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*Animal Production Science*

**Supplementary Material**

# Environmental impacts of the Australian poultry industry: 2. Egg production

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**Sensitivity analysis methodology**

Each inventory dataset was modelled using the relevant state electricity grid (ALCAS, 2017). Analysis was conducted to determine the effect on the results of modelling a given network using state-specific grids. To determine the maximum possible variation in results, two scenarios were run: one using the electricity network of Tasmania and a second using the network of Victoria (Australia's lowest and highest emission intensity electricity grids). Aside from the change in electricity grid, the production system was identical in both scenarios.

The sensitivity of the results to FCR was tested for cage, cage-free and free range production. The analysis assumed an improvement of 0.1 in the industry average FCR for each housing system (e.g., 2.1 to 2.0) but the model and parameters were otherwise identical to those used to generate the baseline results.

Sensitivity of the model to dietary crude protein (CP) was also tested for free range production by reducing CP by 10% (from 17.4%) to examine the impact of a very low CP diet.

The methodological decision to use a five-year analysis period (2015 – 2019) for LU and dLUC emissions from Australian cropland was also tested, comparing two-year (2018 – 2019) and ten-year (2010 – 2019) analysis periods. The analysis was performed using the reported annualised emissions and sequestration from the NIR (Commonwealth of Australia, 2021) and calculating the impact on net GHG emissions from egg production by following the sequestration or emissions through the supply chain using the volume of cereals per tonne of feed and the industry average FCR.

The sensitivity of the results to assumptions regarding source regions for cereal grains was also tested. The analysis compared results for a model New South Wales-based (NSW) producer who, in the control scenario, sourced 100% of cereal grains from major NSW grain producing regions, with alternative scenarios where 50% of cereal grains were sourced from Western Australian (WA) (Scenario A) and (Scenario B) where 100% of cereal grains were sourced from a combined eastern seaboard market (QLD, NSW and Victoria [VIC0). Aside from the assumptions regarding source region and transport distances, the model supply chain was identical in each scenario.

The sensitivity of the model to allocation method was not included as this has previously been performed and reported by Wiedemann & McGahan (2011).

**Table S1. Proportion of national flock housed in each state**

| State | Proportion of national flock[a] |
|---|---|
| Queensland (QLD) | 35 % |
| New South Wales & Australian Capital Territory (NSW/ACT) | 30 % |
| Victoria (VIC) | 19 % |
| Tasmania (TAS) | 3 % |
| South Australia & Northern Territory (SA/NT) | 5 % |
| Western Australia (WA) | 8 % |

**Data from Australian Eggs Limited (2021)**

**Table S2. Background databases used to model major inputs**

| Input | Background database |
|---|---|
| Grid electricity | AusLCI 1.39 |
| LPG | AusLCI 1.39 |
| Natural Gas | AusLCI 1.39 |
| Transport – trucks etc. | AusLCI 1.39 |
| Refrigerants | AusLCI 1.39 |

**Table S3. Average commodity inputs (n = 8) per 1000kg of pullet feed**

| Commodities | Average | Range |
|---|---|---|
| Wheat (kg) | 331.7 | 15.4 – 633.0 |
| Barley (kg) | 72.3 | 7.2 – 168.0 |
| Sorghum (kg) | 313.2 | 0.0 – 628.5 |
| Other cereals and grain by-products (kg) | 5.2 | 0.0 – 48.0 |
| Soybean meal (kg) | 96.4 | 42.0 – 186.3 |
| Canola meal (kg) | 69.8 | 40.1 – 100.0 |
| Plant oils (kg) | 6.5 | 0.0 – 42.0 |
| Other plant protein, e.g., field peas, lupins (kg) | 26.5 | 0.0 – 153.9 |
| Tallow/Poultry oil (kg) | 1.4 | 0.0 – 12.0 |
| Low-cost additives, e.g., salt, lime (kg) | 70.8 | 14.2 106.6 |
| High-cost additives, e.g., synthetic amino acids, enzymes, premixes (kg) | 6.2 | 2.0 – 12.3 |
| ***Total*** | **1000.0** | |

**Table S4. Background databases used to model feed inputs (base model, excluded water model)**

| Feed commodity | Background database |
|---|---|
| Sorghum | AusLCI 1.39 |
| Wheat | AusLCI 1.39 |
| Barley | AusLCI 1.39 |
| Other cereals | AusLCI 1.39 |
| Soybean meal | ecoinvent 3.8 |
| Canola meal | AusLCI 1.39 |
| Other plant proteins | Custom datasets |
| Tallow/poultry oil | Custom datasets* |
| Meat meal | Custom datasets* |
| Other animal protein | ecoinvent 3.8 |
| Low input additives | Custom datasets, AusLCI 1.39, custom processes* |
| High input additives | custom processes* |

*Tallow/poultry oil and meat meal from Australian meat processing impacts in other published work by the authors (Wiedemann et al., 2015, 2017). Raw materials treated as residuals with no impact, rendering processes attributed to the final product. GHG impacts were 2.1kg $CO_2$-e/kg for tallow/poultry oil and ranged from 1.0 – 1.9kg $CO_2$-e/kg for meat meal. Low and high input additive processes derived from ecoinvent 3.8, LCAFood and ETH-ESU processes. GHG impacts per kilogram of high input additives ranged from 2.8 - 3.5kg $CO_2$-e/kg and GHG impacts ranged from 0.1 – 1.2kg $CO_2$-e/kg for low input additives. Other plant protein GHG impacts ranged from 0.2 – 0.3kg $CO_2$-e/kg and were derived from AusAgLCI and LCAFood processes, and NSW Department of Primary Industries data.

**Table S5. Australian average input data for combined breeding and hatchery operations (n = 9)**

| | Average | Range |
|---|---|---|
| **Inputs (reported per 1000 day-old chicks)** | | |
| Grid electricity, kWh | 139.8 | 126.0 – 153.7 |
| LPG, MJ | 234.0 | 205.6 – 262.4 |
| Diesel, L | 2.5 | 0.9 – 4.0 |
| Petrol, L | 0.3 | 0.1 – 0.5 |
| Fresh water consumption, L | 2302 | 2031.7 – 2572.7 |
| Feed consumption, kg | 385.9 | 355.52 – 416.6 |

**Table S6. Average input data (n = 7) for pullet rearing reported per 1000 pullets reared**

| | Average of pullet rearing facilities surveyed | Range* |
|---|---|---|
| **Inputs (reported per 1000 pullets reared)** | | |
| Grid electricity, kWh | 558.3 | 0.0 – 889.9 |
| Solar-generated electricity, kWh | 21.3 | 0.0 – 149.0 |
| LPG, MJ | 42.1 | 0.0 – 126.0 |
| Diesel, L | 4.1 | 0.0 – 7.7 |
| Fresh water consumption, L | 18800 | 9408 – 36800 |
| Feed transport, km | 76.6 | 16.0 – 182.0 |
| Feed consumption, kg | 5136.2 | 4944.8 – 5678.8 |

*Zero values were typically related to facilities that used an alternative energy source (for example, zero grid electricity because solar was used).

**Table S7. Emission factors for Australia's electricity grids for 2020**

| State | Scope 2 & 3 combined emission factors (kg $CO_2$-e/kWh) |
|---|---|
| Queensland (QLD) | 0.91 |
| New South Wales & Australian Capital Territory (NSW/ACT) | 0.86 |
| Victoria (VIC) | 0.96 |
| Tasmania (TAS) | 0.14 |
| South Australia | 0.36 |
| Western Australia (WA)* | 0.70 |

**South West Interconnected System.*

*Data from Commonwealth of Australia* (2020).

**Table S8. Sensitivity analysis results for state electricity grids, reported per kilogram of eggs**

| | Fossil energy (MJ) | Greenhouse gases, excl. LU and dLUC (kg $CO_2$-e) | Greenhouse gases, LU and dLUC (kg $CO_2$-e) | Total GHG (kg $CO_2$-e) |
|---|---|---|---|---|
| **TAS** | 9.4 | 1.1 | 0.8 | 1.8 |
| **VIC** | 11.6 | 1.3 | 0.8 | 2.0 |

**Table S9. Sensitivity analysis results for diet and performance scenarios**

| | Fossil energy (MJ) | Fresh water (L) | Stress weighted water (L $H_2O$-e) | AWARE water ($m^3$) | Land occupation ($m^2$) | Greenhouse gases, excl. LU and dLUC (kg $CO_2$-e) | Greenhouse gases, LU and dLUC (kg $CO_2$-e) | Total GHG (kg $CO_2$-e) |
|---|---|---|---|---|---|---|---|---|
| **C1** | 10.0 | 171.2 | 82.8 | 15.7 | 7.4 | 1.2 | 0.7 | 1.8 |
| **CF1** | 11.2 | 183.9 | 85.6 | 16.9 | 7.8 | 1.3 | 0.7 | 2.0 |
| **FR1** | 11.4 | 197.7 | 97.2 | 18.5 | 8.3 | 1.4 | 0.8 | 2.1 |
| **FR2** | 11.7 | 204.6 | 100.5 | 19.0 | 8.7 | 1.4 | 0.8 | 2.2 |

**Table S10. Sensitivity analysis results for grain source regions**

| Scenario | Fossil Energy (MJ) | Fresh Water (L) | Stress weighted water (L $H_2O$-e) | AWARE water ($m^3$) | Land occupation ($m^2$) | Greenhouse gases, excl. LU and dLUC (kg $CO_2$-e) | Greenhouse gases, LU and dLUC (kg $CO_2$-e) | Total GHG (kg $CO_2$-e) |
|---|---|---|---|---|---|---|---|---|
| **Control** | 9.8 | 213.9 | 156.8 | 15.1 | 4.9 | 1.2 | 0.7 | 1.8 |
| **A** | 10.3 | 152.9 | 87.0 | 13.5 | 6.2 | 1.2 | 0.7 | 1.9 |
| **B** | 10.9 | 155.4 | 76.6 | 12.5 | 6.3 | 1.2 | 0.7 | 1.9 |

**Table S11. Data for sensitivity analysis of LU and dLUC emissions from Australian cropland**

| | Units | 2015 - 2019 | 2018 – 2019 | 2010 - 2019 |
|---|---|---|---|---|
| Land use (LU) emissions | kg $CO_2$-e/ha | -240.17 | -238.57 | -97.19 |
| Land use change (dLUC) emissions | kg $CO_2$-e/ha | 105.25 | 93.18 | 131.35 |
| Net LU & dLUC emissions | kg $CO_2$-e/ha | -134.92 | -145.38 | 34.16 |
| LU & dLUC emissions from Australian cropland | kg $CO_2$-e/kg eggs | -0.09 | -0.10 | 0.02 |

**Table S12. Scenario analysis results for adoption of solar on-farm (including feedmilling and grading) equivalent to 40% of total on-farm electricity demand**

| | Fossil energy (MJ) | Greenhouse gases, excl. LU and dLUC (kg $CO_2$-e) | Greenhouse gases, LU and dLUC (kg $CO_2$-e) | Total GHG (kg $CO_2$-e) |
|---|---|---|---|---|
| **QLD electricity grid only** | 11.8 | 1.4 | 1.1 | 2.4 |
| **QLD electricity grid and solar** | 10.5 | 1.3 | 1.1 | 2.3 |

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