# Feasibility study on the desirability of the UK pig industry adopting carcase cooling as an on-farm method for the storage of fallen pigs prior to disposal

Dr Marie Kirby and Dr Robert Wilkinson

September 2014

# Foreword

This report was prepared in response to a request to investigate the possibility of introducing carcase cooling as a method for on-farm storage of fallen pigs in the United Kingdom. In Denmark and the Netherlands, carcase cooling on pig units has been established since 2008, with the use of cooling wells and subsequently cooling containers.

This report investigates the concept of carcase cooling and evaluates its potential for adoption by the UK pig industry. To be able to establish this, considerable co-operation and help was required in sourcing data, insight and views from different areas within this sector. A substantial amount of insight was gained directly from the continent with the report from Tine Zimmermann and Lisbeth Shooter of Patriotisk Selskab. Gaining this first-hand information has been vital to completing this report. Special thanks are also given to Stephen Woodgate, Chief Executive of FABRA; Bob Bansback, Visiting Professor in Agricultural Economics at Harper Adams University; Ian Campbell, Director of NFSCo and Sue Rabbich, Environmental Projects Manager, BPEX. Thanks are also due to people who collected data to aid this report including Jane Rockingham, NFSCo; Mr Thomasse, Coolworks; Daka and those who provided data or information anonymously.

Contents page

## List of Tables



## List of Figures

## List of Plates



## List of Appendices



## Abbreviations

| | |
|---|---|
| ABP | Animal by-product |
| AD | Anaerobic digestion |
| ASF | African swine fever |
| FABRA | Foodchain and Biomass Renewables Association |
| FFA | Free fatty acids |
| HAU | Harper Adams University |
| MBM | Meat and bone meal |
| NFSCo | National Fallen Stock Company |
| PAP | Processed animal protein |
| PEDv | Porcine epidemic diarrhoea virus |
| TSE | Transmissible spongiform encephalopathy |
| UK | United Kingdom |
| VAT | Value added tax |

## 1.0 Summary


1. With the prohibition of on-farm burial and open-burning of fallen stock in 2002, farmers had to use alternative, more expensive methods to dispose of carcases. This legislation was imposed following the occurrence of Transmissible Spongiform Encephalopathy (TSE) disease in the United Kingdom (UK) which affects ruminants. Although pigs cannot be naturally infected with TSE diseases, both ruminants and non-ruminants are covered by these legislative changes.

2. The Houston report (2012) identified that carcases and animal by-products should be reassessed and no longer treated as a waste product, but a value added product which is in demand. Irrespective of collection method, all fallen stock are either incinerated or rendered. If rendered, the value of the rendered product can be dramatically affected by the quality of the carcase material supplied to the renderer. In Denmark and the Netherlands, the rendering associations have encouraged on-farm cooling of carcases to prevent bacterial degradation which decreases carcase quality. Anecdotal evidence suggests that bacterial degradation of carcases stored >15°C can reduce carcase value by 20% per tonne of carcase material, compared to material stored at <10°C. This potential loss in revenue to the renderer has encouraged renderers in Denmark to offer pig farmers a 30% discount in the cost of collecting carcases if the carcases are cooled prior to collection.

3. The aim of this report is to investigate the concept of using carcase cooling and the feasibility of its adoption in the UK. To achieve this, the developmental history of carcase cooling was examined, along with the different cooling methods currently available in Denmark, the Netherlands and the UK. Cost benefit analyses are presented for these cooling systems and how suitable these cooling systems are for the UK. As pigs cannot naturally transmit TSE disease, but have been restricted by the same legislation as ruminants, this report will focus upon reducing the cost of fallen stock disposal to the pig industry which normally has low profit margins.

4. In Denmark and the Netherlands, carcases are collected directly from farms by the rendering companies, so intermediate collectors are not involved as they are in the UK. Several different cooling methods have been evaluated, with the use of cooling containers from the continent, or refrigerated container boxes from the UK proving to be of potential benefit to the UK pig industry. The benefit of these systems is that they limit bacterial degradation of the carcase prior to collection, so carcases can be stored for a longer duration. This reduces the number of collections required each year and therefore the possible risk of disease transmission by the collection vehicle. In addition, the use of separate access roads for the collection vehicles and the farm staff delivering fallen stock to a dedicated collection site aids to increase the farmers' awareness of biosecurity and disease reduction, further improving biosecurity. By further increasing farmers awareness to biosecurity issues will aid in their compliance to legislation regarding fallen stock and may stop the use of unsuitable

methods. Additional benefits of carcase cooling systems include providing a secure storage method for carcases against wildlife, pests and flies; a reduction in odours on-farm, during transport and at the rendering or incineration plant; improvements in the public perception of the animal by-products industry and the fact that it is easy to use, clean and disinfect. For these reasons, many farmers in Denmark, the Netherlands and throughout Europe are using carcase cooling techniques even where a collection discount is not available.

5. Initially when carcase cooling was introduced to Denmark, the rendering industry offered a 30% collection discount for cooled carcases. Depending on the cooling method adopted, the payback period of some of the systems are relatively short. For example assuming the best case scenario and a 30% collection discount, payback periods could be a minimum of 6.7 years for a small cooling well, 4.2 years for a cooling container and 3.6 years for a refrigerated container box. With various different carcase cooling methods available to the farmer, the farmer in Europe has a choice as to which system best suits their needs. The cooling containers appear to be the most appropriate methods; however there are some fundamental gaps in knowledge and design of this system. Further research is required to fully understand the true potential of these systems prior to recommendation for adoption by industry. Future research should focus upon quantifying the true effects of storage temperature and duration upon the carcase yield, quality, odour emissions and microbial stability. Research should also concentrate upon improving the design of the cooling container to increase process efficiency and produce a system which can cool larger carcases. An investigation into the financial impacts of poor biosecurity on-farm and the environmental factors associated with the animal by-products industry should also be considered to understand the true magnitude of this problem. This evidence would, in future, aid to inform livestock producers to invest in such systems. Carcase cooling may not only be suitable for use by the pig industry but could be used across the different livestock sectors, working with intermediate collection centres and processing plants to develop an integrated ABP industry solution. This would help to provide cost benefits to a sector with normally low profit margins.

## 2.0 Introduction

6. In 2002, Commission Regulation (EC) 1774/2002 prohibited the open-burning and burial of fallen stock on-farm due to the possible disease transmission risk of Transmissible Spongiform Encephalopathy (TSE). Farmers were then required to use alternative, approved methods of carcase disposal, many of which increased the cost of disposal.

7. The Houston report (2012) investigated alternative methods to increase the value of fallen stock and animal by-products (ABP), in an attempt to decrease the cost of disposal of these materials. If farmers, collectors and processors consider themselves as part of an ABP supply chain, by working together, economies of scale can be produced to turn a waste into a valued product, to the benefit of all sectors of the industry (Houston, 2012).

8. Anecdotal evidence suggests that when carcases are stored in containers outside, there is a reduction in yield quality and quantity of fallen stock being delivered to the renderers. In continental Europe, pig carcases are cooled on-farm, to provide a fresher carcase for rendering. Fresher carcases produce rendered products of greater value as the rendered fat can be used for biodiesel production. It has been speculated that if 5,000 pig units undertook carcase cooling on-farm, it could be worth £7.5million per annum to the United Kingdom (UK) pig industry (Houston, 2012). In addition to the value which could be obtained by cooling carcases, Houston (2012) highlighted the poor biosecurity practices which commonly occurs on-farm, particularly regarding fallen stock. Improvements to biosecurity procedures could be made which would benefit the whole industry in reducing disease transmission.

9. This report will determine the feasibility of using carcase cooling in the UK and the potential benefit this could have upon the value of the rendered products. To achieve this objective, the cooling systems currently available in Denmark and the Netherlands were investigated to evaluate the practicalities and cost-effectiveness of the different approaches. The structure of the individual pig industries and their collection/disposal systems on the continent were compared to the systems in the UK. A comparative cost benefit analysis was then performed for the UK, with possible recommendations made for the UK situation (where appropriate).

## 3.0 Literature review

10. Commission Regulation (EC) 1774/2002 prohibited the open-burning and burial of fallen stock on-farm due to the possible disease transmission risk of TSE from burying infected carcases in the soil. Prior to 2002, burial and open-burning were traditional methods of fallen stock disposal used on-farm. This resulted in farmers having to use alternative disposal methods which incurred greater costs. Although natural transmission of TSE to pigs is not thought to occur, both ruminants and non-ruminants are affected by Commission Regulation (EC) 1774/2002.

11. A few areas of the UK are exempt from this legislation due to their remote locations, which limits regular access to disposal companies. These areas include parts of the Highlands and Islands of Scotland; Bardsey Island and Caldy Island in Wales; the Scilly Isles and Lundy Island in England; and Rathlin Island and the Copeland Islands in Northern Ireland (DARDNI, not dated and DEFRA, 2013a). However, if there is a notifiable disease outbreak and the renderers/incinerators cannot cope with the increased volume of carcases, burial or open-burning may be reinstated to destroy these carcases (DEFRA, 2013a).

12. Commission Regulation (EC) 1774/2002 defines three different categories of ABP depending on the possible disease status of the material. The legislation also includes any possible further uses of the carcase, how each category must be disposed of and how any products produced from the disposal processes can be used. Category one ABP is defined as carcases confirmed or suspected to have had a TSE or notifiable disease or carcases which contain a prohibited residue. Category two ABP includes fallen stock, carcases which contain veterinary drug residues, slaughterhouse waste and animal manure/digestive track contents. Category three ABP is not intended for human consumption, ABP which are not typically consumed by humans (for example the skin and hooves), blood from non-ruminants, milk and fish (Commission Regulation (EC) 1774/2002). Category one material can only be disposed of via incineration or rendering followed by incineration of the rendering products; category two disposed of via incineration or rendering with the rendering products being used for anaerobic digestion (AD), composting, oleochemical uses or be processed into organic fertilisers/soil improvers. Category three ABP can be disposed of via incineration, rendering, AD, composting, technical plants, pet food manufacture or placed in an approved landfill (Commission Regulation (EC) 1774/2002).

13. The UK pig industry comprises of indoor and outdoor production systems, concentrated mainly within East Anglia and East Yorkshire. In 2013, there were an estimated total number of pigs within the UK of 4,885,000, to include 284,000 sows and 66,000 gilts. This represents an overall increase of 9.0% in the total number of UK pigs during 2013 compared to 2012. This increase can be attributed to a 10.0% increase in the number of fattening pigs and a 0.3% decrease in the number of

breeding pigs (DEFRA, 2013b). This lead to an increase in pig meat production of 1.3%, which in conjunction with higher clean carcase weights, unprecedented high pig prices and a decrease in costs, lead to an increase in pig meat value of 12% to £1.3 billion. There are approximately 7,800 pig holdings in the UK with an average herd size of 401 sows in a farrow to finish unit (BPEX, 2014). The UK produced 833,000 tonnes of pig meat, of which 207,000 tonnes are exported to the EU and the rest of the world. The UK also has to import a further 722,000 tonnes per year, mainly from the EU (712,000 tonnes) (DEFRA, 2013b). Figure 1 illustrates the production of pig meat (thousands of tonnes) per EU country in 2013.

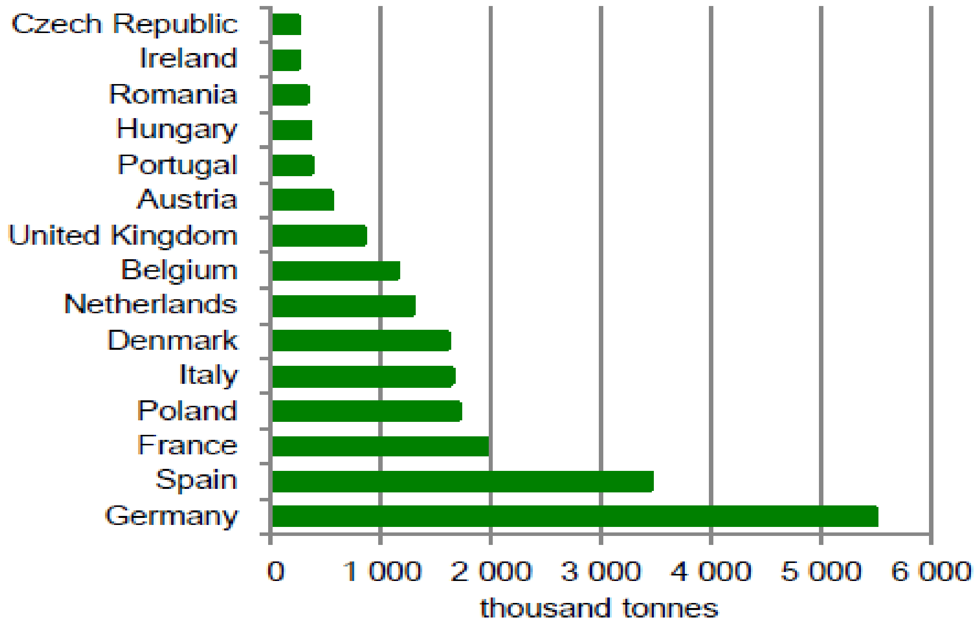


Figure 1 Pig meat production for EU countries (thousands of tonnes) in 2013

(Source: DEFRA, 2013b)

14. Average mortality levels of the UK pig industry (both indoor and outdoor units) are 4.5% for sows (EU average 5.7%); pre-weaning mortality 12.7% (EU average 12.7%); rearing mortality 2.5% (EU average 2.7%) and feeding mortality 2.5% (EU average 2.6%) (BPEX, 2014). This equates to approximately 5,308 tonnes of pig carcases alone (sows 1,917 tonnes; gilts 356 tonnes; pre-weaning 767 tonnes; weaned piglets 378 tonnes and finishing pigs 1890 tonnes) in the UK per annum (DEFRA, 2013b and BPEX, 2014), in addition to porcine slaughterhouse ABP material. These 5,308 tonnes of pig carcases equated to approximately 4% of the 140,000 tonnes of fallen stock per annum (2011-2013) (Pers. Comm. Mr Woodgate, Chief Executive of FABRA).

### 3.1 The UK perspective

15. Livestock farmers within the UK can arrange for the collection of fallen stock directly with collection companies or they can join the National Fallen Stock Company

(NFSCo) and arrange the collection of fallen stock via NFSCo registered collection companies.

16. NFSCo was established in 2004 as a not for profit community interest company to aid farmers with the disposal of their fallen stock. Originally, NFSCo was financed by the government to provide its members with a 50% subsidy for the collection of fallen stock. At this time, farmers had to join the scheme (one-off fee) with the level of subsidy gradually reduced to 0% in 2008 (Pers. Comm. R Bansback, taken from a report made to NFSCo in 2008). After 2008, farmers could join the scheme for free. The aim of NFSCo is to maintain competition between local collection companies, provide farmers with a single monthly direct-debt payment for all fallen stock collections and an annual compliance statement to aid traceability for farm assurance schemes. Traceability of carcase movements and disposal method used is required in Commission Regulation (EC) 142/2011. For collectors, the benefits of joining NFSCo include the scheme organising the collection of payments from farms with collectors paid within four weeks of invoicing, increased cash flow security and a dispute resolution service with farmers (NFSCo, 2014). Therefore, some NFSCo register collectors will not collect fallen stock from non-NFSCo registered farms.

### 3.1.1 On-farm storage methods of fallen stock

17. When an animal dies on-farm, farmers have to remove the carcase from the premises and send it for further processing without undue delay. A specific timescale of undue delay is not defined within the Commission Regulation (EC) 1774/2002 as the timescale can depend on several factors, for example availability of a collection company, storage method used on-farm prior to further processing and the accessibility of the farm (DARDNI, not dated). Farmers can deliver fallen stock to intermediate collection centres (knackers' yards, hunt kennels, maggot farms, zoos, veterinary research centres and university research centres) in leak-proof containers/vehicles or arrange for collection with an approved collection company.

18. If fallen stock is to be collected from the farm, carcases must be stored in leak-proof, vented containers with lids, in an area which other livestock and wildlife do not have access to (Gov.UK, 2013a). However is it known that fallen stock may be stored and delivered to collectors in containers which are broken/cracked that allow carcase fluid to be lost from the container, reducing the cost of collection as cost is based upon weight (Anonymous, 2012). This demonstrates a lack of understanding by the farmer as to the potential biosecurity and disease transmission issues which may be occurring on-farm and between farms by using unfit containers. There are a range of storage containers available to purchase or farmers can make their own. It is advised that containers should be easy to wash and disinfect and the movement of people, equipment and vehicles should be kept to a minimum (Gov.UK, 2013b). If fallen stock is stored within a chiller or freezer, collection can be delayed as the carcase

will not deteriorate as quickly (DARDNI, not dated). If a farmer suspects the animal has died of a notifiable disease or has died suddenly, they must notify the local Animal Health and Veterinary Laboratories Agency immediately (Gov.UK, 2013b). Fallen cattle over 48 months of age or over 24 months of age which were born outside of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Slovenia, Spain, Sweden and the UK have to be tested for Bovine Spongiform Encephalopathy (a form of TSE disease) by an approved collector within 24 hours of death (Gov.UK, 2013a).

19. Recently the European Food Safety Authority examined a research proposal to allow on-farm composting of pig placentas and fallen pigs. Although the proposal was rejected due to lack of scientific knowledge, the general principle was accepted prior to more rigorous testing. If this method is approved, it would allow on-farm in-vessel composting of fallen pigs, providing that the mature compost at the end of the process is sent for rendering by authorised plants (EFSA, 2012). Rendering would be required at the end of the process to remove any possible hazards within the material, as the composting conditions are not sufficient to destroy the relevant biological, chemical and physical hazards which may be present (EFSA, 2012).

### 3.1.2 Collection methods of fallen stock

20. If on-farm collection is used, fallen stock could be collected by an intermediate collection centre, or directly by the renderers or off-site incinerator companies. Collection companies use a range of different equipment to collect carcases depending on how these carcases are stored on-farm. Types of collection vehicles range from trailers, trailers with a wench for moving cattle and individual wheelie bin-lift vehicles (for the collection of smaller quantities of fallen stock) to bulk tip trucks, tankers and refrigerated vehicles for larger quantities of fallen stock on-farm or from intermediate collection centres (Saria, 2014).

### 3.1.3 Disposal methods of fallen stock

21. Farmers have several different disposal options available for fallen stock. Farmers can dispose of their fallen stock via on-farm incineration; have it collected by intermediate collection centres, renderers or incinerators from their premises; or deliver fallen stock to an intermediate collection centre. All fallen stock not disposed of via on-farm incineration, are disposed of via off-site incineration or rendering.

22. On-farm incineration is typically conducted in low-capacity incinerations (<50kg per hour) which have to be located away from livestock; are contained within a perimeter fence; have a well-drained hard standing; have separate equipment; are easy to clean and disinfect (including equipment and vehicles) and prevent pests from

entering the area (Commission Regulation (EC) 142/2011). Incinerators can be shared between groups of farmers or a mobile incinerator can be used, however thorough cleaning and disinfection is required of equipment between farms to reduce disease transmission (DEFRA, 2008). In practice, shared or mobile incinerators are not used though, as the biosecurity risk is too high. Only whole carcases can be incinerated to reduce disease spread via the loss of bodily fluids. The ash produced from combustion must be disposed of in an approved landfill. Low-capacity incinerators are also used by knackers' yards and hunt kennels. From the questionnaire of pig farmers conducted as part of this report (Appendix 2), the survey found that on-farm incinerators are not commonly used on commercial farrow-to-finish pig farms, due to increased legislation surrounding their use. On-farm incinerators are more commonly used on large pig farms, breeding nucleuses or farmers concerned with the biosecurity risks associated with collectors retrieving fallen stock use on-farm incineration (see Appendix 2).

23. Alternatively, carcases can either be collected by or delivered to intermediate collection centres, with hunt kennels and knackers' yards licensed to destroy injured and diseased animals on-farm. Intermediate collection centres can either store these carcases prior to further processing (high-capacity off-site incineration or rendering); remove the hides for tanning and/or use the carcases to feed animals not intended for human consumption. Carcases can be fed to dogs within hunt kennels; cats and dogs within shelters; fur animals; zoo animals and maggot and worms farms used for fishing. Any parts of the carcase not eaten have to be sent for further processing (rendering or off-site incineration) (Commission Regulation (EC) 142/2011).

24. Further processing includes rendering or off-site incineration in high-capacity incinerators (>50kg per hour). Upon arrival at the renderers the ABP (including whole carcases) are minced to reduce the size of the material to <50mm. Rendering of ABP categories one and two are usually undertaken together, with the resulting products (meat and bone meal (MBM) and rendered fat (tallow)) classified as category one. For category one material, the ABP is then processed under atmospheric conditions (atmospheric pressure and heated to the required temperature and durations dependent of which method is used (conditions specified in Commission Regulation (EC) 142/2011)). There is no requirement for category one material to be pressure processed (method one) in the UK, if the resultant MBM and rendered fats are combusted as renewable fuels. Category one MBM can be used as a co-fire product for combustion in dedicated energy recovery units or as a fuel in cement manufacture. The rendered fat can be used as a renewable fuel in steam raising boilers or used as a component in biodiesel. If category two and three ABP were processed in separate dedicated processing plants then the raw material could, in theory, be used for composting, biogas production or as a fertiliser, if a pressure processing step (method one of steam-heating the material to 133°C at 3 bars pressure) is incorporated into the process (Commission Regulation (EC) 142/2011). Category three ABP can be rendered separately (using atmospheric

processing methods) and the protein meal, termed processed animal protein (PAP) can be used as an ingredient in pet food or as a fertiliser. Non-ruminant PAP has recently been approved by the EU for use in aquaculture feeds if rendered separately from ruminant material (Commission Regulation (EC) 56/2013).

25. Due to the delays in collecting carcases on-farm and the bulk storage at the collectors, the carcases would have started to degrade by the final delivery to the renderers. Bacteria within the carcase begin to degrade the protein and fatty acids. Odorous gases are a consequence of this biological decay of the carcase. The rate of degradation will vary depending on the time interval and the season, with increased degradation rates during the warmer months.

26. In an attempt to gain a better insight into the effects of temperature, data were obtained from actual rendering plants where data on product yield and free fatty acid (FFA) content of the rendered fat were collected over a 12 month period (Table 1 and Figure 2). These data points were correlated with the average ambient temperatures of the approximate location of the rendering plant. These data confirmed the general expected trends, for example with increased ambient temperatures the yields of products decreased (Table 1) and that the quality of the rendered fat also reduced (increased FFA) as the temperature increased (Figure 2). However, the data should be treated with caution as there is limited scientific rigour in relation of the data collection. These analyses should be regarded as 'indicative' rather than conclusive in any way. Further work is required to fully understand the effects of storage temperature on carcase quality and the subsequent rendered product yield.

27. For example, if APB is stored >15°C compared to <10°C, there is an average loss of raw material of 5.3% at 15°C (Table 1) (FABRA (Pers. Comm.), 2014). The rate of carcase degradation can also be measured by the production FFA produced during the putrefaction process. Achieving a low FFA concentration within the rendered tallow is important as only tallow containing a low FFA concentration can be used for biodiesel production. Figure 2 demonstrates the effect of carcase storage temperature on the production of FFA. The average FFA concentration increased from a 21.9% for carcases stored at 5°C to 34.2% for carcases stored at 17°C (FABRA (Pers. Comm.), 2014). The data set is based on limited data points, but does display a general theme. Further research is required to quantify the detailed effects of temperature storage of carcases on the production of FFA.

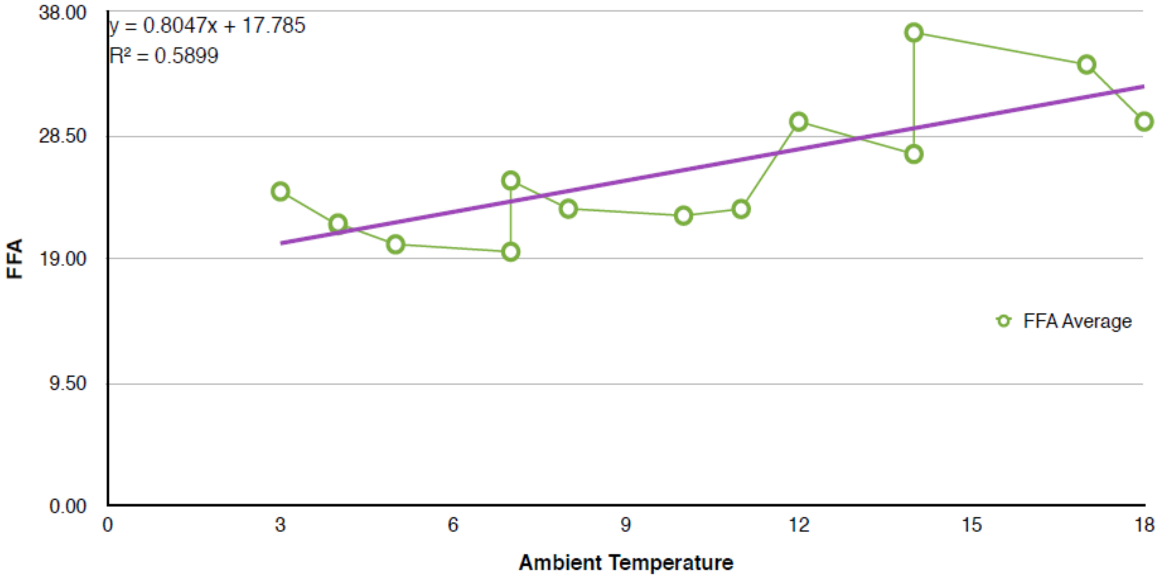


Figure 2 The effect of carcase storage temperature (°C) on the free fatty acid (FFA) concentration (%) (Source: FABRA (Pers. Comm.), 2014)

28. The increased rate of carcase degradation reduces the quality of the carcase for rendering and has a negative impact upon the quality of the rendered products later produced (Sniffer, 2013). The effect that storage temperature has on the raw material yield and quality in relation to the rendered products is demonstrated in Tables 1 and 2.

Table 1 The effect of storage temperature on the rendered product yield (% per tonne animal by-product (ABP)) from the raw carcase material

| | Maximum storage temperature 10°C | Minimum storage temperature 15°C | Difference in raw material yield (%) | Price (£) per 1% change in yield[1] | Total value decrease (£ per tonne ABP) | Total value decrease (% per tonne ABP) |
|---|---|---|---|---|---|---|
| Total rendered product yield (% per tonne ABP) | 37.5 | 32.2 | 5.3 | 1.65 | 8.75 | 5.3 |

N.B [1] Assumes that the average value of rendered tallow is £400 per tonne and the value of meat and bone meal (MBM) is £50 per tonne. Therefore the value of ABP per tonne is £165 (approximately 66% MBM:33% tallow).

Table 2 The effect of storage temperature on the free fatty acid (FFA) concentration of tallow produced from animal by-products (ABP)

| | FFA in oil (%)[1] | Yield of tallow (% per tonne ABP)[2] | Price (£) per 1% change in yield | Total value of FFA (£ per tonne ABP) | Total value decrease (£ per tonne ABP) | Total value decrease (% per tonne ABP) |
|---|---|---|---|---|---|---|
| Maximum storage temperature 10°C | 19.55 | 12.0 | 4.5 | 54.00 | 24.00 | 14.5 |
| Minimum storage temperature 15°C | 36.42 | 12.0 | 2.5 | 30.00 | | |

N.B [1] Assumes that the value of rendered tallow with a low FFA content is £450 per tonne and rendered tallow with a high FFA content is £250 per tonne. [2] This calculation assumes that the yield of tallow is constant irrespective of storage temperature.

29. Cooling the carcases at the time of death would limit bacterial degradation of the carcase until the point of rendering. As shown in the previous data, this bacterial degradation could reduce the rendered product yield by 5.3% if carcases are stored above 15°C. Carcase cooling would provide the renderer with a greater quantity of raw carcase material to process. If a tonne of ABP is worth £165, an increase in the storage temperature of the carcase could reduce the yield by £8.75 per tonne during warmer months (Table 1). Additionally, if carcase degradation is reduced by carcase cooling, subsequently the quality of the carcase would be greater as the FFA concentration would be lower. Rendered tallow with a lower FFA concentration is more suitable for renewable energy production (biodiesel), therefore attracting a higher financial value (£450 per tonne). By not cooling carcases, the FFA concentration of the rendered tallow could increase, reducing the value of that product from £450 per tonne (low FFA) to £250 per tonne (high FFA). Overall this could decrease the value of tallow per tonne by £24 (Table 2). Tallow is an important option for the production of biodiesel. With the demand for renewable fuel sources ever increasing, this could be an important time to exploit this product. Biodiesel produced from tallow could bring in additional revenue to the ABP industry, in addition to reducing the UK's reliance on increasing costly fossil fuels. Additionally, the carbon footprints of the agricultural and rendering industries will also be further reduced by using biodiesel, improving the public perception of the industry.

30. If the changes in yield quantity and quality are combined, storing carcases at ambient temperature during warmer months could decrease the overall value of ABP by £32.75 per tonne or 19.85% compared to a tonne of ABP which had been cooled (<10°C) prior to rendering (FABRA (Pers. Comm.), 2014). Realistically, this decrease in the value of ABP per tonne stored during the warmer months compared to cooled storage could be greater still. The yield of tallow received at the renderers would also decrease along with the increasing FFA concentration of the tallow. Further research is required to determine the effect of carcase storage temperature and duration on the quality and value of rendered products and other potential benefits to the UK rendering industry.

31. Off-site incineration (high-capacity) can treat carcases (>50kg per hour), either incinerating solely ABP or co-incineration of ABP with other materials. Incinerators which treat only ABP are licensed under the Commission Regulation (EC) 142/2011, with co-incineration plants or plants treating more than one tonne per hour licensed under the Waste Incinerator Directive 2000/76 EC. High-capacity incinerators must comply with the same location and operating guidelines enforced for low-capacity incinerators, as previously described. Carcases can be incinerated using a batch or continuous process, being burnt at 850°C until less than 3% total carbon remains within the ash. Incineration produces three products; gas, fly ash and bottom ash (Commission Regulation (EC) 142/2011). When leaving the incinerator, the gas must be passed through an afterburner operated at 850°C for a minimum of 2 seconds or

operated at 1100°C for a minimum of 0.2 seconds. The two ash products can be disposed of via an approved landfill site (Commission Regulation (EC) 142/2011).

32. Commission Regulation (EC) 1069/2009 allows for the development of alternative methods to treat ABP under a scientific licence. Recent research has included the AD (without oxygen) of pig carcases at Harper Adams University (HAU) and the aerobic digestion (with oxygen) of pig and sheep carcases at Bangor University (Bangor University, 2013). At HAU, initial research has shown promising results, with a further two years of work currently being undertaken to develop these results towards an effective on-farm system (Harper Adams University, 2013). At Bangor University, a document was submitted to the European Food Safety Authority in 2013 to outline the scientific case for the incorporation of the aerobic digestion method into European ABP legislation; however the application was not successful (EFSA, 2013).

### 3.2 Denmark and the Netherlands perspective

33. In Denmark, there are approximately 5,000 pig farms, equating to a production of 28 million pigs annually. Up to 90% of the production is exported, either as live piglets (mainly to Germany) or as meat. The meat is slaughtered through the co-operative abattoirs Danish Crown and Tican. Of the meat exported, 70% of this meat is sold to other EU countries, although the meat is transported to over 140 countries around the world. The export of live pigs and meat equates to almost 50% of Danish agricultural exports and more than 5% of Denmark's total exports (DAFC, not dated). Mortality rates in Denmark are 12.8% for sows, 12.8% for piglets and 3.4% for fattening pigs (Zimmermann, 2014). The mortality rate for sows is high due to the high rejection rate of carcases upon slaughter for shoulder sores. Based upon number of total pigs (relative proportions of pigs at each stage of production estimated from this value), the EU mortality rates (see paragraph 14) and the export market of live piglets, Denmark would produce approximately 27,555 tonnes of pig carcase material per annum (in addition to porcine slaughterhouse ABP).

34. In the Netherlands, there are a total of 24.8 million pigs produced annually, with 11.4 million pigs exported per year and 0.9 million pigs imported. Pigs are exported mainly to Germany (63%), with a decreasing export market occurring with Italy, Poland and Spain. Of the total pigs produced, 14.3 million pigs are slaughtered per year which are registered as being produced in the Netherlands (although they may have been exported at some stage in their lives) which equates to 1.3 million tonnes of pig meat produced per year (Productschap Vee en Vlees, 2013 and Homan *et al*., 2014). The mortality rate of fattening pigs in the Netherlands is estimated as 2.4% (Zimmermann, 2014). Based upon number of total pigs (relative proportions of pigs at each stage of production estimated from this value), the EU mortality rates (see paragraph 14) and the export market of live piglets, the Netherlands would produce

approximately 50,099 tonnes of pig carcase material per annum (in addition to porcine slaughterhouse ABP).

35. Disposal of fallen stock within Denmark and the Netherlands is undertaken using the rendering process. In Denmark, rendering was established in 1919 and the rendering of animal carcases and ABP were operated by a company called Daka. Daka was originally owned by the pig-industry cooperative, but they have recently sold 51% of the company to the SARIA Group Ltd. In the Netherlands, rendering was introduced in 1934 and operated by a company called Rendac. Both Daka and Rendac hold licenses for the incineration of carcases, however this is not commonly undertaken. On-farm incineration does not occur (Zimmermann, 2014). In the Netherlands, the government controls the disposal costs charged to farmers by Rendac for the disposal of fallen stock. This ensures that Rendac can dispose of all carcases produced cost effectively, as the government subsidy ended in 2010.

### 3.2.1 On-farm storage methods of fallen stock

36. In the Netherlands and Denmark there are two main methods of storing carcases on-farm prior to disposal; covering with a tarpaulin/carcase cover or cooling, prior to collection. Traditionally, carcases were placed over a concrete grate, covered with tarpaulin or a carcase cover and any seepage from the carcase drained to land or a slurry lagoon. This system allows potentially infected carcase fluid to enter the local environment and come into contact with the local wildlife and pests. This could lead to increased disease transmission and an unhygienic collection, which could allow for further disease transmission. Additionally, carcase covers are also thought to result in increased disease transmission risk as wildlife and vermin can access the carcases (Zimmermann, 2014).

37. If a tarpaulin cover is used, pipes should line the sides of the tarpaulin to prevent it from being blown away (Daka, 2014). The carcase covers should contain approximately 100 holes (diameter of 10mm) distributed uniformly over the cover to allow air movement over the carcase. All carcases should be stored in the shade ensuring the carcase is cool and dry for collection (Daka, 2014). Even under the shade, the temperature beneath the carcases covers would allow for an increased rate of carcase degradation compared to carcase cooling. This would increase the odour emitted from the carcases, attracting flies, other pests and wildlife. These odours could also affect local residents if pig units are located close to urban or suburban areas. Flies entering through the holes of the carcase cover would lay eggs. Once these eggs had hatched, the maggots would degrade the carcase further, reducing both the yield and the quantity of carcase material available for rendering (Zimmermann, 2014).

38. Due to the possible disease transmission risks associated with traditional storage methods and the reduction in the yield and quality of the carcase material, the Danish rendering company Daka introduced carcase cooling to some pig farms in 2008. The aim of cooling the carcases was to obtain a better quality of carcase for rendering which would produce a higher quality of rendered products. Also carcase cooling would allow a more effective collection routine between farms as the frequency of collection could be reduced and less impromptu. It could also improve the image and the environmental impact of the pig industry as the public would not see and smell carcases awaiting collection (Danish Pig Research Centre, 2011).

39. The first method of carcase cooling used in Denmark and the Netherlands is a cooling well. A cooling well is a concrete lined pit dug into the soil with a drain at the base to collect seepage from the carcases (Plate 1). This seepage is collected into a small tank and is later pumped to a connected slurry lagoon or released into the surrounding soil. The airtight well lid can be opened using a hydraulic lift to slide the lid across the top of the well. The well is refrigerated using a refrigerator unit regulated with a thermostat to 5-8°C. In Denmark, cooling facilities are regulated to a maximum temperature of 8°C, whilst in the Netherlands the maximum temperature requirement is 10°C. Mul *et al*., (2002) recommended that carcases should be cooled between -7°C and 5°C to preserve the quality of the carcase prior to rendering. No scientific evidence could be provided as to why these two national pieces of legislation differ, or any evidence on the effect these different storage temperatures have upon the carcase. This is an area requiring further research.

40. Daka initially designed two different sizes of cooling wells. The small cooling well is 2.3m$^2$ and 1.5m deep (approximately 7,900 litres), which contains approximately 3 containers (190 litres) of piglets, 10-15 sows or 20 finishing pigs. The larger cooling well is 3.9m x 2.8m and 1.5m deep (approximately 16,000 litres), which contains approximately 6 containers of piglets (190 litres each), 20 sows or 26 finishing pigs (Zimmermann, 2014). Daka initially wanted to install 1,000 on-farm cooling wells, however only 90 wells have been installed to date. These installations have been mainly on large-integrated farms, with the decreased uptake possibly due to the impact of the recent financial recession. It is estimated that the small cooling well uses 500kWh per year and the large cooling well uses 1,000kWh per year. However Daka have had problems with carcase seepage leaking from the well, due to gaps between the concrete side panels. Cooling wells are located away from or on a different site to the pig unit to reduce possible disease transmission (Zimmermann, 2014).

Plate 1 Carcase cooling well in Denmark (Source: Zimmermann, 2014)

41. The rendering company of the Netherlands, Rendac, later introduced carcase cooling onto farms for similar reasons to Daka. Rendac based their carcase cooling well design upon Daka's design; however they modified the position of the refrigeration unit onto the top of the lid and placed removable containers within the well. In Denmark, collectors found they typically hit the refrigeration unit, so by placing it on top of the lid, this problem was resolved. Also Rendac installed containers within the cooling wells to collect any carcase seepage. This eliminated the leakage problems Denmark had had with their cooling wells (Zimmermann, 2014). The Dutch cooling well is 2.5m x 2m and 1.5m deep (approximately 7,500 litres) and has two carcase containers (950 litres each) (Plate 2), which can store approximately 8 sows or 16 finishing pigs. Initially cooling wells were installed on 13 Dutch farms, with a total of 125 farms now using the system, with a further 3-4 cooling wells sold per week. A Dutch cooling well is estimated to use 800kWh per year (Zimmermann, 2014).

Plate 2 Carcase cooling well in the Netherlands (Source: Zimmermann, 2014)

42. The second method of carcase cooling used in both countries is the cooling container for the containment of piglets. In 1991, Rendac approached the company Coolworks to develop a cooling container for fallen stock. The aim was to improve the quality of carcases for rendering (minimise degradation), to reduce odours, improve company hygiene (reduce disease spread and the presence of vermin) and to improve the public perception of Rendac and the agricultural industry (Coolworks, not dated a). A cooling container is a large, refrigerated container in which smaller, wheelable containers storing the carcases can be placed to cool. These smaller carcase containers can easily be moved into and out of the cooling container for collection and can be located close to pig buildings. They are typically used to store piglets as the size of the container can restrict the storage of larger carcases. On the day of collection, these wheelable carcase containers can be easily moved to the collection site (Zimmermann, 2014). The cooling container can be purchased in various sizes from 240-1,580 litres, holding single or multiple carcase containers of varying sizes (Plate 3).


Plate 3 Carcase cooling containers (various designs)

(Source: Coolworks, not dated b)

43. Cooling containers can be purchased with doors on one side, or with two sets of doors on opposing sides to give a “dirty/clean” container. In a dirty/clean container, carcases are moved into and out of the container on their respective sides only. This allows the container to be placed within the perimeter fence of a pig unit, so the internal containers can be placed close to pig building, but the collection vehicle driver does not have to come onto the unit to collect the containers or the containers do not have to be transported to a separate collection site (Coolworks, not dated b). The cooling container uses a standard three-pin plug socket, with the refrigeration unit using the hermetic system (which does not require refilling) to regulate the temperature between 4-8°C. It is estimated that cooling containers use approximately 400-800kWh per year (Zimmermann, 2014) or £197 of electricity per year (Pers. Comm. Mr Thomasse, Coolworks manufacturer of cooling containers).

44. The popularity of Coolworks cooling containers, marketed as “Euratainers”, has increased dramatically with containers now sold in 13 countries (Belgium, Denmark, Germany, Finland, France, Hungary, Croatia, the Netherlands, Austria, Poland, Spain, Switzerland and Sweden) (Coolworks, not dated c). Euratainers are used by a range of industries to store carcases, ABP and food waste including the agricultural sector, veterinary practices, the public sector, meat processers and catering/retail enterprises (Coolworks, not dated d). A total of 25,000 units have been sold to date. For the agricultural industry, Euratainers are sold to a wide range of farm sizes, with single or multiple containers supplied per farm. Daka initially purchased 3,500 Euratainers to supply to pigs farms in Denmark (largest farm supplied was >3,500 sow unit) (Pers. Comm. Mr Thomasse, Coolworks manufacturer of cooling containers). Daka strongly believes in being proactive to encourage the pig industry to develop solutions for handling fallen stock on-farm; improving on-farm biosecurity,

the quality of the product sent to renderers and the public perception of the farm. Nearly all significant piglet producers in Denmark use carcase cooling containers (Pers. Comm. Daka).

45. Alternatively farmers can freeze carcases on-farm into paper bags, removing them from the freezer on the day of collection (Daka, 2014). The freezer should be emptied within six months after the first carcase has been frozen (Ministry of Food, Agriculture and Fisheries, 2011). Freezing is an uncommon method of storing carcases on-farm in Denmark and the Netherlands (Zimmermann, 2014).

### 3.2.2 Collection methods of fallen stock

46. It is recommended to all farmers that the permanent collection site is located away from live pigs. The collection site should have a permanent access road straight from the main road and a separate access road to the farm for farm staff delivering fallen stock to the collection site. By having two separate access roads to the collection site would prevent possibly contaminated vehicles from crossing the same roads. Also, the collection access road should not cross any internal roads within the farm. This also reduces possible disease transmission around and between the farms (Zimmermann, 2014). This is a concept not so widely known about in the UK, as the location of fallen stock collection sites in the UK tend to be related more to the ease of access than reducing disease transmission. This is a concept that could be embraced by UK pig farms to reduce possible disease transmission within and between farms. As cooling containers are often kept close to pig buildings in Denmark and the Netherlands, these internal containers have to be moved to the collection site on the day of collection. Once emptied, farmers should thoroughly disinfect these containers before they are returned to the cooling containers to reduce disease transmission. The use of separate access roads to the collection site would help to further reduce this transmission risk (Zimmermann, 2014).

47. Carcases stored under a cover should be collected within 24 hours of the animal’s death (Hvolgaard, 2013). In Denmark, a cooling well should be emptied at least every 6 weeks and with cooling containers emptied at least every 2 weeks, from when the first carcase enters the well/container. In the Netherlands, cooling wells should be emptied at least every 2 weeks and cooling containers should be emptied at least once a week, from then the first carcase is placed in the well/container (Zimmermann, 2014). However the manufacturers of cooling containers stated the container could be emptied once every two weeks (Pers. Comm. Mr Thomasse, Coolworks manufacturer of cooling containers). No evidence is currently available as to the effect of storage duration on carcase degradation and this is an area requiring further research.

48. A hydraulic crane mounted onto a truck collects individual carcases, either from underneath a tarpaulin/carcase cover or from a cooling well (Plate 4). Similar equipment is used to collect containers within cooling wells, with the container tilted to allow the carcases to be emptied into the truck (Plate 5). Both methods decrease the requirement for drivers to touch the carcase/containers and possibly transmit disease.

Plate 4 Collection of a pig carcase stored under a cover
(Source: Zimmermann, 2014)

Plate 5 Collection of containers from a cooling well in the Netherlands
(Source: Coolworks, not dated e)

49. To minimise disease transmission, the drivers of the collection trucks should wear disposable gloves; stay as far as possible from the crane when moving carcases; only collect from scheduled locations; collect carcases with notifiable disease at the end of the day and clean/disinfect their footwear and truck tyres prior to leaving a farm. Regular cleaning and disinfection of the equipment used for collecting and

storing fallen stock and is encouraged to farmers, although not regulated (Zimmermann, 2014).

### 3.2.3 Disposal methods of fallen stock

50. All carcases from Denmark and the Netherlands are rendered by either Daka or Rendac respectively. To improve the quality of the rendered products, carcase cooling was implemented by the renderers. To encourage farmers to invest in the technology, Daka initially offered pig farmers a 30% discount on their disposal costs for all carcases cooled prior to collection. This 30% discount was justified by Daka as a greater yield of carcase material was delivered, the rendered tallow produced had a lower FFA content for biodiesel production (hence higher value) and less frequent collections were required as carcases could be stored for a longer duration (as demonstrated in Tables 1 and 2 and paragraph number 30).

51. Initially, Daka wanted to install cooling wells on 1,000 farms, however only 90 farms installed wells. This could have been due to the recent financial recession (Zimmermann, 2014), although looking at the cost benefit analyses the system, they may have been too expensive. After the poor uptake of cooling wells, Daka purchased 3,500 cooling containers to supply to pig farmers as an alternative method of cooling carcases, which may have reduced the possible uptake of cooling wells further (Pers. Comm. Mr Thomasse, Coolworks manufacturer of cooling containers). The cooling discount is only available for cooling wells, not cooling containers. Due to the poor uptake of cooling wells, Daka later reduced the discount of collection from 30% to 15%, as the improvement in yield of the rendered products were not being realised due to the poor uptake. This 15% discount still provides an incentive for farmers to cool their carcases and helps reduce the transport costs to Daka.

52. Rendac introduced carcase cooling to improve public perceptions of farmers with the general public (removing carcases from sight) and to allow more hygienic collection methods. When Rendac introduced cooling wells in the Netherlands in 2008, uptake of the system was far greater than in Denmark. To date, 125 cooling wells have been installed (Zimmermann, 2014), despite Rendac not offering a discount for the collection of cooled carcases. Pig farmers in the Netherlands appear to want to invest in this concept despite there being no financial incentive and that the benefits of carcase cooling outweigh the initial costs. The popularity of cooling containers appears to have increased dramatically, with pig farms choosing to install cooling containers instead of cooling wells. Currently, 25,000 units have been sold to date (not just for agriculture) (Pers. Comm. Mr Thomasse, Coolworks manufacturer of cooling containers). Neither Daka nor Rendac provide a collection discount for carcases cooled using cooling containers. The full collection cost is still charged to

farmers who continue to use traditional carcase storage methods in Denmark (Zimmermann, 2014).

## 4.0 Financial assessment of using carcase cooling in Denmark and the Netherlands

53. A true financial assessment of the advantages and disadvantages of using carcase cooling in Denmark and the Netherlands is hard to conduct, due to the many non-quantifiable benefits carcase cooling may have. An example of the non-quantifiable benefits include improved biosecurity; reduced disease transmission; increased farmers' knowledge and understanding of correct storage and disposal methods to increase compliance to legislation; a greater understanding of disease prevention would help to decrease veterinary costs and the costs associated with the loss of the animal. However, cost benefit analyses have been conducted of the known, quantifiable for cooling systems present in Denmark and the Netherlands (excluding value added tax (VAT)) (see Appendix 1).

### 4.1 Installation and management of carcase cooling facilities

54. Currently installation of carcase cooling wells and containers is conducted by either Daka in Denmark or Rendac in the Netherlands using a supplier, Coolworks. The cost of a cooling well includes the concrete well, lid and refrigeration equipment. In addition to the installation cost of the cooling well, the farmer has to pay for the hole to be dug, any surrounding concrete and the disinfection equipment required. The cooling well has an expected lifespan of 15 years and the refrigeration equipment has an expected lifespan of approximately 5 years. The cooling well will use less electricity for cooling during the cooler winter months, although some electricity will still be required. It is not known if any further management costs are associated with the cooling well, although an annual inspection is recommended.

55. The lifespan of a cooling container is not known, as the original cooling containers installed in 1992 by Coolworks are still operational today, however the refrigeration unit is thought to have a lifespan of 7-12 years. Although an annual service is not required, cleaning the condenser on the top of the cooler is required once a year (Pers. Comm. Mr Thomasse, Coolworks manufacturer of cooling containers).

### 4.2 Cost analysis benefit

56. Zimmermann (2014) outlines the installation and operational costs of carcase cooling wells for pig farmers in Denmark and the Netherlands (see Appendix 1). A small cooling well costs approximately £4,953 and a large cooling well costs approximately

£6,605. The estimated installation costs of a cooling well (irrespective of size) in Denmark is approximately £2,200. The small cooling well uses approximately £88 of electricity per year, with the large cooling well using £132 of electricity per year. However these cost benefits do not include the annual maintenance cost, the cost of digging the hole, the concrete walls required, disinfection equipment required or the annual service cost. Additionally, as the lifespan of the refrigeration equipment is approximately 5 years, the cost of one or two new refrigeration units should be included in the cost benefits. A new refrigeration unit ranges from £500 to £1,000 each (Zimmermann, 2014). The farmer is required to provide sufficient staff to aid with the installation of the cooling wells and apply for any environmental and building permits required (with the aid of Daka) (Houston, 2012). Farmers can store carcases within cooling wells for up to 6 weeks (from when the first carcase is added), which would drastically reduce the number of collections by renderers and increase the biosecurity of the unit.

57. In relation to cooling containers, there are different designs and sizes (from 190l to 1,440l) of cooling containers depending on each farm's requirements. Zimmermann (2014) stated the price of a cooling container to be £3,199 (Appendix 1). In Denmark and the Netherlands, cooling containers are only used for the storage of piglets and are not eligible for the cooling carcase discount of 15% by Daka, although the reason for this is not given. Providing there is sufficient storage space, it is not known why cooling containers could not be used for the storage of larger pig carcases (Zimmermann, 2014). The internal storage containers range from small wheelie bins (240l approximately £40 each), to larger wheelie bins (750l at £150 each) and specialist containers with a cover of 700l at £1,000 each or 950l at £1,100 each (see Plates 3 and 5) (Pers. Comm. Mr Thomasse, Coolworks manufacturer of cooling containers). There are cooling containers now manufactured which contain two 750l internal containers capable of holding 13 sows or 25 finishing pigs. These larger cooling containers could be used for the storage of piglets and larger carcases on-farm (Zimmermann, 2014). The benefit of using the specialist internal containers is that they are wheelable and have a large grab handle to allow a grab collection vehicle to pick-up one single container instead of a wheelie bin vehicle having to collect multiple containers. The choice and number of containers required would depend on the size of the cooling container, the requirement of the farm and the type of collection vehicle available. Zimmerman (2014) estimated that cooling containers use approximately £200 of electricity per year and have no maintenance costs associated with the unit. The lifespan of a cooling container is not known as the original containers produced in the early 1990's are still in use on-farms. The refrigeration unit has an expected lifespan of 7 to 12 years and can be replaced at a price of £990 each. Farmers can store carcases within cooling containers for two weeks after the first carcase is added. The effect on carcase quality of storing carcases within these containers for a longer duration is not known; however the containers are limited to their smaller size compared to other cooling methods.

**5.0 Feasibility assessment of utilising carcase cooling in the UK**

5.1 Practical implications of carcase cooling

58. There are various different methods currently available for cooling carcases in Europe; however the cooling methods are not limited to these designs. A different carcase cooling method is currently being used at HAU for the last 2-3 years. HAU has recently changed their fallen stock storage facilities from using sealed containers kept within a locked shed, to using a refrigerated container box which had previously been mounted onto a lorry. The aim of the refrigeration box was to store carcases at a constant temperature <10°C. By chilling the fallen stock, it was noted that there was a reduction in odour emissions, a reduction in flies, improved biosecurity and improved public perception, as the refrigerated container box is not very conspicuous compared to the previous ambient storage shed. The refrigerated container box (6.8m x 2.3 m and 2.3m high, approximately 36,000 litres) (Plate 6) accommodates numerous wheelable storage containers (various sizes) of fallen stock which can be easily wheeled into and out of the box for collection. A ramp was constructed into the container box for this purpose and a lock installed on the front doors. As HAU has a mixed farming enterprise, the carcase storage facilities had to be able to take a range of different sizes of animal carcases. The installation of a new three-phase electricity supply was required (Plate 7), however the concrete hard standing was already available. Fallen stock was collected weekly and weighed into the collection vehicle.

Plate 6 Refrigerated container box at Harper Adams University for the storage of fallen stock prior to collection (Source: Authors own)

Plate 7 Electrical connection for the refrigerated container box at Harper Adams University (Source: Authors own)

59. Depending on the individual farms' current carcase storage arrangements, little change to infrastructure may be required to enable the installation of this on-farm cooling method. For example a hard standing and containers may already be available for existing carcase storage, along with cleaning and disinfection equipment. An electricity supply would be required for carcase cooling and may have to be installed. Fallen stock collectors would have to be able to weigh and lift large containers (up to 950l), although many collectors already have the appropriate vehicles for this. The size of the refrigerated container box currently used is too large for the weekly mortality rate and a smaller container could be installed. This would help to reduce the electricity costs and improve the efficiency of the system.

60. There are further differences between the UK, Denmark and the Netherlands which should be considered when comparing cooling systems. The cost of carcase collection varies dramatically between the three countries (Table 3). This is due to the generally higher costs of living in Denmark compared to the Netherlands, which is reflected in the lower cost for transporting and processing the carcases. The variation in collection costs in the UK may be due to the collection companies' awareness and compliance to on-farm biosecurity protocols when collecting fallen stock.

Table 3 The average collection costs (£) of dead pigs per container volume and per tonne in the UK, Denmark and the Netherlands

| | UK | | Continental Europe | |
|---|---|---|---|---|
| Category of fallen stock | East Anglia Average (£) | East Yorkshire Average (£) | Denmark Average (£) | The Netherlands Average (£) |
| Container of pigs/piglets (per tonne) | 170 ± 85 | 210 ± 60 | 107 | 36.5 ± 15 |

(Source: Personal communication from the NFSCo and Zimmermann, 2014)

61. The UK has the highest collection costs per volume, followed by Denmark and lastly the Netherlands, with significantly cheaper collection costs. The higher cost in Denmark compared to the Netherlands may have been a reason why the investment in carcase cooling was slower in Denmark than the Netherlands. These differences have a large impact upon the cost analysis benefit for the UK. Collection costs within the UK vary greatly depending on collector prices and geographical location. East Anglia and East Yorkshire are large pig farming areas, with collection costs generally higher in East Yorkshire compared to East Anglia.

62. If carcase cooling was implemented in the UK, the frequency of collection may decrease. This would reduce transportation costs and may then reduce the cost of collection to the pig producer. In the Netherlands, using carcase cooling reduces the number of collections required, saving the pig producer a minimum of €2.35 per collection as a call-out charge (Zimmermann, 2014). As collection vehicle drivers are already employed, changes to collection routes may be required to ensure that sufficient work was still available for these drivers if the frequency of collection was decreased. On the continent, having a lower frequency of collection has allowed fixed collection routes to be developed. This negates random, *ad hoc* collection routes which could vary daily depending on which farms requires the daily collection service, which does not utilise staff efficiently. By having a more fixed collection route, money could be saved by operating more efficient collections routes and use less fuel. A more efficient collection route would also further decrease the greenhouse gas emissions of the rendering industry. A UK rendering company stated that changing from weekly collection to fortnightly collection would not benefit their company by reducing the transportation costs, if the collection was reduced to a monthly collection, this would be financially beneficial to them (FABRA (Pers. Comm.), 2014). In Denmark, collection of cooled carcases is undertaken once every 6 weeks, but in the Netherlands collection is limited to fortnightly. There is no justification which can be found to identify why there is a difference in the legislation between these two countries and the effect this longer storage period has on the carcase is not known. Further research would be required to determine the optimal storage period and conditions.

63. Initially Daka offered a 30% discount on the collection of cooled carcases. This was due to the saving on transport costs and the increased value that could be obtained from the rendered products if the carcases had been cooled on-farm. This reduction is confirmed by the data illustrated in Tables 1 and 2 of the decreased value of rendered products which could be obtained in the UK, if carcases were not cooled prior to rendering compared to cooled carcases. This 20% decrease in the rendered product value, in addition to the reduction in transportation costs by having less frequent collections, substantiates a 30% reduction in collection costs.

64. Due to the lower uptake of cooling wells in Denmark at the time, Daka has reduced the collection discount from 30% to 15%. Uptake was low due to the high cost of the cooling well, long payback period and the economic crisis at the time. Daka reduced the discount as they were not seeing the improvements in rendered product value as there were not sufficient large carcases being cooled to achieve this. However, Daka is still supporting carcase cooling, with the investment in 3,500 cooling containers supplied to pig farms for the cooling of piglets and not large carcases (Pers. Comm. Mr Thomasse, Coolworks manufacturer of cooling containers). Although Daka do not offer the cooling discount for cooling containers, this technology is still actively encouraged and participated in. These cooling containers offer no financial benefit to the farmer for their use (no cooling discount applicable) and have an added electrical cost, compared to using more traditional storage methods (tarpaulin). However the farmers do recognise the benefits of this system, due to the improvements in biosecurity, reduced disease spread and the ease of use.

### 5.2 Cost analysis benefits

65. Cost benefit analyses for carcase cooling were based upon an average UK pig farm (401 sows farrow to finish) and have been conducted using the cooling wells (two different sizes); the cooling containers brought directly from Denmark (two different sizes with two different internal container options) and the refrigerated container box system from HAU. The benefit of having the choice of two different internal collection containers is that the type of internal collection container can be matched to the collection companies' collection vehicle. By matching the internal containers to the collection vehicle this would reduce any possible cost to the renderer of having to change collection vehicle type to collect cooled carcases. The cost benefit analyses were based on the size of the average UK pig unit and the average mortality level of each age group (sows 4.5%, pre-weaned piglet 13.0%, weaned piglets 4.0% and finishers 3.1%) (BPEX, 2014). Data for these analyses have been collected directly from companies, the Zimmermann report and from data collected on-site at HAU. All prices are exclusive of VAT. Similar to the previous cost benefit analyses, these calculations do not take into consideration any benefits which are hard to attach a cost to, for example improvements in biosecurity from using cooling methods.

66. The different costs associated with each cooling method can be found in Table 4, with the overall cost benefit analyses from this data presented in Table 5. The best and worst case scenarios have been presented for each method of carcase cooling. The lifespan and price of replacing a refrigeration unit are variable. Therefore, the best case scenario reflects only having to purchase one new refrigeration unit during the lifespan of the cooling equipment, based upon the lowest price of a new unit. The worst case scenario is based upon having to buy two new refrigeration units, based upon the most expensive price of a new unit during the expected lifespan of the system. Some of the prices in Table 4 could be variable, for example the price of haulage would depend on your location in the UK (cost based upon haulage of 200 miles) and the installation costs may change due to current infrastructure available on the intended farm.

Table 4 The costs associated with each carcase cooling system (£)

| Cooling system | Purchase cost (£) | Haulage (£) | Total installation costs (£) | Annual electrical use (£) | Maintenance (£) | Replacement refrigeration unit (£) - 1 or 2 required | Total cost (plus refrigeration unit(s)) |
|---|---|---|---|---|---|---|---|
| Small cooling well | 4,953 | 495 | 2,202 | 88 | N/A | 500 or 1,000 | 7,736 |
| Large cooling well | 6,605 | 495 | 2,202 | 132 | N/A | 500 or 1,000 | 9,434 |
| Cooling container cel 3 (wheelie bins) | 3,071 | 495 | 400 | 198 | N/A | 990 or 1,980 | 4,164 |
| Cooling container cel 3 (770l bins) | 3,071 | 495 | 2,100 | 198 | N/A | 990 or 1,980 | 5,864 |
| Cooling container cel 6 (wheelie bins) | 2,853 | 495 | 400 | 198 | N/A | 990 or 1,980 | 3,946 |
| Cooling container cel 6 (770l bins) | 2,853 | 495 | 2,100 | 198 | N/A | 990 or 1,980 | 5,646 |
| HAU refrigerated container box | 500 | 833 | 500 | 500 | 292 | N/A | 2,625 |

Table 5 The payback periods of each carcase cooling system (years)

| | Payback period (years) | | | |
|---|---|---|---|---|
| | Best case scenario[1] | | Worst case scenario[1] | |
| Cooling system | At 15% rendering discount | At 30% rendering discount | At 15% rendering discount | At 30% rendering discount |
| Small cooling well | 14.5 | 6.7 | 17.2 | 8.0 |
| Large cooling well | 18.9 | 8.4 | 21.8 | 9.7 |
| Cooling container cel 3 (wheelie bins) | 11.0 | 4.5 | 12.8 | 5.2 |
| Cooling container cel 3 (770l bins) | 14.5 | 6.0 | 16.5 | 6.8 |
| Cooling container cel 6 (wheelie bins) | 10.3 | 4.2 | 12.3 | 5.0 |
| Cooling container cel 6 (770l bins) | 14.0 | 5.8 | 16.0 | 6.6 |
| HAU refrigeration container box | N/A | 3.6 | - | - |

[1] Best case scenario reflects purchasing one new refrigeration unit at the lowest price, whilst the worst case scenario reflects purchasing two new refrigeration units at the highest price

67. Cooling wells are the most expensive cooling system investigated in this report, with the longest payback periods. Cooling wells have an estimated lifespan of 15 years, with the refrigeration units lasting approximately 5 years. In the best case scenario with a collection discount of 15%, the small cooling well should break even at the end of its lifespan, but with a collection discount of 30% a net benefit would be achieved after 6.7 years of operation. In the worst case scenario, a 15% collection discount will not provide a cost benefit to farmers before the end of its lifespan, although with a 30% collection discount, the payback period is reduced to 8 years. For the large cooling well, at a collection discount of 15%, the cooling well will not have been fully paid prior to the lifespan of the system expiring in other scenarios. At a 30% collection discount, the large cooling well could be paid off within 8.4 to 9.7 years (depending on the scenario) and then provide a net benefit to the farmer. However both sizes of cooling wells are the most expensive cooling system to purchase of those considered for this report and have the highest installation costs. In addition to the cost benefit, there are further costs associated with digging the hole, providing the concrete walls and the staff to help with the installation. Thomasse (2014) stated that they are no longer manufacturing cooling wells as they were too expensive for Danish farmers (Pers. Comm. Mr Thomasse, Coolworks manufacturer of cooling containers).

68. The lifespan of a cooling container is not known, as original units made in the early 1990's are still being used. This report considers two of the many different sizes of cooling container which are sold. The two containers are marketed as the "cel 3" and "cel 6" models. The "cel 3" and "cel 6" are the largest containers and can be purchased with the "clean/dirty" system (at no extra cost) to reduce contact between collectors and farm staff, when the container is placed within the perimeter fence of the unit. Each unit can be fitted with six standard 240l wheelie bins or with two specially manufactured 770l bins with a lid and a handle. These bins are designed for easy collection, as a collection vehicle with a hydraulic lift can lift the bin and tip it into the collection vehicle. The refrigeration units are thought to last 7 to 12 years. Payback periods are shorter for cooling containers compared to cooling wells, with shorter payback periods occurring for containers which use the 240l bins compared to 770l bins. Depending on the internal bin choice, at 15% collection discount, the payback periods vary from 10.3 years to 14.5 years (best case scenario) to 12.3 years to 16.5 years (worst case scenario). At a 30% collection discount, the payback periods are dramatically reduced to 4.2 years to 6.0 (best case scenario) to 5.0 years to 6.8 years (worst case scenario). After these time periods, farmers will then receive a net benefit from the system and if the system lasts more than 20/30 years, the only possible on-going cost incurred would be another refrigeration unit.

69. The lifespan of the refrigerated cooling box is unknown as the box was bought second-hand, but may vary from a few years to over ten years. Although the refrigerated cooling box was not very expensive to buy, the on-going electrical and maintenance costs are high. At a 15% collection discount, the on-going costs are still

greater than the saving on collection, however if the collection discount is increased to 20%, then the payback period is estimated to be 24.4 years. However at a collection discount of 30%, the payback period is reduced to 3.6 years. This demonstrates how slight changes in the economics of such a cheap system can dramatically affect the payback periods. Electrical use could be reduced for this method by using a smaller, more appropriately sized container which would further decrease the payback periods. Overall the level of investment required by the farmer to cool carcases is far lower with this system and if the system is still operational after 3.6 years, it will provide a net benefit.

70. Based on the average mortality rate of each age group for the UK in 2013 for an average sized farrow to finish unit, the small carcase well would require emptying weekly and the large cooling well would require emptying every 10 days. The cooling container “cel 3” would require emptying once every 2.5 weeks and for “cel 6” once every 3 weeks. However, the refrigerated container box would be large enough to store months of carcases before reaching capacity. This is presuming all mortality and placentas are stored in the cooling system and disposed of together. Pig units could have multiple cooling units to reduce the frequency of collection.

71. In addition to the pig industry, this cooling method could benefit other ABP sectors that produce small and medium sized carcases. For example, cooling methods could be used within the sheep industry, for the storage of calves and foal carcases within the horse racing industry and by veterinary practices. Larger carcases are typically collected very quickly from farms as there is value in the hide if the hide is removed before it beings to degrade. Once the hide has been removed, the carcase can be processed directly by the renderers or stored at the immediate collection centre prior to further processing. Intermediate collection centres could also use large cooling containers, for example a container similar to the HAU container, for the storage of all carcases collected. These larger cooling containers could also take cattle and horse carcases. Future research could examine the practical application of current cooling systems on a range of different livestock enterprises, collecting operational data, prior to further development.

72. In Denmark and the Netherlands, there are no intermediate collection centres, knackers’ yards and hunt kennels. In the UK, if carcases were cooled on-farm and/or at an intermediate collection centre once they were collected without undue delay, the total volume of cooled carcases received by the renderers would be further increased, compared to pig carcases alone. By adopting this more integrated approach between the animal producers, the intermediate collection centres and the renderers; carcases could be cooled throughout the whole process, retaining the potential value to the renderer of improved rendered products. This would make carcase cooling a more attractive offer to the rendering industry as the total volume of cooled carcases would out-proportion non-cooled carcases. This would dramatically increase the value of the rendered products and may persuade

renderers to offer a collection discount to cooled carcases of multiple species. By initiating this concept with the pig industry first, this would allow data to be collected and analysed which could then be applied to the ABP sector as a whole. The increased efficiencies of carcase cooling producing a reduced collection service (due to longer storage durations) and the implication this has to the renderers could also be investigated.

73. From a cost benefit analysis and feasibility of use view point, the current cooling containers available on the market appear to be worthwhile investigating further. The cooling container appears to be a very attractive method for cooling carcases on-farm, with relatively short payback periods in both the best and worst case scenarios. However there is further development work which would be required based on this design idea for future cooling systems. The cooling containers have a considerable volume of air space above the container, requiring a greater cooling input every time the cooling container is opened and warm air is exchanged with cool air. This increases the inefficiency of the system as energy is wasted cooling the new air space. Future research could develop a sustainable, cost-effective on-farm cooling system for use by all sectors of the UK livestock industry.

74. Additionally, the current cooling container design works by cooling the air within the whole container. As the internal containers have lids, heat is lost slowly through the internal containers. This rate of cooling could be increased by the direct cooling of the internal containers and this should be considered in any future container design. If the cooling of the container is insufficient or requires too long a time period, the benefit in carcase quality will be lost. Similarly designing a new cooling container which has internal partitioned sections would be of benefit. This would allow longer storage durations to be achieved with increased system efficiency, as the partitioned sections could be filled one at a time. Once a partition is filled, it could be sealed remaining cold. Therefore the whole container would not need to be opened for each new carcase addition as the current design requires.

75. Future research work could also quantify the effect of seasonality upon the operation conditions of the cooling system. This would examine the annual electrical use required to cool carcases and if cooling is required for 12 months of the year. Also, cooling containers could be developed for the cooling of larger carcases (currently not undertaken in the large cooling containers).

### 5.3 Environmental implications

76. The costs associated with environmental impacts of different storage and processing methods can be hard to quantify and are outside of the scope of this report. Odour emissions (either on-farm, during transport of at processing) can create problems with the local community and damage the public perception of the whole ABP sector.

For processing plants, there are rules regarding the acceptable levels of odour emissions produced, which are measured at the plant's boundary. Different acceptable odour levels are enforced by individual councils, for example, rendering plants within Bromsgrove District Council must keep odour emissions <2,200 $OU_{E/m}{}^3$ (European odour unit per cubic metre ) using a thermal oxidiser and 1,000 $OU_{E/m}{}^3$ using a carbon filter system (Bromsgrove District Council, 2010). Determination of odour concentrations ($OU_E/m^3$) is based upon a correlation between a physiological response when an odour is detected by the nose and the exposure to a particular sample at a specific concentration. If ABP and carcases cannot be processed quickly upon arrival, refrigeration is a suggested method to store the material to prevent degradation and the emission of odours (DEFRA, 2008; EPA, 2008 and Sniffer, 2013). Odour emissions can be further reduced by storing ABP in sealed containers within a refrigerator. For example blood stored in a sealed container at 4°C produces an odour emission level of 1,000 $OU_{E/m}{}^3$ within the headspace of the container, compared to blood stored at 30°C which has an odour emission level of 60,000 $OU_{E/m}{}^3$ (Sniffer, 2013). Rendering plants have been prosecuted for high levels of odour emissions. For example John Knight Ltd in London received three different fines for high odour emissions totalling £205,000, with an additional £151,650 in court costs between 2009 to 2012 (Newham London, 2012). Similarly residents in Penrith have taken civil action against a local rendering company when discussions between the renderer, council and the local community did not resolve the odour emission problem (Penrith Pong, not dated). Odour emissions and their effect on the local environment should be looked at more closely not only for large processing plants but for the whole supply chain. This is particularly apparent during warmer months when more people are outside and windows are opened. The likelihood of people coming into contact with these odours is increased and complaints are becoming more frequent.

77. Public perception should be considered by farmers within all livestock sectors. Storing carcases in easy access of the general public has previously lead to unwanted images appearing in the media by animal rights activists. Carcases should be stored in a secure location which the general public cannot access. This is one of the benefits of using a lockable cooling container, which would prevent public access.

### 5.4 Biosecurity implications

78. Houston (2012) highlighted the poor biosecurity practices which commonly occurs on-farm, particularly regarding fallen stock and reducing disease transmission. More recently, the pig industry has been in a greater state of awareness of the potential biosecurity threats being imposed by African Swine Fever (ASF) and the Porcine Epidemic Diarrhoea virus (PEDv) in continental Europe. ASF has been identified in several EU countries and PEDv has recently infected areas of North America,

Mexico and parts of Asia. Biosecurity is essential to prevent the movement of disease and safeguard the British pig industry. Improved biosecurity is likely to come from the greater efficiencies of on-farm storage before collection, lower frequency of lorries coming down farm drives to collect fallen stock and the overall benefit of a more structured (and less *ad hoc*) system of collection. Mul *et al*., (2002) determined the main biosecurity risks associated with the collection of fallen stock by surveying 11 experts in this sector. The greatest disease transmission risks were associated with the location of the collection site and the ease of access; the contact of the collection vehicles' grab with the fallen stock containers and the movement of vehicles which are not fully closed (Mul *et al*., 2002). Improvements in biosecurity have the potential to reduce disease risk, which in turn can prevent the following adverse economic consequences

- Reduction in the volume of marketable outputs
- Reduction in the quality (and consequential value) of sales
- A waste or higher level of inputs
- Resource costs associated with disease prevention and control
- Negative animal welfare impacts associated with disease
- Loss of export markets due to disease and its control (pig meat exports currently account for 28% of total UK production and have been steadily growing in recent years) (Source: Bennett, 2003)

79. In relation to the current threat of PEDv and ASF, the Red Tractor scheme has changed its biosecurity policy to reduce possible disease spread. These changes include the direct to slaughter of any pig attending a pig show; a complete record of all antibiotics used on-farm to be kept and discussed annually with a veterinary surgeon and any semen used must be obtained from an assured farm only (Red Tractor, 2014). This demonstrates the level of concern within the UK pig industry relating to possible disease transmission routes and improving biosecurity to decrease these threats.

80. It is clear that biosecurity and environmental factors provide a substantial part of the case study for exploring the viability of cooling systems in the UK. Farmers in the UK could further improve their biosecurity protocols, for example no longer using carcase storage containers which leak carcase fluid upon collection. Carcase cooling presents an opportunity to improve biosecurity by introducing a more controlled, effective storage method which would limit bacterial degradation of the carcases on-farm, prevent carcase fluid release and reduce the frequency of collection. The improvements in biosecurity from using carcase cooling by farmers in Denmark, the Netherlands and elsewhere in continental Europe, is sufficient to invest in the technology even when a financial incentive is not available. This improvement in biosecurity is greater than the cost and payback periods of the system.

81. Benefits from biosecurity do not just accrue to individual and corporate pig producers but also to Government and the industry as a whole (particularly where compensation costs are involved). For example, the loss of export markets due to poor biosecurity on the part of one producer will be an added cost to other producers and processors in the industry, as well as having an impact on UK exports. Yet the individual producer concerned may not have seen that the extra costs of improving biosecurity were worth it in his individual farm situation. There appears to be sufficient market failure in this area due to the lack of clear industry and individual farm cost implications to justify Government funding of more research. If farmers, collectors and processors consider themselves as part of an ABP supply chain, by working together, economies of scale can be produced to turn a waste into a valued product, to the benefit of all sectors of the industry.

82. It is beyond the scope of this feasibility study to provide quantification of the benefits to the pig industry. However possible future studies should quantify the financial impact of poor biosecurity and environmental factors surrounding carcase cooling and the potential impact this could have all stakeholders within the ABP industry. Future experiments could also investigate the survival of key porcine pathogens during the cooled storage of carcases compared to traditional storage methods and how these pathogens grow/are inhibited over time. The level of odour emission should also be incorporated into the experimental research.

## 6.0 List of recommendations

83. Having evaluated the various methods of carcase cooling currently in operation in Denmark, the Netherlands and at HAU, it is clear that on-farm cooling of fallen stock prior to collection and rendering may potentially provide significant economic, environmental and biosecurity benefits to the UK pig industry. Below is a summary of the potential benefits of cooling pig carcases on-farm:

**Economic**

- The on-farm preservation of fallen stock by carcase cooling may increase the storage time and collection interval, and potentially reduce the costs associated with carcase disposal
- Maintaining the quality of carcase material sent to renderers may increase the yield and quality of the rendered products and their economic value
- The introduction of some carcase cooling systems may be cost effective with relatively short payback periods
- Pillar 2 common agricultural policy funding may be available to encourage the development and uptake of on-farm carcase cooling

**Environmental**

- Secure on-farm storage and containment of fallen stock
- A reduction in odour emissions produced during storage, transportation and rendering and a reduction in the costs associated with odour control
- Increase compliance to legislation regarding the treatment and disposal of fallen stock (both on-farm and by processing plants)
- Enhanced public perception of the ABP industry

**Biosecurity**

- Secure on-farm storage and containment may prevent access by wildlife, rodents and flies
- Appropriate siting of on-farm storage facilities with discreet, separate access roads for the farm staff and for the collectors who access the carcase collection site to reduce the possibility of disease transmission and improve biosecurity
- A reduction in the frequency of collection visits and vehicle movements between farms may reduce the possibility of disease transmission and improve biosecurity
- Increased farmer awareness of biosecurity and disease prevention

84. Some of these benefits (for example improved biosecurity and environmental impact) are very difficult to quantify in a robust way for inserting into cost benefit calculations, but are essential to the benefits these systems may bring.

## 7.0 Further research

85. The objective of this feasibility study was to investigate the potential of carcase cooling for on-farm storage of fallen stock prior to disposal by renderers for the UK livestock industry as a whole. Various systems have been examined and a number of potential benefits associated with carcase cooling have been identified (see section 6.0). The current report has focussed on the on-farm cooling of pig carcase material, although the results are relevant and applicable to all sectors of the livestock industry. However, most of the evidence evaluated is anecdotal and further research is required prior to the introduction of carcase cooling into the UK. It is proposed that this could be undertaken at both a strategic and applied level as follows:

**Strategic research:**

Aim:

- To develop carcase cooling as an on-farm method for storage and containment of ABP, and develop a sustainable, cost-effective system that maximises the potential benefits throughout the UK ABP supply chain

Objectives:

- To quantify the effects of storage temperature and duration on ABP degradation, pathogen proliferation and odour emissions (see paragraph 82)
- To quantify the effects of storage temperature and duration on the yield and quality of rendered products and other potential benefits to UK rendering industry (see paragraph 30)
- To quantify the effect of seasonality on the operation conditions of the system (see paragraph 75)
- To quantify the environmental and biosecurity benefits associated with the introduction of on-farm carcase cooling and the potential risks associated with market failure (see paragraph 82)
- To develop a sustainable cost effective on-farm system of carcase cooling suitable for use in all sectors of the UK livestock industry, potentially using renewable energy technologies (see paragraph 73)
- To develop a system of storage, collection and transportation of ABP to maximise the potential benefits of introducing on-farm carcase cooling, throughout the ABP supply chain (see paragraph 81)
- To quantify the potential benefits of introducing on-farm carcase cooling to all stakeholders, including farmers, collectors, renderers, industry bodies and government (see paragraph 82)

86. It is anticipated that funding for strategic research of this nature may be available from a variety of sources including the UK government (DEFRA, the Agri-Tech Strategy or Research Councils UK).

**Applied research:**

Aim:

- To investigate the use of existing on-farm carcase cooling methods on a variety of livestock farms in the UK

Objectives:

- To establish existing carcase cooling methods on a variety livestock farms in the UK (see paragraph 85)
- To monitor the effects of introducing existing on-farm carcase cooling methods on the storage, collection and management of ABP (see paragraph 71)
- To determine the costs and benefits associated with establishment, operation and management of existing carcase cooling methods using a variety of livestock farms in the UK (see paragraph 71)
- To determine the suitability of using current cooling systems for the storage of larger carcases (see paragraph 75)

87. It is anticipated that funding for applied research of this nature may be available from a variety of sources including industry, the Technology Strategy Board (TSB) or from the Knowledge Transfer Partnership (KTP) scheme.

## 8.0 Conclusion

88. A feasibility study was undertaken to investigate the viability of various on-farm carcase cooling methods currently in operation in Denmark, the Netherlands and at HAU. These included cooling wells and a variety of cooling containers. In Europe, renderers are responsible for carcase collection and have a stronger relationship with farmers than in the UK. Anecdotal evidence suggests that the introduction of carcase cooling increases the yield and quality of rendered products, and reduces the frequency of collections, such that a discount on collection costs can be been provided to farmers. In addition, the introduction of carcase cooling provides a secure and safe method for on-farm carcase storage that, together with a reduction in the frequency of collections may significantly reduce the possibility of disease transmission and increase biosecurity. For these reason many farmers in the Netherland and across Europe have introduced carcase cooling methods even when a financial incentive has not been provided. The cost benefit analysis indicates that assuming quantifiable financial benefits similar to those obtained in Denmark are applied; carcase cooling may be cost-effective in the UK, with some methods having relatively short payback periods. In addition, further environmental, societal and biosecurity benefits may arise, but these have not been quantified. The introduction of on-farm carcase cooling may be beneficial, but further strategic and applied research is required to objectively quantify the potential benefits of carcase cooling and develop a cost effective system for introduction in the UK.

*89. Whilst we consider that this work has been carried out in accordance with good industry practice, the University will not be liable for any use which may be made, reliance which may be placed, nor advice or information given, in connection with the results contained herein for commercial purposes.*

## 9.0 References

Bangor University. 2013. Bioreduction: developing an alternative method to store fallen stock prior to disposal. Bangor University. Available from: http://www.bangor.ac.uk/senrgy/research/facilities/henfaes_bioreduction.php.en [Accessed 23 May 2014].

Bennett, R. 2003. Direct costs of livestock disease: the development of a system of models for the analysis of 30 endemic livestock diseases in Great Britain. *Journal of Agricultural Economics*, 54 (1), pages 55 - 71.

BPEX. 2014. The BPEX yearbook 2013-2014. BPEX. Available from: http://www.bpex.org.uk/downloads/303537/303774/The%20BPEX%20Yearbook%20 2013-2014.pdf [Accessed 2 July 2014].

Bromsgrove District Council. 2010. Environmental Permitting (England & Wales) Regulations 2010 (as amended) Permit to operate Animal Rendering Activity. Bromsgrove District Council. Available from: http://www.bromsgrove.gov.uk/cms/pdf/Mayfield%20Rendering%20Final.pdf [Accessed 11 July 2014].

Commission Regulation (EC) No. 1774/2002 of October 2002 laying down health rules concerning animal by-products not intended for human consumption. *Official Journal of the European Union* [Online], L 232. Available from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2002R1774:20070724:EN:PDF [Accessed 2 June 2014].

Commission regulation (EC) No. 142/2011 of 25 February 2011 implementing Regulation (EC) No 1069/2009 of the European Parliament and of the Council laying down health rules as regards animal by-products and derived products not intended for human consumption and implementing Council Directive 97/78/EC as regards certain samples and items exempt from veterinary checks at the border under that Directive. *Official Journal of the European Union* [Online], L 54/1. Available from: http://faolex.fao.org/docs/pdf/eur109216.pdf [Accessed 12 May 2014].

Commission Regulation (EC) No. 56/2013 of 16 January 2013 amending Annexes I and IV to Regulation (EC) No 999/2001 of the European Parliament and of the Council laying down rules for the prevention, control and eradication of certain transmissible spongiform encephalopathies. *Official Journal of the European Union* [Online], L 21/3. Available from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:021:0003:0016:EN:PDF [Accessed 4 June 2014].

Coolworks. not dated a. History. Coolworks. Available from: http://www.euratainer.com/about-us/company/history.html [Accessed 23 July 2014].

Coolworks. not dated b. Euratainer cadaver coolers. Coolworks. Available from: http://www.euratainer.nl/media/doc/downloads/FolderEN.pdf [Accessed 3 June 2014].

Coolworks. not dated c. Partners. Coolworks. Available from: http://www.euratainer.com/sales/sales-partners.html [Accessed 23 July 2014].

Coolworks. not dated d. Who for? Coolworks. Available from: http://www.euratainer.com/about-us/about-euratainer/who-for.html [Accessed 23 July 2014].

Coolworks. not dated e. Koelkelder. Coolworks. Available from: http://www.euratainer.nl/terratainer/koelkelder.html [Accessed 3 July 2014].

DAFC. not dated. Danish pig meat industry. DAFC. Available from: http://www.agricultureandfood.dk/Danish_Agriculture_and_Food/Danish_pig_meat_industry.aspx [Accessed 30 July 2014].

Daka. 2014. Services to farmers. Daka Denmark A/S. Available from: http://typo3.saria.de/en/secdk/services-to-farmers/ [Accessed 3 June 2014].

Danish Pig Research Centre. 2011. Bedre muligheder for opbevaring af døde dyr. Danish Pig Research centre. Available from: http://vsp.lf.dk/Aktuelt/Nyheder/2011/06/21062011%20Bedre%20muligheder%20for%20opbevaring.aspx [Accessed 2 June 2014].

DARDNI. not dated. Fallen stock FAQ. DARDNI. Available from: www.dardni.gov.uk/fallen_stock_guidance_v1_july_11-2.doc [Accessed 19 May 2014].

DEFRA. 2005. Integrated Pollution Prevention and Control (IPPC) Secretary of State's Guidance for A2 animal carcass incineration with capacity of less than 1 tonne per hour. DEFRA. Available from: http://archive.defra.gov.uk/environment/quality/pollution/ppc/localauth/pubs/guidance/notes/sgnotes/documents/sg10.pdf [Accessed 9 July 2014].

DEFRA. 2008. Archive: Farm waste and recycling: Incineration. DEFRA. Available from: http://archive.defra.gov.uk/foodfarm/landmanage/waste/incineration/ [Accessed 19 May 2014].

DEFRA. 2013a. Fallen stock. DEFRA. Available from: http://www.defra.gov.uk/ahvla-en/disease-control/abp/fallen-stock-faq/ [Accessed 22 May 2014].

DEFRA. 2013b. Agriculture in the United Kingdom. DEFRA. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/315103/auk-2013-29may14.pdf [Accessed 29 July 2014].

EFSA. 2012. Scientific opinion on composting and incineration of dead on-farm pigs [Online]. *EFSA Journal*, 10 (2), Available from: http://www.efsa.europa.eu/en/efsajournal/doc/2559.pdf [Accessed 23 July 2014].

EFSA. 2013. Scientific Opinion on Bioreduction application, EFSA Panel on Biological Hazards (BIOHAZ) [Online]. *EFSA Journal,* 11 (12), Available from: http://www.efsa.europa.eu/en/efsajournal/pub/3503.htm [Accessed 29 July 2014].

EPA. 2008. BAT Guidance note on best available techniques for the disposal or recycling of animal carcases and animal waste (1st edition). EPA. Available from: http://www.epa.ie/pubs/advice/bat/bat%20guidance%20note%20disposal%20or%20recycling%20of%20animal%20carcasses%20and%20animal%20waste.pdf [Accessed 9 July 2014].

Gov.UK. 2013a. Animal by-products: collection, storage and disposal. Gov.UK. Available from: https://www.gov.uk/dealing-with-animal-by-products [Accessed 19 May 2014].

Gov.UK. 2013b. Fallen stock: safe disposal. Gov.UK. Available from: https://www.gov.uk/fallen-stock [Accessed 19 May 2014].

HAU. 2013. Research into fallen stock continues. HAU. Available from: http://www.harper-adams.ac.uk/news/202084/research-into-fallen-stock-disposal-continues [Accessed 23 May 2014].

Homan, M.A.C., Schapp, R.H and Wegen, M.A. 2014. Improving business contacts between the Dutch, Hungarian, Serbian and Romanian pig production sector. Ministry of Foreign Affairs of the Netherlands. Available from: http://www.agribusiness-nl-srb.com/sites/default/files/20140319_brochure_hq.pdf [Accessed 30 July 2014].

Houston, S. 2012. A creative study into the scope for increasing value from fallen livestock and animal by-products. RAC 100 Club. Available from: http://dev.bpex.org.uk/downloads/302238/301341/A%20Creative%20Study%20Into%20the%20Scope%20for%20Increasing%20Value%20from%20Fallen%20Livestock%20and%20Animal%20By-products.pdf [Accessed 19 May 2014].

Hvolgaard, A.G.H. 2013. Opbevaring af døde dyr*.* Danish Pig Research Centre. Available from: http://vsp.lf.dk/viden/sundhed%20og%20forebyggelse/smittebeskyttelse/opbevaring%20doede%20dyr.aspx [Accessed 17 June 2014].

Leo Group Ltd. not dated. Purified fats*.* Leo Group Ltd. Available from: http://www.leogroupltd.co.uk/purified-fats [Accessed 16 May 2014].

Ministry of Food, Agriculture and Fisheries. 2011. Bekendtgørelse om opbevaring m.m. af døde produktionsdyr. Ministry of Food, Agriculture and Fisheries. Available from: https://www.retsinformation.dk/Forms/R0710.aspx?id=137411 [Accessed 6 June 2014].

Mul., M., Bokma-Bakker, M. and Eijck, I. 2002. Risk analyses of disposal of pig carcasses smaller than 40kg in the Netherlands. AgEconSearch. Available from: http://ageconsearch.umn.edu/bitstream/6976/2/cp02mu02.pdf [Accessed 11 July 2014].

Newham London. 2012. Animal waste factory hit with record fine. Newham London. Available from: http://www.newham.gov.uk/Pages/News/Animalwastefactoryhitwithrecordfine.aspx [Accessed 9 July 2014].

NFSCo. 2014. Benefits. NFSCo. Available from: http://nfsco.co.uk/benefits.php [Accessed 9 May 2014].

Penrith pong. not dated. Council chiefs meet Alba owner to address odour issue. Penrith pong. Available from: http://www.penrithpong.com/news.htm [Accessed 9 July 2014].

Productschap Vee en Vlees. 2013. Livestock, meat and eggs in the Netherlands. Productschap Vee en Vlees. Available from: http://www.pve.nl/wdocs/dbedrijfsnet/up1/ZamyibaJM_432682PVEpromoENG_LR_definitief.pdf [Accessed 30 July 2014].

Red Tractor. 2014. What has changed. Red Tractor. Available from: http://assurance.redtractor.org.uk/resources/000/966/245/RT_Pigs_Jul14__web.pdf [Accessed 27 July 2014].

Saria. 2014. Transport. Saria. Available from: http://www.saria.co.uk/by-product_processing/transport.html [Accessed 20 May 2014].

Sniffer. 2013. Review of odour monitoring and control techniques at rendering plants. Sniffer. Available from: http://www.sniffer.org.uk/files/5713/6906/0202/ER32_project_report_FNL.pdf [Accessed 9 July 2014].

Ulster Farm By-products Limited. 2014. Rendering process. Ulster Farm By-products Limited. Available from: http://www.ulsterfarm.co.uk/rendering-process/ [Accessed 16 May 2014].

Zimmermann, T.M. 2014. Feasibility study on carcase cooling. Patriotisk Selskab.

10.0 Appendices

Appendix 1 - Danish report plus email answers to further questions

# Feasibility Study on Carcase Cooling

Tine M. Zimmermann, Patriotisk Selskab, Denmark

PATRIOTISK SELSKAB
JORDBRUGSRELATERET RÅDGIVNING

## Table of contents

# Introduction

This report contains a description of the cooling facilities of fallen stock in Denmark and the Netherlands, including the benefits, disadvantages, return on investment calculations and details on management of the system. The report aims to clarify if the cooling facilities could be a potential method of enhancing the decomposition of fallen stock in the UK.

For years the dead pigs has been placed on a concrete grating and covered by a cadaver cover/ tarpaulin. This method has for many years been the preferred method to store dead pigs. In this manner any seepage from the dead pigs will be disposed of. However, storing fallen stock in cadaver cover /tarpaulins has often resulted in unhygienic pick-up as well as an increased risk of spreading diseases and decomposed pigs with subsequent odour problems (especially on hot summer days).

To take precautionary measures against decomposed pigs and the unhygienic ways of storing fallen stock, Daka introduced cooling facilities for fallen stock in 2008. The aim of the cooling facilities was, besides the above, to ensure that fallen stock was out of sight of the public and to obtain a more effective collection of the fallen stock. The cooling facilities have also been introduced to the Dutch farmers for the same reasons as in Denmark.

## 1.1 Background to the cooling facilities

For more than 100 years the pig industry has been an important part of Danish and Dutch agriculture. (Brossard, 2012)

Pig breeding, meat quality, food safety and animal welfare are important in Denmark and the Netherlands. Both countries are among the worlds leaders in these areas and many regulations and legislative changes have been implemented over the years in order to secure their reputation.

These (legislative) changes have not only been aimed at live pigs on-farms, but also with regards to dead pigs and handling of these. Handling of dead pigs is important because it has a significant effect on disease prevention and reducing the spread of infection from farm to farm. Moreover, if correct handling and processing is carried out, the subsequent product is a useful by product.

The storage and handling of fallen stock in Denmark is regulated by the Food Administration Executive Order No. 558 for Storage of fallen stock (The Ministry of Food, Agriculture and Fisheries, 2011). In the Netherlands it is regulated by Guidelines for Criminal Legislation Ministry of Economic Affairs, Agriculture and Innovation, Policy Veterinary (Miijnwetten, 2013). Both countries are signed up to the EU by-production regulations (EU-1069/2009) from the European Union. (European Commission, 2009)

According to EU by-product regulations, fallen stock and dead pigs must be incinerated in accordance with regulations set by empowered authorities. Historically, sources have shown that handling and collection of fallen stock started more than 300 years ago. Back then it was used to produce by-products, for example bone meal.

> *"For a dead horse, stud or cow, which he is asked to tow away, he is given 2 Mark, and besides that he retains the skin. For a calf, pig, dog or sheep 10 Shillings. For a cat 8 Shillings."* (Daka, n.d.)

For many years fallen stock was incinerated by local slaughterhouses. Proper authorization for rendering plants was introduced in Denmark April 1919 and in the Netherlands in 1934 (Rendac, 2014). From 1928 it was against the law to incinerate fallen stock at slaughterhouses in Denmark (Daka, n.d.)

## 1.2 The rendering services in Denmark and the Netherlands

Today, the collection of fallen stock in Denmark (including dead pigs) is handled by Daka and the first Daka factory was established in 1920. Daka receives animal by-products that are not used for or suitable for human consumption from slaughterhouses, the meat industry and agriculture. The animal by-product is used to produce protein-rich feed products for pets, fur-bearing animals, bone meal and fish (blood meal). In addition, the company produces fat products for use in livestock feed and the chemical industry as well as dried plasma approved for use in food products. Other animal by-products are primarily converted into products used in fertilizer and for generating energy, e.g. as raw material in the production of biodiesel. (DAKA, 2014; Visby, 2014)

Since 1934, the handling and collection of fallen stock in the Netherlands has been handled by Rendac. Their activities have become deeply rooted in the agrarian sector and in the meat processing industry. Rendac is using the fallen stock to produce bone meal and animal fat. The animal fat is used to produce electricity at power plants, cement ovens and for Rendac themselves. (Rendac, 2014; Stuifbergen, 2014)

In Denmark and the Netherlands fallen stock must be stored properly so the risk of spread of infectious disease is minimised. The fallen stock can either by stored in cadaver covers / tarpaulins, cooling facilities or freezing facilities. Storing the fallen stock in cadaver cover / tarpaulins is very common in both countries. The cooling facilities were as mentioned earlier in 2008 introduced by Daka. The aim with cooling facilities was to obtain a better product, a more effective collection of the fallen stock and to improve the pig industry image as well as environmental considerations for the farmers (Visby, 2014; Danish Pig Research Centre, 2011). The goal was to install the cooling facilities at 1.000 farms. Unfortunately only 90 farmers, or 5 percent of all farmers in Denmark, have taken up the cooling systems, despite its many advantages. The financial position in 2008 is probably to blame for the poor support; the farmers did not had the ability and desire to invest in the cooling well. (Visby, 2014)

**Figure 0.1: The cooling facilities were developed to ensure a more hygienic storing of the fallen stock (DR.dk, 2010)**

Rendac also introduced cooling facilities for fallen stock in the Netherlands. According to Bas Stuifbergen (Manager of Transport & Logistieck, Nederland, Rendac), Rendac bought a prototype of the cooling well which Daka introduced in 2008. Hence is the cooling well from Rendac, (Varkens , 2013), a further development of the Danish cooling well. (Visby, 2014; Stuifbergen, 2014) The background for implementing the cooling facilities in the Netherlands was to ensure that the fallen stock was out of sight of the public and to secure a more hygienic storing of the fallen stock (Stuifbergen, 2014). The systems were tested by 13 farmers around the Netherlands and today 125 farmers have implemented the cooling well. According to Bas Stuifbergen will the number of cooling well increase in the future and at the present moment is 3-4 cooling well sold per week. (Stuifbergen, 2014)

The cooling facilities has many benefits and challenges, which will be described in the following chapter. The design, management and the cost – both in Denmark and the Netherlands – will also be described.

# 2. The design and capacity of carcase cooling facilities on farms in Denmark and the Netherlands

According to the legislation in Denmark and the Netherlands, fallen stock must be placed in a designated place to ensure it is not accessible by vermin, birds, dogs, etc. (The Ministry of Food, Agriculture and Fisheries, 2011).

There are two types of cooling facilities for fallen stock – a cooling well or a cooling container. Both the cooling well and the cooling container are available in several sizes (Varkens , 2013; Euratainer, 2014).

## 2.1 The cooling well

As mentioned earlier, the Dutch cooling well is a further development of the Danish cooling well. Therefore the functions of the cooling are very similar with only a few differences. The section below will describe the two cooling well systems.

### 2.1.1 The Danish types of cooling well

The Danish cooling well was developed in 2008 by Daka and is available in two sizes.

The small well is 2.34 m x 2.34 m and has a depth of 1.5 m. The capacity of the small cooling well is approximately 3 containers with piglets or 10-15 sows or 20 slaughter pigs. The size of the containers is 190 Litre. The large cooling well is 3.94 x 2.84 m with a depth of 1.5 m. The large cooling well has room for approximately 6 containers with piglets and 20 sows or 26 slaughter pigs.

**Figure 0.2:Cooling well (Daka, 2012)**

Both cooling well sizes can be used for dead piglets and older pigs. (Danish Crown, n.d.; Visby, 2014) The cooling wells are constructed of four cement pieces and contain a drain in the bottom and refrigeration equipment located on the site (Visby, 2014). The drain is used to drain off the small amount of seepage from the fallen stock into a separate tank. The seepage is later pumped over from the separate tank to the slurry tank (Lorenzen, 2014)

**Figure0.3: A small Danish cooling well (Zimmermann, 2014)**

Most of the cooling well is placed under ground and has a temperature between 5-8 degrees (Krogshede, 2010). The temperature is regulated by an electronic thermostat.

A hydraulic handle is used to lift the cover of the cooling well and push it to the side. The cooling well is airtight.

It is estimated that the small cooling well uses 500 kWh per year and the large cooling well uses 1.000 kWh per year (Visby, 2014).

### 2.1.2 The Dutch types of cooling well

As mentioned earlier, the Dutch cooling well was inspired by the prototype from Daka (Stuifbergen, 2014). The cooling well, also called “Terratainer”, in the Netherlands, is available in one size with 2 insert/containers of 950 litres or no containers.

**Figure 0.4: The Dutch cooling well (Euratainer NL, 2014)**

The Dutch cooling well is 25 m x 2 m with a depth of 1.5 m. The two inserts/containers can store approximately 16 slaughter pigs or 8 sows.

One of the main difference from the Danish cooling well is the integrated inserts/containers, which reduces seepage in the bottom of the cooling well. The small amount of seepage is sent to Rendac, together with the fallen stock, when emptying the cooling well.

Both Danish and Dutch cooling wells are constructed with a drain in the bottom, where seepage can be emptied into a separate tank and pumped to the slurry tank. (Visby, 2014; Stuifbergen, 2014)

The cooling well is placed under ground with refrigeration equipment on the top of the cover. As with the Danish cooling well, the temperature in the Dutch cooling well is regulated with an electronic thermostat and kept at a temperature between 5-8 degrees.

A hydraulic handle is used to lift the cover of the cooling well and push the cover to the side. The cooling well is airtight.

It is estimated that the cooling well uses 800 kWh per year (Stuifbergen, 2014).

## 2.2 Types of cooling container in Denmark and in the Netherlands

An alternative to the cooling well is a cooling container "Euratainer". The cooling container is constructed similar to a reefer container. However in the cooling container it is possible to place one or several containers. The appearance and sizes of the cooling systems for containers is very different, cf. figure 2.2.1. (Euratainer, 2014; Visby, 2014).

The capacity of the cooling container is between 190-1.440 litres and can only be used for piglets. (Visby, 2014; Euratainer NL, 2014) Propane is used as a refrigerant in the cooling container. . The temperature is electronically regulated and kept between 4 and 8 degrees. (Euratainer, 2014)

It is estimated that the cooling containers use between 400 and 800 kWh per year. The advantage of the cooling container is that it can be plugged in to a standard power socket.


**Figure 0.5: Different types of cooling containers (Euratainer NL, 2014; Euratainer NL, 2014)**

Furthermore, Rendac offers another cooling container with a tipping system, which makes it easier to Rendac´s truck to collect the container (Rendac, 2014).

# 3 The management of carcase cooling facilities on farms in Denmark and the Netherlands

## 3.1 Location of the cooling facilities

The law requires that fallen stock must be kept in such way that they do not present a risk of spreading infectious agents and that they are safe from scavenger animals. The decay of the carcasses must also be prevented (The Ministry of Food, Agriculture and Fisheries, 2011).

It is recommended that the pick-up site is located at a suitable distance from production buildings, and that fallen stock and live pigs not are handled next to each other. The pickup place must be at the same place every time. Furthermore a permanent road access is permitted, and the truck is not allowed to reverse. Finally, it is recommended that the fallen stock is placed so the truck does not cross internal roads on the farms (Knowledge Centre For Agriculture, 2013; Stuifbergen, 2014).

To prevent spreading of infectious diseases, pick-up location for dead pigs should not be the same as the pick-up for living pigs.(Visby, 2014; Stuifbergen, 2014).

It is therefore recommended that the cooling well is placed as far away from the farm. Often is the pick-up site and the location of the cooling well found together with the rendering service (Daka or Rendac) (The Ministry of Food, Agriculture and Fisheries, 2011; Stuifbergen, 2014)

The cooling container is typically placed near to the pig buildings, so it is easier to fill with animals.

## 3.2 Filling and emptying

In Denmark and in the Netherlands, the cooling well and cooling containers are filled in the same way. It is normal for fallen stock to be transported by tractor or truck from the farm buildings to the cooling well (Lorenzen, 2014). When the capacity of cooling well is reached, Daka or Rendac is booked to collect the fallen stock (Visby, 2014; Stuifbergen, 2014).

**Figure 0.6: Collection of fallen stock. Dutch cooling well with two containers there are able to tilt. (Euratainer NL, 2014)**

In Denmark and in the Netherlands, fallen stock stored in cooling facilities must be picked up not later than 24 hours after it has been found dead. However, because of the positive hygiene results for the cooling facilities for fallen stock, it is now possible to store the fallen stock for longer.

Legislation in Denmark require that fallen stock is stored in cooling facilities at a maximum temperature of 8 degrees (The Ministry of Food, Agriculture and Fisheries, 2011). In the Netherlands the requirement is 10 degrees (Nederlandse Voedsel- en Warenautoriteit, 2014).

In Denmark the law dictates that the cooling well must be depleted no later than 6 weeks after entrance of the first dead animal into the cooling well (The Ministry of Food, Agriculture and Fisheries, 2011; Hvolgaard, 2013). However, according to Jesper Visby, Transport Manager at Daka and Torben Lorenzen, Farmer, it is common for fallen stock to be picked up by Daka every other week.

**Figure 0.7: Daka truck (DAKA, 2014)**

The cooling containers for piglets must be depleted every other week (The Ministry of Food, Agriculture and Fisheries, 2011). In the Netherlands fallen stock is allowed to be stored in the cooling well for a maximum of 2 weeks (Nederlandse Voedsel- en Warenautoriteit, 2014).The cooling containers must be collected very week (Rendac, 2014).

The cooling containers are placed at the collection location during the morning of the day of collection.

A crane is used to empty the cooling facilities after the hydraulic cover is lifted. It is possible to tilt the containers from the cooling well and from the cooling container with a crane from Rendac. This opportunity is not available by Daka, and according to Jesper Visby, Transport Manager at Daka, they are considering a similar solution.

Containers and covers may be possible sources of infection. The handling of these objects must therefore be carried out in accordance with the rules for protection of the herd against infection. Significant attention is given to preventing infection when the cooling facilities are being emptied.

The risk of disease spread from farm to farm is mainly due to the location of the farm entrance and the location of the collection point.

Frequent visits to multiple farms by the truck increases the risk of disease spread. The risk of disease spread is variable, depending of the type of pathogen. However, hygiene measurements can be taken in order to reduce this risk, for example:

1. Thorough cleaning of the fallen stock container and other materials used before bringing them onto the farm
2. Applying the clean- and dirty road principle
3. Cleaning and disinfection of the grapple and truck tyres after each collection
4. Cleaning and disinfection of footwear before entering the cabin of the truck
5. Ensuring that the driver wears disposable gloves and overalls

The drivers from Daka and Rendac are aware of the risk infection, but they are often not familiar with the health status of the farm. The drivers therefore stay as far away as possible from where the crane is controlled. The driver is not allowed to collect fallen stock from other locations other than the scheduled collection locations.

All drivers are familiar with and trained in the guidelines and receive a handbook with the rules, practical guidelines and procedures.

All scheduled collection routes are registered, thus it is possible to map the routes. Collection of fallen stock from farms with notifiable diseases or other serious health problems is done at the end of the route (Knowledge Centre For Agriculture, 2013; Stuifbergen, 2014).

## 3.3 Control of seepage

Using cooling facilities to store fallen stock is more environmental friendly than the use of the cadaver /tarpaulin, where the seepage is directly into the soil. Storing fallen stock at a maximum of 8-10 degrees reduces the amount of seepage, compared with storing fallen stock under a cadaver cover (even if it was placed in the shadow). When fallen stock is properly stored, there is no fluid originating from the animals and thus the risk of infection is further reduced (Brent Auvermann, 2004). The small amount of seepage from fallen stock (Lorenzen, 2014) is in the cooling well. This is collected in a separated tank through a drain in the bottom and later led to the slurry tank, or directly via the inserts/containers, where it is collected together with the fallen stock (Visby, 2014; Varkens , 2013).

Unfortunately have there been some leaking problems with Danish cooling wells. According to Jesper Visby, Transport Manager at Daka, the problem with leaking seepage is related to the construction of the cooling well as it is constructed from four pieces of concrete.

The seepage from the cooling container from both Denmark and the Netherlands is collected in the container where the dead piglets are stored. When the container is collected, all content, including the seepage from the dead piglets is passed to Daka or Rendac (Varkens , 2013).

## 3.4 Cleaning and sterilization

In Denmark and the Netherlands there are requirements regarding handling of cooling facilities after emptying. There should also be appropriate arrangements for cleaning and disinfection in place. (Sørensen, 2014; The Ministry of Food, Agriculture and Fisheries, 2011). There are, however, no set requirements to how often the cooling facilities must be cleaned and sterilised.

It is important to prevent disease spread and all owners and staff must have established standard operating procedures for handling the fallen stock. Vehicles and tools, which are used to transport the fallen stock to the collect location area, should be cleaned with a high-pressure cleaner and disinfected (Stuifbergen, 2014; Knowledge Centre For Agriculture, 2013).

It is standard procedure on farms to clean and disinfect the cooling well and the cooling containers (Lorenzen, 2014; Stuifbergen, 2014). After cleaning and disinfection, the cooling container is moved back to the collection point (Visby, 2014).

## 3.5 Gasses

The benefit of storing fallen stock at 8 - 10 degrees is that the decomposition/ bacterial conversion process of proteins is reduced (Danish Environmental Protection Agency). If the storage temperature was lower, the cadaver could be kept in good condition for longer. When the decomposition is going slower, the chemical and microbial activities, as well as their associated odours, is reduced.

Storing fallen stock in a cooling well or a cooling container results in fewer gases / odours compared to the cadaver /tarpaulin because these containers are airtight.

Frequent removal of carcasses from farms, and quick handling at the rendering plant, may also reduce odour nuisance further.

## 4 The challenges associated with the carcase cooling system

This section will describe some of the challenges associated with the cooling system.

As mentioned earlier, there have been some leaking problems with the Danish cooling well, relating to its construction. These problems have resulted in leaking of seepage from the cooling well. The Dutch cooling well has solved the potential leaking problem by using inserts/containers in the well, thus ensuring that fallen stock not is directly in contact with the bottom of the cooling well.

Another issue with the Danish cooling well is the location of the refrigeration equipment. According to Jesper Visby, Transport Manager at Daka, Daka has experienced the crane on the truck hitting the refrigeration equipment when it is emptied. Rendac has solved this problem by placing the refrigeration equipment on the cover of the cooling well.

Vermins and dogs can be a problem when fallen stock is stored in cadaver covers / tarpaulins. The challenges related to vermins and dogs are eliminated by storing the fallen stock in cooling facilities. It is not possible for animals to enter the cooling well and the cooling container because both are airtight and closed safely with lock.

Cooling any dead pigs (cadavers) also helps improve the standards of hygiene on the farm. It is common knowledge that proper storage minimises the risk of infection. Fallen stock is less infectious than live animals, as breathing has ceased. Moreover, it is primarily contact infection (handling infection) that can transmit diseases. Airborne infection from fallen stock is minimal.

## 5 Costs associated with the carcase cooling system

### 5.1 Denmark

It is not cheap to invest in a cooling well or container. In Denmark, the purchase cost of a small cooling well is around £4,953. A large one costs around £6,605 (Visby, 2014). The investment will also need to include fitting at approximately £2,202.

The annual running cost for a small cooling well is around £44 and approximately £88 for a big cooling well.

Danish farmers get a 15% discount on the collection fee from Daka if they have invested in a cooling well. Below are examples of the payback time for investing in a large and small cooling well respectively.

The cost of a cooling container depends on the size of the container and is around £2.095-£5.350 (exc. VAT). The annual running cost is around £22-66. The collection cost for a container of 190 litres is £21.18 and £26.70 for a 240 litre container. There is no discount for installing the cooling containers on farms in Denmark.

### 5.1.1 Example 1

The first calculation is based on a farm with 13.500 fattened pigs and investing in a small cooling well. The assumed mortality rate for slaughter pigs is 3.4% (based on the average for 2012 from the Danish Pig Research Centre). This equates to 459 dead pigs.

| **Investment** | |
|---|---:|
| Big cooling well | £4,953 |
| Construction costs | £2,202 |
| Total cost | £7,155 |
| **Running cost** | |
| Cost reduction to Daka per year | £443 |
| Electricity | £88 |

The collection cost by Daka for dead pigs is £6.44 per unit. This equates to an annual collection fee of £2,956. The cooling well investment results in a 15% discount. Collection of the dead pigs by Daka is therefore £2,512.43.

The payback time for the investment is over sixteen years.

| **Collection cost** | |
|---|---:|
| Pigs per unit | £644 |
| Cost per year, 459 x 6,44 GBP | £2,956 |
| **Daka discount** | |
| Cost reduction to Daka per year | £443.5 |
| **Total** | |
| Pick-up cost  per year | £2,512.5 |

### 5.1.2 Example 2

This calculation is based on a pig unit with 1,000 sows and 30,000 breeding pigs. The large well costs £6,605 and a further £3,199 will need to be invested in two separate containers of 240 litres. Installation costs are £2,202. The average mortality rate for sows is 12.8% and 22.4% for piglets.

| **Investment** | |
|---|---:|
| Big cooling well | £6,605 |
| Cooling container | £3,199 |
| Construction costs | £2,202 |
| Total cost | £12,006 |
| **Running cost** | |
| Cost reduction to Daka per year | £419.5 |
| Electricity | £132 |

It is estimated that the cooling containers for breeding pigs are filled up every other week (Sørensen, 2014). The collection cost of a cooling container of 240 litres is £26. The annual collection fee to Daka is £1,352. Without cooling facilities for the dead piglets, the collection cost is approximately £2,704.

| **Collection cost** | |
|---|---:|
| Sow per unit | £21.85 |
| Container 240 litre | £26 |
| Cost per year | £4,149 |
| **Daka discount** | |
| Cost reduction to Daka per year | £419.5 |
| **Total** | |
| Pick-up cost  per year | £3,729.5 |

The cost of collecting a dead sow is £21.85. Assuming an average mortality rate this equates to 128 dead sows per annum. The annual collection fee to Daka is thus £2,797 without the discount. The investment in the cooling well gives the farmer a discount of 15%. This gives an annual cost for sows of £2,377. The discount is approx. £420. The total annual payment to Daka is therefore £3,729.5 (a 26 year payback time).

The collection costs for a container of 190 litres is £21 and £26,50 for a container of 240 litres. There is no discount for installing the cooling containers on-farm, but it means fewer collections.

## 5.2 The Netherlands

The price of the Dutch cooling wells including the inserts/containers is approximately £8,233 plus installation costs of £1,646 GBP.

### 5.2.1 Example 1

The calculation is based on a farm with 13,500 fattened pigs and an investment in a cooling well. The assumed mortality rate for slaughter pigs is 2.4% (based on statistics from the Netherlands in 2011 (Hoornenborg, 2014). This results in 324 dead fattened pigs per annum.

| **Investment** | |
|---|---:|
| Big cooling well | £6,605 |
| Cooling container | £3,199 |
| Construction costs | £2,202 |
| Total cost | £12,006 |
| **Running cost** | |
| Electricity | £132 |

| **Collection cost** | |
|---|---:|
| Pigs per unit | £0.89 |
| Container 950 litre | £15,75 |
| Cost per year | £661.5 |
| Pick-up subscription | £40.63 |
| **Total** | |
| Pick-up cost  per year | £705.13 |

Rendac's collection price for dead slaughter pigs is £0,89 per unit or £15.75 per 950 litre insert/ container. It is estimated that each container can hold up to 7-8 fattened pigs, which results in approximately 42 filled containers. The annual collection fee to Rendac is estimated at £661.5, plus an additional collection fee of £1.93 each pick-up, totalling £40.63.

The total cost to Rendac is therefore £705.13 (excl. VAT). At this present moment Rendac does not give any discount to farmers who have invested in the cooling well system. However, Bas Stuifbergen, Manager Transport & Logistiek Nederland at Rendac, says that they are considering some sort of discount scheme.

## 6 Summary

There are many advantages of the fallen stock cooling system. By investing in cooling facilities the pickup frequency can be reduced, and the management of fallen stock is more environmental friendly. Gas and seepage from fallen stock are minimised, and storage is out of site of the public. The cooling well is airtight, thus preventing animals from eating dead pigs and reducing the spread of infectious diseases.

Cooling facilities also helps to improve the standards of hygiene on the farm.

Unfortunately cooling wells are very expensive and many farmers are not prepared to invest. Instead it is more common to use cadaver covers / tarpaulins and schedule more collection of fallen stock.

It is easy for farmers to see the lower pick up frequencies associated with investing in cooling containers and the cost savings that can be generated.

# 7 Reference


Brent Auvermann, A. K. (2004). *Carcass Disposal: A Comprehensive Review.* Taxas A&M University.

Brossard, L. (28. 11 2012). *INRA, France.* Hentede 2014 fra Overview of pig production in the European Union: http://people.ufpr.br/~labsiszoot/Eventos/COFECUB2012/BROSSARD2012_Overview%20of%20pig%20production%20in%20the%20European%20Union.pdf

DAKA. (2014). *SecAnim.* Hentede 2014 fra Værdiskabende biporudkter sikrer de naturlige ressourcer: http://www.daka.dk/index.php?id=11733&L=10

Daka. (n.d.). Daka historie.

Danish Argiculture & Food Council. (2014). *Danish Pigs Meat Industry*. Hentede 23. 04 2014 fra http://www.agricultureandfood.dk/Danish_Agriculture_and_Food/Danish_pig_meat_industry.aspx

Danish Crown. (n.d.). *Ny kølebrønd fra DAKA.* Hentede 25. 04 2014 fra http://www.danishcrown.cn/page24599.aspx

Danish Environmental Protection Agency. (u.d.). *Executive Summary - Slaughterhouses.* Hentede 07. 05 2014 fra Resumé: http://mst.dk/media/mst/68530/Slagterier%20DA%20endelig.pdf

Danish Pig Research Centre. (2011). *Bedre muligheder for opbevaring af døde dyr.* Hentede 2014 fra http://vsp.lf.dk/Aktuelt/Nyheder/2011/06/21062011%20Bedre%20muligheder%20for%20opbevaring.aspx)

Danish Pig Research Centre. (2013). *Reduktion af dødeligheden med 20 pct.* Hentede 06. 05 2014 fra http://vsp.lf.dk/Aktuelt/Velfaerd/Reduktion%20af%20dodeligheden%20med%2020%20pct.aspx

DR.dk. (2010). *25.000 pattegrise dør hver dag*. Hentede 06. 05 2014 fra http://www.dr.dk/DR1/kontant/2010/10/26181428.htm

Euratainer. (2014). *Welcome at Euratainer.* Hentede 01. 05 2014 fra http://www.euratainer.com/

Euratainer NL. (2014). Hentet fra http://www.euratainer.nl/kadaverkoeling.html

European Commission. (14. 11 2009). *Healt and Consumers.* Hentet fra EU rules on animal by-products : http://www.foedevarestyrelsen.dk/SiteCollectionDocuments/25_PDF_word_filer%20til%20download/01kontor/Biprodukter/Biproduktforordningen%201069-2009.pdf

Hoornenborg, G. (07. 05 2014). Veterinarian at Vet-Team ApS - Specialpraksis vedr. svin og mink. Denmark.

Hvolgaard, A.-G. H. (2013). *Opbevaring af døde dyr.* Hentede 2014 fra http://vsp.lf.dk/viden/sundhed%20og%20forebyggelse/smittebeskyttelse/opbevaring%20doede%20dyr.aspx

Knowledge Centre For Agriculture. (04 2013). *Udlevering af døde kreaturer.* Hentede 08. 05 2014 fra Smittebeskyttelse: file:///C:/Users/TMZ/Downloads/FarmTest-94-Udlev-af-doede-kreaturer%20(1).pdf

Krogshede, M. B. (2010). *maskinbladet.dk - dagens landbrug.* Hentede 12. 04 2014 fra Daka udvikler ny kølebrønd: http://www.maskinbladet.dk/artikel/daka-udvikler-ny-kolebrond

Lorenzen, T. (2014). Farmer.

Miijnwetten. (2013). *Richtlijn voor Strafvordering Regelgeving Ministerie van Economische Zaken, Landbouw en Innovatie, Beleidsterrein Veterinair.* Hentede 05. 05 2014 fra Hoofdstuk I. Destructiewet: http://mijnwetten.nl/richtlijn-voor-strafvordering-regelgeving-ministerie-van-economische-zaken-landbouw-en-innovatie-beleidsterrein-veterinair/hoofdstuk1

Nederlandse Voedsel- en Warenautoriteit. (2014). *Ministerie van Economische Zaken*. Hentede 2014 fra Kadavers/verwijderen van dode dieren: https://www.vwa.nl/onderwerpen/meest-bezocht-a-z/dossier/kadavers-verwijderen-van-dode-dieren/wat-moeten-bedrijven-doen-om-dode-landbouwhuisdieren-hobbydieren-en-dierentuind

Rendac. (2014). *Rendac.* Hentet fra Producten en activiteiten: http://www.rendac.nl/nl/producten-en-activiteiten/

Stuifbergen, B. (08. 05 2014). Manager Transport & Logistiek Nederland.

Sørensen, M. (2014). Swine Consultant.

The Ministry of Food, Agriculture and Fisheries. (2011). *Bekendtgørelse om opbevaring m.m. af døde produktionsdyr.* Hentede 01. 05 2014 fra BEK nr 558 af 0170672011: https://www.retsinformation.dk/Forms/R0710.aspx?id=137411

The Ministry of Food, Agriculture and Fisheries. (01. 06 2011). *ekendtgørelse om opbevaring m.m. af døde produktionsdyr.* Hentet fra Retsinfomation.dk.

Varkens . (2013). *Varkinforatie voor de varkenshouderij.* Hentede 01. 05 2014 fra Uit het zicht : http://www.varkens.nl/galleries/uit-het-zicht

Visby, J. (2014). Transport Manager.

Zimmermann, T. (2014). Environmental consultant at Patriotisk Selskab. Denmark.

# Emails questions and answers

## Legislation:

Q. Why is there a difference between the two domestic pieces of legislation regarding how long cooled carcasses can be stored for and at what temperatures?
A. I have just talked to the Ministry of agriculture. Their explanations are that the Danish temperature level is selected so spoilage is reduced and the hygiene is high. Furthermore Denmark in general has a more restricted policy on which temperature level food and dead animals should be stored related to other countries in Europe.

Q. Is incineration used anywhere in Denmark and the Netherlands (either on-farm or at centralised plants)?
A. It is not legal to incineration on-farms and they should be incardinated by empowered authorities. In Denmark only Daka are authorities and in the Netherlands only Rendac is authorities.

## Environmental considerations:

Q. What are the benefits to farms using carcase cooling with respect to the environmental considerations (page 4). Can the improved biosecurity and environmental issues of carcase cooling be quantified?
A. The benefits in regards to environment are primarily the reduction in odours, less flies and no seepage from the system compared to conventional systems. There are no studies available to quantify the benefits, though. However, the outlined benefits are all based on anecdotal evidence from speaking to users of the system.

Q. Does much does carcases cooling reduce carcase seepage?
A. Not a significant amount compared to covered carcases.

Q. If carcases are placed over a concrete grate, is any seepage collected from beneath the carcase? If so, what happens to this seepage?
A. The small amount of seepage from carcases placed under a cadaver covers are seeped into the soil through the concrete grate where there is columns.

Q. Does the carcase seepage not need to be treated along with the carcase and therefore should not be sent to a slurry lagoon?
A. The small amount of seepage from the carcasses is collected in a separated tank through a drain in the bottom of the cooling well and later lead to the slurry lagoon. The seepage from the cooling container (from piglets) is send to Daka/Rendac together with the dead piglets.

Q. Is this slurry treated in a different process before land application?
A. No, difference in treatment, as there are no requirements in regards to legislation.

Installation and design:

Q. Does the well or container costs/installation costs include the costs for digging the hole, the refrigeration equipment and any disinfectant equipment required?
A. The price is not including digging the hole, but we have given an estimate of the installations costs in the submitted report. The refrigeration equipment is included in the total price of the cooling system. Any disinfectant equipment is not included and needs to be purchased additionally.

Q. How long does the equipment last for? What are the annual maintenance and labour costs? Do you have to disinfect (by law), who does this and does the farm provide the equipment?
A. The refrigeration equipment has longevity of approx. 5 years, and the actual cooling container has longevity of approx. 15 years. The same goes for the cooling well. These estimates are based on information from DAKA and the Dutch company RENDAC

Q. Do you find a seasonal variation in the electricity use, for example less refrigeration required in the winter months?
A. The cooling system will be using less electricity during the winter months. However, it will still need an electricity supply for the cooling system - It may just need less energy to obtain to the same level compared to the summer period.

Q. If the lifespan of a refrigerator unit is approximately 5 years, how much would it cost to replace the refrigerator unit after this time?
A. The cost for a new refrigerator unit is app. between £500 to £1.000.

Q. What is the capacity of the 3 small containers for piglets in the small cooling well in litres (page 5)?
A. The size of each container is 190 Litres.

Q. What is the capacity of the large cooling well in litres and the capacity of the 3 small containers held within the well, in litres (page 5)?
A. The capacity of the large cooling well is app. 16.000 litres. Containers in the large cooling well are usually 190 litres, but larger containers can be used.

Q. The Dutch large cooling well – is the capacity of each container 950l or is that the capacity between the two containers?
A. Each containers has a capacity of 950 Litres

Costs associated with carcase disposal:

Q. Do we know what benefit cooling carcases has to the renderer in terms of a better quality/quantity of carcase product?

A. The structure of the animal is improved by the cooling process, which means that when it comes to the processing part of the dead animal, it is shorter. The machinery uses less energy, and the carcass needs to go through fewer drying processes to exclude the fluid from it.

Q. On a Danish website, it states DAKA has a 30% discount for using carcase cooling. Is this incorrect?

A. When Daka in 2008 introduced the cooling well the discount was on 30 % to whose farmers who installed the cooling well. But today is the discount only 15 %.

Q. On a different note, in your last email you mentioned that Daka decreased their discounts from 30% to 15%. Do we know why this is?

A. According to Jesper Visby at Daka was the discount temporarily and they did not gain the expected success as hoped. Today Daka is trying to sell the cooling well idea to others company because it was a loss business for them.

Q. How was the 15% reduction in collection costs justified - less frequent collections or a better quality product? Why don't they do this in the Netherlands? Also why is this cost not available for cooling containers?

A. When DAKA introduced the cooling system the offered a discount on the collection costs. The main advantage for the farmer is the less frequent collections. The Netherlands' are considering offering a discount as well to make it more attractive for the farmer to change to the cooling system. The cost is not available for cooling containers due to the smaller amount of carcasses they receive through this system, which are mainly from piglets. Larger pigs have a higher value, when processing by-products from carcasses.

Q. If only 5% of pig farms in Denmark have taken up carcase cooling, what percentage is this of the whole pig population in Denmark? What is the typically size of the farms which use carcase cooling? Of the remaining pig farms, what percentage of pig farmers cover their carcases or use freezing?

A. There is an approx.. 4000 pigs farms in Denmark. The remaining part of the farms, which are not using the cooling system, use carcase covers. No farms use freezing in Denmark or the Netherlands. It is mainly the larger, integrated pig farms, which have installed the cooling system on farm. The 5% refers to cooling wells, but I know that the cooling containers not are so widespread as wish in Denmark.

Q. Why do you think fewer Danish cooling wells were not installed (possibly due to the financial recession), yet in the Netherlands they have installed more cooling wells in a shorter time period?
A. I think that the reason for fewer installed cooling wells in Denmark is to find in the collection prize. In Denmark is the pick-up prize still per carcases even though they are stored in the cooling well. The only discount is the 15 %, and fewer pickups. The total savings is to low related to the investment.

Q. For example 2, I am confused regarding the collection of the cooling containers. The report stated it would cost £2,704 (one collection every week per year at £26 per collection x two containers) but the cost for the cooled containers is £1,352 per year (collection every two weeks instead of weekly). If there is sufficient space in 2x240l containers for two weeks supply of carcases (cooled or not), should the figures be based on 2x240l weekly collection of non-cooled carcases, when the farm is probably only filling 1x240l container per week (so would only need to pay for one collection per week). Perhaps I have completely misunderstood - I apologise if I have.
A. I haven't misunderstood the example and have right in yours considerations. The figures should be based on 1 x 240 l per week. Thereby is the collection price for a container £1,352 per year. I am apologise for the unfortunate mistake.

Q. Also for the Netherlands example 1, the value of £8,233 is used for a cooling well but in the table the cost of £6605 is used. Which is correct? This question also applies for the installation costs (£1646 in text and £2202 in table).
A. I am sorry but there has been a clerical error. The correct price is the price in the table.

## Appendix 2 - Questionnaire of pig farms and summary of results

General comments

- 20 questionnaires were completed, approximately 30% of all breeding sows in the UK were accounted for as 6 breeding companies answered the questionnaire
- On-farm incineration was popular within the nucleus herds on breeding farms, due to biosecurity concerns with the collection of fallen stock in these high health herds
- Some individual farms used on-farm incineration due to biosecurity concerns of using collection companies
- General impression was that pig producers would like to see an on-farm method of containment/disposal which was cheaper than on-farm incineration, but maintained biosecurity

Question 1 – Do you operate/work on an indoor or outdoor pig unit?

- 18 indoor units compared to 4 outdoor units (some respondent had both types of units)

Question 2 – How many breeding sows and finishers do you have?

- Number of sows ranged from:
  - small units: 5 – 430 (8 units)
  - medium units: 720 – 750 (2 units)
  - medium to large units: 2,000 – 9,500 (5 units)
  - large units: 42,000 (2 units)
- Number of finishers ranged from:
  - small units: 50 – 650 (3 units – 50, 160 and 650 finishers)
  - medium units: 1,700 – 12,751 (9 units)
  - medium to large units: 60,000 – 70,000 (2 units)
  - large units: 170,000 – 330,000 (2 units)

Question 3 – In which county do you farm?

- Respondents ranged from throughout England and also from Scotland and Northern Ireland

Question 4 – Are you a member of the NFSCo?

- Members of the NFSCo – 11 were and 7 were not

Question 5 – How is your fallen stock collected?

| | Sows | Finishers |
|---|---|---|
| Renderers | 7 | 6 |
| Off-site incinerators | 0 | 0 |
| Collection company | 5 | 8 |
| Hunt kennels | 0 | 0 |
| On-farm incineration | 7 | 4 |
| Other (please explain) | 0 | |

- Renderers and collection companies were the most popular disposal methods for sows and finishers respectively
- On-farm incineration was typically used by the nucleus herds of breeding units or by units which were concerned with the biosecurity issues of having a collection vehicle enter their property

Question 6 – What type of equipment for containment/collection do you use?
- A range of different methods were used. The most popular were wheelie bins (9 respondents), with three respondents having their wheelie bins collected by a tip truck
- 6 respondents used containers (not specified or homemade) with a further 3 respondents using buckets which were attached to a Loadall to empty into a collection vehicle. Two respondents used Dolavs
- Single respondents were recoded as using a freezer (due to low quantities of fallen stock), a dead box (but not within a container), a skip, a bunded area which contained a tank and an old chemical store container

Question 7 – Do you practice perimeter collection with a clear dividing line between farm staff and the collector?
- 13 respondents used perimeter collection, whilst 6 respondents did not

Question 8 – Are collection facilities located off-site?
- 11 respondents did store carcases off-site, however 8 respondents did not

Question 9 – How often is fallen stock disposal of?
- The majority of respondents used weekly collections (9 respondents), with once every 24/48 hours the second most popular choice (4 respondents). Two respondents used fortnightly collections, due to the lack of fallen stock, whilst 6 respondents used “other” frequencies. These included 2 respondents which used twice weekly collection and the remaining respondent only occasionally

Question 10 – What is your estimated cost of disposal (per sow and/or per finished pig)?

- Disposal costs varied from individual disposal costs of £15-£25 per sow and £8-£12 for a finished pig
- Per calendar month – 1 respondent pays £1,000 (720 sows and 1,900 finishers), another respondent pays £100 (300 sows and 3,000 finishers), whilst the last respondent pays £300-£400 (600 sows and 4,000 finishers)
- 1 respondent pays 12.5p per kg of finished pig
- 1 respondent pays £320 per tonne
- 1 respondent only considers the cost of diesel for his on-farm incinerator
- 1 respondent is part of BQP and BQP pays for disposal costs

Question 11 – What is your estimated mortality rate (percentage) per age group?

- Pre-weaned piglet: 6 - 15%
- Weaned to fattened pigs: 1 – 15% (typically <6%)
- Sows and boars: 1 -8% (typically <3%)
- Mortality rates, especially with sows, were higher at the breeding units

Question 12 – Do you have any other comments relating to fallen stock collection and/or improvements you would like implemented?

- Varied responses. The most popular themes was the dislike of moving carcases and potentially spreading disease around the country (5 respondents). To overcome this, many farmers would use on-farm incineration but it was too expensive (5 respondents)
- To retain fallen stock on land, 4 respondents wanted to use on-farm composting and 1 respondent wanted to introduce policed burial
- 2 respondents wanted to use on-farm incineration but did not think it was a viable process, whilst 1 respondent did use on-farm incineration but wanted to use the ash on the land which he was told he was not allowed to do
- 1 respondent said there was limited options for disposal and 1 other respondent said that all disposal methods were too expensive
- 1 respondent states he would like to use carcase cooling, whilst another respondent said that carcase cooling would be too expensive
- 1 respondent said he tried using skips but they did not work very well