed flock size is determined to be equivalent to the annual average layer hen population (Watt, personnel communication, 2010). Because these birds are typically in production for 18 calendar months (i.e. greater than a calendar year) this flock size is much more static than it is for broilers grown in New Zealand. When these birds reach the end of their commercial laying life, a new flock of layer hens will enter the commercial layer flock for egg production, thus ensuring a consistent or steady number of hens in egg production. Therefore the proposed average annual flock size for layer hens will also be equivalent to the annual number of layer hens in production. According to Statistics New Zealand for 2008, the hens in lay for egg production were 3,405,415 birds (Statistics New Zealand, 2009).

3.2.2 Replacement Stock (Pullets) intended for Egg Production

As with the hens used for egg production (See Section 3.2.1), the flock size of the pullets intended for egg production are determined by Statistics New Zealand. Statistics New Zealand accomplishes this through the same surveying as previously mentioned. These birds are reared (i.e. grown) for approximately 18 weeks before they are placed in commercial egg producing flocks. Pullet flocks are static as new chicks are constantly becoming reared for egg production. This is to ensure a continuous and steady supply of layer hen stocks available for the production of eggs. Therefore the proposed average annual flock size for reared pullets will also be equivalent to the annual number of pullets reared for the production of eggs. According to Statistics New Zealand for the 2008 calendar year, a total of 913,030 birds were reared for egg production (Statistics New Zealand, 2009).

3.3 NEW ZEALAND NON-CHICKEN POULTRY INDUSTRY:

3.3.1 Turkey and Duck Meat Production

In New Zealand the other type of poultry commercially produced is turkey and duck. Statistics New Zealand currently determines the non-chicken meat (i.e. turkey and duck) industry's annual flock size through an identical modelling formula utilized for the broiler industry (see equation 2). Thus, for the flock size for both turkey and duck flock sizes in New Zealand ('$_t$' and '$_d$', respectively) the following morality ratio estimators and number of rotations were used for the 2008 calendar year:

X_t is the condemned ratio of breeding stock (0.00028).

Y_t is the ratio of breeding stock that are dead on arrival to processing plants (0.00019).

Z_t is the ratio of the breeding stock lost while still in sheds (0.06450).

R_t is the average number of breeding stock growing cycles per annum (3.5750).

X_d is the condemned ratio of breeding stock (0.00004).

Y_d is the ratio of breeding stock that are dead on arrival to processing plants (0.00004).

Z_d is the ratio of the breeding stock lost while still in sheds (0.02590).

R_d is the average number of breeding stock growing cycles per annum (6.4000).

According to 2008 data, this was the equivalent to an annual average population of 206, 653 turkeys and ducks (Statistics New Zealand, 2009). However, an average annual flock size for both turkey and duck flocks can be more accurately determined by taking the average number that turkeys and ducks (separately) are alive for ('Days Alive' in equation 2) multiplied by the ratio of the numbers of turkeys or ducks produced annually (including the number of birds that are lost from a combination of mortality and those which are condemned) to the number of days in a calendar year. This approximation would better represent the annual average turkey and duck flock sizes in New Zealand and is also consistent with Equation 10.1 from the 2006 IPCC (International Panel on Climate Change) Guidelines for National Greenhouse Gas Inventories to determine the annual average population (IPCC, 2006).

Because differentiating the annual turkey flock size from the annual duck flock size cannot be performed from the data provided by Statistics New Zealand, Industry data (PIANZ, 2010) has been compiled to show the total number of turkey or ducks that were processed for the

2007-2009 calendar years. The tonnage of turkey and duck meat for these years is based off of an approximate carcass weight of 6 kg per turkey carcass and 2.5 kg per duck carcass from industry (Chrystal, Crozier, Dick, Houston, personnel communications, 2010) and is summarized in the following table:

Table 5: Processing numbers associated with Turkeys and Ducks from 2007-2009

Year	Total Number of Turkeys Processed	Approximate Tonnage of Turkey Meat Produced (Tonnes)	Total Number of Ducks Processed	Approximate Tonnage of Duck Meat Produced (Tonnes)
2007	304,213	1825	656,421	1641
2008	267,314	1604	724,994	1812
2009	260,990	1566	778,000	1945

Based off of equation 2 and production data (PIANZ 2010), the average annual flock population for both turkeys and ducks for the 2008 calendar year is 74,407 turkeys and 87,688 ducks.

3.3.2 Turkey and Duck Breeding Stock

Statistics New Zealand currently determines the breeding flock sizes through surveying farms for the size of their breeding flock (i.e. on June 30^{th}) for a given calendar year (Chou, personnel communication, 2010). The breeding flock sizes for both turkeys and ducks are also lumped into the 'other poultry' category that is reported by Statistics New Zealand. The commercial non-chicken breeding stock in New Zealand remains static throughout an entire calendar year to ensure that genetic lines of turkey and ducks are successfully produced for meat production. Based off of Industry data (PIANZ 2010), the 2008 breeding flock size for turkeys and ducks was approximately 3,020 and 5,150 birds, respectively.

Combining the breeding and meat flock sizes together for both turkeys and ducks gives a total turkey flock size of 77,427 birds and a total duck flock size of 92,838 birds for the 2008 calendar year. Compared to the Statistics New Zealand's estimation of the number of live birds in New Zealand on the 30^{th} of June 2008, this amounts to a combined difference (or a total overestimated flock size) of 36,388 birds under the 'other poultry' category. The reason for this difference is similar to the reason explained for the difference in broiler bird numbers (see Section 3.1.1).

3.4 LIMITATIONS:

The current method of determining both the annual population for the layer hen flock (for both hens in production as well as pullets that are reared for egg production) as well as both the turkey and duck breeding flocks do not include ratio estimators to account for mortality and loss during the calendar year.

In regards to the layer industry, the Comparative Assessment of Layer Hen Welfare in New Zealand – Final Report (March 2009) published produced by AssureQuality Limited and Avivet Limited (Black and Christensen, 2009) has been able to demonstrate that mortality for hens in lay does vary between the different types of commercial egg operations (i.e. cage, barn, free range) which would make it more difficult to determine an industry average for hen mortality. It is suggested that if layer hen mortality is to be included in any determination of an annual flock size, that mortality would be weighted based upon the total size of each different type of egg operation within New Zealand.

On the contrary to this, the current level of information collected by Statistics New Zealand gathers both hen and egg numbers based upon every farm that contains more then 25 layer hens, whereas the definition of a commercial egg producer is all persons who purchase more than a 100 chicks per calendar year and pays towards Commodity Levies (Eggs) Order 2005. Thus the current information provided by Statistics New Zealand will also cover a proportion of the backyard and semi-commercial layer sectors in New Zealand.

Additionally, the combined turkey and duck breeding flocks in New Zealand is considerably smaller than the breeding stock for the broiler industry (i.e. according to the 2008 calendar year, the breeding flock for the non-chicken industry was 1.06% of the broiler breeding flock). However if non-chicken mortality were to be included for the non-chicken meat industry, the mortality factors should be weighted based upon the breeding flock sizes of both the turkey and the duck breeding flocks within New Zealand.

3.5 KEY FINDINGS:

Because rotations of broiler and other poultry flocks (i.e. turkey and ducks) are typically less than a calendar year, the current method of determining the annual flock size does not take this into consideration. The newly proposed method to determine an average annual flock size for the broiler and other poultry flocks in New Zealand is consistent with the equation proposed by IPCC 2006.

The annual broiler flock for the 2008 calendar year is currently overestimated by 6,156,780 broiler birds or by 42% of the total average annual broiler flock.

The annual other poultry (i.e. turkey and duck) flock for the current 2008 calendar year is currently being overestimated by 36,388 birds or by approximately 18% of the total average other poultry flock.

4 Methane Emissions

In order to develop a New Zealand specific emission factor for methane from both broilers and layer hens, the gross energy intake from feed as well as the digestibility of the feed (in percent) can be utilized in order to provide appropriate information to determine the daily volatile solid excretion. This value is important as it is used to determine the methane emission factor for the specific bird in question (i.e. broiler, hen, breeder, pullet, turkey and/or duck). Calculations for methane from manure management for poultry follow the IPCC default calculations (Pickering, 2009). Methane is only calculated for poultry in manure management as there is believed to be very little enteric fermentation for chicken manure. Manure only produces methane in waste systems due to the anaerobic nature of the manure. When manure is deposited directly onto pasture, such a small amount (or none) of methane is produced that it is not counted. The following equation is used to estimate the amount of methane (**M**) produced for the given year.

$$\mathbf{M\ (kg\ CH_4/yr) = EF_{m(i)}*N}$$

(equation 3)

Where:

$EF_{m(i)}$ is the methane manure management emission factor for type of poultry, '$_i$', where 0.117 kg CH_4/bird/year is the current IPCC default (IPCC, 1996).

N is the average annual population.

The following equation can be used to determine the methane manure management emissions factor (IPCC, 1996):

$$EF_{m(i)} = \left(VS_{(i)} * y\right) * \left[B_{o(i)} * 0.67 kg/m^3 * \sum_S MCF_S * MS_{(i,S)}\right]$$

(equation 4)

Where:

$EF_{m(i)}$ is the annual methane emission factor for poultry type, '$_i$'.

$VS_{(i)}$ is the daily volatile solid excreted for poultry type, '$_i$', in kg dry matter/bird/day.

y is the number of days in a calendar year.

$B_{o(i)}$ is the maximum methane producing capacity for manure produced by poultry type, '$_i$', in m^3 CH_4/kg.

0.67 is the conversion factor of m^3 CH_4 to kilograms CH_4

MCF_S is the methane conversion factors for each manure management system by '$_S$'.

$MS_{(i,S)}$ is the fraction of poultry type, '$_i$', which has manure handled using manure management system, '$_S$'.

'$_S$' is the manure management system, in which, there are only 2 systems used in the poultry industry in New Zealand (i.e. PR&P/free range and solid storage/dry lot litter management – "other"). These two systems have a methane conversion factor (MCF), both of which have an estimated MCF value of 1.5% (IPPC, 1996).

The current default values assigned to both the broiler and layer hen industries are summarized in Table 6.

Table 6: Current assigned default values for both the broiler and layer hen industries

Variable	*Default for poultry in temperate climate (IPCC, 1996)*
VS	0.1
B_0	0.32
MCF	PR&P 1.5%
	Other 1.5%
MS	PR&P 3%
	Other 97%

4.1 VS – DAILY VOLATILE SOLID EXCRETION:

Daily volatile solid excretion (where kgdm means kilograms of dry matter) can be determined for each poultry type using the IPCC default equation (IPCC, 1996):

$$\text{VS (kgdm/day)} = \text{GE} * \frac{1}{18.45} * \left(1 - \frac{\text{DE\%}}{100}\right) * \left(1 - \frac{\text{ASH\%}}{100}\right)$$

(equation 5)

Where:

GE is the gross energy intake from feed (MJ/day)

18.45 is the conversion factor for dietary GE per kg of dry matter (MJ/kg).

DE% is the digestibility of the feed (in percent).

ASH% is the ash content of the manure (in percent).

In both the broiler and layer hen industries within New Zealand, the gross energy and digestibility of feed for both broiler or layer hens can be determined. The average gross energy and digestibility of broiler feed is 1.7 ± 0.2 MJ/day and 76.7 ± 2.9%, respectively (see the Appendix for a breakdown of the gross intake and digestibility data gathered across both the broiler and layer industries) (PIANZ, 2009). The average gross energy and digestibility of layer hen feed is 1.3 ± 0.0 MJ/day and 82.0 ± 0.0%, respectively (EPFNZ, 2010)

Using the current IPCC default value for ASH of 28 % (IPPC, 1996), the average daily volatile solid excretion is 0.015 kg of dry matter/day for broiler birds. The average daily volatile solid excretion is 0.009 kg of dry matter/day for layer hens. This value for VS along with the IPCC default values for B_o, MCF and MS can be used to calculate $EF_{(m)}$ for broiler and layer hens (IPCC, 1996). Thus, assuming the same MS fraction of poultry type, the $EF_{(m)}$ for broiler and layer hens in New Zealand equates to 0.018 CH_4/bird/yr and 0.011 CH_4/bird/yr, respectively. Once the methane emission factor is determined, the methane emissions generated from the management of broiler and layer hen manure can be estimated. For the 2008 calendar year, the methane emissions generated from both the broiler and the layer hen industries were 153,976 kg CH_4 and 36,503 kg CH_4, respectfully. Both the breeding and pullet flocks generated a total of 14,013 kg CH_4 and 9,787 kg CH_4, respectfully. Assuming that one kg of methane emissions is the equivalent of 21 kg of CO_2 emissions (MAF, 2010) both the broiler and layer industries in 2008, produced a net equivalent of 3,527 tonnes of CO_2 and 973 tonnes of CO_2, respectfully.

The commercial diets of both turkey ducks and broiler chickens are similar in dietary content thus, the poultry industry would expect that the daily emissions generated from these birds would be very similar (Chrystal, personnel communications, 2010, MacAlpine, personnel communications, 2010). Industry notes that the main difference between chicken and turkey and duck production is that turkeys and ducks are generally grown for a longer number of days which will have a greater influence on the total amount of emissions being generated on a per annum basis (Chrystal, MacAlpine, personnel communications, 2010).

Using the same methane emission factor as determined for broiler birds for both the turkey and duck flocks in New Zealand, the methane emissions generated from both of these industries are 1,405 kg CH_4 and 1,685 kg CH_4, respectfully, for the 2008 calendar year. Assuming that one kg of methane emissions is the equivalent of 21 kg of CO_2 emissions (MAF, 2010) both the commercial turkey and duck meat industries in 2008, produced a net equivalent of 30 tonnes of CO_2 and 35 tonnes of CO_2, respectfully.

4.2 LIMITATIONS:

The current method of determining the methane emission factors for both turkey and ducks grown in New Zealand are based off of the same gross energy intake and digestibility values supplied for the broiler industry. The commercial diets of both turkey ducks and broiler chickens are similar in dietary content thus the poultry industry would expect that the daily emissions generated from these birds would be very similar (Chrystal, personnel communications, 2010, MacAlpine, personnel communications, 2010). Industry reiterates that the main difference between chicken and either turkey or duck production is that turkeys and ducks are generally grown for a longer number of days which will have a greater influence on the total amount of emissions being generated on a per annum basis (Chrystal, MacAlpine, personnel communications, 2010).

4.3 KEY FINDINGS:

From industry supplied data, the gross intake of energy from feed for both the commercial broiler and the layer hen industries is estimated to be 1.7 ± 0.2 MJ/day and 1.3 ± 0.0 MJ/day, respectively.

From industry supplied data, the digestibility of feed for both the commercial broiler and layer industries is 76.7 ± 2.9% and 82.0 ± 0.0%, respectively.

Based off gross intake of energy from feed and the digestibility of feed, the methane emission factors were determined to be 0.018 and 0.011, respectively, for both broiler and layer hens within the commercial broiler and layer hen industries within in New Zealand.

Based off of the 2008 calendar year, the commercial broiler and layer hen flock in New Zealand produced an estimated 3,527 tones and 973 tones of CO_2 equivalent emissions generated from the production of methane gas (respectively). The commercial non-chicken industry produced a total of 30 tones and 35 tones of CO_2 equivalent emissions generated from the production of methane gas from both turkey and duck flocks (respectively).

5 Nitrous Oxide Emissions

Calculations for nitrous oxide from manure management for poultry follow the IPCC default calculations (IPCC, 1996). Nitrous oxide is accounted through the direct emissions of poultry manure/compost from soils, emissions from poultry wastes and through indirect emissions associated with nitrogen volatising and nitrogen leeching from soils. The following equation is used to estimate the amount of direct nitrous oxide (N_2O-N) emissions produced by poultry of type, “i", from its manure in a given year.

$$\mathbf{N_2O\text{-}N_{(i)}\ (kg\ N_2O\text{-}N/bird/yr) = N_{(i)} * N_{ex\ (i)} * MS_{other} * EF_{3(other)}}$$

(equation 6)

Where:

$N_{(i)}$ is the average annual population of poultry type, ‘$_i$’.

$N_{ex\ (i)}$ is the annual average nitrogen excretion per bird of poultry type, ‘$_i$’. The IPCC default for ‘poultry’ is 0.6 kg N/bird/yr (IPCC, 1996).

$MS_{(i,\ other)}$ is the fraction of poultry type, ‘$_i$’, which has manure handled using manure management system, ‘$_S$’. The IPCC default for “other” management systems is 0.97 (IPCC, 1996).

$EF_{3(other)}$ is the emission factor for manure other management system. The IPCC default for manure without bedding is 0.005 N_2O–N/kg (IPCC, 1996).

In the broiler industry within New Zealand, feed intake and live weight gain of broiler birds are adjusted according to a general broiler growing schedule/model (Chrystal, 2010). This model plans/predicts bird weight gain and in regards to manure, the amount of nitrogen excretion during a growing cycle. Table 7 depicts the various parameters measured in this model. Thus, over a typical growing cycle of 37 days (this row is highlighted in Table 7) the total amount of nitrogen excreted per bird can be estimated and is equivalent to approximately 0.0634 kg N/bird/cycle. Multiplying this by the number of cycles in a year (i.e. 6.0821 in the 2008 calendar year) gives a nitrogen excretion factor (N_{ex}) of 0.39 kg N/bird/yr.

Table 7: A typical growing model and parameters used to chart bird growth in the broiler industry

Day	% Male	Nitrogen Excretion (gm/bird/day)	Energy Conversion (MJ/kg)	Lipid Index	Live weight (g)	Weight Gain (g/day)	Cumulative Food Intake (g)	Daily food Intake (g)
0	50	0	0	0	50	0	0	0
1	50	0.188	8.2	116	64	13.8	9	9
2	50	0.225	12.4	125.2	75	10.9	21	11
3	50	0.263	12.7	131.4	87	12.5	34	13
4	50	0.325	12.4	136.1	103	15.7	50	16
5	50	0.378	13	138.5	120	17.4	69	19
6	50	0.437	13.2	139	140	19.8	91	22
7	50	0.508	13.3	138.3	163	22.7	116	25
8	50	0.591	13.5	136.7	189	26.2	145	29
9	50	0.667	13.9	134.2	217	28.5	178	33
10	50	0.773	13.8	131.4	251	33.1	216	38
11	50	0.876	14.2	128.1	287	36.5	259	43
12	50	0.993	14.4	124.5	328	40.9	308	49
13	50	0.933	14.7	123.1	375	46.6	364	56
14	50	1.134	15.7	128.3	424	49.9	428	64
15	50	1.243	16	132	478	53.9	498	70
16	50	1.374	16.3	134.5	536	58	575	77
17	50	1.495	16.6	136.2	598	61.9	658	83
18	50	1.616	16.9	137.1	664	65.6	748	90
19	50	1.738	17.1	137.3	733	69.3	845	97
20	50	1.864	17.4	136.8	806	73.2	948	103
21	50	1.985	17.7	135.8	883	76.4	1058	110
22	50	2.11	17.9	134.3	963	79.9	1174	116
23	50	2.227	18.2	132.5	1045	82.6	1296	122
24	50	2.337	18.6	130.4	1130	85	1424	128
25	50	2.371	19	131.3	1223	92.4	1565	141
26	50	2.501	20.5	132.6	1312	89.6	1712	147
27	50	2.601	20.6	133.6	1405	92.2	1864	152
28	50	2.685	21	134.2	1498	93.5	2020	157
29	50	2.768	21.3	134.5	1593	95	2181	161
30	50	2.833	21.6	134.6	1689	95.6	2346	164
31	50	2.917	22.2	134.5	1783	94.4	2513	167
32	50	2.675	22	134.5	1880	97.4	2683	170
33	50	3.047	24.5	136.3	1972	91.2	2860	178
34	50	3.108	24.9	137.7	2063	91.4	3041	181
35	50	3.168	25.1	138.9	2155	92	3224	183
36	50	3.216	25.5	139.8	2247	91.8	3410	186
37	50	3.263	25.8	140.5	2339	91.9	3598	188
38	50	3.308	26	141	2431	92	3787	190
39	50	3.32	27.2	141.4	2518	87.3	3977	190
40	50	3.285	26.8	141.7	2606	87.8	4163	186
41	50	3.31	27.1	141.7	2693	87	4351	187
42	50	3.334	27.4	141.5	2779	86.3	4538	188

Thus in the 2008 calendar year, the broiler industry produced a total amount of nitrous oxide emissions directly from bird wastes of 15,868 kg N_2O-N. Based off of a crude protein diet of 22%, this equates to approximately 0.127 kg N/bird/cycle, or an approximate nitrogen excretion to nitrogen intake efficiency ratio of approximately 50%. This is consistent with what is expected for broiler chickens grown in the New Zealand industry (Chrystal, personnel communications, 2010).

For the laying industry in New Zealand, the nitrogen excreted by both layer hens and pullets reared for egg production can be estimated through data on the analysis of the manure produced by the laying birds. Table 8 summarizes the results from a typical analysis of layer hen manure which includes the percentage of nitrogen within the manure (EPFNZ, 2010b):

Table 8: A manure analysis performed on laying hen manure illustrating the fresh weight of the percentage of nitrogen in the manure

REPORT OF MANURE ANALYSIS Results are based on established methods of analysis, available on request. Results apply to the sample(s) as received.	
Moisture % w/w	52.69
pH	6.9
C:N Ratio	5
Organic Matter % w/w (dry weight)	62.3
--	FRESH WEIGHT
Total Nitrogen % w/w	3.16
Total Carbon % w/w	17.1
Phosphorus % w/w	1.07
Potassium % w/w	0.74
Sulphur % w/w	0.24
Calcium % w/w	3.28
Magnesium % w/w	0.28
Sodium % w/w	0.10
Arsenic (Total) mg/kg *	--
Cadmium (Total) mg/kg *	--
Chromium (Total) mg/kg *	--
Lead (Total) mg/kg *	--
Mercury (Total) mg/kg *	--
Nickel (Total) mg/kg *	--
* Tests subcontracted to an outside facility	

For more information in regards to the manure analysis for laying hens, please refer to the Appendix. Based on the average excretion of 28 g per day of excreta from laying hens, where, this average is based off of the average of 20 - 30% of dry matter of excreta from a layer diet of 110 gm/day (Kerry Mulqueen, personnel communications, 2010). Thus, the total amount of nitrogen excreted from an individual layer hen or pullet within a calendar year would amount to a nitrogen excretion factor (N_{ex}) of 0.32 kg N/hen/yr. Based off of the nitrogen excretion factor of 0.32 kg N/hen/yr, the layer hen industry produced a total amount of nitrous oxide emissions directly from bird wastes of 5,285 kg N_2O-N in the 2008 calendar year.

Both the breeding and pullet flocks generated a total of 1,444 kg N_2O-N and 1,417 kg N_2O-N, respectfully. The commercial diets of both turkey ducks and broiler chickens are similar in dietary content thus the poultry industry would expect that the daily emissions generated from these birds would be very similar (Chrystal, personnel communications, 2010, MacAlpine, personnel communications, 2010). Industry notes that the main difference between chicken and turkey or duck production is that turkeys and ducks are generally grown for a longer number of days which will have a greater influence on the total amount of emissions being generated on a per annum basis (Chrystal, MacAlpine, personnel communications, 2010). Using the same nitrogen emission factor determined from broiler birds, the turkey and duck meat industries produced a total amount of nitrous oxide emissions directly from bird wastes of 145 kg N_2O-N and 174 kg N_2O-N (respectfully) for the 2008 calendar year.

5.1 DIRECT EMISSIONS- ANIMAL WASTES APPLIED TO SOILS

When poultry wastes are applied to soils, the emissions from the manure can also be accounted for. However, the direct emission calculations do not include animal waste excreted directly onto pasture range and paddock, as this is accounted for under poultry production. The following equation is used to estimate the amount of nitrous oxide from direct emissions from manure applied to soils ($N_2O_{direct\ from\ AW\text{-}N\ (i)}$) for poultry type, '$_i$', in a given year:

$$\mathbf{N_2O\text{-}N_{direct\ from\ AW\text{-}N\ (i)}\ (kg\ N_2O\text{-}N/yr) = N_{ex} * MS_{(i,\ other)} * N_{(i)} * (1\text{-}Frac_{GASM}) * EF_1}$$

(equation 7)

Where:

$N_{ex\ (i)}$ is the annual average nitrogen excretion per bird of poultry type, '$_i$'. The IPCC default for 'poultry' is 0.6 kg N/bird/yr (IPCC, 1996).

$MS_{(i,\ other)}$ is the fraction of poultry type, '$_i$', which has manure handled using manure management system, '$_S$'. The IPCC default for "other" management systems is 0.97 (IPCC, 1996).

$N_{(i)}$ is the average annual population of poultry type, '$_i$'.

$Frac_{GASM}$ = Fraction of total animal manure emitted as NO_x or NH_3. The current IPCC default is 0.2 kg NH_3–N + NO_x–N/kg (IPCC, 1996).

EF_1 = proportion of direct emissions from N input to soil (0.01 kg N_2O–N/kg and is New Zealand specific for all animal manure).

In the 2008 calendar year, the broiler and layer industries produced a total direct emissions from animal wastes (applied to soils) of 25,388 kg N_2O-N and 8,456 kg N_2O-N, respectfully. Both the breeding and pullet flocks generated a total of 2,310 kg N_2O-N and 2,267 kg N_2O-N, respectfully. Using the same nitrogen emission factor determined from broiler birds, the turkey and duck meat industries produced a total amount of direct emissions from animal wastes (applied to soils) of 232 kg N_2O-N and 278 kg N_2O-N (respectfully) for the 2008 calendar year.

5.1.1 Direct Emissions- Animal Production Wastes

Direct emissions from manure deposited during ranging (pasture range and paddock) are calculated in this section. The following equation can be used to determine the amount of nitrogen emission from the manure deposited directly during ranging for poultry type, "i" (**N_2O-$N_{range(i)}$**), in a given year:

$$\mathbf{N_2O\text{-}N_{range(i)}\ (kg\ N2O\text{–}N/yr) = N_{(i)} * N_{ex} * MS_{(i,\ PR\&P)} * EF_{3(PR\&P)}}$$

(equation 8)

Where:

$N_{(i)}$ is the average annual population of poultry type, '$_i$'.

$N_{ex\ (i)}$ is the annual average nitrogen excretion per bird of poultry type, '$_i$'. The IPCC default for 'poultry' is 0.6 kg N/bird/yr (IPCC, 1996).

$MS_{(i,\ PR\&P)}$ is the fraction of poultry type, "i", which has manure handled using manure management system, "S". The IPCC default for pasture range & paddock is 0.03 (IPCC, 1996).

$EF_{3(PR\&P)}$ = emission factor for direct emissions from waste in the pasture range and paddock animal waste management system. An emission factor of 0.01 kg N_2O–N/kg has been newly assigned to direct emissions from wastes in this type of management system (Pickering, personnel communications, 2009).

In the 2008 calendar year, the broiler and layer industries produced total direct emissions from animal production wastes of 1,472 kg N_2O-N and 478 kg N_2O-N, respectfully. Both the breeding and pullet flocks generated a total of 118 kg N_2O-N and 132 kg N_2O-N, respectfully. Using the same nitrogen emission factor determined from broiler birds, the turkey and duck meat industries produced a total amount of direct emissions from animal production wastes of 14 kg N_2O-N and 17 kg N_2O-N (respectfully) for the 2008 calendar year.

5.2 INDIRECT N_2O EMISSIONS- VOLATISING OF NITROGEN:

Nitrogen in manure generally volatises as ammonia (NH_3) and is then re-deposited on land surfaces elsewhere, where it can then turn into nitrous oxide. In the agricultural section of the Inventory all animal manure is lumped together to calculate these emissions and therefore poultry is not reported separately. However, to determine the contribution that poultry of type, i, has towards the indirect nitrous oxide emissions due to volatizing of nitrogen ($N_2O_{(G)}$-$N_{Vol\ (i)}$) in a given year, the following equation is used:

$$N_2O_{(G)}\text{-}N_{Vol\ (i)}\ (kg\ N_2O\text{-}N/yr) = [(N_{(i)} * N_{ex}) * Frac_{gasm}] * EF_4 \qquad \textbf{(equation 9)}$$

Where:

$N_{(i)}$ is the average annual population of poultry type, ‘$_i$’.

$N_{ex\ (i)}$ is the annual average nitrogen excretion per bird of poultry type, ‘$_i$’. The IPCC default for ‘poultry’ is 0.6 kg N/bird/yr (IPCC, 1996).

$Frac_{GASM}$ = Fraction of total animal manure emitted as NO_x or NH_3. The current IPCC default is 0.2 kg NH_3–N + NO_x–N/kg (IPCC, 1996).

EF_4 = proportion of nitrogen input that contributes indirect emissions from volatising nitrogen (0.01 kg N_2O–N per kg NH_3–N and NO_x–N).

In the 2008 calendar year, the broiler and layer industries produced total indirect emissions from the volatising of nitrogen of 6,543 kg N_2O-N and 2,179 kg N_2O-N, respectfully. Both the breeding and pullet flocks generated a total of 595 kg N_2O-N and 584 kg N_2O-N, respectfully. Using the same nitrogen emission factor determined from broiler birds, the turkey and duck meat industries produced total indirect emissions from the volatising of nitrogen of 60 kg N_2O-N and 72 kg N_2O-N (respectfully) for the 2008 calendar year.

5.3 INDIRECT N_2O EMISSIONS – LEACHING OF NITROGEN

In the New Zealand Inventory, indirect emissions from leaching are calculated on an individual source bases. These sources include 1) nitrogen fertiliser, 2) pasture range and paddock (split out into dairy, beef, sheep, deer, poultry, swine, horses and goats), 3) anaerobic lagoon (split out into dairy, beef, sheep, deer, poultry, swine, horses and goats), and 4) solid storage, dry lot and other waste management systems. In order to calculate the contribution that poultry of type, "i", has towards this in a given year, the following equation can be used:

$$\mathbf{N_2O\text{-}N_{Leach\ (i)}\ (kg\ N_2O\text{-}N/yr) = (N_{(i)} * N_{ex}) * Frac_{leach} * EF_5}$$

(equation 10)

Where:

$N_{(i)}$ is the average annual population of poultry type, '$_i$'.

$N_{ex\ (i)}$ is the annual average nitrogen excretion per bird of poultry type, '$_i$'. The IPCC default for 'poultry' is 0.6 kg N/bird/yr (IPCC, 1996).

$Frac_{leach}$ = Fraction of nitrogen input to soils that is lost through leaching and run-off. The current IPCC default is 0.07 NH_3–N + NO_x–N/kg (Pickering, Personnel Communications, 2009).

EF_5 = proportion of nitrogen input that contributes to indirect emissions from leaching nitrogen. The current IPCC default is 0.025 kg N_2O–N per kg (IPCC, 1996).

In the 2008 calendar year, the broiler and layer industries produced total indirect emissions from the leaching of nitrogen of 5,725 kg N_2O-N and 1,907 kg N_2O-N, respectfully. Both the breeding and pullet flocks generated a total of 521 kg N_2O-N and 411 kg N_2O-N, respectfully. Using the same nitrogen emission factor determined from broiler birds, the turkey and duck meat industries produced total indirect emissions from the leaching of nitrogen of 52 kg N_2O-N and 63 kg N_2O-N (respectfully) for the 2008 calendar year.

5.4 TOTAL NITROUS OXIDE GENERATED EMISSIONS

The total amount of nitrous oxide emissions from each type of poultry, i, in a given year can be determined by summing the direct, animal and indirect emissions and multiplying this by a ratio of 44/28 to convert N_2O–N to N_2O (kg/yr). The following equation can be used:

$$N_2O =$$

$$44/28*(N_2O\text{-}N_{(i)} + N_2O_{direct\ from\ AW\text{-}N} + N_2O\text{-}N_{range(i)} + N_2O_{(G)}\text{-}N_{Vol\ (i)} + N_2O\text{-}N_{Leach\ (i)})$$

(equation 11)

Thus in the 2008 calendar year, the broiler and layer industries produced a total nitrous oxide emissions of 86,424 kg N_2O and 28,786 kg N_2O, respectfully. Both the breeding and pullet flocks generated a total of 6,944 kg N_2O and 7,731 kg N_2O, respectfully.

Assuming that one kg of nitrous oxide emissions is the equivalent of 310 kg of CO_2 emissions (MAF, 2010) both the commercial broiler and layer industries produced a net equivalent of 29,229 tonnes of CO_2 and 11,317 tonnes of CO_2, respectfully in the 2008 calendar year. The net equivalent for the turkey and duck industries is 244 tonnes of CO_2 and 293 tonnes of CO_2 (respectfully) for the 2008 calendar year.

5.5 LIMITATIONS:

The current method of determining the methane emission factors for both turkey and ducks grown in New Zealand are based off of the nitrogen excretion values obtained from the broiler industry. The commercial diets of both turkey ducks and broiler chickens are similar in dietary content thus the poultry industry would expect that the daily emissions generated from these birds would be very similar (Chrystal, personnel communications, 2010, MacAlpine, personnel communications, 2010). Industry reiterates that the main difference between chicken and turkey or duck production is that turkeys and ducks are generally grown for a longer number of days which will have a greater influence on the total amount of emissions being generated on a per annum basis (Chrystal, MacAlpine, personnel communications, 2010).

5.6 KEY FINDINGS:

From data supplied by the broiler industry in New Zealand, the nitrogen excretion factor (N_{ex}) was found to be equivalent to 0.39 kg N/bird/yr.

From manure data supplied by the layer industry, the nitrogen excretion factor (N_{ex}) was found to be equivalent to 0.32 kg N/bird/yr.

Based off of the 2008 calendar year, the commercial broiler and layer hen flock in New Zealand produced an estimated 29,229 tones of CO_2 equivalent emissions and 11,317 tones of CO_2 equivalent emissions generated from the production of nitrous oxide gasses (respectively). The commercial non-chicken industry produced a total of 246 tones and 306 tones of CO_2 equivalent emissions generated from nitrous oxide gasses from both the production of turkey and duck flocks (respectively) for meat consumption.

6 Total Carbon Dioxide Equivalent Emissions from the Poultry Industry

The total sum of CO_2 equivalent emissions from both methane and nitrous oxide gasses generated from both the broiler and layer industries is 32,757 tonnes of CO_2 and 12,288 tonnes of CO_2, respectfully, for the 2008 calendar year. For the commercial turkey and duck meat producing industries in the 2008 calendar year, the total sum of CO_2 equivalent emissions from both methane and nitrous oxide gasses generated is 274 tonnes of CO_2 and 328 tonnes of CO_2, respectfully. Table 9 summarizes the CO_2 equivalent emission values across the poultry and layer hen industries for the 2008 calendar year:

Table 9: CO_2 equivalent emissions for the Broiler, Layer, Turkey and Duck industries

	year	CO_2 equivalent emissions from the production of methane gas (tones)	CO_2 equivalent emissions from the production of nitrous oxide gas (tones)	total CO_2 equivalent (tones)
Broiler Industry	2007	3,743	31,017	34,760
	2008	3,528	29,230	32,757
	2009	3,404	28,207	31,612
Layer Industry	2007	914	10,644	11,558
	2008	972	11,316	12,288
	2009	953	11,099	12,053
Turkey Industry	2007	33	274	307
	2008	30	244	274
	2009	30	246	275
Duck Industry	2007	33	275	308
	2008	35	293	328
	2009	37	306	343

Based off of the 2008 calendar year data and at a fixed New Zealand emissions unit of $25 per tonne of CO_2 emissions (MAF 2010), this translates into approximately $818,934 NZD for the production of chicken meat and $307,208 NZD for the production of eggs, $6,849 NZD for the production of turkey meat and $8,212 for the production of duck meat.

Based upon the modified annual average flock sizes and the data supplied by both the poultry and layer hen industries, the newly proposed total CO_2 equivalent emissions for the broiler, layer, turkey and duck industries can also be used to propose alternative emission factors other than the current emission factor for 'poultry', i.e. 0.8 per tonne of carcass weight which is based upon the IPCC 1996 default emission factors and is currently proposed by MAF (MAF, 2010).

Based on the total CO_2 equivalent emissions from the 2007-2009 calendar year for the broiler, layer, turkey and duck industries as well as the total tonnage of chicken/turkey/duck carcass weight or the total amount of eggs produced for these calendar years, the chicken, turkey and duck emission factors (per tonne of carcass weight) are approximately 0.23 ± 0.01, 0.17 ± 0.00 and 0.18 ± 0.01, respectively. The egg emission factor (per thousand of eggs) is approximately 0.013 ± 0.001. Table 10 provides a summary of the emission factors along with an average based for the 2007-2009 calendar years.

Table 10: Proposed emission factors for the Broiler, Layer, Turkey and Duck industries

	year	total CO_2 equivalent (tones)	total tonnage of meat produced or total number of eggs produced	emission factor (per tone of carcass weight or 1,000 eggs)
Broiler Industry	2007	34,760	144,167	0.24
	2008	32,757	142,167	0.23
	2009	31,612	136,680	0.23
			average	**0.23**
			standard deviation	**0.01**
Layer Industry	2007	11,558	832,102,116	0.014
	2008	12,288	919,628,592	0.013
	2009	12,053	942,908,832	0.013
			average	**0.013**
			standard deviation	**0.001**
Turkey Industry	2007	307	1,825	0.17
	2008	274	1,604	0.17
	2009	275	1,566	0.18
			average	**0.17**
			standard deviation	**0.00**
Duck Industry	2007	308	1,641	0.19
	2008	328	1,812	0.18
	2009	343	1,945	0.18
			average	**0.18**
			standard deviation	**0.01**

This is an estimated 71% decrease in the emission factor for the production of broiler chicken and an estimated 61% decrease in the emission factor for eggs. For non-chicken production, it is an estimated 79% decrease from the default factor assigned for the production of turkey meat and approximately a 77% decrease from the default factor for the production of duck meat.

Based off of 2008 data and a fixed New Zealand amount of NZ$ 25 per tonne of CO_2 emissions (MAF 2010), this translates into approximately $818,925 NZD for the production of chicken meat and $307,200 NZD for the production of eggs across both the broiler and layer hen industries in New Zealand. For the turkey and duck meat industries in 2008, this will translate into $6,850 NZD and $8,200 NZD, respectively.

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Appendix

Current cost breakdown for chicken meat and egg production in the emissions trading scheme:

Current cost breakdown for chicken meat and egg production in the emissions trading scheme:

Chicken Meat:

year	production (tonnes)*	CO_2 equivalent (tonnes)	Total ETS cost[&]	Price/meat (tonne)
2005	154,982	123,986	3,099,640	$20.00
2006	144,634	115,707	2,892,680	$20.00
2007	144,318	115,454	2,886,360	$20.00
2008	142,167	113,734	2,843,340	$20.00
2009	136,680	109,344	2,733,600	$20.00

Egg Production:

year	production (eggs sold)*	CO_2 equivalent (tonnes)	Total ETS cost[&]	Price/egg
2005	935,198,172	30,862	771,538	$0.001
2006	837,361,356	27,633	690,823	$0.001
2007	832,102,116	27,459	686,484	$0.001
2008	919,628,592	30,348	758,694	$0.001
2009	942,908,832	31,116	777,900	$0.001

** from Statistics New Zealand.*
[&] Based off a price of $25 per tonne of CO_2 emissions with no government allocation to industry.

Current non-chicken cost breakdown for turkey and duck meat production in the emissions trading scheme:

Current non-chicken cost breakdown for turkey and duck meat production in the emissions trading scheme:

Turkey Meat:

year	production (tonnes)*	CO_2 equivalent (tonnes)	Total ETS cost[&]	Price/meat (tonne)
2007	1,825	1,460	36,500	$20.00
2008	1,604	1,283	32,075	$20.00
2009	1,566	1,253	31,325	$20.00
Duck Meat:				
2007	1,641	1,313	32,825	$20.00
2008	1,812	1,450	36,250	$20.00
2009	1,945	1,556	38,900	$20.00

** from Statistics New Zealand.*
[&] Based off a price of $25 per tonne of CO_2 emissions and no government allocation to industry.

Additional gross energy intake and digestibility data from the Broiler industry:

Chicken type:	GE (MJ/Day):
Broiler	1.5
Broiler	1.8
Broiler	1.8
Average:	1.7
Standard Deviation:	0.2

Chicken type:	DE (%):
Broiler	80
Broiler	75
Broiler	75
Average:	76.7
Standard Deviation:	2.9

Additional information on the manure analysis for laying hens:
The data was analyzed by Analytical Research Laboratories (ARL), Head Office Level 1, 32 Oxford Terrace, P.O. Box 1049, Christchurch, New Zealand and the following procedural information was supplied by them.

The hen manure was collected from approximately 55 hens over a 5 day period. The manure was collected twice daily and deposited in a container. The container remained sealed and was stored at room temperature between the collection times. At the end of the 5 day period, the manure was sent off to ARL for analysis (PIANZ, 2010). Although several analyses were performed on the manure to determine the various elemental components of it, the nitrogen content of the hen manure was accomplished through the use of the 'Dumas' combustion method. The analytical machine performing the analysis was a LECO carbon, nitrogen and sulphur analyzer (LECO CNS 2000), with the levels of nitrogen determined by a thermal conductivity cell within the instrument.

The analytical procedure (ARL reference: m-B071) is summarized as follows:

a) A sample of the previously dried and ground material is accurately weighed. Between 0.2g and 0.5g of the dried and ground material is typically used for analytical purposes and the material is then placed into a crucible.
b) The material is introduced to a gas tight chamber containing a furnace set at 1100°C. The chamber is flushed with inert helium, to eliminate the atmospheric nitrogen.
c) The sample is pushed into the hot furnace area, and pure oxygen is 'lanced' over the sample area, creating complete combustion of the sample. The gases produced are flushed into a ballast tank, and temperature / pressure equilibrium is obtained. The gases are then passed through the thermal conductivity cell where they are analyzed for nitrogen.
d) The response from the cell is used against an existing calibration (created by analysis of 'known' concentration samples), and a percentage result, for the specific weight added, is produced.

Blanks and quality control check samples were performed prior to the manure analysis. The sample was blank corrected, and for the manure analysis to be accepted, the blank sample gave acceptable results within a pre-established range. The analytical instrument was calibrated against the LECO Orchard leaves standard material (Part No. 502-055; lot #1026).

The uncertainty of the results from the analysis of nitrogen in the manure was 3.16% +/- 0.26%.