

# **‘Clean, Green and Ethical’ Animal Production in Thailand** **A Thai-Australian Partnership in Education**

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# CLEAN, GREEN AND ETHICAL PIG PRODUCTION IN AUSTRALIA

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## **Abstract**

The concept of 'clean, green and ethical' pig production is attracting growing attention around the world as producers, international traders of pig, and consumers are becoming increasingly aware of sustainable and socially acceptable animal production systems. While the terminology 'clean, green and ethical' does not lend itself readily to an all-encompassing definition, in pig production it broadly refers to a rearing system with scientifically sound and ethical practices that underpins the production of safe and wholesome pork. Both the physical environment and management of the environment, for example controlling nitrogen and phosphorus emissions, are relevant to 'clean, green and ethical' pig production. Outdoor housing systems used in Australia based on litter (straw, rice hulls) portray a more natural image of pig production than conventional indoor housing systems based on steel and concrete, even though many of the same practices (e.g. antibiotic injections) and problems (e.g. enteric diseases) occur in both systems. Animal welfare is also an important and often contentious issue for pig production; evidence of this includes the recent spate of announcements by large vertical integrators in the USA and Canada of plans to phase out sow stalls following intense pressure from animal rights lobbyists. Other factors to be considered in 'clean, green and ethical' pig production include Quality Assurance (QA), the ability to trace individual pigs to their property of origin, aspects of pig genetics, the use of feedstuffs free of genetic modification, no hormonal or antibiotic residues in pig meat, and specific-pathogen free herds. Issues associated with antibiotic use are integral to the basic premises of 'clean, green and ethical' pig production. Restrictions or outright bans on the use of antibiotic feed additives, as occurred in the European Union from January 1<sup>st</sup> 2006, reinforce the notion that antibiotics denigrate the notion of 'clean, green and ethical' production even though pig welfare is likely improved by their use. This paper reviews the practical approach that Australia has taken to the production of pigs and pig meat that will meet the discerning needs and demands of our current and future domestic and international markets. We have also used some international data and commentary to highlight certain aspects of our discussions.

## **Introduction**

The concept of 'clean, green and ethical' pig production is slowly gaining traction in Australia, but by no means has the same impetus and influence as in other parts of the world (Kanis and de Greef, 2003). This has occurred predominately in response to standards imposed by the industry, the expectations set by importers of Australian pig meat, and by the attitudes of consumers towards greater food safety and accountability in the agricultural production sector, of which the pig industry is part. Nevertheless, there does not appear to be the scrutiny placed on the contentious aspects of pig production in Australia as there is in other parts of the world despite, for example,

several highly publicised piggery ‘invasions’ that have occurred. Australia has a per capita consumption of pig meat of 22 kg/head/year, which is low by international standards; this is due primarily to the higher consumption of beef and veal (36 kg/head/year) and poultry meat (35 kg/head/year). The lower consumption of pig meat relative to other meats together with the geographical isolation of Australian pig farms relative to those of other pig producing countries (e.g.. those in Europe) may also contribute to the lack of public awareness of pig production systems. Such proximity and awareness has the potential to increase societal concerns giving pig production a much higher public profile, as has occurred in some European countries for example.

We believe it is difficult to separate the terms ‘clean, green and ethical’ from ‘sustainable’ when discussing pig production. Pig farming is a business endeavour and producers who want to stay in business need to have some focus on sustainability. Defining the term ‘sustainable’ is also difficult, but broadly relates to meeting the demands of today without destroying the possibilities for future generations to satisfy their needs. Azar *et al.* (1996) and Robèrt *et al.* (2002) commented that four system conditions have been used to describe a sustainable society, specifying that nature should not be subjected to:

- Systematically increasing concentrations of substances extracted from the Earth’s crust;
- Systematically increasing concentrations of substances produced by society;
- Degradation by physical means, and
- Human needs being met worldwide.

Agriculture and the production of pigs have an impact on each of these conditions. Sustainability in agriculture, as in other industries, is increasingly using the term ‘triple bottom line’ to refer to the environmental, social and economic aspects of sustainability. However, Stern *et al.* (2005) commented that sustainable pig production must consider the ‘quadruple bottom line’ to include *animal husbandry*, since animals are used for food, and this encompasses ethical considerations about the treatment of the animals (pigs). However, application of the ‘quadruple bottom line’ to pig production results in conflict because animal husbandry is inseparable from animal welfare, and the imposition of higher welfare standards adds to the cost of production (Appleyby, 2005). Examples of this include:

- The trade-off between economic efficiency and space allowance per pig (higher space allowance may enhance freedom to move but incurs higher costs and does not necessarily provide production advantages; Payne *et al.*, 2006),
- The desire to promote natural behaviour by rearing outdoors versus potentially greater losses of nitrogen and phosphorus to the environment, and
- Keeping pigs outdoors and allowing them to express natural behaviours versus greater feed costs due to higher maintenance costs linked to activity and exposure to greater extremes of temperature. Some of these conflicts will be discussed later in this paper.

#### **‘Clean’ Pork – Antibiotic use, food safety and quality assurance**

The focus of ‘clean’ pork is human safety. This can be defined as safe, wholesome, and free of chemical and antimicrobial residue. This key component of ‘clean, green

and ethical' pig production relates to food safety and hence the use of and attitudes towards antibiotics in the system. In Australia, the wholesomeness of pork is managed along the supply chain from the farm to the consumer through a number of programs and government agencies.

Australian Pork Limited (APL), the peak industry body of the Australian pig industry, recognises that antibiotics are important for animal health, welfare, food safety and the environment. However they also advocate judicious use to avoid the development of resistance in pathogenic and non-pathogenic bacteria of the pig. While the use of antibiotics to promote growth remains legal, APL actively discourages this practice; several products in this class have been withdrawn from the market or are currently under review by the Australian Pesticides and Veterinary Medicines Authority with reconsideration of registration or classification as a probable outcome. Examples include avoparcin, dimetridazole, neomycin and virginiamycin. A review by an Australian medical scientist, Professor Peter Collignon (2003), reinforces the view of APL, i.e., "It is essential for producers to be aware of the issues relating to the development of antibiotic resistance in the bacterial flora of pigs treated with antibiotics and implement practices and strategies aimed at minimising this resistance." The situation in Australia contrasts with that in the EU where a total ban on growth promoting antibiotics was introduced on January 1 2006, although countries such as Sweden and Denmark had introduced voluntary bans well before this time.

The National Residue Survey (NRS) run by Agriculture, Fisheries and Forestry, Australia (AFFA) monitors food commodities for residues of antibiotics, pesticides, anti-parasitic and other therapeutic agents. Pig carcasses are randomly selected by the Australian Quarantine Inspection Service (AQIS) for testing in this program funded by producer levies; the prime reason for funding residue monitoring by producers is to preserve and enhance access to domestic and export markets. Random monitoring surveys are useful for detecting potential residue problems for the industry and for producer awareness and education.

### **Quality Assurance schemes in Australia**

The Australian Pork Industry Quality Programme (APIQ) is a farm-level, independently-audited food safety and product integrity quality assurance program based on Hazard Analysis Critical Control Point (HACCP) principles. APIQ defines the minimum standards required to produce safe and wholesome pork products, and is comparable with international quality standards. Pork quality assurance programs in many countries such as the UK are based on the management of animal welfare whereas APIQ was designed to address food safety, in the first instance. Participation in APIQ was originally voluntary, but accreditation now includes a high proportion of pig producers as buyers of pig meat demand assurance of the management of meat quality and pork safety. APIQ documentation, verification and accreditation includes management of medication and chemical use, stock feed and raw feed ingredients, pig herd health, general farm procedures, staff training, loading and transport of pigs, and approval of suppliers of pig farm inputs. Currently, APIQ is being expanded to encompass all pig industry quality programs into a single Integrated Quality Assurance (IQA) program. This includes monitoring and auditing of environmental, animal welfare and transport Codes of Practice.

The Australian Quarantine Inspection Service (AQIS) has operational responsibility for domestic meat inspection and export certification. In addition to Australian standards, AQIS requires all pork exporters to verify that the pork and pig offal they wish to export meets the food safety requirements of the importing country. Verification requires that pigs consigned to export abattoirs are accompanied by a vendor declaration that is backed up by either an on-farm quality assurance (QA) program or by routine residue testing of pigs. To meet these national requirements, the PigPass system has been introduced and is supported by all industry sectors and federal and state governments. The PigPass program links the PigPass National Vendor Declaration system with the APIQ quality assurance program. This affords the ability to trace individual pigs to their property of origin in the event that an exotic disease or chemical residue is detected in the supply chain, and also ensures that Best Practice is employed in on-farm production.

### **Production systems – are they ‘green’?**

There has been a marked shift in production systems in Australia in the past 10-15 years. There has been a move away from conventional indoor rearing and housing for all pigs to a more diverse range of systems accommodating outdoor sows, the use of deep-litter systems in ‘hoops’ or ‘eco-shelters’ for pigs at various stages of the production cycle (eg, weaning to sale, gestating sows), and to some combination of conventional and deep-litter housing. Exact figures are difficult to find, however Barnett *et al.* (2001) estimated that around 5% and 28% of sows in Australia and New Zealand, respectively, were housed outdoors, although in Western Australia, that figure is nearer 10% (over 3,000 out of 32,000 sows; Frey, *pers. comm.*). Morrison (2007) estimated that the progeny of about 30% of the Australian sow herd are housed in deep-litter, large-group systems for a significant part of their growing period, but in Western Australia Payne *et al.* (2000) reports that figure is nearer 75%.

There is a perception that rearing of pigs outdoors and (or) in deep-litter systems is welfare ‘friendly’. Indeed, there is no doubt that pigs display a greater range of natural behaviours and they have the opportunity to exercise and socialise in a manner that is at best restricted in conventional systems. However, the natural rooting and digging behaviour of pigs is also quite destructive. Research in this area is limited, but Eriksen *et al.* (2006) reported that management practices such as nose-ringing aimed at curbing this natural behaviour detracted from the intent of outdoor housing, and do not diminish soil degradation and nutrient leaching that can be associated with this method of husbandry. Such trade-offs remain poorly understood by the consumer.

In terms of greenhouse gas production and ‘green’ farming practices, most feedstuffs used in pig nutrition (with the exception of some feedstuffs such as soybean-based products and premix items) are produced in Australia and generally within the same region as the pig production enterprise, thereby minimising the transport footprint of the production system. Production is not geographically segregated as it is in the USA, and pigs also tend to be slaughtered within the region where they were born. This means that pork has a much lower ‘food mileage’ associated with it than seafood and in some cases, poultry. While cattle and sheep are grass fed in Australia, this benefit is greatly offset by the carbon production associated with rumination. This positions pork as one of the most ‘carbon neutral’ sources of animal protein, and is likely to find increased favour with consumers for this reason.

### **Environmental sustainability**

The impact of pig production on the environment is central to the concept of 'clean, green' production. Environmental sustainability is a central facet of this. Agriculture in Australia does not face the strict restrictions placed on mineral (nitrogen, phosphorus) recharge to the environment that occurs in other parts of the world. Indeed, the argument can be made that animal manures tend to be underutilised as a source of soil nutrients due to the high energy cost of spreading it over the vast crop acreages commonly under cultivation. Australia nevertheless faces other environmental challenges, one of which is a shortage of water in areas of pig production. Water will become an increasingly scarce and costly commodity for the Australian pig industry in the future, but some producers are tackling the problem. The following is taken from the April 2007 issue of *Pork-it-Up*, APL's newsletter:

"Pig producers Ken and Robyn Quick, of Brim in the Wimmera-Mallee district of Victoria, are enjoying the drought relief they receive from turning salt water into purified water with their on-farm desalination plant. The Quicks operate a 4,000-head piggery and run 1,000 head of sheep. With water quickly disappearing from their dam, they made the management decision to desalinate the water from the salty bore. The plant was installed in October 2006. "It was either shut down the farm or install a desalination plant. Water carting would have been too difficult, too costly and no guarantee of supply," Ken said. "The desalination plant produces 70,000 litres of quality water a day. We are now actually saving water. Our pigs are drinking less water because the quality is so great," he said. The pigs have used up to 62,000 litres of water on a very hot day and, on cooler days about 27,000 litres. The plant produces almost 50% good water, with the 25% re-circulated and 25% brine going to an evaporation pond. The evaporation pond may be used for saltbush to feed sheep. Some people have been put off by the cost of the desalination plant; however, the Quicks believe it has saved their property and set them up to be part of the future of farming in Australia." Nevertheless, the desalination plant itself comes with an energy cost.

Conservation and security of water for livestock will be central to the future of pig production in Australia. Similarly, soil salinity and the use of organic matter to alleviate it may fundamentally alter the way animal wastes are valued and used in Australia in the future.

### **Ethical Pork - Animal Welfare**

Many pig-producing countries have legislated codes of practice for pig farming that clearly articulate the conditions under which pigs must be farmed. The material contained in such documents differs between countries according to legislative pressures, consumer opinion (which often influences legislative process), and trade issues. Regardless of the concerns addressed within a code of practice, the existence of such a document indicates to the public and to the industry that the importance pig welfare is recognised at the highest level (of government) and is paramount to the future of the pig industry.

Codes of Practice are not fixed; they are subjected to regular review as new research becomes available, and experience with new systems in practice suggests means of satisfying both welfare and economic pressures. A good example of this dynamic process has been the long-standing debate surrounding gestation stalls

(crates) for gilts and sows. The EU mandates group housing for gilts and sows from 4 weeks after service to 1 week before farrowing (Table 1), but in North America and Australia, no such rule exists. However, a recent report in *Pig International* (May 2007) says: “Cargill Pork has become the latest major pig operator in the USA to announce its intention of phasing out gestation stalls in favour of group housing for pregnant sows.” The announcement by Cargill Pork follows previous statements this year from Smithfield Foods in the USA and Maple Leaf Foods in Canada that they will phase out stalls in gestation within the next ten years. Coincidentally, or not, these decisions follow comments made by restaurant chains in recent times; for example, Burger King says that it will increase purchasing from non-stall production systems. Changing the way that gestating sows are housed represents a massive change for these large producers of pigs in North America.

### **The Australian Model Code of Practice – Pigs**

The revised ‘*Model Code of Practice (MCOP) for the Welfare of Animals – Pigs*’ (2007) has just been released by the Australian Government, and provides both the template for pig farming and a framework for future developments in pig welfare. The MCOP-Pigs is intended as a guide for all people responsible for the welfare of pigs under both intensive, deep litter and outdoor systems. The Code recognises that the basic requirement for pig welfare is a husbandry system managed by trained people and skilled stockpersons. The MCOP-Pigs states that the basic needs of pigs are:

- Readily accessible, appropriate and sufficient food and water;
- Adequate shelter to protect from climatic extremes;
- Opportunity to display appropriate patterns of behaviour;
- Physical handling in a manner which minimises the likelihood of unreasonable or unnecessary pain or distress;
- Protection from, and/or rapid diagnosis and correct treatment of injury or disease;
- Freedom for necessary movement including to stand, stretch, and lie down; and
- Visual and social contact with other pigs.

Discussion of the details of the basic needs outlined in the MCOP-Pigs is beyond the scope of this paper. However, Table 1 is included to highlight the major pig welfare regulations in effect in the EU and in The Netherlands. In comparison, the MCOP-Pigs for the Australian pig industry is less stringent and possibly reflects a more pragmatic approach to the different range of pig production systems used in this country. Alternatively, one might argue that the Australian pig industry is yet to ‘feel the heat’ in relation to the welfare issues.



**Table 1.** Overview of the main rules on welfare of pigs in the EU and The Netherlands (adapted from Kanis and de Greef, 2003).

<i>Item</i>	<b>EU Legislation</b>	<b>Dutch Pig Act (where stricter than EU)</b>
Housing system	Group housing gilts/sows from 4 weeks after service to 1 week before farrowing, by 1/1/2006.	Group housing from 5 days after service to 1 week before farrowing.
Formation of stable groups.	Within 7 days of weaning. Mixing of groups as little as possible. Escaping and hiding from other pigs should be possible.	
Minimum unobstructed floor area.	0.15 m <sup>2</sup> for weaners or rearing pigs of 10 kg up to 1 m <sup>2</sup> for pigs > 110 kg in groups.	About 30% more than the EU.
Concrete slats with group housing.	Minimum slat width: 50 mm for piglets and up to 80 mm for gilts and sows. Maximum width of openings: 11 mm for piglets and up to 20 mm for gilts and sows.	Piglets: 10 mm for concrete slats and 12 mm for other slats.
Nesting material.	To be provided to sows in the week before farrowing.	
Access to water.	Permanent access from 2 weeks of age.	
Tail docking, teeth clipping, of piglets.	Not routinely, and only in case of evidence of injuries; not later than 7 days of age.	
Access to distraction material.	Straw, hay, wood, sawdust, mushroom compost etc., available in sufficient quantities.	
Access to bulky/high fibre feed.	Required for pregnant gilts/sows.	
Light and noise.	Minimum of 40 lux during 8 hours per day, avoid noise levels of 85 dBA.	

NB: producers in The Netherlands have until 2013 to implement the necessary housing changes, and owners of new houses or pig houses that will be renovated must comply immediately.

### **Sustainability - Financial considerations of 'clean, green and ethical' pig production**

In a review covering public concerns related to modern pig production in Western Europe, Kanis *et al.* (2003) concluded that the main issues were food safety and health for humans, animal welfare and animal health, environmental impact, sensory quality and the price of pig meat. In support, a recent welfare-attitudes survey was conducted in Europe on behalf of the European Commission to ascertain the views of more than 29,000 people in the 27 EU states, and also Turkey and Croatia, regarding meat producers, animal welfare and labeling of products. Although not specifically

related to pig meat production, the survey (*Pig International*; May 2007) found that:

- More than 70% of respondents supported offering financial rewards to producers who applied high welfare standards;
- 89% of respondents agreed that imports should have to be produced under the same animal welfare conditions as those originating in the EU;
- 62% of respondents said they were willing to make an extra effort to buy welfare-friendly products, even if it meant changing shopping location or paying more for goods. However, the consumers wanted better labels to indicate the animal welfare standards met in producing the food. In this regard, *Pig International* (May 2007) reported that the European Commissioner said: "I am convinced that good animal welfare offers a competitive advantage...an animal welfare labeling system is not a burden or an additional cost, it is an extra opportunity".

What does improved animal welfare cost to an animal production industry, such as pigs? There are few reports attempting to place a financial cost on sustainable pig production within the 'clean, green and ethical' context. A Swedish group (Stern *et al.*, 2005) evaluated future pig production systems using a whole-farm approach. Three scenarios were modeled:

- (i) *Focus on animal welfare and natural behaviour of animals.* This scenario described a future where the most important sustainability goals are animal welfare and expression of pigs' natural behaviours, good animal health and minimal use of preventative drug treatments. Key aspects of this scenario included: keeping sows and piglets outdoors in summer and indoors in winter, but with access to the outdoors; keeping slaughter pigs in groups during the rearing period and then slaughtering them in the same groups based on age; ley pasture for pigs was included in the crop rotation together with protein crops (e.g., canola, peas); low doses of nitrogen fertilizer were applied to decrease the risk of fungal attacks on crops.
- (ii) *Focus on the external environment and resource effectiveness.* This scenario highlighted the importance of the environment. It worked on the premise that pig production should have as low an impact as possible on the utilisation of nitrogen, phosphorus and trace elements in feed, low total energy per kg pig meat produced by minimal use of fossil energy, minimal emissions of greenhouse gases, minimal use of water and reduced odor production. Key aspects of this scenario included:
  - strictly indoor rearing (for emissions and environmental control);
  - heated buildings with recirculating ventilation to capture ammonia and heat from animals;
  - phase-feeding of pigs and use of enzymes (e.g., phytase) to closely match the nutrient specifications of the diet, particularly nitrogen (protein) and phosphorus, to the animals' actual requirements for pig growth;
  - no castration in order to increase feed efficiency;
  - separate rearing of males and females to different slaughter weights;
  - genetic selection made on the basis of lean tissue growth rate and feed efficiency;
  - crop rotation designed to meet feed demand with locally produced crops, with rotations designed to promote weed control, pest reduction

and soil health.

- (iii) *Focus on product quality and product safety.* The supply chain from farm to retailer was integrated in this scenario so that several different types of pigs and meat quality produced depend on market demand. Key aspects of this scenario included:
- indoor pig rearing with specialised production;
  - buildings with well-controlled environment including ventilation, temperature, feed distribution, etc., to achieve a certified level of production;
  - all male slaughter pigs are castrated (to reduce the risk of boar taint);
  - pig health is well monitored and preventative medical treatments are employed;
  - time of slaughter is based upon individual pig weight;
  - feed production uses precision farming to obtain high crop yields and consistent crop quality; cereals dominate and imported soybean meal is used.

Given these scenarios, Stern *et al.* (2005) modeled the whole farm costs of pig production based on 330 sow farms, which included activities associated with fattening of the piglets, pig feed production, and production of cash crops to the extent needed for creating suitable crop rotations. Essentially, production costs per kg pig meat produced were highest for the animal welfare scenario, whereas costs were similar for the environmentally friendly scenario and the product quality scenario. The production costs (in SEK/kg pork produced) in these three scenarios are depicted in Figure 1, and suggest a 20-24% increase in costs associated with the ‘animal welfare’ scenario relative to the scenarios based on ‘environmental protection’ and ‘product quality’.



**Figure 1.** Modeled pig production costs of three different pig production systems, with and without income support for grain production (a Swedish government intervention) (after Stern *et al.*, 2005).

In an earlier study, Bornett *et al.* (2003) evaluated the impact of animal welfare on the cost and viability of pig production in the United Kingdom. These authors evaluated the profitability of rearing pigs between 6-95 kg live weight by modeling the cost of production in four production systems, as follows:

- (i) A fully-slatted system (fulfilling minimum EU space requirements) with

- no bedding;
- (ii) A partly-slatted system (proportion of the floor as a solid lying area but no bedding);
- (iii) A straw-based system complying with the UK-based Royal Society for the Prevention of Cruelty to Animals - Freedom Food standards, which specifies requirements aimed at raising welfare standards (eg, space allowances more than the legal minimum, provision of straw); and
- (iv) A free-range system in which the pigs have access to a straw-bedded hut at all times, together with an outdoor pen in the early stages and paddocks in later stages of the growth cycle.

A complete description of the housing systems is illustrated in Table 2. In summary, the cost of higher welfare in the Freedom Food and free-range systems was 4-8% more than production in conventional, slatted systems. Labor and bedding costs were the major expenditures associated with the higher cost in the Freedom Food system; feed costs also contributed to the high rearing costs in the free-range system. Rearing pigs under organic conditions cost 31% more than under conventional, free-range conditions, but this additional cost was covered by premiums paid to producers for meat from the organic production system.

Appleby (2005) argued that major improvements in farm animal welfare would result in only small increases in the price of food at the retail level. However, the obstacle to such change is what Appleby (2005) referred to as 'economic inertia': this is producers' tending to resist legislation or pressure to improve animal welfare, because in existing price structures, buyers continue to expect low prices for meat. Any increased cost of production, for example caused by housing alterations to enhance space allowance per pig, would therefore be borne by producers, and the producers would suffer losses or decreased profits (Appleby, 2005). Finally, Appleby (2005) commented that from a perspective of doing what is appropriate for animal welfare and the environment, free-market competition should no longer be the sole determinant of meat prices. Nevertheless, Kanis and de Greef (2003) commented that for The Netherlands, pig production is a compromise between the industry's corporate social responsibility (i.e., incorporating food safety, welfare, environmental restrictions in effluent dispersal etc.) and its survival in the economic competition of the EU and world markets.

## Conclusion

Issues of concern to consumers in the near future include the impact of relationships between how food is produced, and environmental factors arising from climate change. This includes management of carbon generation and water consumption, both new aspects of the environmental impact of pork production. Consumers already express preference for foods with a demonstrated history of regard for animal welfare and the environment. With respect to greenhouse gases, and although Australia has recently ratified the Kyoto Protocol, carbon trading will continue to be hotly debated and will most likely become part of the cost of doing business, including the production of feedstuffs for pig feeds and the production of pig meat *per se*.

This paper has illustrated that while 'clean, green and ethical' production systems for pigs already exist in various forms, the economy of such systems remains in question, as is the willingness, and in many instances the ability, of consumers to pay

for it. This also has a strong geographical and societal bias. Issues of concern to producers also include managing the burden of regulation, achieving and maintaining the technical knowledge and skills to implement such systems effectively, and to attract and retain sufficiently skilled staff to engage in the high level of animal care required in such systems. However, if farmers, researchers and government agencies continue to evaluate production systems in terms of the 'quadruple bottom line', it should be possible to create productive and sustainable farming systems that are economically *and* socially acceptable.

**Table 2.** Description of housing systems for pigs at four production stages (I: 6-16 kg; II: 16-35 kg; III: 35-60 kg; IV: 60-95 kg) (after Bornett *et al.*, 2003).

Items	Fully-slatted	Partly-slatted <sup>A</sup>	Freedom Food <sup>B</sup>	Free-range <sup>C</sup>
Description (Stage) and space allowance, m <sup>2</sup> /pig	I: 0.20 II: 0.35 III: 0.50 IV: 0.65.	I: 0.30 II: 0.45 III: 0.65 IV: 0.75.	I: 0.23 II: 0.40 III: 0.65 IV: 0.75.	I: 0.75 II: 0.40 III: 0.68 & pasture IV: 0.75 & pasture.
Environmental control/heating	Full environmental control. Stage I: heating.	Basic environmental control. Stage I: heating.	Natural ventilation. Stage I: heating.	Basic environmental control. No heating.
Feed	<i>Ad libitum.</i>	<i>Ad libitum.</i>	<i>Ad libitum.</i>	<i>Ad libitum.</i>
Cleaning and mucking out	Slurry removed at intervals. Pressure-washed end of each batch in Stages I and II; 3 times/year in Stages III and IV.	Slurry removed at intervals. Pressure-washed end of each batch in Stages I and II; 3 times/year in Stages III and IV.	Muck scraped 3 times/week with tractor. Pressure-washed end of each batch in Stages I and II; 3 times/year in Stages III and IV.	Huts moved to new site on field at end of each batch and straw burnt, all stages.
Other	Pigs inspected twice daily. Vet/medicine records kept, all stages.	Pigs inspected twice daily. Vet/medicine records kept, all stages.	Pigs inspected twice daily. Vet/medicine records kept, all stages.	Pigs inspected twice daily. Vet/medicine records kept, all stages.

<sup>A</sup> Solid floor kennel with slatted dunging area (20%).

<sup>B</sup> Kennels and solid dunging area, straw provided.

<sup>C</sup> For Stages I and II: hut with straw and enclosed run; for Stages III and IV: hut with straw and access to paddock.

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