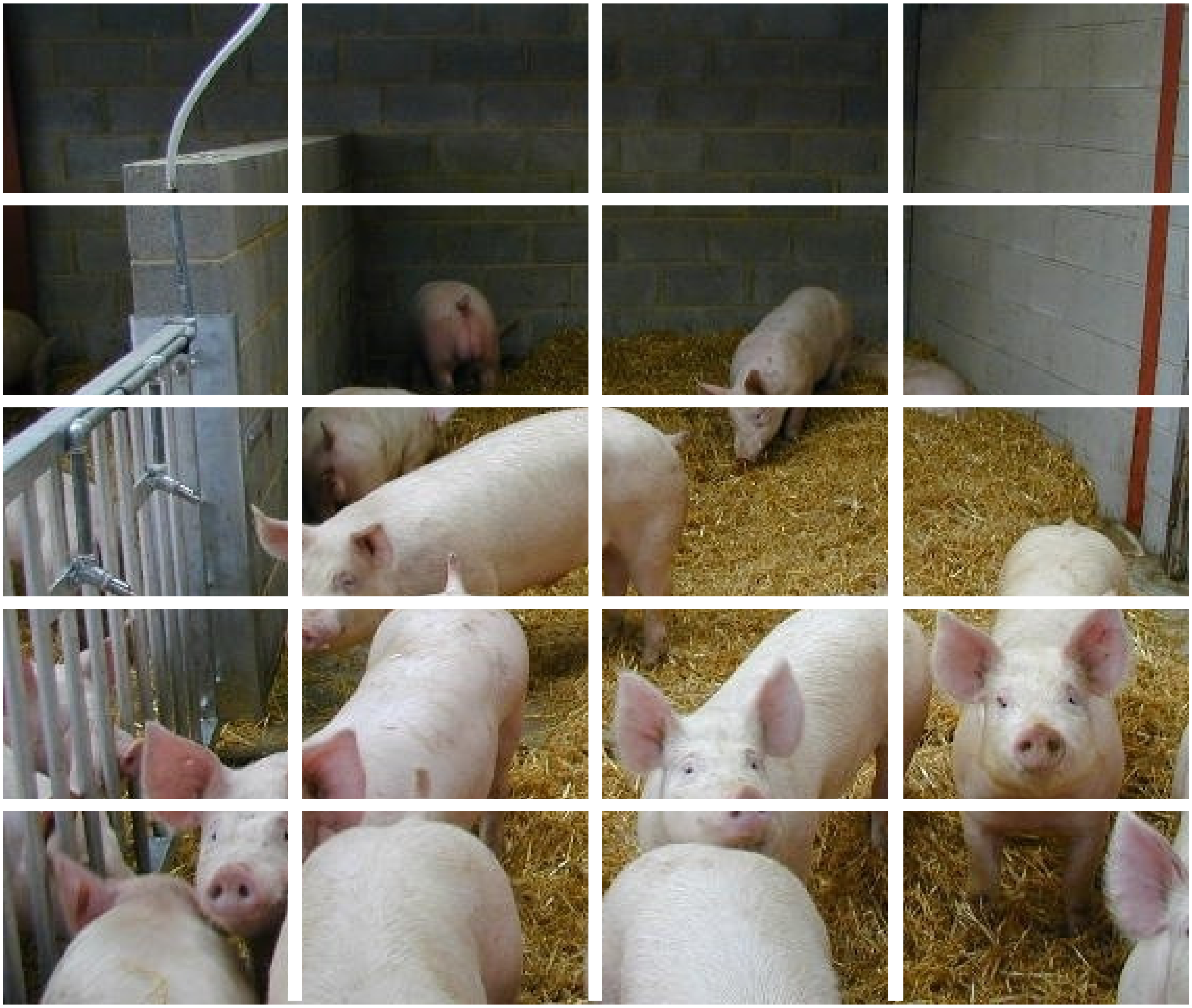

LCA of British Pork

Final Report

August 2013

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LCA of British Pork

August 2013

Reference 0196904

Prepared by: Saori Smith

For and on behalf of
Environmental Resources Management

Approved by: Simon Aumonier
Signed:

Position: Partner

Date: 28 August 2013

1 INTRODUCTION

1.1 BACKGROUND

In 2009, the Agriculture and Horticulture Development Board Meat Services (AHDBMS) commissioned and funded an environmental assessment to understand the sources and scale of environmental impacts across the life cycle of pork production. The primary aim of the study was to estimate the environmental profile of pork produced in the UK.

To this end, a streamlined, or 'scoping', life cycle assessment (LCA) was undertaken, which assessed the entire life cycle of British pork whilst minimising the primary data collection and employing readily available data, where possible. The LCA investigated the environmental impacts considered to be of greatest importance to pork production and pig farming, *viz*.: climate change; eutrophication; acidification; and abiotic resource depletion.

In 2010, AHDBMS wished to build on the findings of the scoping LCA by using the 2008 data applied in that study and evaluating the improvements achieved in the British pork industry since 2001, as well as forecasting improvements potentially achievable by 2020.

Now, in 2013, BPEX, a division of the Agriculture and Horticulture Development Board (AHDB) wishes to update the 2010 study using most recent performance data. This update applies actual performance data between 2008 and 2012; and forecast data for 2014 and 2020, to understand the impact of changes made in the British pork industry.

BPEX provided pig performance data for the years 2008 to 2012 and forecast data for 2014 and 2020. Further detail relating to the data used in the LCA is provided in *Table 2.3* to *Table 2.6* in *Section 2.3*.

1.2 OBJECTIVE OF THE STUDY

The overall aims of this study are threefold:

- to estimate the environmental impacts associated with pork production for 2008 to 2012, across all the farm processes up to when the pig leaves the farm, and to assess footprint of forecast performance for 2014 and 2020;
- to facilitate communication with suppliers and other stakeholders of the environmental improvements achieved since 2008; and
- to inform decisions regarding any further data collection to validate secondary data used in this study and to improve the robustness of the model.

2 METHOD OF ASSESSMENT

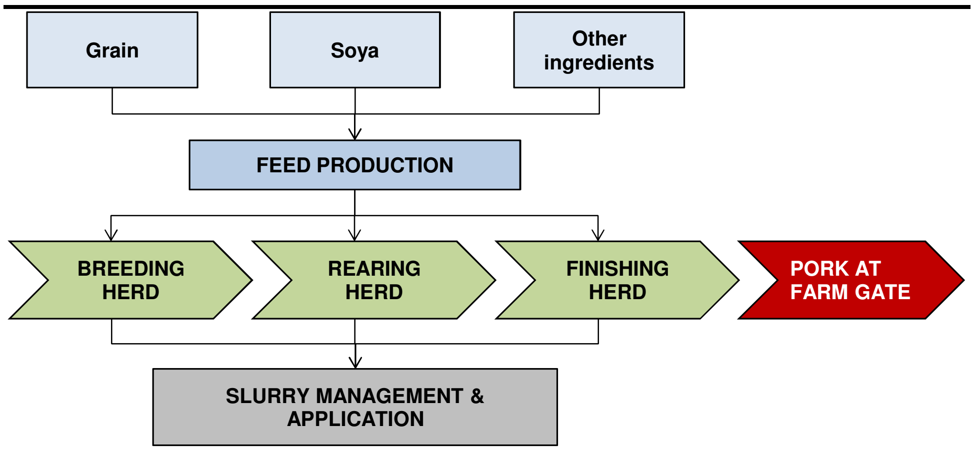
2.1 DESCRIPTION OF THE PRODUCT ASSESSED

This study comprises a life cycle assessment (LCA) to estimate the environmental profile of British pork production. The functional unit to which the results relate is:

Pork, at farm gate, sufficient for 1kg of pork product

Figure 2.1 summarises the pork production life cycle from feed production and pig breeding to finishing (cradle-to-gate). The study relates to the weight of pig (dead weight) required to produce 1 kg of pork product. The study does not include slaughtering and meat processing operations.

Figure 2.1 Summary of pork production life cycle (cradle-to-gate)



2.2 DESCRIPTION OF THE PORK PRODUCTION PROCESS

Production of feed uses energy and water and, for crop inputs, substances are emitted from growing, harvesting and processing the crops. The main inputs for farming are energy and pig feed, which are both consumed throughout the lifetime of the pig. During growth, pigs produce excreta, which are managed as slurry or farmyard manure. These products are stored and later applied to fields as fertilisers. Upon reaching a certain weight, the pigs are transported off the farm to the abattoir, where they are slaughtered and the meat is processed and packaged. This assessment ends at the point at which pigs leave the farm gate.

For the purposes of this study, pig farming has been divided into four separate processes, as follows.

- **Sow breeding,** involving breeding and upkeep of sows producing piglets for pork. During sow breeding, sows are either lactating (producing milk for nourishing piglets) or dry (not producing milk). Piglets remain with the sow until they reach 7 kg in weight.

- **Rearing,** involving the weaning and rearing of piglets until they reach about 35-40 kg in weight.
- **Finishing,** involving the final rearing of pigs until they reach about 100-110 kg in weight, after which they are taken to slaughter.
- **Sow replacement,** involving the breeding, rearing and finishing of gilts used to replenish the sow breeding herd.

The processes take into account feed production, rearing of pigs and the storage and management of slurry and farmyard manure, including its application to fields as fertiliser.

Pigs are housed in the UK in a number of different systems, which can be broadly categorised as follows:

- indoors on slatted flooring (fully or partly slatted);
- indoors on solid flooring with straw bedding; and
- outdoors with straw bedding.

Based on the most recent Farm Practice Survey in 2009, *Table 2.1* shows the pig housing systems employed in British pig production.

Table 2.1 ***Pig housing systems***

Breeding herd – lactating sows	
Lactating sows housed indoors, slatted flooring	70%
Lactating sows housed indoors, straw-based flooring	30%
Rearing herd	
Dry sows housed indoors, slatted flooring	10%
Dry sows housed indoors, straw-based flooring	90%
Rearing herd	
Rearing herd housed indoors, slatted flooring	45%
Rearing herd housed indoors, straw-based flooring	30%
Rearing herd housed outdoors, straw-based flooring	25%
Finishing herd	
Finishing herd housed indoors, fully-slatted flooring	39%
Finishing herd housed indoors, partly-slatted flooring	30%
Finishing herd housed outdoors, straw-based flooring	31%
Sow replacement herd	
Sow replacement herd housed indoors, slatted flooring	60%
Sow replacement herd housed outdoors, straw-based flooring	40%

The 2010 LCA provided an assessment of pigs indoors on slatted flooring only. The type of housing employed has an impact on key factors that contribute to the environmental impact of pork production, namely agricultural emissions from manure/slurry storage and management. For this reason, the 2008 impact assessment results presented in this study, which considers a range of housing types, cannot be compared to the results originally presented in the 2010 LCA report, which considered only one housing type.

2.3 *DATA*

2.3.1 *Animal Feed*

Based on the results of the 2010 LCA, it is known that the main contribution to environmental impacts associated with pork production is from the production of animal feed consumed by pigs during growth. The main components of pig feed are: wheat; barley; wheatfeed; and soybean meal.

The 2010 LCA made use of secondary data for pig feed due to a lack of appropriate primary data relating to the production of pig feed at that time. For this update, pig feed composition data for 2012 production relating to different stages of pig growth were obtained from two pig feed producers in the UK. These two feed producers account for a significant proportion of the UK market share and together are considered to be representative of commercial pig feed currently on the UK market. This does not include home mill and mix. However, based on information from BPEX, home mill and mix is not considered to be substantially different from commercial products. Therefore, for the purposes of this study, the feed mixes provided by the two feed producers are considered to be representative of pig feed in the UK.

The composition of animal feed depends on a number of factors and is subject to considerable variation throughout a given year and between different years. However, due to an increase in the prices of certain key ingredients of animal feed, there has been a more significant change in the composition in recent years. Based on information received from BPEX, it was determined that this change was realised in the UK pork production industry from 2011.

Therefore, for years 2008 to 2010, the study assumes secondary pig feed composition data, as were used in the 2010 LCA. From 2011 and 2012 and the 2020 forecast, the study assumes that feed composition data received from the two UK feed producers for 2012 are representative of overall feed production. The environmental impact of pig feed was estimated by applying environmental emission factors sourced from ecoinvent (1) and the Danish LCA Food Database (2).

For the 2008 results, the 2010 LCA used feed emission factors from a secondary source. For this update, to enable the results for the old and new feed compositions to be compared, improved emission factors were calculated for 2008 based on feed composition data from the secondary source, but using the same emission factors as for the new feed composition. For this reason, the 2008 impact assessment results presented in this study do not precisely match the results originally presented in the 2010 LCA report.

A detailed comparison of how feed compositions have changed since 2008 is not possible for this study due to confidentiality of animal feed data. The

(1) ecoinvent© (http://www.ecoinvent.org/database/)
(2) LCA Food Database (http://www.lcafood.dk/)

confidential nature of the data on feed prevents the reporting of its composition and the contributions to the overall footprint made by individual ingredients.

As described above, the composition of animal feed is subject to variation, and is therefore subject to an inherent uncertainty. However, the feed compositions used in this study are considered to be the most representative of the current UK pig industry.

2.3.2 *Impacts relating to production of ingredients in specific countries*

Information relating to the source country of grains and soybean inputs was not available. For grains, which are predominantly sourced from within Europe, the impact of production in different countries was not considered to be of great significance and therefore average European production was assumed. However, soybeans and soybean products (including meal) are sourced from outside Europe, predominantly Brazil, where local farming practices could influence their environmental impact.

Using UK trade statistics, the main source countries for soybeans and soybean products (including meal) imported into the UK were identified. These accounted for 99% of total UK imports between 2008 and 2012, as shown in *Table 2.2*.

Table 2.2 ***UK imports of soybeans 2008-2012 (% of total UK soybean imports)***

Country	2008	2009	2010	2011	2012	Average 2008-2010	Average 2011-2012
Brazil	76%	86%	73%	92%	90%	78%	91%
Canada	4%	6%	12%	6%	6%	7%	6%
USA	18%	4%	8%	0%	0%	10%	0%
Argentina	1%	2%	6%	0%	1%	3%	1%
China	1%	1%	1%	1%	1%	1%	1%
Total	99%	99%	99%	99%	99%	99%	99%

Source: HM Revenue & Customs – UK Trade Info (https://www.uktradeinfo.com/Pages/Home.aspx)

Soybean production in each of the five countries in *Table 2.2* was modelled using ecoinvent [(1)] data. Climate change impacts resulting from land use change for the production of soybeans were estimated in accordance with the Greenhouse Gas Protocol Product Standard [(2)]. A weighted average for soybean production for imports to the UK was then calculated based on the average split of supply for:

- 2008 to 2010 in relation to feed prior to the change in composition; and
- 2011 to 2012 in relation to feed following the change in composition.

(1) ecoinvent© (http://www.ecoinvent.org/database/)
(2) GHG Protocol Product Life Cycle Accounting and Reporting Standard (www.ghgprotocol.org/standards/product-standard)

2.3.3 *Pig Farming*

The pig farming process was modelled based on actual and forecast performance data from the British pig farming industry, provided by BPEX, and supplemented with secondary data, as required.

The pig farming performance data were used to calculate the feed and energy inputs and excreta outputs per pig to produce the pig farming inventory. The quantity of feed consumed is calculated based on annual consumption data provided by BPEX. Consumption of straw and electricity and generation of slurry and farmyard manure and associated emissions are calculated using secondary data and assumptions.

Table 2.3 to *Table 2.6* set out the data used in the study. Data sources can be identified according to the following colour coding:

Orange	BPEX Key Performance Indicators
Blue (normal text)	British pig farming performance data from BPEX
Blue (bold text)	**Calculated using British pig farming performance data from BPEX**
Green	Secondary data from the Defra Cranfield study
Grey	Farm Practice Survey 2009

Table 2.3 ***Production data for breeding herd – sows producing piglets, average of indoor slatted, indoor straw-based & outdoor straw-based housing***

Data point description	Unit	2008	2009	2010	2011	2012	2020	Notes
% dry sows indoor slatted housing	% of breeding herd	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	Farm Practice Survey 2009
% dry sows indoor straw-based housing	% of breeding herd	9.0%	9.0%	8.9%	8.9%	9.0%	9.2%	Farm Practice Survey 2009
% dry sows outdoor bred	% of breeding herd	6.7%	6.7%	6.6%	6.6%	6.7%	6.8%	Farm Practice Survey 2009
% lactating sows indoor slatted housing	% of breeding herd	35.0%	35.0%	35.0%	35.1%	35.0%	34.9%	Farm Practice Survey 2009
% lactating sows indoor straw-based housing	% of breeding herd	15.0%	15.0%	15.0%	15.0%	15.0%	14.9%	Farm Practice Survey 2009
% lactating sows outdoor bred	% of breeding herd	33.3%	33.3%	33.4%	33.4%	33.3%	33.2%	Farm Practice Survey 2009
Total feed per sow per year	kg	1,456	1,278	1,230	1,169	1,208	1,360	
Feed per sow per farrowing day	kg	7.0	7.0	7.0	7.0	7.0	7.0	Assumed to be constant.
Farrowing index	litters per sow	2.25	2.26	2.24	2.23	2.26	2.30	
Days in farrowing house per litter	days	26.99	26.99	26.99	26.99	26.99	26.99	Assumed to be constant.
Farrowing days per year	no. of days	**60.7**	**60.9**	**60.5**	**60.1**	**61.1**	**62.1**	Calculated from BPEX data
Unproductive days per year	no. of days	**304.3**	**304.1**	**304.5**	**304.9**	**303.9**	**302.9**	Calculated from BPEX data
Electricity per sow per year	MJ	630	625	620	614	609	567	2008 and 2020 forecast from 2010 LCA. Assumes decreases at constant rate.
Slurry per sow per year	tonnes	**1.31**	**1.31**	**1.32**	**1.32**	**1.31**	**1.31**	Calculated based on average Cranfield data & BPEX housing system estimates
Manure per sow per year	tonnes	**2.18**	**2.18**	**2.17**	**2.17**	**2.18**	**2.18**	Calculated based on average Cranfield data & BPEX housing system estimates
Sow weight	kg	250	250	250	250	250	250	Assumes consistent year on year.

Data point description	Unit	2008	2009	2010	2011	2012	2020	Notes
Livestock unit		500	500	500	500	500	500	Assumed to be constant.
Piglets weaned per sow per year	no. of pigs	22.1	22.3	22.0	22.6	23.9	28.0	
Pigs per litter	no. of pigs	**9.82**	**9.89**	**9.82**	**10.15**	**10.58**	**12.17**	Calculated from BPEX data

Table 2.4 ***Production data for rearing herd – weaner piglets (7-14 kg), average of indoor slatted, indoor straw-based & outdoor straw-based housing***

Data point description	Unit	2008	2009	2010	2011	2012	2020	
% weaners indoor slatted housing	% of breeding herd	45%	45%	45%	45%	45%	45%	Farm Practice Survey 2009
% weaners indoor straw-based housing	% of breeding herd	30%	30%	30%	30%	30%	30%	Farm Practice Survey 2009
% weaners outdoor bred	% of breeding herd	25%	25%	25%	25%	25%	25%	Farm Practice Survey 2009
Weaner start weight	kg	7.4	8.0	7.5	7.4	7.5	8.0	
Weaner exit weight	kg	35.9	36.8	35.1	35.8	36.6	30.0	
Feed conversion ratio		1.73	1.80	1.75	1.71	1.75	1.50	
Electricity per week	MJ per piglet per week	4.60	4.56	4.52	4.49	4.45	4.14	2008 and 2020 forecast from 2010 LCA. Assumed decreases at constant rate.
Average daily weight gain	kg	0.478	0.481	0.486	0.477	0.488	0.530	Assumed constant increase rate from 2011 to 2020
Slurry per piglet	tonnes	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.03**	Calculated based on average Cranfield data & BPEX housing system estimates
Manure per piglet	tonnes	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.01**	Calculated based on average Cranfield data & BPEX housing system estimates
Livestock unit		500	500	500	500	500	500	Assumed to be constant.

Data point description	Unit	2008	2009	2010	2011	2012	2020	
Mortality rate	%	2.40%	2.45%	2.71%	2.54%	2.52%	2.40%	

Table 2.5 ***Production data for finishing herd***

		2008	2009	2010	2011	2012	2020	
% finishers indoor slatted housing	% of breeding herd	39%	39%	39%	39%	39%	39%	Farm Practice Survey 2009
% finishers indoor straw-based housing	% of breeding herd	30%	30%	30%	30%	30%	30%	Farm Practice Survey 2009
% finishers outdoor bred	% of breeding herd	31%	31%	31%	31%	31%	31%	Farm Practice Survey 2009
Finisher start weight (live weight)	kg	35.9	36.8	35.1	35.8	36.6	30.0	
Finisher end weight (live weight)	kg	103.05	103.30	103.90	103.10	101.69	110.00	
Finisher carcass weight (dead weight)	kg	77.1	76.9	79.0	79.4	77.6	79.66	
Feed conversion ratio		2.87	2.77	2.95	2.82	2.82	2.30	
Electricity per week	MJ	5.3	5.3	5.3	5.3	5.3	5.3	Assumed to be constant.
Average daily weight gain	kg	0.766	0.819	0.766	0.784	0.794	0.875	
Slurry per pig	kg	0.30	0.28	0.31	0.30	0.28	0.32	Calculated based on average Cranfield data & BPEX housing system estimates
Manure per pig	kg	0.11	0.10	0.11	0.11	0.10	0.11	Calculated based on average Cranfield data & BPEX housing system estimates
Livestock unit		500	500	500	500	500	500	Assumed to be constant.
Mortality rate	%	3.30%	2.92%	3.00%	2.93%	2.84%	2.00%	

Table 2.6 *Production data for sow replacement herd*

		2008	2009	2010	2011	2012	2020	
% finishers indoor straw-based housing	% of breeding herd	60%	60%	60%	60%	60%	60%	Farm Practice Survey 2009
% finishers outdoor bred	% of breeding herd	40%	40%	40%	40%	40%	40%	Farm Practice Survey 2009
Start weight	kg	35.9	36.8	35.1	35.8	36.6	30.0	
End weight	kg	109.0	109.0	109.0	109.0	109.0	109.0	Assumed to be constant.
Feed conversion ratio		2.87	2.83	2.78	2.74	2.70	2.35	
Electricity per pig per week	MJ	5.3	5.3	5.3	5.3	5.3	5.3	Assumed to be constant.
Average daily weight gain	kg	0.757	**0.765**	**0.773**	**0.780**	**0.788**	0.850	Assumed increases at a constant rate from 2008 to 2020.
Slurry per pig	kg	0.29	0.28	0.29	0.28	0.28	0.280	Calculated based on average Cranfield data & BPEX housing system estimates
Manure per pig	kg	0.16	0.15	0.15	0.15	0.15	0.15	Calculated based on average Cranfield data & BPEX housing system estimates
Livestock unit		500	500	500	500	500	500	Assumed to be constant.
Sow replacement rate	no. of pigs	45.5%	47.2%	48.8%	49.2%	50.0%	45.5%	
Sow replacement mortality	%	4.28%	4.28%	4.28%	4.28%	4.28%	4.28%	Assumed to be constant.

Table 2.7 sets out the pig farming inventory data per pig produced. The data in *Table 2.7* represents an average British pig and comprises a weighted average of inputs, outputs and emissions to air of pigs in all housing types across the total life cycle.

Table 2.7 ***Inventory data per pig output – 2008 to 2012 and 2020 forecast***

	Unit	2008	2009	2010	2011	2012	2020
Inputs							
Feed	kg	347.5	327.2	340.9	321.5	320.5	291.0
Straw	kg	171.7	164.7	174.0	169.6	165.7	154.4
Electricity	MJ	156.1	150.2	154.9	152.2	148.5	128.2
Outputs							
Slurry	tonnes	0.45	0.43	0.46	0.44	0.43	0.42
Manure	tonnes	0.29	0.28	0.30	0.29	0.28	0.25
Emissions to air							
Ammonia	kg NH_3-N	2.43	2.32	2.04	1.97	1.90	1.95
Methane	kg CH_4	3.10	2.97	3.14	3.05	2.96	2.94
Nitrous oxide	kg N_2O-N	0.002	0.002	0.002	0.002	0.002	0.002

2.4 ENVIRONMENTAL IMPACT CATEGORIES

This study assesses the environmental impact of the production of British pork against four environmental impact categories: climate change; eutrophication; acidification; and resource depletion. A description of these impact categories and why they are considered to be important is provided in *Table 2.8* below.

Table 2.8 ***Environmental Impact Category Descriptions***

Impact category	Description and importance	Unit
Climate change 	Climate change is a measure of the adverse impact of greenhouse gas (GHG) emissions that cause heat to be trapped in the atmosphere and results in a temperature rise of the Earth's surface. GHGs include carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), amongst others. The main consequence of climate change is global warming, which results in increased temperatures and regional climate changes. This increases adverse effects to human health, agriculture and wildlife.	kg CO_2 eq
Eutrophication 	Eutrophication is a measure of nutrient pollution in aquatic ecosystems typically generated from phosphorous or nitrogen compounds through sewage, storm water run-off, fertiliser or manure. This can lead to excessive microbial consumption which, in turn, results in oxygen depletion. Oxygen depletion can result in short or long term damage and potentially death to organisms that are exposed.	kg PO_4 eq

Acidification 	Acidification is a measure of the impact from acids, which are emitted to the atmosphere and deposited in water and soil. These can be ammonia from slurry/manure, or sulphur dioxide (SO_2) from the combustion of fossil fuels, which have the potential to react with water in the atmosphere to cause a change in acidity. Any change from the natural pH can have detrimental effects on plant and aquatic life.	kg SO_4 eq
Resource depletion 	Abiotic depletion is a measure of the extraction of scarce minerals and fossil fuels. An abiotic depletion factor is determined based on the remaining global resource reserves and their rates of de-accumulation. Consumption of resources that cannot be regenerated, or may take thousands of years to do so, limits the options of future generations and can result in more expensive and damaging exploration and extraction of poorer or less available reserves.	kg Sb eq

3 RESULTS

3.1 PERFORMANCE EFFICIENCIES ACHIEVED BETWEEN 2008 & 2012 AND FORECASTED FOR 2020

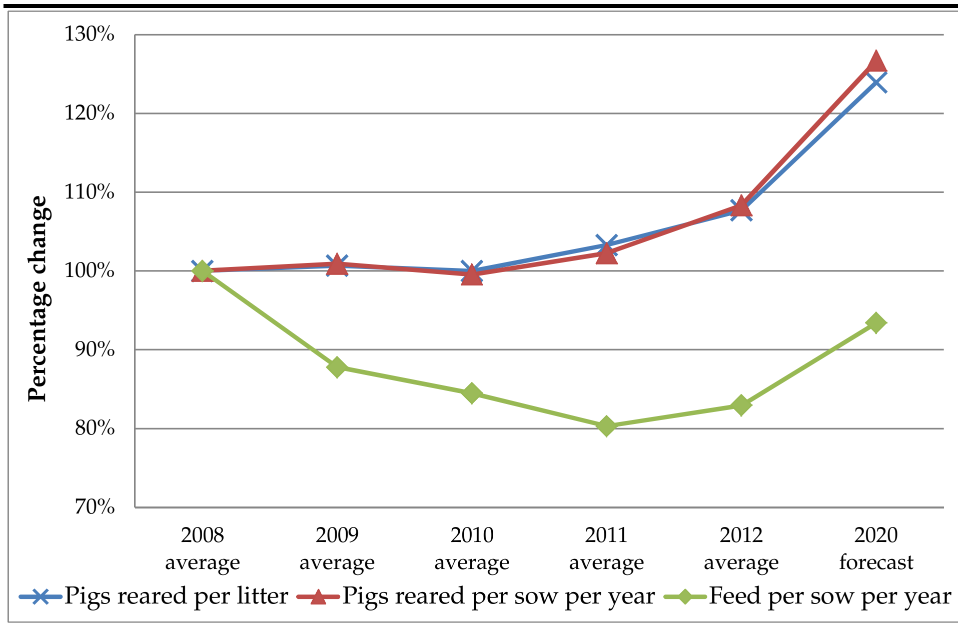
The following describes the BPEX pig farming performance data provided for this study and the year on year improvements observed.

3.1.1 *Performance efficiencies of breeding herd parameters between 2008 & 2012 and forecasted for 2020*

Figure 2.1 shows the average percentage change in the British pig herd for the following breeding parameters:

- number of pigs reared per litter;
- number of pigs per sow per year; and
- quantity of feed per sow per year.

Figure 3.1 ***Year on year improvement for specific breeding herd parameters between 2008 & 2011 and forecasted for 2020***



The following is evident from the performance efficiencies of breeding herd parameters achieved between 2008 and 2012.

- Between 2008 and 2012, the number of pigs reared per litter has steadily increased, resulting in an 8% increase in the number pigs per litter in 2012 over the figure for 2008.

- Between 2008 and 2012, the number pigs reared per sow per year has generally increased, resulting in an 8% higher number of pigs reared per sow in 2012 than in 2008.
- The increased pig production identified above is in the context of a reduction in the quantity of feed per sow per year, which decreased by 17% between 2008 and 2012. The quantity of feed per year steadily decreased up to 2011 and showed a slight increase in 2012 of 3% compared with 2011.

The following is evident from the performance efficiencies of breeding herd parameters forecasted for 2020.

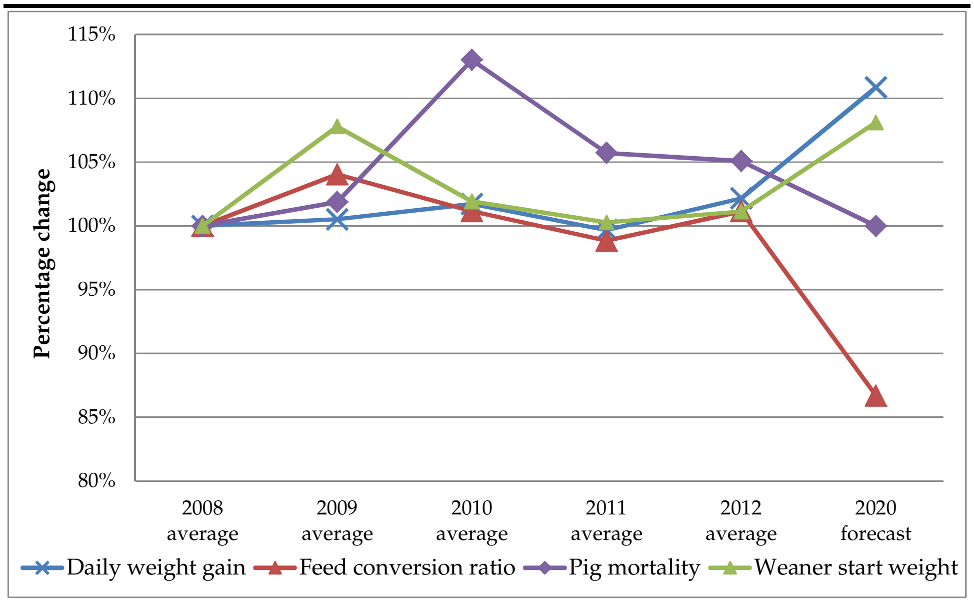
- The number of pigs reared per litter is forecast to increase by 16% between 2012 and 2020.
- The number of pigs per sow per year is forecast to increase by 18% between 2012 and 2020.
- The forecast data for 2020 suggests an increase in the quantity of feed per sow per year of 10% between 2012 and 2020.

3.1.2 Performance efficiencies of rearing herd parameters between 2008 & 2012 and forecasted for 2020

Figure 3.2 shows the average percentage change in the British pig herd for the following rearing herd parameters:

- weaner start weight;
- daily weight gain;
- feed conversion ratio; and
- pig mortality.

Figure 3.2 *Year on year improvement for specific rearing herd parameters between 2008 & 2012 and forecasted for 2020*



The following is evident from the performance efficiencies of rearing herd parameters observed between 2008 and 2012.

- Daily weight gain remains relatively constant between 2008 and 2012, showing a slight increase of 2% in 2012 compared with 2008.
- Feed conversion ratio is seen to have increased by 4% between 2008 and 2009 and then to have remained relatively constant, resulting in a 1% increase in 2012 compared with 2008.
- Pig mortality, referring to the proportion of rearing herd pigs that die during this life cycle stage, is shown to increase up to a peak of 13% greater than 2008 levels in 2010, with a subsequent decline through to 2012 that results then in a figure 5% greater than 2008 levels.
- With the exception of one year (2009), weaner start weight remained relatively constant between 2008 and 2012, resulting in a 1% increase in 2012 compared with 2008. In 2009, weaner start weight increased by 8%. However, given that other years are relatively consistent, the value for this year is considered to be anomalous.

The following is evident from the performance efficiencies of rearing herd parameters forecasted for 2020.

- Daily weight gain is forecast to increase from 2012 up to 2020, with an expected daily weight gain in 2020 that is 9% greater than 2012.
- Feed conversion ratio is forecast to decrease from 2012 up to 2020, with an expected feed conversion ratio in 2020 that is 14% lower than in 2012.
- Pig mortality is forecast to decrease from 2012 up to 2020, with pig mortality in 2020 expected to be 5% lower than in 2012.

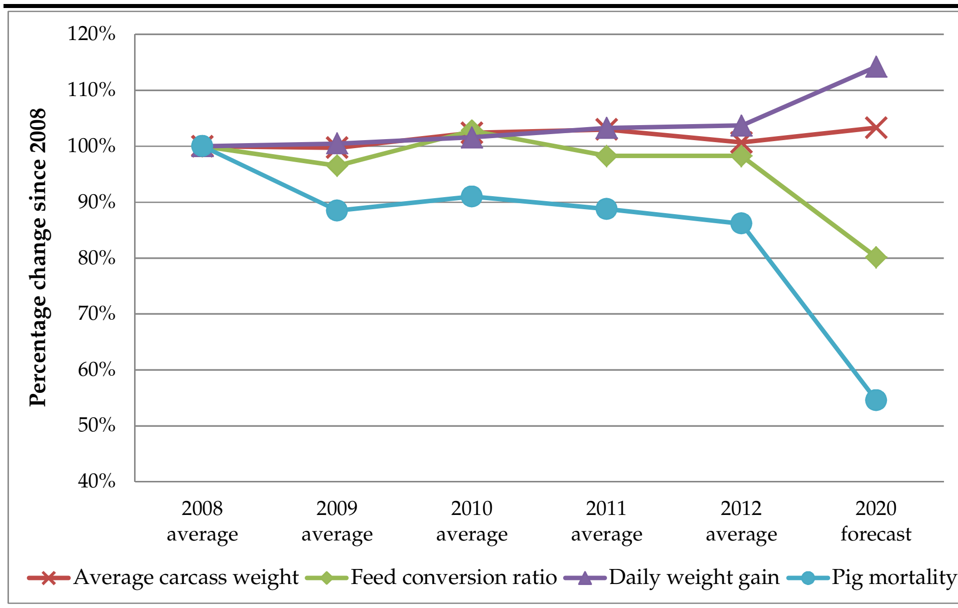
- Weaner start weight is forecast to increase from 2012 up to 2020, with weaner start weight in 2020 expected to be 7% greater than in 2012.

3.1.3 *Performance efficiencies of finishing herd parameters between 2008 & 2012 and forecasted for 2020*

Figure 3.3 shows the average percentage change in the British pig herd for the following finishing herd parameters:

- average carcass weight;
- feed conversion ratio;
- daily weight gain;
- pig mortality.

Figure 3.3 ***Year on year improvement for specific finishing herd parameters between 2008 & 2012 and forecasted for 2020***



The following is evident from the performance efficiencies of finishing herd parameters achieved between 2008 and 2012.

- Average carcass weight remained relatively constant between 2008 and 2012, showing a slight increase of 1% in 2012 compared to 2008.
- Feed conversion ratio remained relatively constant between 2008 and 2012, showing a slight decrease of 2% in 2012 compared to 2008.
- Daily weight gain showed a steady increase between 2008 and 2012, resulting in a 4% increase in 2012 compared to 2008.
- Pig mortality decreased between 2008 and 2012, resulting in a 14% decrease in 2012 compared to 2008.

The following is evident from the performance efficiencies of finishing herd parameters forecasted for 2020.

- Average carcass weight is forecast to increase from 2012 up to 2020, with the average carcass weight in 2020 expected to be 3% greater than in 2012.
- Feed conversion ratio is forecast to decrease from 2012 up to 2020, with the feed conversion ratio in 2020 expected to be 18% lower than in 2012.
- Daily weight gain is forecast to increase from 2012 up to 2020, with the daily weight gain in 2020 expected to be 11% greater than in 2012.
- Pig mortality is forecast to decrease from 2012 up to 2020, with pig mortality in 2020 expected to be 32% lower than in 2012.

3.2 *ENVIRONMENTAL IMPROVEMENTS ACHIEVED BETWEEN 2008 AND 2012*

3.2.1 *Total environmental improvements per kg of pork*

Based on the efficiencies reported by BPEX across British pig producers, improvements have been achieved for all four of the environmental impact categories assessed. The impacts results for 2008 to 2012, including the percentage improvement achieved in 2012 compared to 2008, are shown in *Figure 3.2*.

Table 3.1 Comparison of 2008 to 2012 results (per kg of pork)

		2008	2009	2010	2011	2012	Change 2008-2012
Climate change	kg CO_2-eq	6.18	5.93	5.88	4.55	4.55	26.3%
	% change per year		4.0%	0.9%	22.6%	0.0%	
Eutrophication	kg PO_4-eq	0.072	0.069	0.068	0.063	0.059	13.2%
	% change per year		3.6%	1.8%	7.3%	1.0%	
Acidification	kg SO_2-eq	0.207	0.201	0.198	0.191	0.187	9.4%
	% change per year		2.7%	1.5%	3.7%	1.8%	
Resource depletion	kg Sb-eq	0.0090	0.0086	0.0085	0.0083	0.0083	8.3%
	% change per year		4.4%	1.5%	2.6%	0.0%	

Table 3.1 indicates the following:

- Between 2008 and 2012, the environmental impact of British pork production decreased for all categories assessed, indicating the effect of improved performance and efficiencies.

- In addition, changes to pig feed composition have contributed to the improvement in environmental impacts. Between 2010 and 2011, the impact from climate change decreased significantly, by 22.6%. 2011 marks the year that new feed compositions were introduced. These results reflect the change in the ingredients of the new compositions, which comprise a greater synthetic proportion.

3.2.2 *Environmental improvements per life cycle stage*

Table 3.2 shows the improvements made at each life cycle stage for each environmental impact category assessed.

Table 3.2 Environmental impact improvement per life cycle stage (% improvement 2008-2012)

Impact category	Breeding herd	Rearing herd	Finishing herd	Sow replacement
Climate change	37%	12%	27%	24%
Eutrophication	13%	15%	12%	10%
Acidification	1%	14%	9%	6%
Resource depletion	24%	(8%)	8%	6%

The following is evident from *Table 3.2*.

- The breeding herd life cycle stage achieved considerable improvements in climate change and resource depletion impact categories between 2008 and 2012, showing a 37% and 24% improvement, respectively. A more modest improvement was achieved in eutrophication impacts, showing a 13% improvement. Acidification impacts for the breeding herd life cycle stage are shown to reduce by 1% in 2012 compared to 2008.
- The rearing herd life cycle stage achieved environmental impact improvements of 12% in climate change impacts, 15% in eutrophication impacts and 14% in acidification impacts in 2012, compared with 2008. The impact from resource depletion increased by 8% in 2012 compared with 2008. The increase in resource depletion impacts is a result of the change in feed composition from 2011. The new feed composition for younger pigs (young weaners) includes ingredients not included in the feed compositions for other ages of pig, which are key contributors to resource depletion impacts.
- The finishing herd stage achieved a considerable improvement in climate change impacts of 27% between 2008 and 2012. More modest improvements were achieved for eutrophication, acidification and resource depletion impacts, showing improvements of 12%, 9% and 8%, respectively.
- The sow replacement stage achieved a considerable improvement in climate change impacts of 24% between 2008 and 2012. More modest improvements were achieved for eutrophication, acidification and

resource depletion impacts, showing improvements of 10%, 6% and 6%, respectively.

- The impact of the change in pig feed composition results in the greatest benefit to climate change, which sees a significant improvement across all life cycle stages.

Figure 3.4 to *Figure 3.7* shows the contribution from each life cycle stage to total environmental impacts from 2008 to 2012.

Figure 3.4 Climate change contributions from each life cycle stage – 2008 to 2012

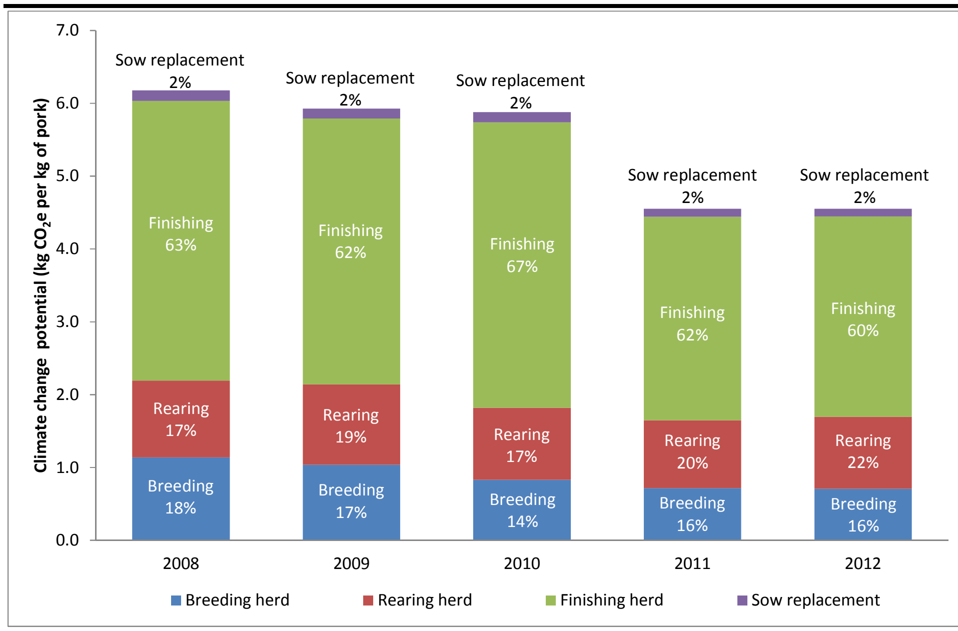


Figure 3.5 Eutrophication contribution from each life cycle stage – 2008 to 2012

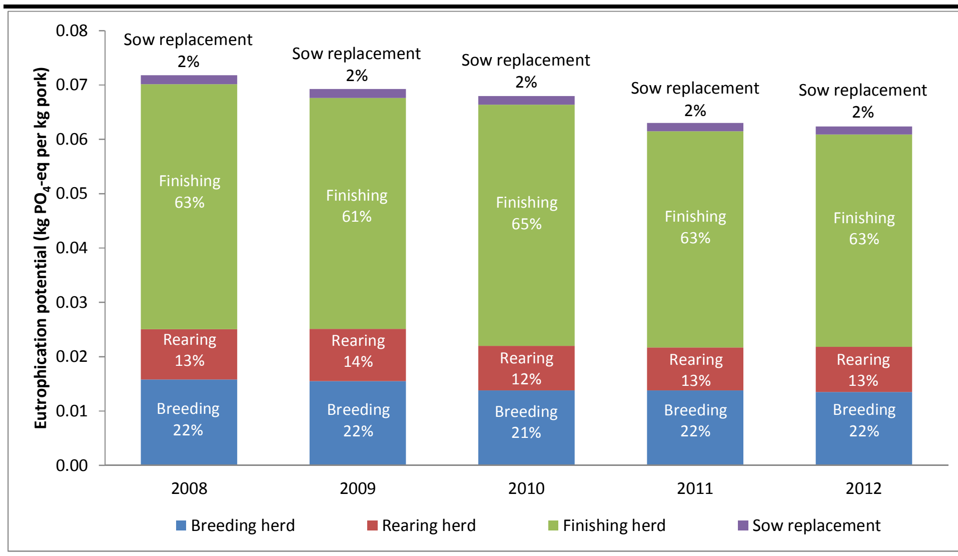


Figure 3.6 Acidification contribution from each life cycle stage – 2008 to 2012

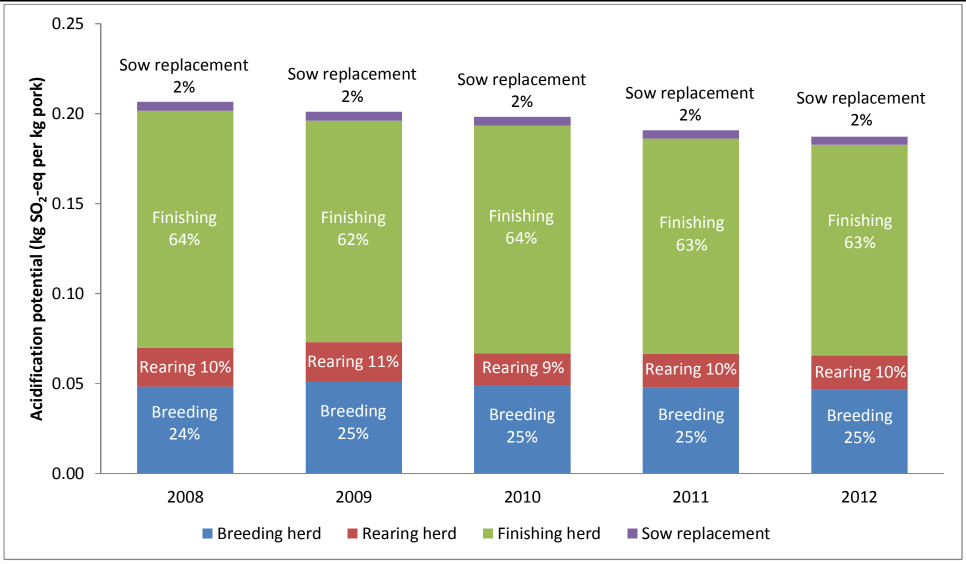
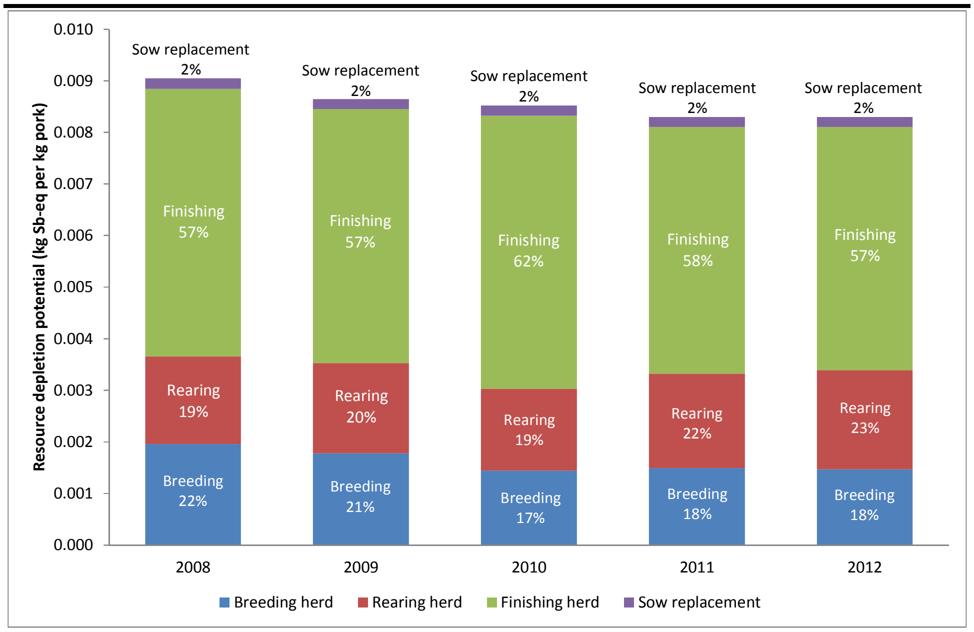


Figure 3.7 Resource depletion contribution from each life cycle stage – 2008 to 2012



- The finishing life cycle stage makes the most significant contribution across all of the environmental impact categories and across all of the years assessed, ranging from 57% up to 67%. This is mainly due to the longer time that the pigs spend in the finishing herd and the significant weight gains achieved. The contribution from the finishing herd to the total results is comparable across all of the years assessed.

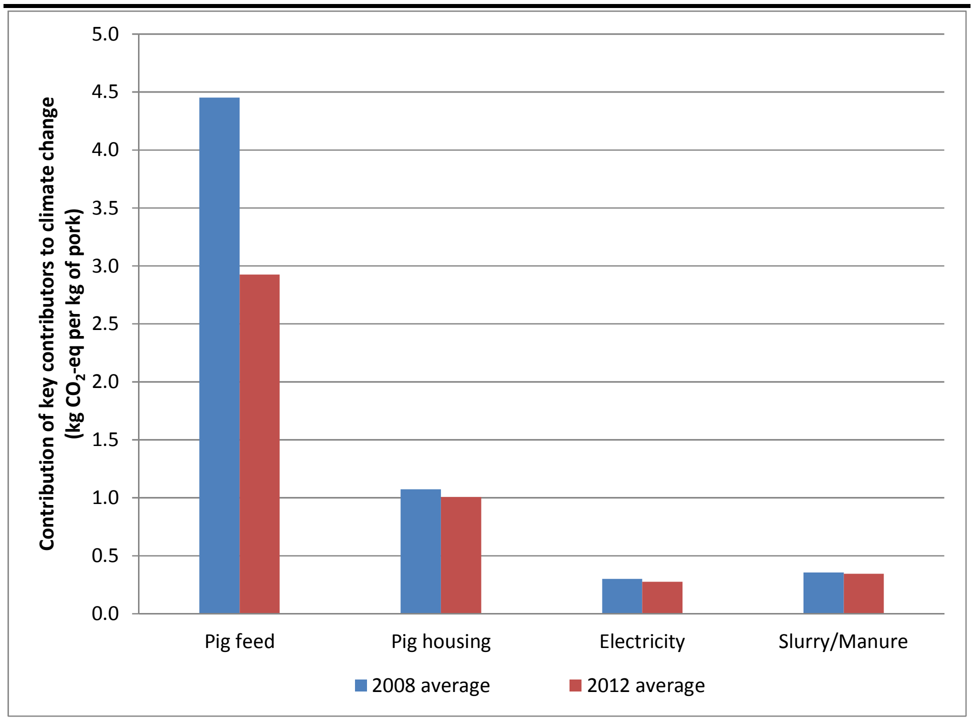
- The sow replacement life cycle stages makes the least significant contribution, accounting for 2% across all of the environmental impact categories and across all of the years assessed.

3.2.3 *Contribution to climate change impacts from specific inputs – 2008 & 2012*

Figure 3.8 presents the change between 2008 and 2012 in the contribution to climate change impacts made by certain key inputs to the life cycle.

- **Pig feed** – comprising impacts from the production of animal feed.
- **Pig housing** – comprising emissions to air of ammonia, nitrous oxide and methane from the housing of slurry and, in the case of methane, from enteric fermentation from the pigs themselves.
- **Electricity** – comprising electricity consumed during pig growth.
- **Slurry/Manure** – comprising impacts from excreta storage, management and ultimate landspreading as fertiliser.

Figure 3.8 Change in contribution to climate change from specific inputs – 2008 and 2012



The following is evident from *Figure 3.8*.

- Pig feed makes the most significant contribution to climate change, accounting for 4.45 kg CO_2-eq per kg of pork in 2008 and 2.92 kg CO_2-eq per kg of pork in 2012, which equates to 72% and 64% of the footprint respectively. Climate change impacts per kg of old composition pig feed (ie 2008 to 2010) range from approximately 0.9 kg CO_2-eq per kg to approximately 1.2 kg CO_2-eq per kg. Climate change impacts per kg of new composition pig feed (ie 2011 onwards) range from approximately 0.5 kg CO_2-eq per kg to approximately 1.1 kg CO_2-eq per kg.

- The key factors that influence the climate change impact of pork are pig feed (quantity and composition); pig housing (type of housing); electricity consumption; and slurry/manure storage and management. The climate change impacts per kg of pork result from each of these key factors has decreased between 2008 and 2012.
    - The climate change impact resulting from the quantity and composition of pig feed per kg of pork has reduced from 4.45 kg CO_2-eq to 2.92 kg CO_2-eq, equating to a total reduction of 34% from 2008 to 2012.
    - The climate change impact resulting from the type of pig housing employed for the herds has reduced from 1.07 kg CO_2-eq to 1.01 kg CO_2-eq, equating to a reduction of 6% from 2008 to 2012.
    - The climate change impact from electricity has reduced from 0.30 kg CO_2-eq to 0.28 kg CO_2-eq, equating to a reduction of 8% from 2008 to 2012.
    - The climate change impact resulting from slurry/manure management has reduced from 0.35 kg CO_2-eq to 0.34 kg CO_2-eq, equating to a reduction of 3% from 2008 to 2012.

3.3 *ENVIRONMENTAL IMPROVEMENTS FORECAST TO 2020*

Table 3.3 shows the environmental impact resulting from operational efficiencies forecasted by BPEX across British pig producers. *Table 3.3* presents the impact assessment results for performance in 2012, compared with the results for forecasted performance in 2012. *Table 3.3* also shows the potential percentage improvement achievable between 2012 and 2020.

Table 3.3 Comparison of 2012 results and 2020 forecast – per kg of pork

Impact category	Unit	2012	2020 forecast	% improvement
Climate change	kg CO_2-eq	4.551	4.116	10%
Eutrophication	kg PO_4-eq	0.062	0.059	6%
Acidification	kg SO_2-eq	0.187	0.180	4%
Resource depletion	kg Sb-eq	0.008	0.007	11%

Table 3.3 shows that, based on the operational efficiencies forecasted across British pig producers, environmental impact improvements are expected between 2012 and 2020 across all environmental impact categories.

Table 3.3 shows that, over the eight years between 2012 and 2020, the following improvements are forecast:

- improvement in climate change impacts of 10%;
- improvement in eutrophication impacts of 6%;
- improvement in acidification impacts of 4%; and
- improvement in resource depletion impacts of 11%.

3.3.1 *Forecast environmental improvements per life cycle stage – 2012 to 2020*

Table 3.4 shows the forecast improvements made at each life cycle stage in 2020, as compared with 2012, for each environmental impact category assessed.

Table 3.4 Forecast environmental improvements per life cycle stage - 2012 to 2020

Impact category	Breeding herd	Rearing herd	Finishing herd	Sow replacement
Climate change	12%	38%	(2%)	31%
Eutrophication	14%	37%	(4%)	28%
Acidification	17%	36%	(8%)	27%
Resource depletion	13%	37%	(1%)	31%

The following is evident from *Table 3.4*.

- The rearing life cycle stage is forecast to achieve the greatest environmental improvements across all of the impact categories, with a 38% improvement in climate change impacts, a 37% improvement in eutrophication impacts, a 36% improvement in acidification impacts and a 37% improvement in resource depletion impacts.
- The breeding herd stage is forecast to achieve environmental impact improvements of 12% in climate change impacts, 14% in eutrophication impacts, 17% in acidification impacts and 13% in resource depletion impacts.
- The sow replacement life cycle stage is forecast to achieve environmental impact improvements of 31% in climate change impacts, 28% in eutrophication impacts, 27% in acidification impacts and 31% in resource depletion impacts.
- The quantity of feed per pig is forecast to decrease from 2008 to 2020 for rearing, breeding and sow replacement stages. As feed is the main contributor to impacts across all categories, less feed consumed per pig results in lower impact across categories. In turn, less feed consumed leads to less excreta produced per pig which leads to a reduced impact from the storage and management of excreta, as well as from agricultural emissions of ammonia, methane and nitrous oxide.
- The finishing herd stage is forecast to increase its environmental impact by 2% for climate change, 4% for eutrophication, 8% for acidification and 1% for resource depletion. The increase in environmental impacts for the finishing stage in 2020 compared to 2008 is due to a higher quantity of feed per pig forecasted for 2020 than in 2008. In addition, the time

period for the finishing stage and the exit weight of the finishing herd is forecasted to increase between 2012 and 2020, consequently increasing the quantity of excreta produced, which increases impacts from excreta storage and management, as well as agricultural emissions of ammonia, methane and nitrous oxide.

3.3.2 *Contribution to climate change impacts from specific inputs – 2012 & 2020*

Figure 3.9 presents the forecast change between 2012 and 2020 in the contribution to climate change impacts from key contributions, as described in *Section 3.2.3*.

Figure 3.9 Change in contribution to climate change from specific inputs – 2012 to 2020

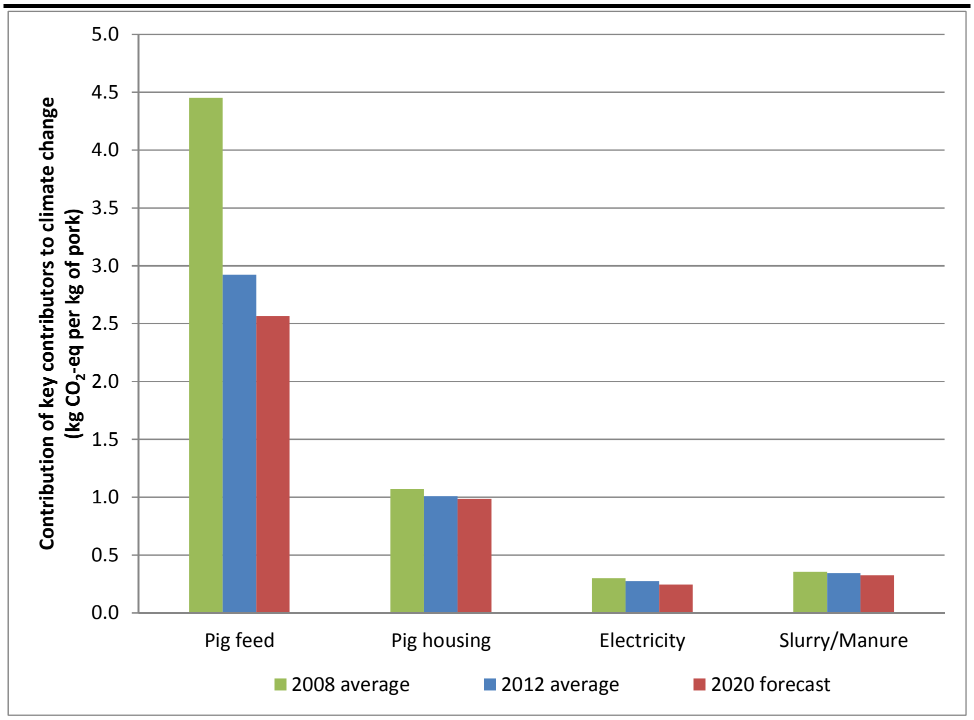


Figure 3.9 shows that the impact from all key contributions is expected to continue to reduce up to 2020.

- Pig feed is expected to continue to make the most significant contribution to climate change impacts, accounting for 2.92 kg CO_2-eq per kg of pork in 2012 and is expected to account for 2.56 kg CO_2-eq per kg of pork in 2012, which equates to 64% and 62% of the footprint, respectively.
- The climate change impact per kg of pork resulting from key factors of pig feed, pig housing, electricity consumption and slurry/manure storage and management is forecasted to continue to decrease between 2008 and 2012.
    - The climate change impact resulting from the quantity and composition of pig feed is expected to reduce from 2.92 kg CO_2-

eq to 2.56 kg CO_2-eq, equating to a total reduction of 12% from 2012 to 2020.

- The climate change impact from pig housing is expected to reduce from 1.01 kg CO_2-eq to 0.98 kg CO_2-eq, equating to a reduction of 2% from 2012 to 2020.
- The climate change impact from electricity is expected to reduce from 0.28 kg CO_2-eq to 0.24 kg CO_2-eq, equating to a reduction of 12% from 2012 to 2020.
- The climate change impact from slurry/manure is expected to decrease from 0.34 kg CO_2-eq to 0.33 kg CO_2-eq, equating to a reduction of 5% from 2012 to 2020.

4 *CONCLUSIONS*

In order to aid the future assessment and reporting of environmental improvements achieved in the industry, the BPEX commissioned an update to the streamlined LCA of British produced pork, originally undertaken in 2010. The 2010 LCA comprised a cradle-to-gate assessment of pig production from 2001 to 2008 and forecast for 2020 with the objective of estimating changes in the environmental profile of British produced pork. This study updates the original LCA, and estimates changes in the environmental profile of British produced pork from 2008 to 2020.

As with the original LCA in 2010, this study has been undertaken using industry data and predictions relating to anticipated operational performance. A streamlined LCA reduces the need to collect primary data by relying on published industry data and published life cycle inventories.

This study considers the following environmental impacts:

- climate change;
- eutrophication;
- acidification; and
- resource depletion.

This study builds on the findings from the 2010 LCA, which identified potential for environmental improvement as a result of optimised performance efficiencies. A key difference regarding the 2008 to 2020 period to which this updated study relates, is with respect to changes in the composition of pig feed, which resulted from price fluctuations of key feed ingredients. This has caused the environmental impact of pig feed to decrease across all impacts. Pig feed makes the most significant contribution across the life cycle to all of the environmental impact categories. Thus, a change in the environmental impact of pig feed has the potential to have a major influence on the overall results.

The confidential nature of the data on feed prevents the reporting of its composition and the contributions to the overall footprint made by individual ingredients. However, across all pig feed composition sources and across all life cycle stages, the most significant contributions to environmental impacts are from inputs of crops (eg wheat, barley, soybean) and crop products (eg wheatflour, soybean meal).

Table 4.1 provides a comparison of the environmental impact assessment results for 2008, 2012 and 2020 (1).

(1) For the 2008 results, the 2010 LCA used feed emission factors from a secondary source. For this update, to enable the results for the old and new feed compositions to be compared, improved feed emission factors were calculated for 2008

Table 4.1 Comparison of 2008, 2012 and 2020 results – per kg of pork

Impact category	Unit	2008 average	2012 average	2020 forecast	% improvement 2008 to 2020
Climate change	kg CO_2 eq	6.18	4.55	4.12	33%
Eutrophication	kg PO_4^{3-} eq	0.072	0.062	0.059	18%
Acidification	kg SO_2 eq	0.207	0.187	0.180	13%
Resource depletion	kg Sb eq	0.0090	0.0083	0.0074	19%

Based on the assumption that the current feed composition continues to be used by the British pork industry up to 2020, the following can be ascertained.

- Climate change impacts will decrease by 33% by 2020 compared to 2008 levels.
- Eutrophication impacts will decrease by 18% by 2020 compared to 2008 levels.
- Acidification impacts will decrease by 13% by 2020 compared to 2008 levels.
- Resource depletion impacts will decrease by 19% by 2020 compared to 2008 levels.

For wider reporting of the results and for any future annual analysis of improvements achieved, it is recommended that the data be revised and updated to better reflect the current situation. In particular, as demonstrated in this updated LCA, changes feed composition are likely have a significant impact on the results for pig production as a whole.

based on feed composition data from the secondary source but using the same emission factors and assumptions as for the new feed.

5 COMPARABILITY OF RESULTS FROM THIS STUDY WITH THE 2010 LCA

This study provides an update to the streamlined LCA of British pork production undertaken in 2010. However, the results from this study cannot be directly compared with the results from the 2010 LCA due to key differences relating to the system boundary and data sources. These are identified in relevant sections of this report and are summarised below.

5.1 ANIMAL FEED

Due to there being insufficient data available, the 2010 LCA used secondary data sourced from the Cranfield LCA Model of Agricultural Systems to represent animal feed at different stages of the pig life cycle. For this update, BPEX identified that there have been changes in the composition of swine feed since 2011 and wished to reflect these changes in the updated LCA.

Primary data were sourced from two UK producers of pig feed, and the environmental impact of these feeds was estimated by applying environmental emission factors sourced from ecoinvent (1) and the Danish LCA Food Database (2). In order to enable a reasonable comparison with pork production prior to 2011 (ie before the composition of swine feed was changed), feed composition data from the Cranfield LCA Model of Agricultural Systems was re-modelled using the same emission factors as for the new composition.

A detailed comparison of how feed compositions have changed since 2008 is not possible for this study due to confidentiality of animal feed data.

As a consequence of these changes, the 2008 impact assessment results presented in this study do not precisely match the results originally presented in the 2010 LCA report.

5.2 PIG HOUSING

The 2010 LCA assumed that 100% of pigs at all rearing stages were housed indoors on slatted flooring. This update provides an assessment of pigs housed in different types of housing, as per the most recent Farm Practice Survey in 2009. The type of housing employed in pig production dictates the type of excreta produced and how it is stored and managed. This affects the quantity and type of agricultural emissions released from storage and management of excreta.

(1) ecoinvent© (http://www.ecoinvent.org/database/)
(2) LCA Food Database (http://www.lcafood.dk/)

Therefore, the impact assessment results derived in this study, which considers different types of housing at each life cycle stage, cannot be compared with the impact assessment results from the 2010 LCA, which considered only one type of housing.

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ERM's Manchester Office

Floor 11
5 Exchange Quay
Manchester
M5 3EF

T: +44 (0)161 958 8800
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