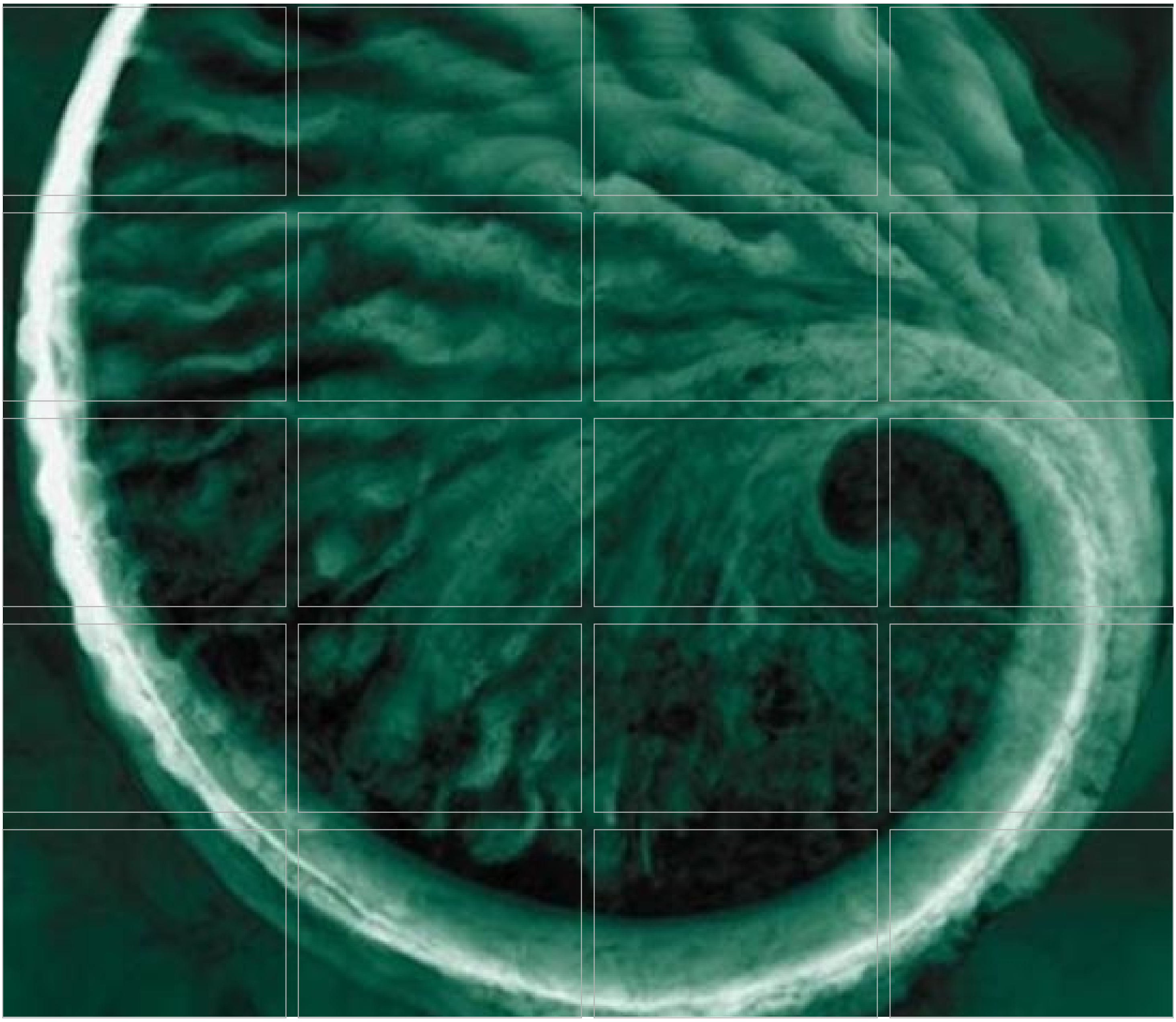

Life Cycle Assessment of Pork

Report

August 2009

Delivering sustainable solutions in a more competitive world

ERM

AHDBMS

Life Cycle Assessment of Pork

Report

August 2009

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For and on behalf of Environmental Resources Management
Approved by: Simon Aumônier
Signed:
Position: Partner
Date: August 2009

CONTENTS

EXECUTIVE SUMMARY

Environmental Resources Management Limited (ERM) was commissioned by the Agriculture and Horticulture Development Board Meat Services (AHDBMS) to conduct a scoping Life Cycle Assessment (LCA) study in order to estimate the environmental impacts associated with pork production across the pig life cycle and to identify opportunities for improvement. The aim is to provide AHDBMS with a better understanding of where such impacts arise.

It is intended that the study will aid AHDBMS in facilitating the communication of the environmental impacts of pork production.

The modelling undertaken as part of this study quantifies the impacts on: climate change; eutrophication; acidification; and abiotic resource depletion associated with the pork production to farm gate (sufficient to produce one kg of pork product). Pig production (comprising feed production, pig rearing, and slurry and manure management and spreading on land) is the life cycle phase that contributes the most to the environmental profile of pork products. Of this, feed production is the element of pig production that makes the largest contribution. For example, the feed contributes 78% of the total carbon footprint of pork production.

Benchmarking with data provided by two producers (Producer A and Producer B) showed that a number of general farming efficiency factors, as achieved by the two producers, can reduce the environmental profile of pork production considerably. For example, Producer A and B achieve carbon footprints that are 7% and 11% lower respectively than those for average British pork production. More efficient measures include: achieving more pigs per litter; lower feed conversion ratio; lower sow feed consumption; lower mortality; and lower sow culls. For Producer B, the use of a liquid co-product as part of the finisher feed also contributes to a lowered environmental profile.

A further reduction in impact is seen from pigs produced from Producer B as a result of the anaerobic digestion of slurry from the finishing herd before it is spread on land. Anaerobic digestion of slurry leads to significant savings with regard to climate change, eutrophication and acidification. These savings result from the generation of electricity, and thereby the avoidance of electricity produced from fossil fuels. It must be highlighted that the anaerobic digestion model is based on a number of assumptions. Despite these uncertainties, the figure demonstrates the benefit of recovering the energy held in the slurry before its application to land.

In addition to the benchmarking exercise, "what if?" scenarios were developed and used to assess the environmental gains that could be achieved if the average British producer achieved the same performance results as the top third of producers, as presented in the Pig Year Book 2009. Such a raising of the bar would deliver benefits in the order of a 3.1% improvement in acidification, 3.8% improvement in eutrophication, 3.9% improvement in non-renewable energy consumption, and a 4.2% reduction in contributions to climate change.

In considering the potential for improving the environmental impacts of British pork production, the results show that the main areas in which improvements can be achieved in pig farming are as follows::

1. using feed as efficiently as possible;
2. achieving higher numbers of pigs per litter; and
3. managing the slurry/manure in ways that reduce its impacts.

Study limitations

The most important limitations to this study are identified as follows.

- This is a scoping LCA study. As such, readily available information and data is used in the form of pig farming data from the Defra research project *Determining the Environmental Burden and Resource Use in the Production of Agricultural and Horticultural Commodities* conducted by Cranfield University (subsequently called the Cranfield study) (Williams *et al* 2006) and the BPEX Pig Year Book 2009. Where there are missing data, these have been substituted with surrogate data or left as data gaps.
- Data reported in the Pig Year Book 2009 are reported according to outdoor or indoor breeding, but not however according to wider farming methods such as fully slatted housing or loose bedding. As such, some variations in the farming method may not be accounted for.
- Secondary data, sourced from the Cranfield study, were used to model systems where data were not available from the BPEX Pig Year Book 2009. These data are considered to be the best currently available for UK pig production and suitable for use in this study. Nevertheless, it must be highlighted that the data are some years old now and a number of modelling assumptions are not fully described in the supporting material to the Cranfield model.

1 INTRODUCTION

1.1 BACKGROUND

Pork production and pig farming is receiving increasing attention in the UK from the likes of retailers, TV chefs, and the general public. This places a focus on pork production and the impact that it has on the environment.

To this end, the Agriculture and Horticulture Development Board Meat Services (AHDBMS) wishes to understand the sources and scale of environmental impacts, and particularly releases of greenhouse gases contributing to climate change, across the life cycle of pork production.

The primary aim of this study is to estimate the environmental profile of British produced pork. To this end, the method of Life Cycle Assessment (LCA) has been used. To minimise the resources expended in the first instance, the project is limited to a 'scoping LCA'. This minimises the collection of primary data and employs readily available data wherever available. Although climate change is the main focus of this study, other environmental impacts that are important when considering pork production and pig farming are also considered, *viz*.: eutrophication; acidification; and abiotic resource depletion.

1.2 PROJECT OBJECTIVES

The overall aims of this study are threefold:

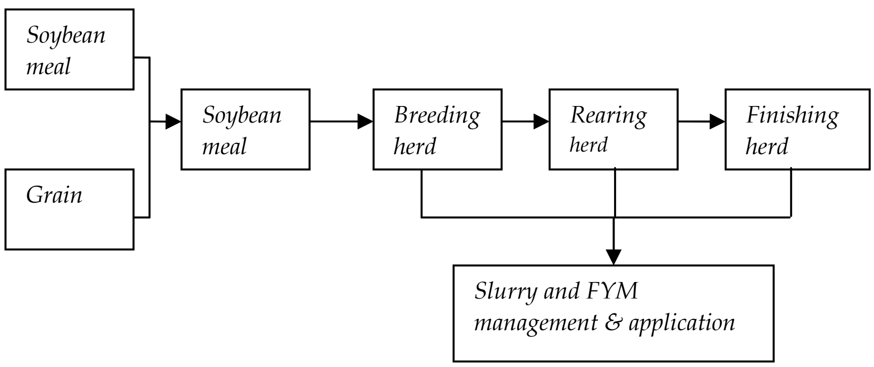
- to estimate the environmental impacts associated with pork production across the life cycle and to identify opportunities for improvement;
- to facilitate communication of these environmental impacts (in particular greenhouse gas emissions) with suppliers, and potentially with other stakeholders; and
- to inform decisions regarding any further data collection to validate secondary data used in this study and to improve the robustness of the model.

The life cycle assessment (LCA) method is used to estimate the environmental profile of British pork production.

The measure to which the results relate (the functional unit) is 'pork at farm gate, (sufficient for 1 kg of pork product).

Figure 2.1 below summarises the pork production life cycle. Wheat, wheat feed, barley and soya bean meal are the main components of the feed. During the production of the feed, energy and water are consumed and substances are emitted from the growing of the crop, from harvesting and processing and from transport. The feed is consumed by the pigs during growth, and, in turn, animal excreta are managed as slurry and farm yard manure (FYM). These products are stored, and later applied to fields as a fertiliser. On reaching a certain weight, the pigs leave the farm and are brought to the abattoir where they are slaughtered and the meat is processed and packaged. This study ends at the point at which the pigs leave the farm gate.

Figure 2.1 Summary of the pork production life cycle



The pork production in this assessment represents British pork produced at an average British pig farm during 2007.

2.1 *DESCRIPTION OF THE DIFFERENT LIFE CYCLE STAGES OF PORK PRODUCTION*

In the following, the different life cycle stages are described in more detail.

2.1.1 *Feed*

Pigs are fed a pelletised compound feed, own-milled feed, or liquid feed (often called co-product feed) combined with dry (solid) feed.

Increased farm sizes and the need for automisation has made dry feeding the most common feeding method employed on British pig farms. Compound feed, as generally used in the UK, is factory produced by a couple of main suppliers. The feed is generally labelled with percentage ranges for the different feed ingredients. The main ingredients are wheat, wheatfeed, barley, and soybean meal.

Computerised feeding systems and lower costs have led to a revival in the use of industrial co-products from the human food industry. The type of liquid feed very much depends on the food processing industries in the vicinity of the individual farms, as transporting the liquid feed long distances is generally not economically viable. The most commonly known liquid feed is whey. Others include liquid potato, chocolate, yoghurt and brewery co-products. Some liquid feeds, such as derivatives from the cereal processing industry, are branded and sold under names such as Greenwich Gold and Abrocarb.

In accordance with the specific dietary and nutritional needs of the pig during its life cycle, the feed provided varies in terms of both its ingredients and quantity. Three different kinds of feed are considered in this study, feed: for sows; for weaners; and for finishers.

It has not been possible to obtain detailed information about the exact feed combination through the feed producers contacted during this study, due to the commercially sensitive nature of the data. Consequently, the LCA data used for solid feed data in this study is drawn from the Cranfield study (Williams *et al* 2006). A comparison of recent Defra statistics and those used for developing the concentrate feedstuff models in the Cranfield study shows little difference in the mean distribution of main raw feeds used by feed blenders. Considering the wider uncertainties encompassed in the data and the models, the feedstuffs models of the Cranfield study are considered appropriate for use in this study.

The liquid feed used in the case study on different feed types is based on data provided by Producer B. The liquid feed is combined with a dry feed balancer on the farm. It was outside the scope of this study to model the life cycle impacts of the different food products for which the liquid feed is a co-product. Instead, environmental input output data [1] have been used, based on the cost paid by the farmer for the feed.

Table 2.1 below shows a dry matter (DM) based comparison of the LCA data for the different dry feeds and the liquid feed. As can be seen, the impacts of the liquid feed are considerably lower than those of the dry feed. This difference is to a large extent a reflection of the price paid by the farmer compared to the price of the main food product. It suggests a considerable environmental saving to the farmer when using liquid feed as part of the pig feed.

It should be noted that this is an example of liquid feed as it is based on data from one farm only. As such, the price that the farmers pay might vary considerably, based on the co-product and the demand for it. Finally, using a simplified method rather than modelling the food products in detail and allocating precisely to the co-product will inevitably lead to an inherent uncertainty in the modelling of the liquid feed.

Table 2.1 ***Comparison of LCA data for dry and liquid feed as per DM content*** *(normalised against non-organic dry feed for finishing herd)*

	Dry feed, sows, non-organic	**Dry feed, weaners, non-organic**	**Dry feed, finishers, non-organic**	**Liquid feed, finishers**
Data source	Williams et al 2006	Williams et al 2006	Williams et al 2006	ERM 2007
Climate change	88%	107%	100%	14%
Eutrophication	78%	113%	100%	4%
Acidification	82%	108%	100%	15%
Abiotic resource depletion	90%	103%	100%	3%

2.1.2 *Pig farming*

Pig farming has been divided into four separate processes representing: breeding herd; rearing herd; finishing herd; and sow replacement. The processes take into account both the feed production, the rearing of the pigs, the storage and management of manure/slurry, as well as application of these to the field.

[1] Economic input output (I/O) tables map the economic flows between sectors in an economy. Environmental I/O (EIO) data are developed when the economic I/O data are combined with environmental data for each industry sector. The results express the environmental load according to the unit value of a sector.

In the UK, some 60% of pigs are bred indoors. Sows are housed for approximately 60 days per year in farrowing pens. When dry, the sows are generally housed in groups in larger pens. The piglets are weaned after three to five weeks, when they reach a weight of approximately 7 kg. The weaners are then moved to weaning pens where they spend some seven weeks until they reach a weight of 30 kg. The weaners are then move to larger finishing pens for a further 10 to 18 weeks until they reach a weight of approximately 100 kg. The pigs are kept in pens with either fully, or partly, slatted flooring, or with straw bedding. Slatted flooring allows pig manure to fall directly into a drainage system below the pens, draining to an on-site slurry management system. If straw bedding is used, once soiled, this is removed from the pens and used on the farm as farm yard manure.

The remaining 40% of UK pigs are bred outdoors. In the outdoor system, sows are housed outdoors with each sow having its own house in a fenced area, in which the piglets are born. Once weaning age is reached, the piglets are put into their own fenced areas. In the majority of outdoor farms, once the weaned pigs reach finishing age, they are moved indoors. Pigs bred and grown organically are often finished indoors[1]. Buildings for finishers in an outdoor or organic system will generally contain loose bedding rather than slatted flooring.

Alongside pig rearing for pork production, sow replacements are produced. These replacement sows substitute the breeding sows that come to the end of their productive life, or for some other reason are culled.

Table 2.2 ***Physical performance modelled***

	Indoor bred, non-organic
Pigs weaned per sow per year	22.89
Sow feed (kg) per sow per year	1334
Average live weight at slaughter (kg)	101.6
Finishing mortality (%)	3.3
Sow culls (%)	41.6
Rearing feed conversion ratio	1.74
Finishing feed conversion ratio	2.87

Source: Pig Year Book 2008.

No national data have been identified for pig farming using liquid feed as part of the feedstuff. As such, this farming method is only assessed through a benchmark case study.

During pig production, inputs to the farm are required in the form of feed, energy, and potentially bedding. This is reported in *Table 2.3* below, along with outputs and emissions.

Table 2.3 Inventory for pig farming (per individual pig output)

	Indoor bred pigs, dry feed, fully slatted housing
Inputs	
Feed (kg)	383
Straw (kg)	0.00418
Electricity (kWh)	45.1
Outputs	
Pig (live weight) (kg)	101.6
Slurry (kg)	767
Farm yard manure, FYM (kg)	15.4
Emissions	
Ammonia (kg NH_3)	1.34
Nitrous oxide (kg N_2O)	0.00814
Methane (kg CH_4)	2.00

The quantity of feed consumed is calculated based on 2007 data supplied by the farming industry to Agrosoft Ltd and subsequently collated in the Pig Year Book (BPEX 2008). Straw and electricity use, slurry and farm yard manure (FYM), and emissions are calculated using the Cranfield model (Williams et al 2006).

3 RESULTS

The four environmental impact categories against which the results are reported can be described as follows.

- **Climate change potential** is an increase in temperature caused by the emission of carbon dioxide (CO_2) and other greenhouse gases into the atmosphere. The results are expressed in kg CO_2 equivalents and represent a time horizon of 100 years.
- **Eutrophication potential** is a reflection of the amount of nutrients (eg nitrate and phosphate from manure/slurry) leached to the aquatic environment. Nitrates and phosphates are essential for life but increased concentrations in the aquatic environment can cause excessive growth of algae, reducing the oxygen within the water and damaging ecosystems. The results are expressed in kg phosphate (PO_4^{3-}) equivalents.
- **Acidification potential** relates to the release of acidic gases (eg 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 form 'acid rain', resulting in reduced pH in natural habitats (eg lakes) and thereby causing ecosystem impairment. The results are expressed in kg SO_2 equivalents.
- **Abiotic resource depletion potential** estimates the extraction of scarce minerals and fossil fuels. An abiotic depletion factor is determined for based on the remaining global resource reserves and their rates of deaccumulation. The results are expressed in kg antimony (Sb) equivalents.

3.1 ENVIRONMENTAL IMPACT OF BRITISH PORK FROM INDOOR PIG FARMING, SLATTED FLOORING

The environmental profile per kg of British pork product using the indoor farming method of slatted flooring is shown in *Table 3.1* below.

Table 3.1 Environmental profile of British pork product, indoor pig farming, slatted flooring, per functional unit

Impact category	**Unit**	**BPEX, indoor, slatted flooring, non-organic**
Climate change potential	kg CO_2 eq.	6.2
Eutrophication potential	kg PO_4^{3-} eq	0.055
Acidification potential	kg SO_2 eq	0.18
Abiotic resource depletion potential	kg Sb eq	0.033

The results are described in further detail below.

3.1.1 *Climate change potential*

Emissions contributing to climate change, or the carbon footprint, resulting from the production of pork to farm gate (sufficient to produce 1 kg of pork product) is 6.2 kg CO_2 equivalents. Pig production comprises feed growing and production, pig rearing, and slurry/manure management. Further assessment of pig farming, as displayed in *Figure 3.1*, shows that the impacts of the finishing herd accounts for 58% of total impacts, the rearing herd 21%, the breeding unit 18%, and sow replacement 3%.

Figure 3.1 Contribution to the life cycle carbon footprint from the different stages of pork production (per functional unit)

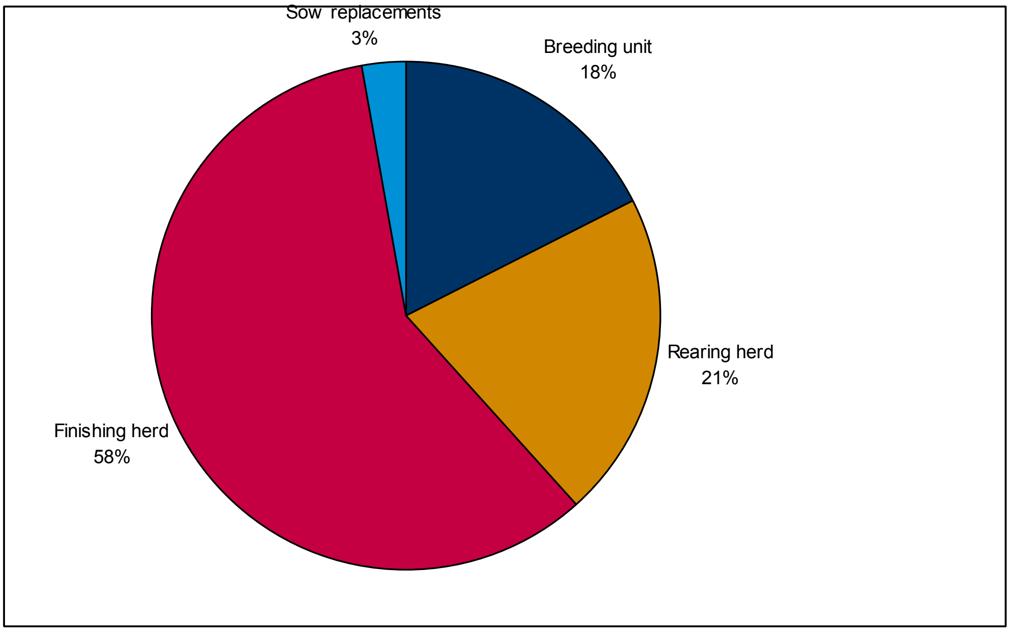
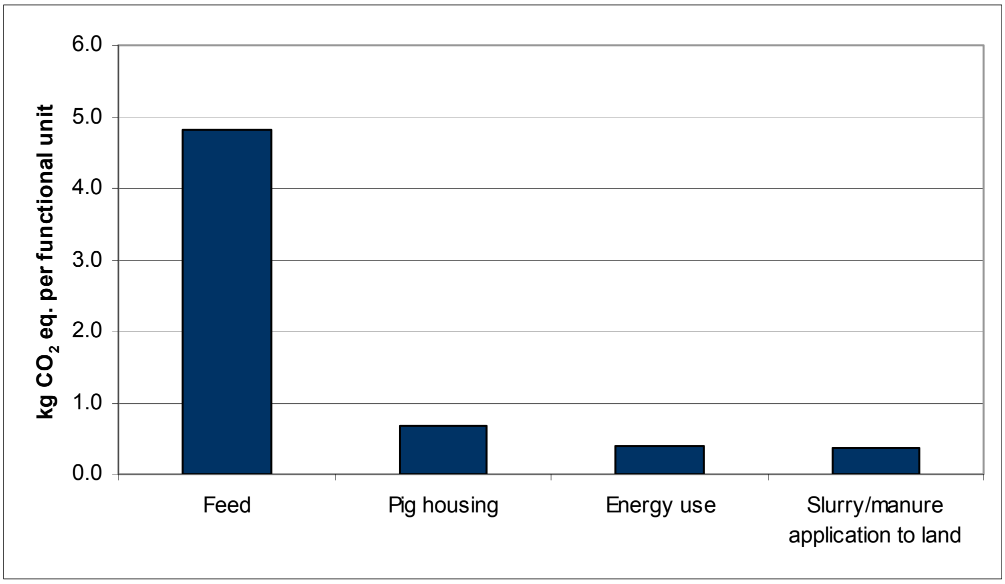


Figure 3.2 shows that pig feed contributes a considerable proportion of the carbon footprint of pig farming, and therefore of the full product chain. Feed contributes 4.8 kg CO_2 equivalents, which is 77% of the total carbon footprint of the pork product. The greenhouse gas emissions per kg feed as used in this study range between approximately 0.82 and 0.99 kg CO_2 eq (depending on whether it is sow feed, rearing herd or finishing herd feed). Since approximately 313 kg of feed is required to raise one pig, it is not surprising that the feed accounts for a significant proportion of the carbon footprint.

The impacts from pig housing are essentially resulting from the emission of ammonia, nitrous oxide and methane from the housing of the slurry and, in the case of methane, also from enteric fermentation from the pigs themselves.

Electricity use is estimated, based on the Cranfield model, as no average electricity consumption data for British pig farming have been identified. For indoor pig farming, it is assumed that only electricity is used, including for the provision of heating.

Figure 3.2 ***Contribution to the life cycle carbon footprint from the different stages of pig farming*** *(per functional unit)*



The contribution from slurry application to land is relatively small, because the need for less artificial fertiliser has been taken into account. The production and distribution of artificial fertiliser has environmental impacts and therefore when fertiliser is substituted by slurry or manure, the greenhouse gas emissions of artificial fertilizer are avoided. Because they are avoided, these are subtracted from those emitted from slurry/manure and its application.

3.1.2 Eutrophication potential

The production of pork to farm gate (sufficient to produce 1kg of pork product) from indoor bred pigs on slatted flooring has an estimated eutrophication potential of 0.055 kg PO_4^{3-} equivalents. The breakdown in the contribution to eutrophication from the stages of pig farming are shown in *Figure 3.3*.

The most important pig farming contributions to eutrophication are nitrate, ammonia, nitrogen oxides, and, to a limited extent, phosphate.

Figure 3.3 ***Contributions to life cycle eutrophication potential of British pork production (indoor pig farming, slatted flooring)***

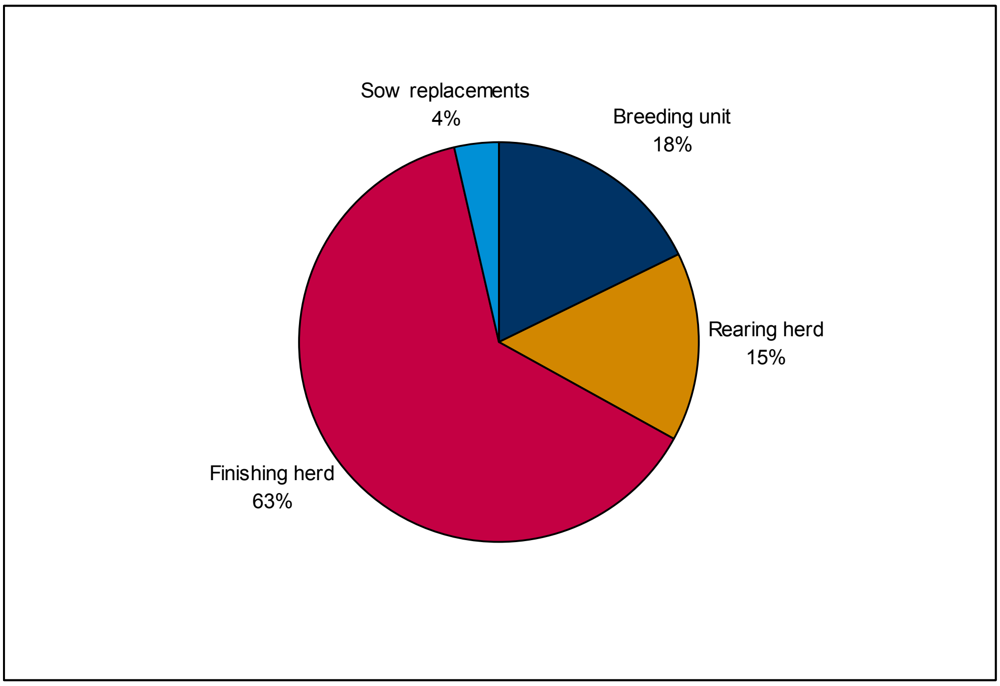
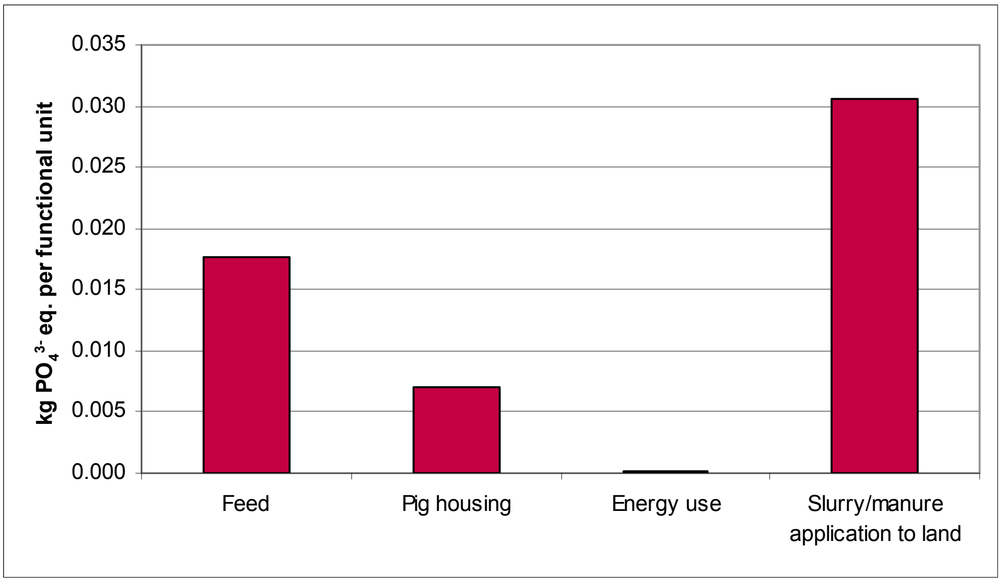


Figure 3.4 below shows that the highest contribution to eutrophication is slurry/manure application to land. Its contribution is 0.031 kg PO_4^{3-} equivalents, accounting for 53% of the total eutrophication potential. A significant contribution to this is the nitrogen in the slurry/manure not taken up by the crop. Instead, this is leached to watercourses. Pig feed contributes 0.018 kg PO_4^{3-} equivalents, accounting for approximately 33% of the total eutrophication potential. Nitrate and ammonia emitted during cultivation of the feed components make the major contributions. The single contribution from pig housing is ammonia from slurry/manure in the housing units and from its storage. The contribution from energy use on the farm is very low.

Therefore, the key areas for focus when considering eutrophication are the management of nitrogen through the reduction of nitrate leached from fields and ammonia emitted from the slurry.

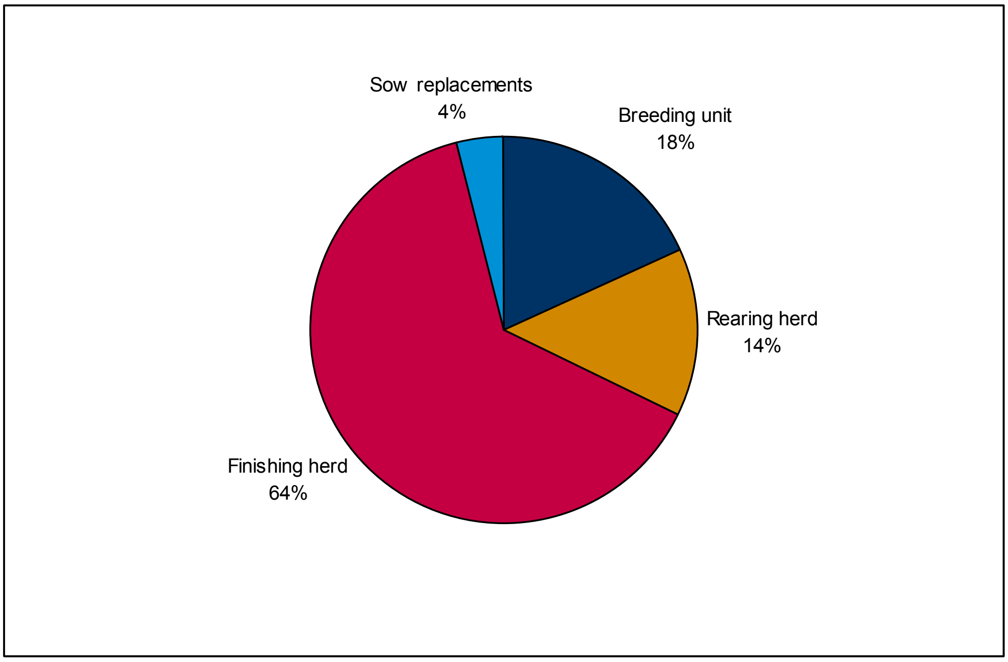
Figure 3.4 ***Contribution to life cycle eutrophication potential from the different stages of pig farming***



3.1.3 *Acidification potential*

The contribution to acidification resulting from pork production amounts to 0.18 kg SO_2 equivalents. The contribution from each part of the herd is shown in *Figure 3.5.*

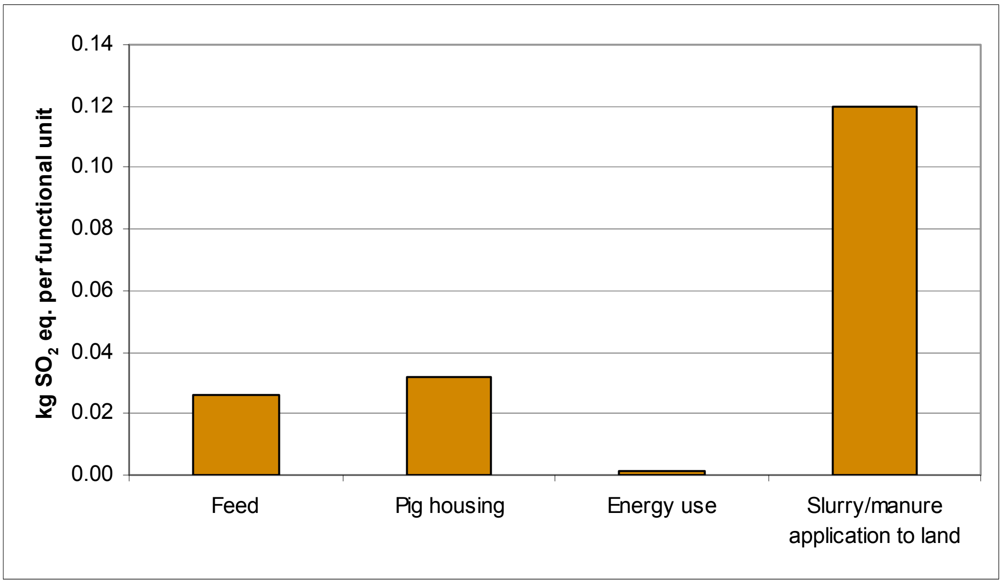
Figure 3.5 ***Contributions to life cycle acidification potential of British pork production (indoor pig farming, slatted flooring)***



Ammonia makes the major contribution to the life cycle acidification potential. Other contributions, such as nitrogen oxides, sulphur oxides and sulphur dioxide, which arise from energy production, are much less significant to this impact category.

The main contribution to the acidification potential comes from ammonia emitted from slurry/manure application to land. This accounts for 67% of the total acidification potential. Pig housing contributes through the emission of ammonia from the slurry/manure management. Some contribution is also seen from the feed. This is mainly from the soya meal due to the transport of this from South America and the associated emissions as well as the processing of feed.

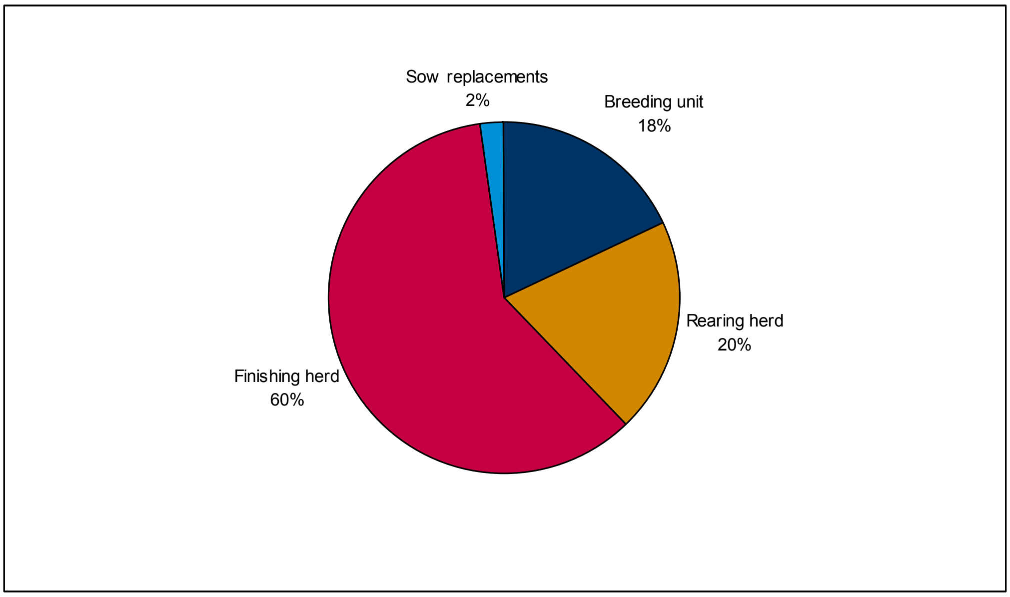
Figure 3.6 ***Contribution to the life cycle acidification potential from the different stages of pig farming***



3.1.4 Abiotic resource depletion potential

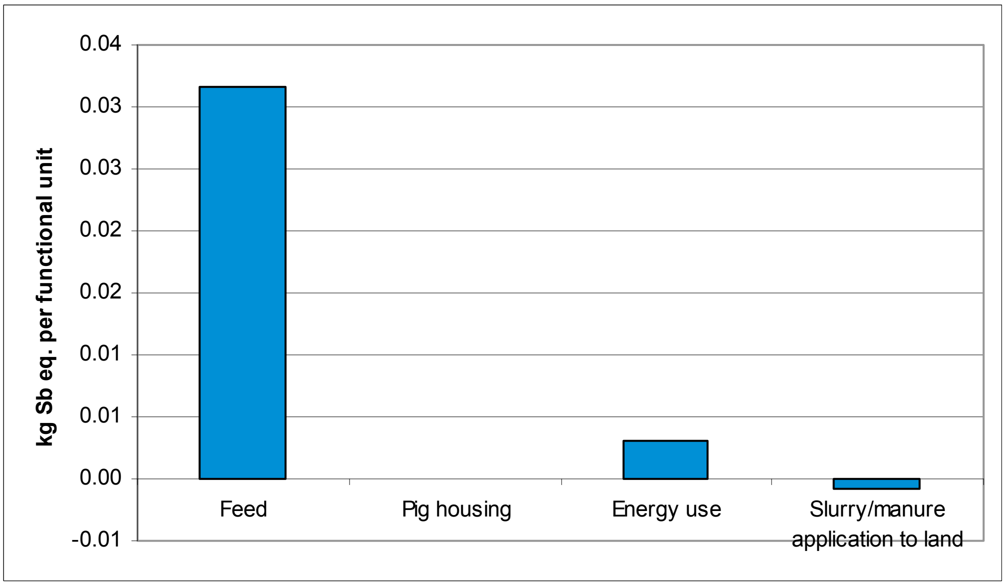
Abiotic resource depletion is the depletion of fossil resources such as oil, natural gas and coal. One kg of pork produced to farm gate (sufficient to produce 1kg of pork product) from indoor bred pigs on slatted flooring has an estimated abiotic resource depletion potential of 0.033 kg Sb equivalents.

Figure 3.7 ***Contributions to the life cycle abiotic resource depletion potential of British pork production (indoor pig farming, slatted flooring)***



As shown in *Figure 3.8*, the main contribution from the pig farming phase comes from the feed. Again, this is mainly due to the transport associated with crop production and distribution, as well as with feed processing. A small contribution is also seen from energy use on the farm. The overall contribution from slurry/manure application to land is 'negative', because less abiotic resources are used when applying slurry/manure to the fields compared to the artificial fertiliser that is substituted.

Figure 3.8 ***Contribution to the life cycle abiotic resource depletion potential from the different stages of pig farming***



3.2 "WHAT IF?" SCENARIOS

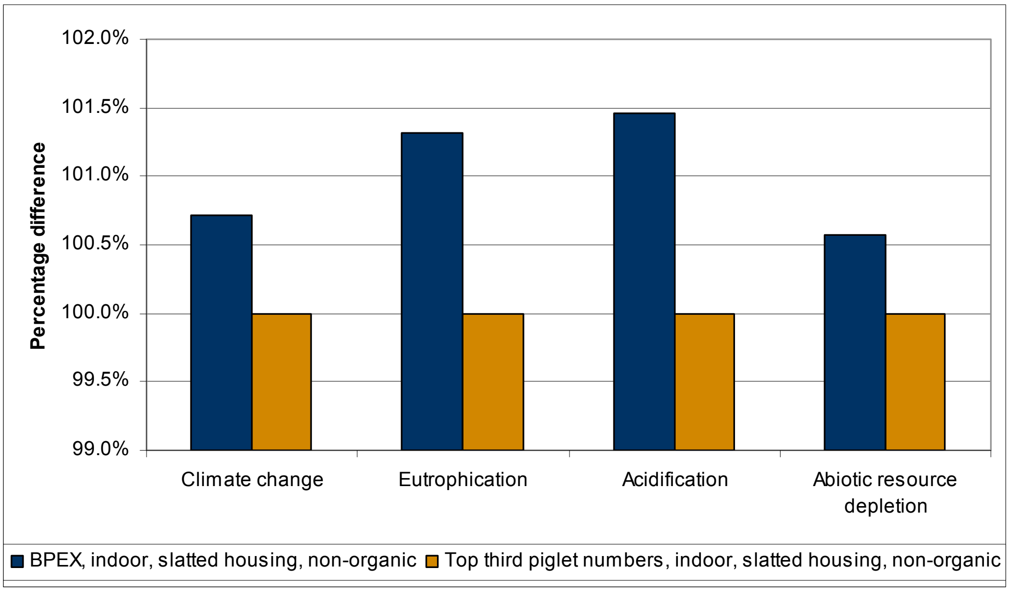
In addition to the benchmarking exercise, "what if?" scenarios were created to assess the benefits achieved if the pigs produced, feed conversion rate, mortality rates, etc achieved by the top third of producers represented the UK average.

Only the farming method of indoor bred pigs on slatted flooring has been considered. Similar results would be achieved for the other farming methods.

3.2.1 *What if the number of pigs produced per sow is the same as the top third?*

In 2008, the top third of producers produced an average of 24.85 pigs per sow per year compared to a British average of 22.89 pigs per sow per year. It is assumed that this is partly achieved through the higher sow feed consumption of 1387 kg per year for the top third of producers compared to the British average of 1334 kg, and the higher replacement percentage of 47.67% compared to the British average of 45.53%. This has therefore been taken into account in the assessment.

Figure 3.9 *Benefits of achieving the number of pigs per sow as the top third producers*



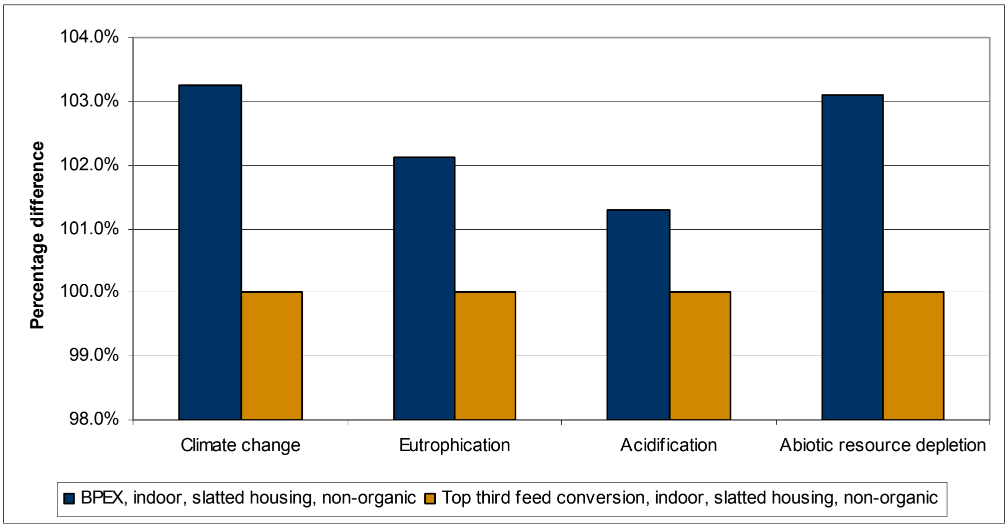
The benefits of achieving the same number of pigs per sow as the top third producers are shown in *Figure 3.9* below. The benefits achieved range from a 0.6% improvement in abiotic resource depletion to a 1.4% improvement in acidification impacts.

3.2.2 *What if the feed conversion rates are the same as the top third?*

In 2008, the top third of producers achieved average feed conversion rates of 1.51 for their weaning herds and 2.61 for their finishing herds compared to a British average of 1.74 and 2.87 respectively.

The benefits of achieving the feed conversion rates of the top third of producers are shown in *Figure 3.10* below. No other variables have been considered. The benefits achieved range from a 1.3% improvement in acidification to a 3.2% improvement in the climate change impact category.

Figure 3.10 Benefits of achieving the feed conversion ratios of the top third producers

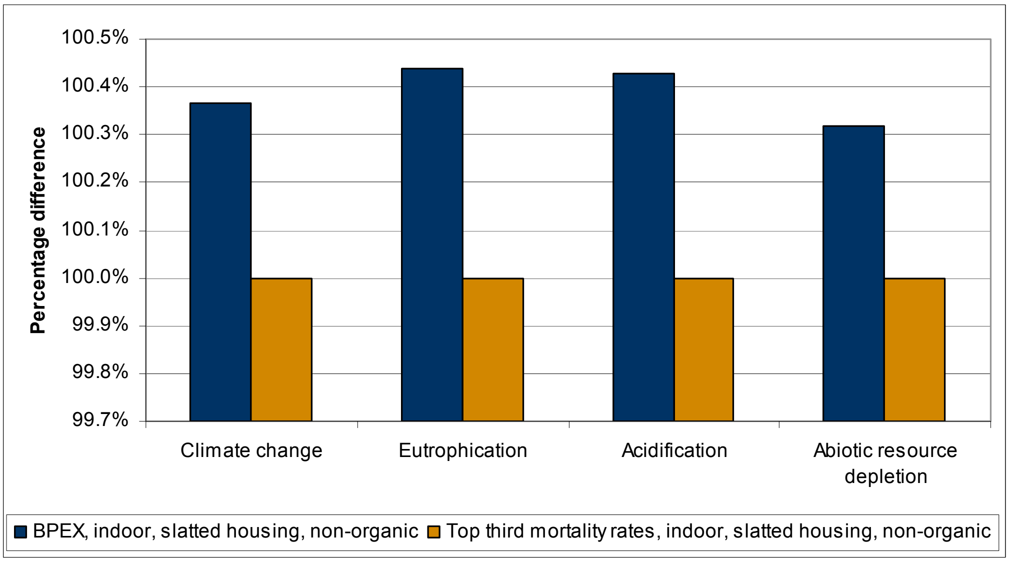


3.2.3 *What if the mortality is the same as the top third?*

In 2008, the top third producers achieve average mortality rates of 1.8% for their weaning herds and 3.0% for their finishing herds compared to a British average of 2.4% and 3.3% respectively.

The benefits of achieving the mortality rate of the top third producers for the weaning and finishing herds are shown in *Figure 3.11* below. The benefits achieved range from a 0.3% improvement in abiotic resource depletion to a 0.4% improvement in the other impacts.

Figure 3.11 ***Benefits of achieving the mortality rates of the top third producers***

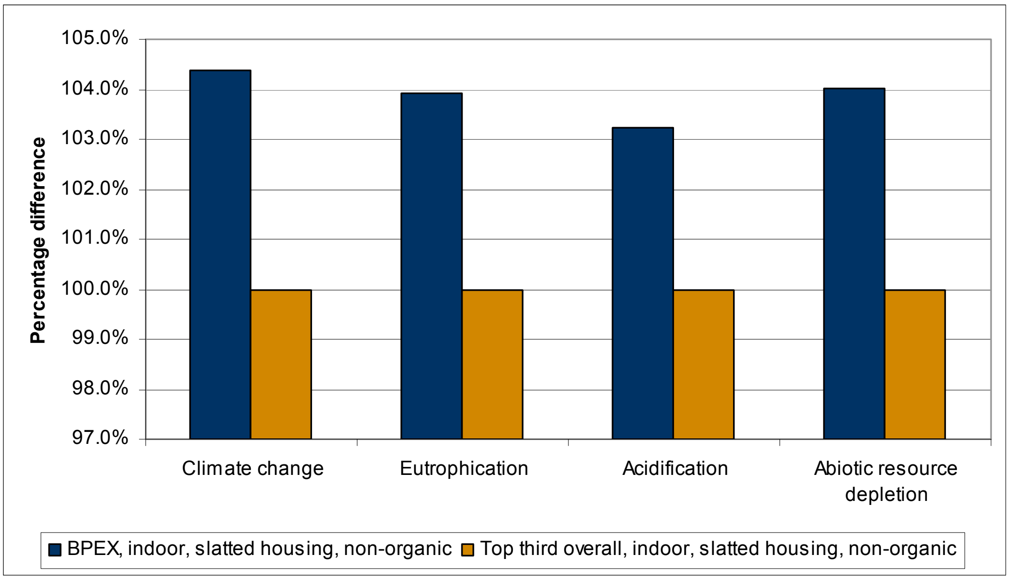


3.2.4 *Benchmarking of top third producers against British average*

In *Figure 3.12* below, the overall results for the top third of producers are compared to the average BPEX data for indoor bred pigs on slatted flooring.

The figure illustrates the combined benefits of achieving the piglet numbers, the feed conversion rates, and mortality rates of the top third of producers. The benefits achieved range from a 3.1% improvement in non-renewable energy consumption to a 4.2% improvement in contributions to climate change. The improvement achieved for the top third producers means that the climate change contributions from their pork, per kg pork product consumed, amounts to 5.9 kg CO_2 equivalents.

Figure 3.12 ***Benchmarking of top third producers against BPEX average***



3.2.5 *What if the best housing type with regard to manure management were used?*

The Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques for Intensive Rearing of Poultry and Pigs lists ammonia emission factors for different housing types or systems.

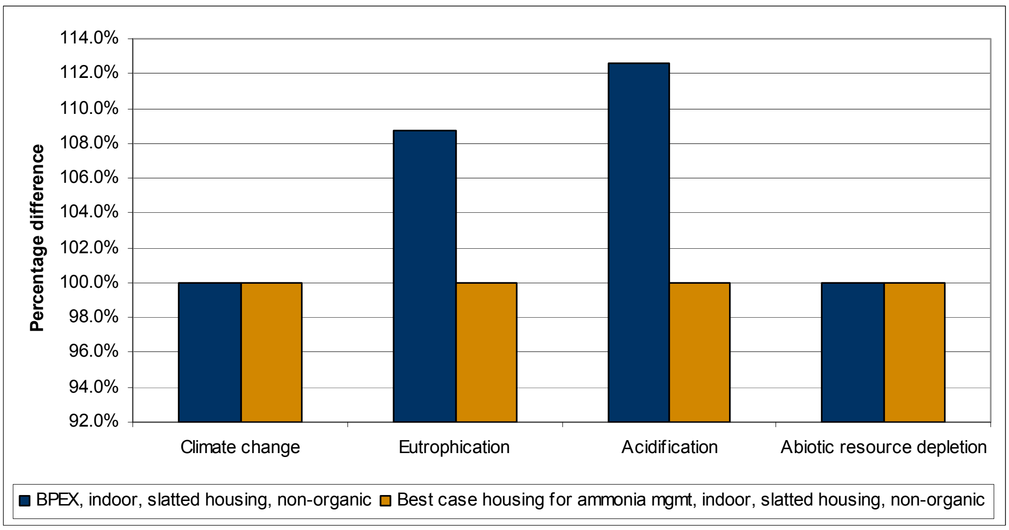
In order to illustrate the potential benefits to be achieved using alternative housing methods, the overall results for the average BPEX data for indoor bred pigs on slatted flooring as modelled in this study have been benchmarked against best case data as listed in the BREF document. The emission factors are listed in *Table 3.2* below.

Table 3.2 IPPC BREF emission factors used for comparison *(fully slatted flooring only)*

Pig	**Housing type/system**	**Emission factor reduction (%)**	**Emission factor (kg NH_3-N/animal place/year)**
Sows	Fully slatted floor with flush gutters / tubes and aeration	55%	1.35
Farrowing sows	Fully slatted floor and manure surface cooling fins	70%	0.90
Weaning pigs	Pens or flatdecks with fully slatted floor and flush gutters / tubes and aeration	50%	0.15
Finishing pigs	Fully slatted floor with flush gutters / tubes and aeration	70%	1.24

The potential benefits of incorporating the best case housing system for ammonia management are shown in *Figure 3.133* below. Benefits are only seen for eutrophication and acidification as ammonia does not contribute to climate change or cause abiotic resource depletion. The potential benefits are a 8.0% improvement in the eutrophication impact and a 11.2% improvement for acidification.

Figure 3.13 Benefits of best case housing system for ammonia management



4 DISCUSSION AND CONCLUSIONS

The overall aims of this study were threefold:

- to estimate the environmental impacts associated with pork production across the pig life cycle and to identify opportunities for improvement;
- to facilitate communication of the environmental impacts (in particular greenhouse gas emissions) with suppliers, and potentially with other stakeholders; 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.

The modelling undertaken as part of this study has quantified the impacts of: climate change; eutrophication; acidification; and abiotic resource depletion associated with the production of pork to farm gate (sufficient to produce one kg of pork product).

- The process of pork production (comprising feed production, pig rearing, and slurry and manure management and spreading on land) is the life cycle phase that contributes the most to the environmental profile of pork production.
- Of this, feed production is the element of pig production that makes the largest contribution. For example, the feed contributes 78% of the total carbon footprint of pork production from pigs raised indoor on slatted flooring.

Table 4.1 Environmental profile of British pork production (1 kg pork produced)

	Climate change	**Eutrophication**	**Acidification**	**Abiotic resource depletion**
	kg CO_2 eq	kg PO_4^{3-} eq	kg SO_2 eq	kg Sb eq
BPEX, indoor, fully slatted	6.2	0.055	0.18	0.033

The BPEX data have been benchmarked with data provided by two producers of conventionally bred pigs (Producer A and B). This has shown that a number of general farming efficiency factors, as achieved by the two producers, can reduce the environmental profile of pork production considerably. For example, Producer A and B achieve carbon footprints that are 7% and 11% lower respectively than those for average British pork production. The efficiencies include such measures as more pigs per litter achieved, lower feed conversion ratios, lower sow feed consumption, lower mortality and lower sow cull percentages. For Producer B, the use of liquid co-product as part of the finisher feed also contributes to a lowering of the environmental profile.

For Producer B, an additional reduction in the impact is also seen due to the anaerobic digestion of the slurry from the finishing herd before it is spread on land. Anaerobic digestion of slurry leads to significant savings with regard to climate change, eutrophication and acidification. This is due to the generation of electricity, and thereby the avoidance of electricity produced from fossil fuels. It should be highlighted that the anaerobic digestion model is based on a number of assumptions. Despite these uncertainties, the figure demonstrates the benefit of recovering the energy held in the slurry before its application to land.

In addition to the benchmarking exercise, "what if?" scenarios were developed and used to assess the environmental gains that could be achieved if the average British producer achieved the same performance results as the top third of producers, as presented in the Pig Year Book 2009. Such a raising of the bar would deliver benefits in the order of a 3.1% improvement in acidification, 3.8% improvement in eutrophication, 3.9% improvement in non-renewable energy consumption, and a 4.2% reduction in contributions to climate change.

In considering the potential for improving the environmental impacts of British pork production, the results show that the main improvements can be achieved in the pig farming phase of the pork production life cycle. Evaluating the results in further detail suggest that the measures for achieving the greatest improvements are:

1. using feed as efficiently as possible;
2. achieving higher numbers of pigs per litter; and
3. managing the slurry/manure in ways that reduce its impacts.

With regard to slurry management, in order to illustrate the potential benefits to be achieved using alternative housing methods, the overall results for the average BPEX data for indoor bred pigs on slatted flooring as modelled in this study were benchmarked against best case data as listed in the BREF document for Intensive Rearing of Poultry and Pigs. This showed the potential benefits delivered to be an 8.0% improvement in the eutrophication impact and a 11.2% improvement for acidification.

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