Lighting in pig buildings: In practice

Contents

The information in this booklet was compiled by Dom Charman, Independent pig specialist and AHDB.

Lighting for pigs

Overview

AHDB Pork carried out a literature review of all available scientific work related to lighting for pigs. The full literature review can be found online. In this document, the key factors highlighted by the review are considered in terms of making on-farm decisions related to lighting. For more detail on any of the items found in each section, please refer to the literature review hyperlinks.

Options for pig building lighting

Incandescent bulbs were standard for lighting homes for many years, until a move towards fluorescent energy-saving-type bulbs. More recently, there has been widespread uptake of light emitting diode (LED) lighting in homes. This change is reflected in the pig industry, with lighting installations shifting from either fluorescent batten/tube fixtures or halogen floodlights (in slatted and straw buildings, respectively) towards LED lights. This document will focus on LED lighting. LED lighting offers the pig industry:

- Reduced energy costs (versus fluorescent or halogen lights)
- A potentially more appropriate type of light (because the spectrum provided by most LED lights more closely matches the sensitive region of pigs' eyes)
- Better availability (because fluorescent tubes and halogen bulbs are being replaced in the market by LEDs)

LED lights – description

LED lamps work by passing electricity through a semiconductor, which in turn releases photons. Like many technologies, the recent rate of development of LEDs has been rapid. Efficiency and cost improvements have seen widespread commercial and residential uptake of LED lighting.

The waveband at which light is emitted depends on the composition of the material within the LED. Individual semiconductors emit monochromatic light and arrays of chips are used to achieve different colours. These emit a blend of different monochromatic wavebands, which are typically red, green and blue (known as RGB). Alternatively, phosphor coatings are used to absorb blue light and fluoresce it into white wavebands. While using phosphor coatings creates a more balanced spectral output, they reduce efficiency.

The process of electroluminescence is relatively inefficient and wasted energy is converted into heat. This heat energy warms the semiconductor and reduces the efficiency of light production. LED light output decreases with operating temperature. Operating efficiencies are typically quoted at 25°C, but the temperature of the semiconductor can warm to between 60°C and 80°C. These higher temperatures can give losses of >10% of light output.

Many LED lights designed for use in agriculture have heat sinks to remove heat from the semiconductors. In pig buildings, it is important to ensure these sinks (often aluminium fins) remain clear of contamination and are cleaned between batches so that they operate efficiently, while taking care not to force water into light housings.

All LED lighting systems operate using direct current (DC) with either a centralised AC-to-DC rectifier, or each lamp containing a rectifier within its body and electronics. Power conversion from AC to DC can cause energy losses of up to 7%, depending on the system applied.

Effect of light on pigs

Behaviour

Entrainment of light responses in pigs

There is little research on how long pigs take to acclimatise to a new photoperiod and the results of those few studies are conflicting. Some research has suggested that pigs require just 1 week to become entrained to a new photoperiod, while other studies suggest this may take 6 weeks or even longer.

The photoperiod is the period of time over which light is provided or experienced. When describing photoperiods, the notation 'L:D' is used, i.e. 16L:8D denotes a photoperiod of 16 hours of light (L) and 8 hours of dark (D). The dark period is just as important as the light period for establishing a rhythm and driving seasonal responses.

It is generally accepted that seasonal fluctuations in melatonin (the 'night-time' or 'darkness' hormone) are responsible for seasonal changes in animals (such as changes in coat or fur, breeding or feeding behaviours). The increase or decrease in melatonin levels experienced is largely accepted as being more important than having a continuously high or low level. However, some research has found that, for some animals, fixing a constantly high or low photoperiod at certain times of certain cycles can have an effect, regardless of the photoperiod provided prior to this.

For example, if a pig was moved from a farrowing house at 16L:8D to a weaner shed at 8L:16D, it would perceive a shortened day length. If a pig was moved from a farrowing house at 8L:16D, it would perceive no change. If, when trialled on farm, a new photoperiod has beneficial effects on production or behaviour, then the photoperiod from which those pigs came must also be considered because it may be the decrease or increase that has the effect, rather than the absolute photoperiod.

Effect of light on the use of functional zones

Minimal research has been conducted to show how different lighting zones can influence pigs' behaviour, but Nina Taylor has conducted some in depth work in the UK. Nina's work found that pigs have no preference for differing light intensities for activity, eating or drinking, but pigs preferred to dung in more brightly lit areas and rest in dimly lit areas.

Pigs are known to have separate dunging and lying areas, so it is unclear whether the pigs preferred to sleep in the dark and therefore dunged in the light, or vice versa. Nevertheless, this points to the potential to clearly define pigs' dunging and lying zones in straw buildings (using, for example, such as Suffolk-style pens for dunging). The effectiveness of this strategy may depend on the natural light present and the levels, type and uniformity across a zone of the artificial light provided.

Figure 1 shows a plan view of a Suffolk-style building, with false colour mapping of the lighting design. This figure shows lighter dunging areas and handling areas (in green) and a darker lying area in the centre of the building, in blue.

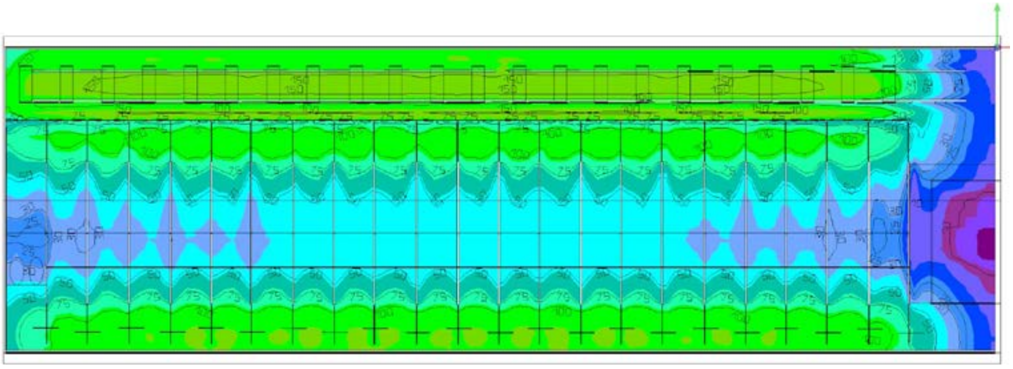

Figure 1. Plan view of a light map of a straw flow Suffolk-style building

Lighting hotspots – effect on vice

Anecdotally, lighting 'hot spots' – i.e. areas that have much higher levels of light than the surrounding pen, such as under a roof light – have been found to cause competition among pigs and potentially contribute to undesirable behaviours, such as dunging and lying in the wrong places.

Light in the breeding herd

Sows and piglets and photoperiod

Currently, the only recommendation for sows and lighting is that sows in service housing (post-weaning and before/during service and, on some farms, perhaps during early pregnancy, too) should be kept under 300 lux of light at floor level for 16 hours a day (16L:8D). Anecdotally, some units following this guidance have seen improvement, or at least a stabilisation of fertility. Some papers in the literature review conflict with this view quite noticeably, suggesting that short or decreasing photoperiods have a beneficial effect on sow fertility percentages and, in some cases, the number of piglets born alive.

Some studies have shown that lactating sows and piglets benefit from longer photoperiods (16L:8D), with sows weaning heavier piglets and having more piglets per litter.

While some studies advocate short photoperiods from weaning through the oestrus and dry periods and longer photoperiods during lactation, there is some conflict in the literature. Any changes made on farm to explore the effects of increasing or decreasing photoperiods should be done gradually, paying attention to effects on production and pigs' welfare and behaviour.

Sows and piglets and intensity

The best light level for farrowing houses remains unclear. One study of piglets reared under four different light levels, ranging from 40–453 lux, on a 18L:6D photoperiod, found no difference in a variety of parameters.

While more work is needed in this area to provide guidelines for practical use on farm, studies have clearly shown that very low light levels (<10 lux) have negative effects on production in lactating sows. It is important to appreciate that, in a fully ventilated farrowing house with windows, the light intensity could be as low as 10 lux if the lights are turned off on a cloudy day. Figure 2 shows a farrowing house with modern LED lights placed in the corridor.

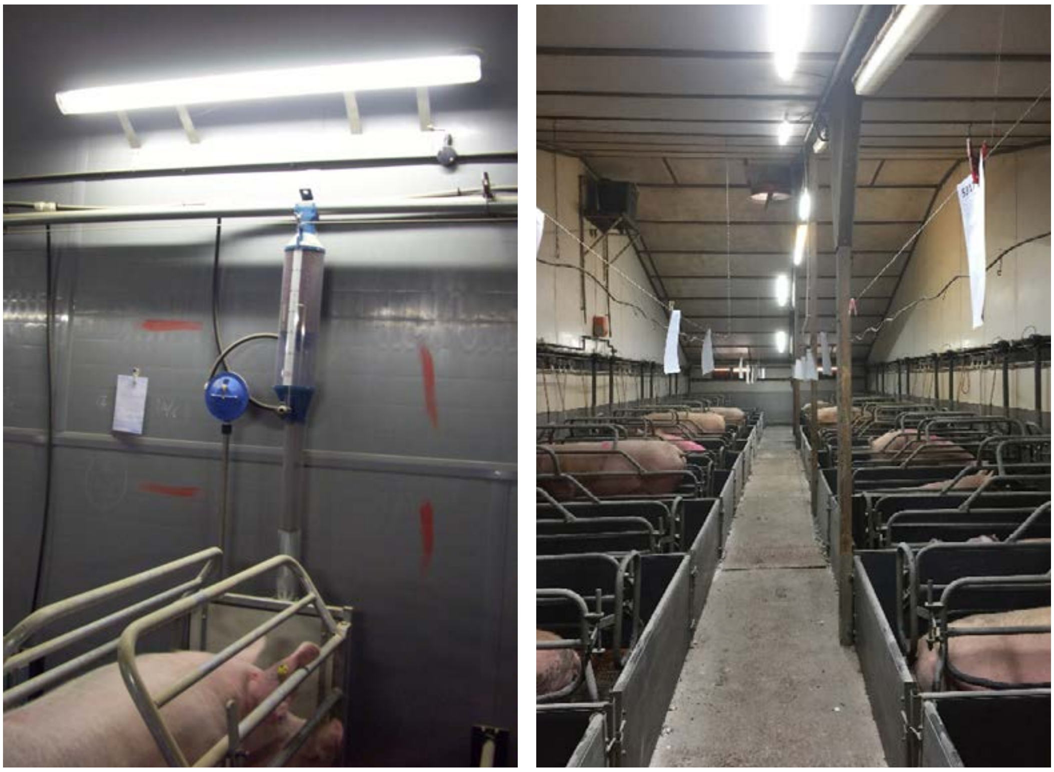

Figure 2. LED strip lights in a modern farrowing house

Light in the growing and finishing herd

Weaners and photoperiod

Some work has shown that when the photoperiod is increased immediately after weaning, pigs are better able to find feed. Increasing the photoperiod to 16L:8D in weaned pigs can improve health, feed intake and gain.

Data on extending photoperiods in weaning pigs is inconclusive. Until more research is carried out, one approach is to carefully increase the photoperiod of individual units by 2 hours of light at each step, up to a maximum of 16L:8D. If any signs of increased vice or aggressive interactions are noticed in pigs, then revert by 2 hours of light.

Finishers and photoperiod

Research generally shows that feed conversion ratios (FCR) and daily liveweight gains (DLWG) both benefit from photoperiods that are longer than the 8 hour legal minimum. One study found that increasing the photoperiod from 8L:16D to 14L:10D (70 lux) improved FCR by 17% and DLWG by 20% (in heavy European pigs that started the trial at an average of 112.5 kg liveweight). A further study by the same authors discovered that when pigs were finished under a photoperiod of 16L:8D (40 lux), their FCR improved by 10% and DLWG improved by 15% over the entire finishing period (days 1–155), starting with an average liveweight of 26 kg compared with pigs finished under 8L:16D.

Finishers and light intensity

Research has largely neglected the effects of light intensity on finishers. One study compared light levels of 40 lux (the UK legal minimum[1]) and 80 lux, both using a 12L:12D photoperiod. The pigs entered the study at 75 kg and finished at 160 kg liveweight (the study was conducted in Europe using pigs for heavy hams). The increased light had no effect on production parameters, but the group of pigs kept under 80 lux showed fewer head-to-head interactions and reduced aggressive interactions. The pigs in the 80 lux group also showed more social, nose-to-nose interactions.

This study suggests that increasing the intensity of light in finishing pigs may help to tackle aggressive behaviour. Light systems that can provide an intensity of 80 lux and which are dimmable would allow changes in light intensity to be made as a response to outbreaks of aggressive behaviour (for example, at mixing), although more study is needed in this area.

Figure 3 shows a computer model of a modern slatted finisher building. It is important to use models to predict how many lights are needed and where they should be placed to achieve desired light intensity levels in pig buildings.

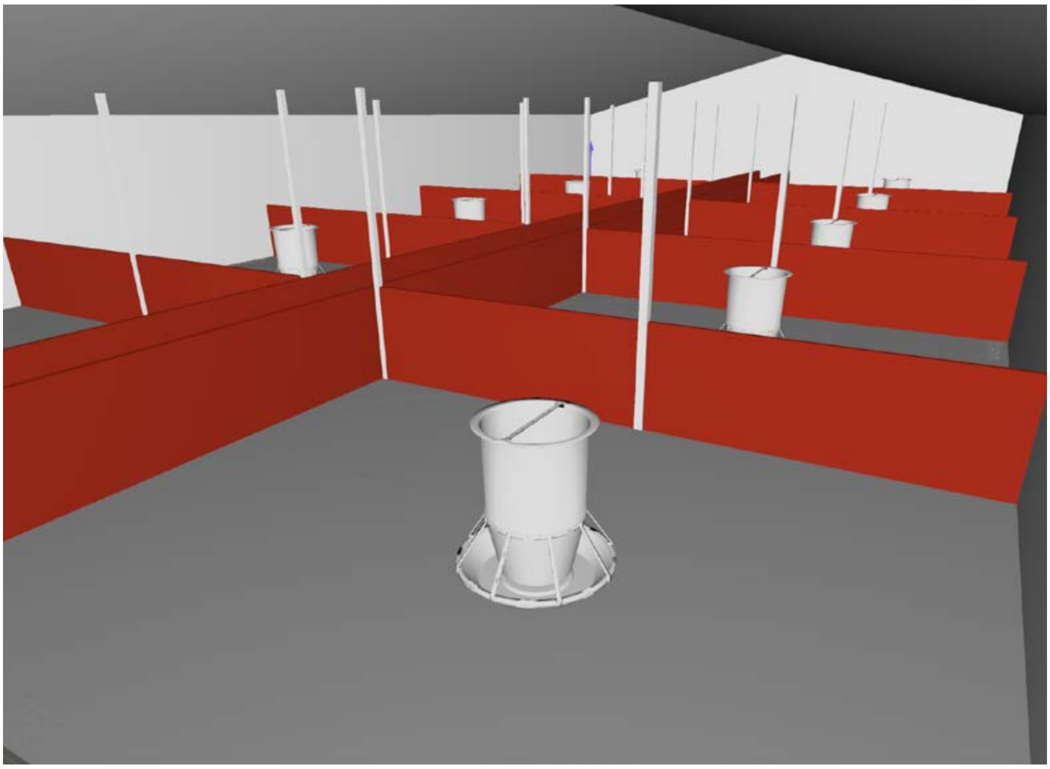

Figure 3. Bare lighting model of a slatted finisher building

Finishers and wavelength (colour) of light

Several lighting manufacturers advocate the use of specified wavelength lighting (SWL) for pigs. These lights emit only part of the light spectrum. The poultry sector has found advantages to using different colours of light for various tasks such as catching or to reduce vice.

AHDB Pork conducted a pilot study exploring the use of mostly blue lighting in weaner and finisher pigs. Anecdotally, the pigs reared under blue light were calmer. However, before recommendations can be made for the use of SWL or coloured lights in pig production, more scientific trial work is needed.

[1] The RSPCA Assured scheme (formerly Freedom Foods) requires a light level of 50 lux rather than 40 for at least 8 hours a day, and a specific break of 6 hours from artificial light.

Figure 4 shows the Biolumen 500 strip, a light designed to provide white, blue and near-ultraviolet (UV) light for pigs.

Figure 4. Biolumen Ltd 500 strip, an LED strip light producing blue, white and near-UV light for pigs

Figure 5 compares the spectrum emitted by the Biolumen 500 strip light (left) with that of a conventional 6000 Kelvin 'cool white' LED strip. More of the light produced by the 500 strip falls into the blue region.

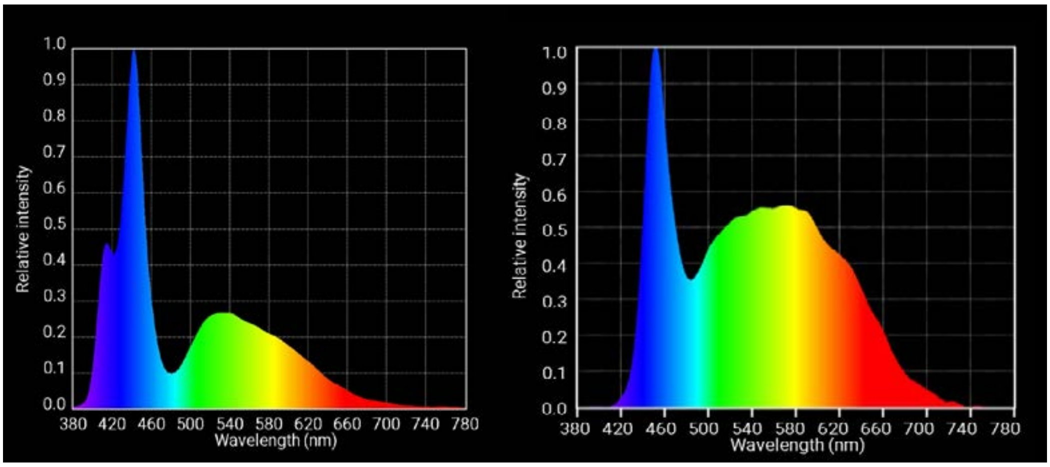

Figure 5. The spectrum emitted by a Biolumen 500 strip light (left), compared with that of a conventional 6,000 K cool white LED strip light (right)

Controlling and designing lighting for pigs

What is the aim?

When discussing the design or build of a new pig facility, stocking density, ventilation rates, feeder space and water capacity are all considered, but lighting rarely comes up. However, it is important to consider light as a variable that is part of the controlled environment, not just a 'bolt-on' to help staff to see the pigs.

Light modelling

Lighting specialists use software to build representative models of existing or planned buildings, then by adding specific lights to the model, they can predict how the light will present in the building. These models also take into account the location and orientation of the building, different times of year and levels of cloud cover for buildings that rely heavily on natural light (such as Suffolk-style straw buildings). Light intensity (lux), uniformity and myriad other factors can be predicted based on the specific lighting unit chosen and its placement within the building.

These models also consider the variability in reflectance of wall, floor or ceiling materials or coverings and the effect that pen furniture or other objects in the building will have on light distribution. For example, the model shows that if dividing gates or partitions are changed to vertically barred gates/partitions (as shown in Figure 6) this will allow more light to fall through rather than solid (paneltim-type) gates (as shown below in Figure 7).

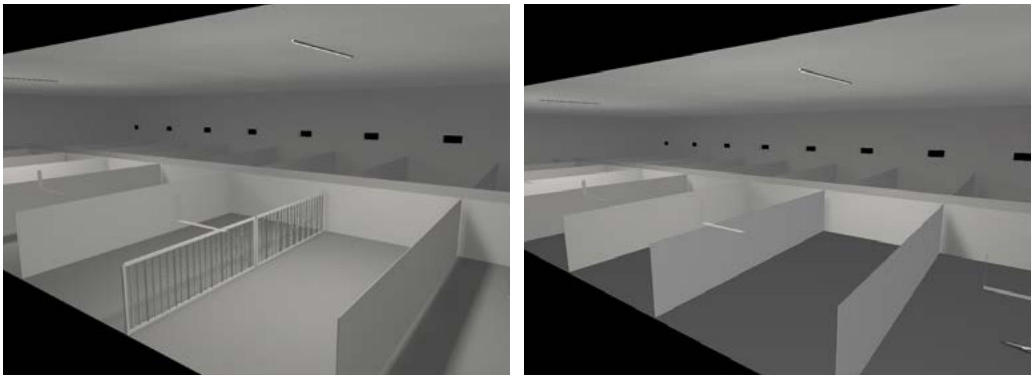

Figure 6. Left rendered image shows a vertically barred pen division, while the right image shows the same building with solid paneltim-type pen divisions

The image on the right in Figure 7 shows three pig pens in plan view, all with solid partitions (as in Figure 6, right) and a single LED strip light shown in the red box. The image on the left in Figure 7 shows an identical building with an identical light, but the middle partition has been replaced with vertically barred gates that allow more light to be 'thrown' into the pen (as in Figure 6, left).

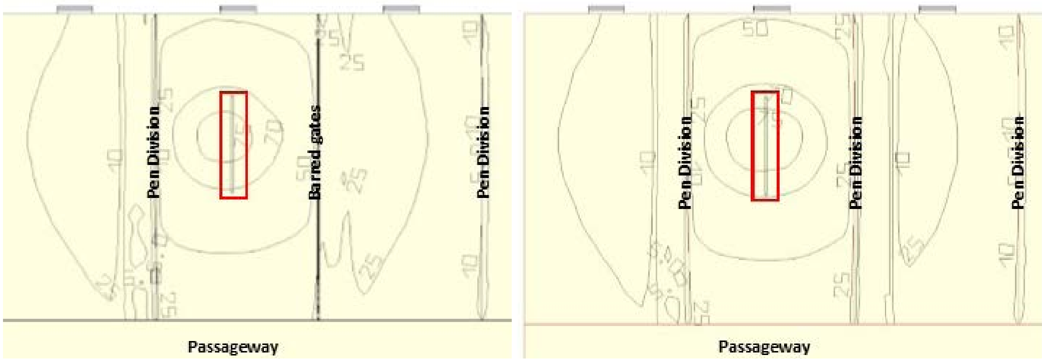

Figure 7. Plan view of the pens shown in Figure 6, showing light distribution at floor level. This image clearly shows how a barred partition affects light 'throw' compared with a solid partition

Figure 8 shows the same comparison but with false colours to help visualise the light. As before, the image on the right shows the solid pen partition, and the vertically barred partition is shown in the picture on the left.

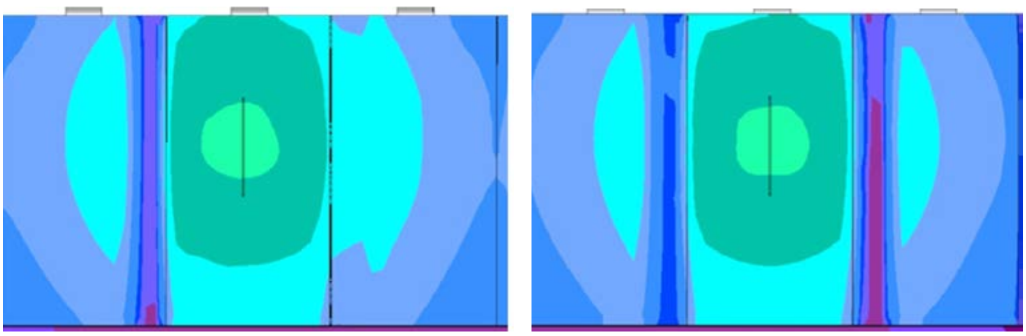

Figure 8. Plan view identical to Figure 6, with false colours used to help visualise light levels. As in Figures 6 and 7, the pen with the barred partition is shown on the left and the solid partition is shown on the right

Reflectance should be carefully considered in light models for pig buildings. When a new group of pigs enters a clean building, the surface reflectance changes almost immediately and continues to do so because of dust, dung and other materials sticking to them. Changes in reflectance are even more pronounced in straw-based buildings, in which the (condition, and therefore) reflectance of the floor covering is always changing.

The left-hand image in Figure 9 shows a model of a straw-based, Suffolk pen-style building, constructed using Dialux. The model was constructed using the builder's/architect's technical drawings of the building and is scaled identically. Once a model has been built, lights are added and simulations are run to determine where the light will fall. The right-hand image in Figure 9 visualises this using false colour mapping.

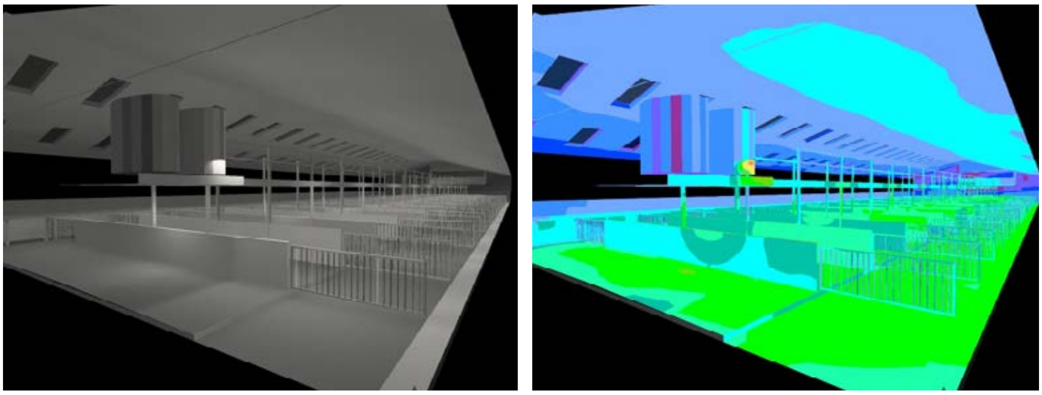

Figure 9. Left image shows a Suffolk-style straw building with vertically barred gates. Right image shows the same building, with false colour used to visualise the lighting

Light modelling software is a powerful tool for the pig industry. It not only allows calculation of the amount of light that is being delivered to pigs, but also shows light uniformity, the effect of natural light, the running costs of different systems and a variety of other factors relating to lighting systems in pig buildings. By simulating this information before spending money on a new lighting system, it allows unbiased comparisons of systems to be made.

When considering a new lighting system it is important to check that the supplier can model lighting, or that they can provide Luminaire files for an independent consultant to do so. Luminaire files are digital files representing the lights that can be used in simulation software.

Wall colour

The effect of using darker wall coverings – i.e., black plastic panels rather than the normal white ones – in slatted pig buildings is currently being explored. The company behind this idea has suggested that the colour 'calms' the pigs and reduces glare from reflectance. There has been no scientific research on this subject in pigs, but it is an area for future consideration.

Dark as a component of lighting

One question that arises when considering lighting for animals is, "How dark is dark?" Clearly, dark is a critical part of a lighting system.

It is easier to create a darker environment (perhaps lower than 5 lux at floor level) in fan-ventilated buildings. Many ventilation manufacturers offer louvres or other components that combine with standard pig building ventilation systems to reduce natural light. In naturally ventilated buildings this is more difficult because air often enters the building via the same pathway as the light, therefore restricting light may also restrict ventilation.

Pig buildings sometimes have light sensors to determine the level of light outside the building. This then controls the light inside and helps to reduce electricity usage. These sensors must be maintained and be cleaned and free from obstructions. Using these sensors in a naturally ventilated building (linked to a ramp up/down of lights instead of on or off) seems sensible. However, in a fully ventilated and insulated building it is best to block out natural light completely so as to control light as much as possible.

Combining the dark and light

Studies show that pigs stop producing melatonin at a light intensity of about 40 lux and increasing light above this level does not further alter melatonin production. Therefore, biologically, at 40 lux (or more), a pig considers its environment to be 'light'. However, this does not mean that there is enough light for all normal pig behaviour. One study revealed a marked reduction in negative interactions between pigs at 80 lux compared with a control group at 40 lux, suggesting that it may not be necessary to use light levels far in excess of this to drive changes in production (for example, fertility or growth). Further work on this is needed.

To achieve any minimum level of light, whether 40 lux as the legal minimum, 50 lux as required by RSPCA Assured, or higher lux levels in an attempt to improve performance or reduce negative behaviour, lighting should be planned and producers should seek impartial, specialist advice.

Controlling lights

There are many options for controlling lighting systems, from simple timer and light sensors, to full control systems that can ramp lights up or down on specific regimens, create 'dawn' and 'dusk' and alter the photoperiod or intensity of light provided.

Digital Addressable Lighting Systems Interface (DALI) is a standard used within the lighting industry that is covered by several international standards. Lights can be certified as DALI compliant/compatible. The choice of control systems for these lights is much greater and customers are not restricted to manufacturer-specific control systems.

Some ventilation controllers that are commonly used on UK pig units also include lighting control programmes (either DALI or 0–10 V compatible). The DOL 639 (Figure 10) is able to control lighting by dimming and timing and has light sensor inputs to maintain constant lighting levels.

Figure 10. The Skov DOL 639 ventilation computer can also control lighting programmes and accept input from light sensors to maintain constant light levels

Things to consider

Things to consider when installing a new system for more control over light are:

- Are the lights/is the system DALI certified or 0–10 V compatible? If so, this will provide more control choices
- Do you have a light control feature on your existing or planned ventilation controller? Some modern ventilation controllers support either DALI or 0–10 V control channels for lighting or dimmers
- What do you want to control? Just photoperiod? Will it always be fixed? A simple timer is a good choice for this
- Do you want to be able to recreate a specific 'natural' lighting rhythm? Some more advanced controllers allow users to enter a season/date range they wish to recreate and then automatically condense this into a shorter time period
- Do you want a dawn/dusk period, and if so, over how long should the transition be? Generally, 15–30 minutes is a good starting point. Most advanced controllers can now gradually ramp lights up from a low percentage of output to a higher one over a fixed time period
- Is an internal or external lighting sensor a valid addition? Some poultry systems use indoor sensors to control light levels, although these are often designed to maintain a constant intensity because artificial light output drops over the lifetime of a luminaire

Measuring light

Overview

In a fully ventilated building in which light can be controlled, measuring light should be as essential a part of the environment as the ventilation, feed or water. In existing pig buildings, measuring light is normally done with a simple lux meter/light meter, as is laid down in the welfare standards. More complex light meters can be used to determine many different parameters of light, including spectra, peak wavelengths and S:P ratios. One such light meter is shown in Figure 11. This equipment measures light level in lux, spectrum produced and many other parameters of light. It is too costly for individual farms, but is an example of a useful tool for advisors.

Figure 11. The Asensetek Lighting Passport, a 'smart' light meter

As with most pig unit tasks that require entry to the pig pen, taking light measurements more easily achieved if the pen is empty, in a clean building between batches. However, the reflectance of light from clean walls may mean that measurements taken are not entirely representative of the light available when the pigs are in residence.

When taking spot measurements for light in pig buildings, consider the following:

- Are the lights clean and do they all work? Is water trapped inside light bodies or behind diffusers?
- From what height should be the measurements be taken? Ideally, measurements should be taken at a representative pig eye height. This can be easier said than done in buildings that house pigs from 25 kg to finishing weight, but a fixed height should be used (floor height may be easiest)
- How many measurements are needed? Depending on the quality of the lux meter and the natural variation in light, the number of measurements required can vary significantly. Make sure at least three readings are taken for each spot and make a note of the level of background or natural light
- When should measurements be taken? Natural light coming through windows and ventilation fixtures is present even in fully ventilated buildings, so in these buildings, it may be best to take measurements when it is dark outside (considering the amount of light coming from the moon, stars or other outside light sources, such as yard security lights, etc.)

Try to measure uniformly. Lay out a grid on the floor of a pen (using stock marker or chalk) and take measurements in circles, with the centre of the circle being underneath the light. Plotting the lux level measured onto a drawing of the pen will then indicate where dark spots under lights may occur and can be more easily visualised.

Alternatively, existing buildings can be modelled on a computer, with examples of the existing lights placed into the model. This will show where the light is 'thrown' and how much will strike each surface. Modelling existing light in this fashion also allows additional or alternative lights to be positioned in the model and the effect this would have on the building to be explored without capital expenditure. Lighting installation/adaptation plans can then be generated to replicate the effects of the model in the existing building. Figure 12 below shows an example of three pens, with an existing light (surrounded by the red box) in the centre pen and isolines denoting the amount of light on the floor (in lux).

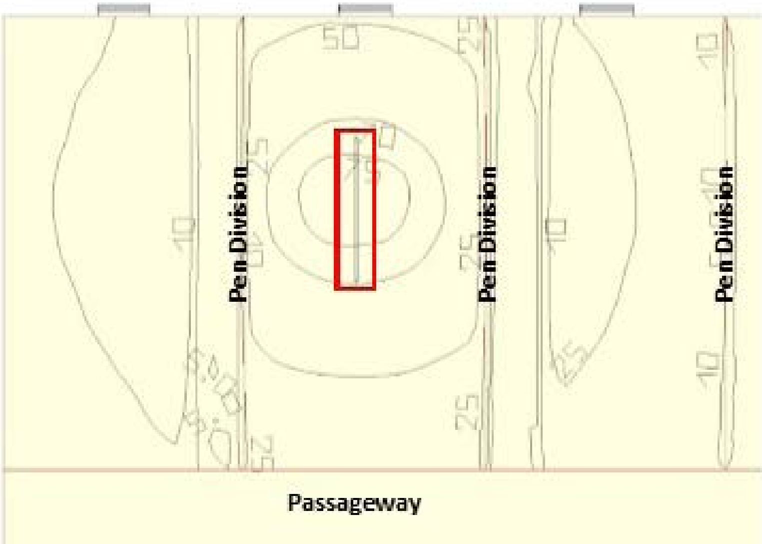

Figure 12. Isolines showing light distribution in pig pens

Selecting lights and lighting systems

Which lights are best suited to your system? There is a variety of physical presentations of lights: tiles, tube units, LED fluorescent tube replacements (which fit the original fittings, often with the need to remove ballast devices or make other alterations), battens, flexible strips and globelike designs, such as the ALIS shown in Figure 13.

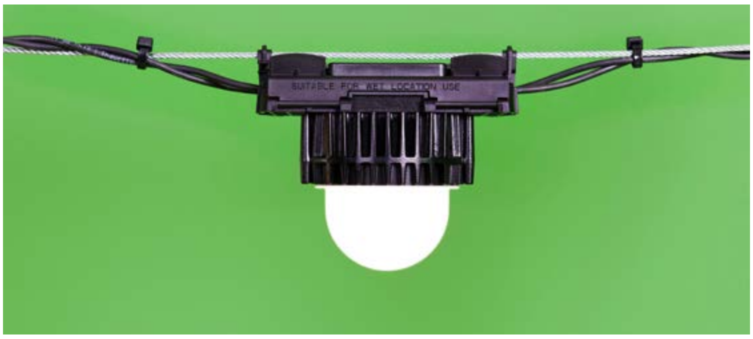

Figure 13. Greengage ALIS barn lamp wide

When selecting lights for a unit it is important to take impartial third party advice – the cost of lighting a new pig building can potentially vary by thousands of pounds, depending on the type of lights chosen, the level of luminal intensity/lux required and the level of variance/control required in the lighting control system. Alongside this guide, AHDB has published several documents, including the ***Controlled environment for livestock*** publication, which offers some guidance on the subject and a document comparing some of the LED lights available on the market.

Most lighting suppliers can produce lighting models and will provide fitting maps/guidance, with maps and coordinates to indicate where the lights should be positioned. These models ensure that the targeted level of light is achieved in the correct places and show the uniformity of light achieved.

Uniformity is a unitless index ranging from a theoretical 0 to 1, which is a ratio of the minimum level of illuminance to the average level of illuminance in an area. For example, at a height of 10 cm, the central pig pen shown in Figure 12 has a minimum illuminance of 32.4 lux and an average illuminance of 60.4 lux, giving a uniformity ratio of 0.54. All lighting design software programs provide overall uniformity figures for buildings or for specific regions, such as pens or passageways.

The effects of uniformity on pigs have not yet been subject to research, but if the objective is to light areas within a big building differently, or to achieve uniformity, then it is important to consider. For example, in a slatted pen, the aim may be to encourage uniform lying and dunging behaviour across the whole pen, whereas in a straw flow-type building, the aim may be to encourage lying/dunging behaviour in specific areas.

In this case, the aim is to achieve uniform lighting within the lying area and a separate level of uniform lighting within the dunging area.

Other key points to consider, in terms of practicality, are:

- At what height will the lights be mounted?
  - This information is needed for modelling. It is also important to consider the height of staff in pens (in ventilated buildings)
  - The height of machinery in straw-based buildings is more often an issue – not only the listed machine height, but also how high booms/bales will be when turning into buildings or attempting to lift bales clear of pen divisions or other building furniture
- Is the person fitting the lights 'on board' with the design?
  - In pig buildings, there is a tendency to mount light fixtures on existing furniture; for example, wooden purlins or other structures within the building, both for convenience and to ensure lights are clear of machinery working below. However, this rarely makes optimal use of the lights and will not match the design

Modern buildings

A modern pig building lighting system should have:

- **LED lights – these are the most energy-efficient lights available and are practical in nearly all types of pig housing**
- **Good luminous efficacy – how much light per watt will you get? While LEDs are more efficient than legacy technology, energy still has a cost**
- **Lights that are IP67 rated or higher – to ensure the chosen lights have a reasonable service life under the cleaning regimens seen in pig units (unless in an area not routinely pressure washed)**
- **Dimmable lights – to allow some degree of control over the lighting**

Installing lighting systems

Designing and installing lighting into a pig building must be done systematically. The lamps/luminaires are not standalone devices – they all need power. For some, this power should be delivered via a centralised rectifier or other such device that converts from the normal 240 V AC to another voltage and to DC; some need control cables to signal to lights, or other components to dim or perform some other function; and some may require specialised cabling (such as induction systems). When exploring the options for lighting a pig building, it is important to compare the full cost of systems.

Typically, a system might include:

- Luminaires/lamps
- A power supply
- A controller
- Light sensors – indoor, outdoor or both
- Catenary wires (with tensioners, supports, etc.)
- Clips or extrusions for mounting to wires or a solid surface
- Control or signal cables
- Power cables
- Cable clips/ties
- Blanking plugs/plates for the end light in a run of daisy-chained lights

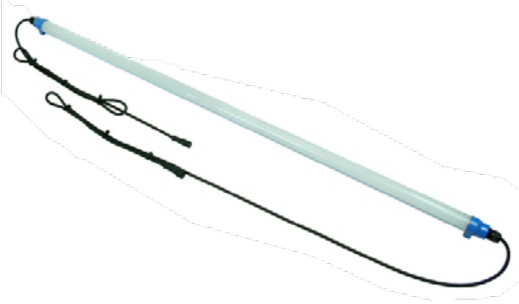

Figure 14. LSLCo UK LED strip

Figure 15. Biolumen 500 strip light, showing mounting hardware for catenary wire

Figure 16. Biolumen light controller

Figure 17. Greengage DTD Controller V1

Comparing systems

Look for:

- Amount of light they provide, rather than the number of lights
- Complexity of the layout needed to achieve the desired effect
- Type/quality of light they provide
- Control allowed by the system

Cost and ease of installation

As with the purchase of any new building equipment, consideration must be given to the installation as part of the cost.

- Many LED lighting systems can now largely be installed by the user, with both written and video guides available from manufacturers. This is particularly true of induction or plug and play systems
  - To install lights to achieve the desired effect, the installer must be appropriately guided and have a suitable plan to show where to mount lights
- Mounting catenary wires over long runs requires attention to detail. The weight being placed on the cable over a certain length should be calculated and the cable (and any supporting wires) should then be specified accordingly
  - Your lighting supplier may be able to supply the catenary wire or suggest a preferred partner
  - The wire should be rated to take a specific weight and also have maximum length information available

  - Where long runs are needed, catenary wires can be supported from above by descending wires or brackets
  - Guidance should be sought from the manufacturer or supplier before installing catenary wire systems
- The wide variety of lighting systems available means that installation costs cannot be included within this guide
  - Using unit staff to install user-installable lights will have an inherent cost
  - Even with 'user installable' or plug and play lamps, it is often necessary (and advisable) for the system to be commissioned by a suitably qualified/certified electrician and for them to connect any hardwired components into the building's electrical system

Comparing the costs of LED systems

When comparing the costs of different LED systems, they should be considered equally.

Compare systems like-for-like
Do the systems being compared achieve the same level of light (in lux) in the same places, to the same degree of uniformity?

The running cost of the system
Individual lamps may have higher or lower performance in terms of lumens per watt of energy consumed, but how many of these lamps are needed to achieve the same light level and uniformity? For example, a light that requires half the energy but twice as many lamps will use the same amount of total power.

Return on investment
What is the lifetime of the system versus its capital cost? Where systems have multiple components (e.g., power pods or controllers), which components have a limited life? What L and B value are being used to quote lifetime? (See Glossary for further detail on Lifetime Decay Standards).

Value

Reduced energy costs

The results of an AHDB pilot study exploring the effect of blue light on pigs suggest that by using LED lighting (regardless of the colour) at the point of installation, the additional cost over and above fluorescent fittings would be paid back within 2–4 years thanks to energy savings.

All lights have a specified wattage. Use the below to calculate cost savings:

$$\left(\begin{array}{c}\text{Total wattage of fluorescent system}\\ \text{– Total wattage of LED system}\end{array}\right) \times \begin{array}{c}\text{Hours of use}\\ \text{per day}\end{array} = \begin{array}{c}\text{Total watt hour}\\ \text{savings per day}\end{array}$$

To arrive at a cost saving per year, this figure can then by multiplied by 365 days and the current energy price being paid by the unit.

Improvement in performance by extending photoperiod

When lighting is considered as a critical part of environmental control, there is a financial cost. This cost may come from increased use of electricity in existing installations to extend photoperiods, the capital cost to increase the number of lights fitted in a new build, or reinvestment in the lighting system for existing buildings to update systems and provide more control.

Scientific work exploring increasing photoperiods in pigs gives us an indication of the potential on-farm value of controlling light.

In a study exploring the effect of 16L:8D on finisher pigs, an improvement of 10% in FCR and 15% in DLWG was seen. Table 2 shows the effect of this on UK average performance figures.

Table 2. Potential impact of trial results on industry average figures

Figure	Q3 2018 AHDB average	Potential (16L:8D)
DLWG (g/day)	814	932 (15% improvement)
FCR	2.79	2.51 (10% improvement)
Cost to finish	161.3 p/kg DW	155.3 p/kg (DW)
Days to finish (30–100 kg LW)	86	75

These figures represent a saving of about 6 p/kg DW in terms of improvement in FCR. Assuming a carcase weight of 86 kg, this would represent a saving of £5.16 per pig. The improvement in growth may reduce staff and energy costs for farrow-to-finish producers and, for any finisher not limited by a batch system upstream (for example a contract finisher), would represent the opportunity to finish more batches per year.

Maintenance of lights

As with any components of the controlled environment in pig buildings, lighting systems should be properly maintained to ensure maximum service life and performance. For many lights, this means keeping the light emitting surface clean, but it is important to refer to and follow any manufacturer guidelines for other aspects that may require attention over time.

Some LED lights include an exposed heat sink to help cool the lights and maintain their efficiency and light levels. These heat sinks are often aluminium fins on the rear of lights, as shown in Figure 18.

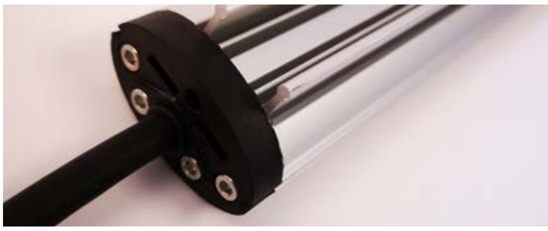

Figure 18. Biolumen 500 strip light, showing extruded heat sink on the rear

The heat sinks should be kept clean and free from dust and other particulates, where possible, because this will reduce the efficiency of the lamp and potentially reduce the light output. It can also pose a fire risk.

When purchasing a new lighting system, seek maintenance guidelines from the supplier. If a supplier is unable to provide these, it is worth considering alternative suppliers. As with any equipment, lifetime will depend on proper maintenance.

Disposing of lights

Lights at the end of their lifecycle must be disposed of properly. Several legislations cover the disposal of electrical goods, including the Waste Electrical and Electronic Equipment (WEEE) Directive. The WEEE Directive covers a variety of lighting types (including gas discharge and other lamp types). To determine whether or not the lamp is covered by the WEEE Directive and if it must be disposed of in a particular way, look for the symbol shown in Figure 19, which means it cannot be disposed of via landfill. Speak to your waste collection contractor if you are unsure.

Figure 19. The WEEE Directive symbol denotes that lights or other electrical goods cannot be disposed of in landfill

Appendix

Knowledge base

Lumens and lux

Many people who work in the pig industry are familiar with lux as the main lighting parameter. According to UK animal welfare legislation:

"Where pigs are kept in an artificially lit building, then lighting with an intensity of at least 40 lux shall be provided for a minimum period of 8 hours per day."[2]

To understand lux, it is important to first understand lumens. Lumens are a measurement of 'luminous flux' or 'luminous power' and are defined as the total output of a lamp, including all light, emitted in any direction, which can or could be detected by the human eye. The energy efficiency of lamps is recorded as 'luminous efficacy', which has the unit of lumens per watt (of electrical input).

Lumens are useful for defining the total output and efficiency of a lamp. In most practical situations (including within pig buildings), the amount of light that reaches a surface or target (in this case the surfaces in pig buildings or pigs' eyes) is a better measure. The amount of light reaching a surface is termed 'illuminance'. Illuminance is normally measured in lux.

Lux is a measure of intensity over surface area; 1 lux being equivalent to 1 lumen per square metre. Lux is derived from measurements of lumens, so is weighted for the human eye (i.e., it is a measurement based on how much of the light might be used by the human eye). In this sense, perhaps lux is not the most useful light measurement for pigs, because their eyes differ from those of humans. However, for the time being, lux is the most easily measured unit. It is also the unit quoted in global legislation and the one used historically to measure light levels in pig research on the subject.

Colour rendering, colour quality scale (CQS) and colour temperature

Colour rendering is the ability of an artificial light source to reproduce colours as viewed by the human eye. In other words, a light with poor colour rendering would mean a person is not well able to truly perceive the colours of an object.

Colour quality scale (CQS) is standardised measure of colour rendering. It is measured on a scale of 1–100, with 100 being theoretically 'perfect' light, which renders all colours exactly as they are perceived (and most closely matching daylight as a reference).

The validity of this measurement for pigs is not so obvious; however, it is important for stockpersons to properly view pigs. For example, they might need to easily tell the difference between an animal that is merely dirty, or an animal that has an injury. Therefore, consideration of the effect of CQS on a stockperson's ability to perform stock checks is very important.

CQS does not appear on lamp labels as a matter of course, but colour 'temperature' often does. The colour temperature of light is measured in Kelvin and is an indication of how the colour of the light would be perceived (often described as a measure a daylight similarity in residential light fittings and bulbs). Colour rendering index (CRI) is an older equivalent of CQS. Some lamps are labelled with both their abbreviated CRI and the first two digits of the colour temperature in Kelvin. Table 3 shows some examples of this system and how it is applied.

Table 3. Light colour label examples

CRI	Temperature (Kelvin)	Colour label
70–79	3,500	735
80–89	4,000	840
90–100	6,500	965

[2] 40 lux is often referred to as 'enough light to easily read a newspaper'. However, this is quite misleading because a newspaper can be read in considerably less light. The best way to determine whether or not you are achieving 40 lux, or any target light level, is to measure it with a suitable light meter.

Peak wavelength (λP)

Peak wavelength (λP) is measured in nanometres (nm) and is based on a relative measurement of the intensity of the different wavelengths supplied by a light source. The most intense wavelength supplied (relative to all those supplied) is described as λP. An alternative measurement, known as dominant wavelength (λD), is also used; however, this is weighted for the human eye and as such may not be applicable to pigs. Figure 20 shows an example of a light with a λP of 630 nm (left) and a light with a λP of 450 nm (right). While λP shows us the wavelength that is most strongly emitted by a lamp, it does not always tell us what colour the light will appear to be. This is determined by λD.

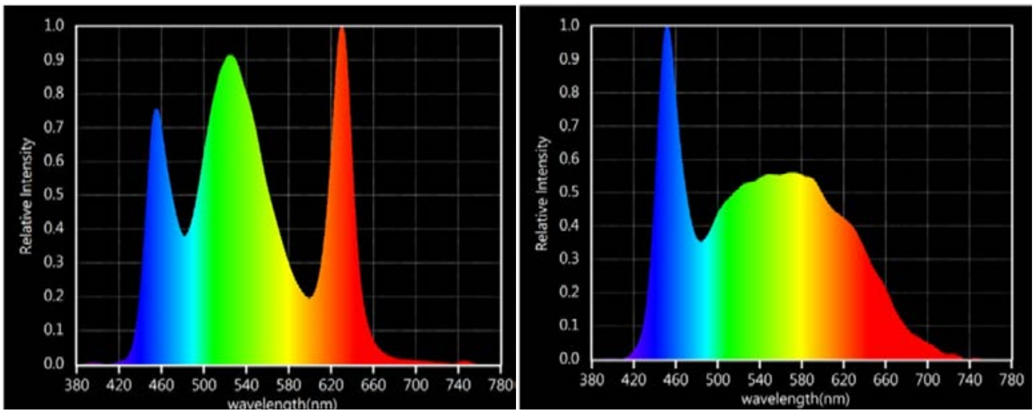

Figure 20. Light with a λP of 630 nm (left) and a light with a λP of 450 nm (right)

Scotopic to photopic light ratio (S:P ratio)

The luminal flux of a lamp in lumens is, in fact, a measurement of the photopic lumens produced by the light. The eyes of all mammals, including pigs, have two types of cells: cone cells and rod cells. Cone cells provide photopic, or ‘day’ vison and allow us to see different colours. Rod cells provide scotopic, or ‘night’ vision. In simplified terms, S:P ratios provide a measure of how much ‘rod-visible’ light is available. For example, a lamp producing 2,000 lumens with an S:P ratio of 2.1, produces 2,000 photopic lumens, but a total of 4,200 visually effective/enhanced lumens (VEL). This is because light is perceived using a combination of rod and cone cells.

While the impact of S:P ratios on pigs is unknown, it is possible that pigs, compared with humans, may rely more on rod cells to perceive their environment. This is because pigs, which evolved under relatively low light levels under forest canopies, lack long wavelength cone cells and have only short and medium wavelength cones.

S:P ratios are also affected by how much of a lamp’s total output falls within each band of short, medium or long wavelength lighting. Since human scotopic vision falls more within the short and medium wavelengths, the scotopic values of luminous flux from a lamp may be more representative of a pig’s perception.

IP ratings

IP ratings denote the level of ingress protection a light (or other item) has against solid particles (for example, dust) and water. Table 4 provides an explanation of these ratings.

Table 4. Lamp IP ratings explained

Dust protection		Water protection	
First number	Level of protection	First Number	Level of protection
0x	No protection	x0	No protection
1x	Objects >50 mm	x1	Vertically dripping water
2x	Objects >12 mm	x2	75–90° dripping water
3x	Objects >2.5 mm	x3	Sprayed water
4x	Objects >1 mm	x4	Splashed water
5x	Dust protected (vacuum)	x5	Water jets
6x	Dust-tight	x6	Powerful water jets
		x7	Effects of immersion
		x8	Indefinite immersion

For example, a lamp with an IP rating of IP67 is considered to be dust-tight and protected against powerful water jets. A lamp with an IP rating of IP54 is considered to be dust protected and protected against splashed water.

Lifetime decay standards

When a lifetime figure is quoted for an LED light, it is important to understand the ‘L’ and ‘B’ values used. Generally the standards used are: L90B10, L80B10 and L70B50, but others are sometimes used (L70B10, for example).

The L figure refers to the output of the LED in terms of the percentage of its total initial luminous flux. The B figure refers to the number of lamps as a total of the percentage that failed to achieve that percentage luminous flux.

For example, an L70B50 figure of 30,000 hours means that after 30,000 hours of operation, in an installation of 100 lamps with an initial luminous flux of 3,000 lumens, at least 50 of these lamps would achieve an output of 2,100 lumens or more. The same installation with an L80B10 figure of 30,000 hours would have at least 90 lamps producing 2,400 lumens or more.

Glossary

CQS (colour quality scale) – Tests to measure (on a scale of 0–100) how well a light source allows a human eye to perceive colour. A CQS of 100 means the light source allows the human eye to render colour perfectly. CQS tests cover a wider range of colours than CRI (see below) and are considered by some to be a more accurate way of measuring LED light sources

CRI (colour rendering index) – A measurement (from 0 to 100) of how well a light source allows a human eye to perceive colour. A CRI of 100 means the light source allows the human eye to render colour perfectly. And older system compared to CQS

Dominant wavelength (λD) – The wavelength that most closely represents the colour of light perceived by the human eye

LED (light emitting diode) – A type of semiconductor light source that emits light when a current flows through it

Lumens – A measurement of light output, i.e. the output of light from a lamp

Lux – A measure of light intensity. 1 lux is equal to 1 lumen per square meter

Peak wavelength (λP) – The wavelength that has the highest relative intensity in a measured light source

Photopic – ‘Day vision’ enabled by cone cells

Scotopic – ‘Night vision’ enabled by rod cells

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