Dairy Lighting Technology Review

For

AHDB Dairy

Written by **Jonathan Sandercock** and **Mike Bond**

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Contents

T: 024 7669 6512 | F: 024 7669 6360 | W: www.nfuenergy.co.uk

NFU Energy, 10th Street, Stoneleigh Park,
Kenilworth, Warwickshire CV8 2LS

1. Summary

Many factors contribute to a good dairy lighting system beyond using the most recent and efficient technology. Managing the photoperiod length, light intensity and uniformity can have significant physiological effects on a dairy herd. Impact on milk production is of key interest in this review, but other benefits such as calf growth, udder health and cow fertility are all affected by lighting systems.

This report explores the benefits of photoperiod length, illumination level and spectral output, and includes a cost benefit analysis of a typical upgrade path. Below are some of our key findings.

Photoperiod length

Long Day Photoperiod, LDPP (16 hours light, 8 hours dark) has a positive effect, improving milk yield by up to 2kg/day compared to a natural day length. LDPP improves natural hormonal response, calf growth and feed efficiency; reduces time to puberty; gives stronger, healthier production cows, when compared to 24-hour artificial lighting regime. It gives a lower Somatic Cell Count (SCC) in milk when compared to a 24-hour regime.

Short Day Photoperiod, SDPP (8 hours light, 16 hours dark) gives increased levels of melatonin, lower levels of prolactin, and lower milk yield in production cows. Dry cows exposed to SDPP give up to 3kg/day increased production in the following lactation.

24-hour Photoperiod suppresses the natural day/night circadian rhythm of the herd. It gives a higher SCC in milk, and no increase in milk production when compared to LDPP regime.

Dairies should expose production cows to a long-day photoperiod, and house dry cows in a separate area that can provide short-day photoperiod. 24-hour lighting should be avoided.

Illuminance levels also affect milk yield. The following are recommendations based on scientific research included in this report. Further study could refine the range of values specifically for UK dairy farms. For any lighting system upgrade, a lighting plan is recommended.

Area	Illumination Level (lux)
Cattle Housing	100-200
Passageways	50-100
Parlour Standing Area	200
Night-time Observation	<10

Spectral output

Blue wavelength is linked to melatonin suppression, which can improve milk yield.

Low levels of red light may be used at night as they are unlikely to trigger a hormonal response.

However, recent studies suggest that spectral output is less important than photoperiod length and illuminance. Standard cool white lighting provides ideal working conditions for operatives. Light levels should be uniform throughout housing and passageways, to eliminate shadows and alleviate cow stress.

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Business case considerations

Based on electrical energy saved, the payback period of a like-for-like LED lighting upgrade is around 8 years. This is less than the life expectancy of the LED fittings and is a worthwhile investment.

If the new lighting system is used to extend the natural winter photoperiod to 16 hours per day, milk yield increase can shorten this payback period to as little as 6 weeks.

Other benefits such as animal and worker welfare are difficult to quantify financially, but should be considered.

2. Background

The GrowSave programme's Dairy Sector work aims to identify and publicise the latest technologies that can help dairy producers to improve their efficiency – specifically energy efficiency, but also it highlights and promotes climate and environmental improvement actions.

In considering the future for the dairy industry and agriculture, we must consider the move towards the "triple P" concept: People, Profit, Planet. This principle outlines the importance of stewardship in an increasingly environment-conscious world, where reputational benefits may also contribute to access to funding, secure the right to supply, or form part of a claim for Environmental Land Management payments (ELMs). The pressure from government to move towards the concept of public goods, ELMs, the Clean Air Act, Agriculture Bill and new welfare codes all provide the rationale for this work to be done.

This report focusses on lighting in dairies, because of its obvious relevance to the sector. The review is wide ranging and contains discussions of techniques, technologies, and principles, in detail depending on availability of evidence. The report is intended as an introduction to light system management for the UK dairy industry and will benefit the industry, also guiding further GrowSave activity.

The report shows that some claims made by manufacturers are upheld by evidence, but others are of less benefit: there are differences between specialist equipment and the products available at wholesalers.

Brief

- To identify emerging lighting technologies in the Dairy Sector
- To highlight research and evidence on the benefits of Long Day Photoperiod (LDPP)
- To investigate technologies' viability and cost effectiveness
- To investigate uptake through anecdotal evidence

Methodology and references

Beginning with a list of sector participants provided by AHDB and NFU Energy's own client base, each invitee was approached with an explanation of the work in hand and a request for a brief phone conversation. Everybody we approached agreed to take part. At this initial discussion, each participant's involvement in the sector was established, and in the case of producers and consultants, they were asked to provide any relevant insights into the areas of technology they considered important and relevant. Where this led to further contacts being provided for follow-up, these were also contacted, for a discussion of their experience and knowledge.

Phone conversations were conducted during July 2021, and a visit was made to a producer who has installed new lighting. Participants who provided us with input to this report include industry professionals, lighting suppliers and milk producers.

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The report summarises the outcomes of these conversations and provides details on the issues discussed, providing recommendations for each. These are, primarily, Long Day Photoperiod and Tailored Spectral Output.

3. Providing Enough Light

Most dairy farms in the UK can be split into two categories: those that have recently upgraded to new LED lighting systems, some taking their lead from others within the sector, and those who still use older technologies such as fluorescent or high-pressure sodium (HPS) lighting that have been in their sheds for years.

The general industry recommendation, apparent from marketing, is that LED lighting is the superior option, especially products that can provide short wavelength light (cool white). In recent years these have become cost-competitive with more established technologies.

The testimonials of dairy producers we approached during this study support this theory: all state how delighted they have been with the results of upgrading to LED. However, what is also clear is that existing lighting systems were often inadequate, not providing the minimum lighting levels recommended by scientific research.

Adequate light levels can be provided by any technology; LEDs bring energy savings and benefits such as spectral output control and dimming capability, but it is unclear whether they also improve herd productivity.

Photoperiod Length and herd performance impact

An important factor in dairy lighting system design is determining how long each day the cattle should be exposed to light, to improve production. Dairies in the UK vary, some using natural daylight cycles, or extended periods supplemented by artificial light sources with some hours of darkness, others adopting a 24-hour lighting regime.

It is important to consider that the photoperiod length has other physiological effects beyond simply manipulating milk yield. It can have a significant impact on calf and heifer growth, quality of milk, and overall animal health.

Long Day Photoperiod

Research indicates that a photoperiod of 16-18 hours followed by 6-8 hours of near total darkness during lactation has a positive effect on milk yield of up to 3kg per day, when compared to a short photoperiod of 9-12 hours light (Dahl & Petitelere, 2003). Cattle increase their feed intake to match the energy requirement for these higher levels of production.

There is debate in the scientific community as to the exact reason that LDPP elicits such a positive response over other light management techniques, however, evidence suggests that exposure to these long days results in increased circulating levels of IGF-1 (Dahl, 2000), an insulin-like growth hormone responsible for nutrient metabolism in dairy cattle.

Prolactin is another important hormone linked to having galactopoietic properties and is essential for maintaining lactation. Like IGF-1, circulating levels of Prolactin are higher in cows exposed to LDPP (Peters, 1981)

The extended hours of lighting also reduce the level of circulating Melatonin, a hormone released during dark periods that is shown to reduce milk yield. A study in New Zealand showed that cows treated with Melatonin supplements yielded up to 23% less milk per day (Auldist, 2007).

A combination of these hormonal responses mediated by LDPP is probably responsible for increased milk production in dairy cows.

There is also evidence that LDPP promotes calf growth and reduces the average age of puberty in heifers. A study carried out by Valenzuela-Jiminez (2015) concluded that heifers treated with LDPP had a significant increase in heart girth, weight and udder biometry, and a lower risk of dystocia when compared to those exposed to shorter natural daylight periods.

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Dry matter intake remained the same, showing that heifers in LDPP conditions are more feed efficient. Another study, by Petitclerc *et al* (1985), supports this theory by proving a positive correlation between LDPP and mammary gland development, among other findings.

Short Day Photoperiod

A photoperiod of 8 hours followed by 16 hours of darkness, known as short day photoperiod (SDPP), leads to increased levels of melatonin, typically resulting in lower milk yield. However, this is the preferred light management system for dry cows. Melatonin is a powerful hormone providing many health benefits in cattle. Cows exposed to SDPP during the dry season show increased expression of prolactin receptors at the mammary, immune and hepatic tissues, leading to greater milk production in the following lactate period by as much as 3-4kg per day. This theorem is expounded in a 2015 paper from the Dept of Animal Sciences at the University of Florida (Dahl, 2015).

Therefore, to maximise production, a suitable lighting control system should be implemented that can accommodate both LDPP and SDPP depending on the season/current lactate period, with dry cows receiving SDPP treatment, and lactating cows exposed to LDPP.

24-hour Photoperiod

A study carried out by Asher (2015) shows the comparison of LDPP against 24-hour lighting. It was concluded that milk yield did not change between the two photoperiods, however there was significantly lower somatic cell count (SCC) in cows exposed to 6-8 hours of near total darkness. Therefore, extending the photoperiod beyond 16-18 hours is unnecessary, and could be considered detrimental to cow health and milk quality.

Shorter lighting periods use less electricity for similar levels of production, and are more energy efficient when energy cost is considered against the benefits. Correctly timed controls are key to facilitating this. By adhering to LDPP and SDPP conditions, depending on the cows being treated, lights should operate for either 16 or 8 hours per day, respectively (or less when natural daylight is sufficient and lights are controlled by suitable sensors).

Illumination levels

When artificial light is used within cow housing to increase the perceived day length in cattle housing, an illuminance level of 200 Lux at cow eye level (approx. 1.5m above floor level) is often recommended by dairy lighting specialists.

While this figure is founded on scientific research, and light levels in several studies have matched or exceeded this, it is typically recommended as the minimum lighting level required within a milking parlour, and not the housing itself. In a recent study by Dong-Hyun et al (2021), an illuminance level of 100 Lux provided by LED light sources within cow housing provided the highest level of milk production. This study was carried out on a farm with an automatic milking system; the authors also commented that other factors, such as the study's location in Korea, may have influenced the result. Korea's lower latitude will provide different levels of solar irradiance during a typical day than in the UK. Further study on the effect in dairy housing of light between 100 and 200 Lux is needed, to determine what is most beneficial in the UK.

LED lighting is known for its low energy consumption, but it is also capable of being dimmed with little or no loss of efficiency. This technological advantage over fluorescent/sodium light fittings could allow farmers to install a light system capable of providing 200 Lux, but then dim the lights appropriately between 100-200 Lux to deduce the ideal lighting levels for their farm. However, this may come at a capital cost premium.

Philips (2000) concluded that 40-120 Lux is the ideal illuminance range for cow movement in passageways and should be considered when designing a shed lighting system layout.

T: **024 7669 6512** | F: **024 7669 6360** | W: **www.nfuenergy.co.uk**

NFU Energy, 10th Street, Stoneleigh Park,
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Yield Increase

Based on Dahl's suggested milk yield increase, specifically attributed to providing a 16-hour LDPP rather than average natural daylight, the following cost benefit can be established:

- Yield increase of 2kg per day per cow
- A herd of 250 will produce an extra 480 litres of milk per day
- At a milk value of 30p/litre, allowing a processing cost 1p/litre, this is worth £140

At a typical electricity tariff of 15p/kWh, this will pay for over 900kWh of energy and is more than enough to support the extra lighting usage.

Implementation

A good lighting control system could improve the consistency of milk production through providing year-round stable day/night cycles for the cattle, releasing the farmer from the day-to-day manual control of lights.

Quite often, farms house their entire herd within one shed, separating dry cows and production cows into different areas. Here, a zonal control system is required to maintain the appropriate photoperiod in each zone.

Dairy lighting specialists work closely with farmers to develop tailored light coverage plans specific to their sheds, capable of zonal control, correct illuminance levels, and suitable control solutions. These can range from simple manual switching to fully automated light level sensing systems, depending on the building and the customer's needs.

Some manufacturers' lighting and control systems offer dimming. The benefits of this are not well documented in research papers, but if required, LED lighting technology is more readily dimmed than fluorescent lighting; sodium lighting cannot be dimmed at all. Dimming may be employed to save energy, and cost, when natural daylight is available and so artificial lighting is needed less, if at all; savings from this mode will depend on individual buildings. Controls and sensor locations must be chosen with care, to ensure that interference responses are avoided, and a stable lux level is provided; it is important to discuss each application with the manufacturer. Also, it should be understood that if sensors become dirty, their sensitivity is reduced, and this can lead to less dimming and smaller savings.

Cattle are not susceptible to flicker: some LED products for cattle have simpler and cheaper driver circuitry to keep costs low. However, dimming features can produce radio interference, which can affect identification systems, particularly automatic tag monitoring.

Where dimming is provided, it can simulate sunrise and sunset through a dimming timer, in preference to a sharp switching step-change; however, there is little evidence to support this improves herd health or productivity.

Cost Benefit

If the yield increase of an LDPP regime is combined with an upgrade to more efficient lighting, the combined improvements create an attractive business case. Running costs are reduced through energy savings, yield income rises, and the two factors combined bring a quick return on investment.

A 400W high-pressure sodium lowbay will consume around 450W and even if the luminaire reflector and cover are kept clean, overall efficiency will not exceed 100 lumens/Watt. An LED fixture typically provides 130 lumens/Watt, and therefore surpasses the sodium fixture by 30%. In theory, a scheme using LEDs will either provide the same lux level as SON but use 30% less power, or provide 30% more light for the same power.

An example of a combined upgrade to new lighting with LDPP is described below.

T: **024 7669 6512** | F: **024 7669 6360** | W: **www.nfuenergy.co.uk**

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- A dairy is lit for 12 hours daily, by ten 400W sodium fittings. At an electricity tariff of 15p/kWh, this will cost £8.10 per day to run.
- The farmer upgrades to 45 LED battens rated at 75W each, providing the same overall light level but with better uniformity and daylight output. Running costs fall to £6.10 per day.
- The scheme costs £6,000 to install (including the new wiring required) and the saving of £2 per day results in a payback period of over 8 years. This is less than the life expectancy of the LED lights and is still worth installing, especially if electricity prices continue to rise.
- The farmer now extends the operation to 16 hours per day during the lactation season. Running costs return to their original level, but yield increases by £140 per day. This covers the cost of the installation in around 6 weeks.

Conversely, if a new scheme is designed to boost light levels while maintaining the existing photoperiod, rather than to save energy, any increased milk yield or animal welfare benefits must be estimated based on anecdotal evidence only and cannot be guaranteed.

4. Tailored Spectral Output

When considering upgrading a lighting system, it is becoming more difficult to recommend anything other than LED lighting. Research and development are heavily invested into improving LED light sources, with ever-improving efficiency: LEDs already outperform alternatives in terms of lumens per Watt.

This transition brings new opportunities to tailor the spectral output of artificial lighting, as LEDs can provide specific wavelengths with relative ease. Coloured LEDs can be used in conjunction with White LEDs to tailor a light fixture’s output for its intended purpose.

What constitutes an ideal light spectrum for dairy cattle is currently inconclusive. Dairy lighting specialists often describe their products as providing short wavelength light in the range 460-480nm. It is well documented that such light is more effective at suppressing Melatonin secretion from the pineal gland in mammals (Asher, 2015). By adopting LDPP during lactation, as discussed earlier in this report, Melatonin suppression for longer periods of time leads to higher milk yield.

However, a recent study (Lindkvist S., 2021) suggests that the wavelength of light that cattle are exposed to is less critical than the photoperiod length and light intensity. It was concluded that the spectral output of light sources used in a dairy shed should be selected to be of most benefit to the operatives’ working environment.

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While the evidence is inconclusive, it would be sensible to assume that a light source that closely matches natural daylight would be effective for production. Figure 1 shows that a white LED light source is uniquely positioned to achieve this, as its broad-spectrum output is similar to daylight. As illustrated, older lighting technologies such as fluorescent and incandescent do not reproduce the range of wavelengths in sufficient intensities, producing spectral distributions very different to that of natural daylight. LEDs do not waste energy producing light wavelengths outside the visible spectrum, unlike many traditional sources.

With equal illuminance levels, a scheme based on LEDs will use less energy than the equivalent fluorescent or high-pressure sodium (HPS) systems common in UK dairies. Instant response to switching is also a big advantage of LEDs.

For overnight periods, light levels need to remain <10 lux to minimise any hormonal response during the cattle's period of rest (Muthuramalingam P., 2006). Other research (Jacobs G., 1997) has shown that cattle are di-chromatic with light receptors in the short to medium wavelengths. Providing a long wavelength light source (red end of the spectrum) for overnight lighting should minimise the risk of disturbing the resting herd. Humans have an additional receptor for red light, so can still observe cattle with relative ease if necessary, during the dark period.

Having a light source that can switch from an output that matches natural daylight, to a low intensity red light overnight, would meet established practice across the industry. While some lighting specialists are working toward solutions that can achieve this using a single light fitting, the same result could be realised with two separate lights controlled independently, which may prove to be more cost-effective currently.

It is believed that the di-chromatic nature of bovine vision enhances colour contrast and makes shadows appear more extreme (Cow Talk, 2015). This, in combination with a cow's limited depth perception from predominantly monocular vision (see image), can make shadows appear as holes in the ground, impeding their movements and causing stress.

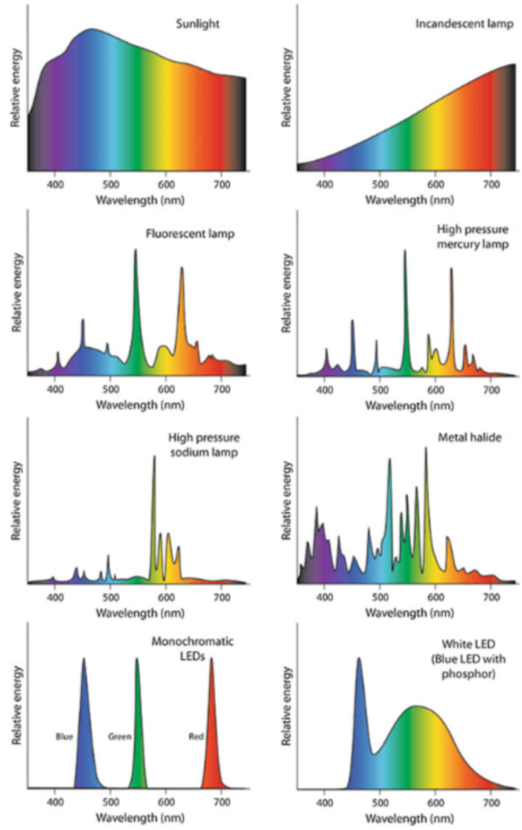

Figure 1 - Spectral output and intensity of different light sources

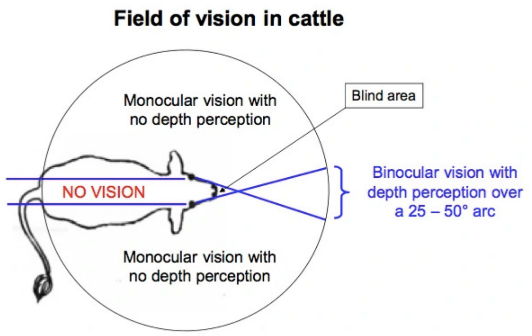

Figure 2 - Bovine field of view

Therefore, a dairy shed lighting system should use light sources that can provide good uniformity across the housing area to minimise shadowing.

Wavelength and CCT

The colour of light is often referred to by its Correlated Colour Temperature (CCT) in Kelvin, referring to its position on a chromaticity diagram. Light of a given CCT will consist of a blend of various wavelengths, each measured in nanometers (nm); a monochromatic light will have only one wavelength and will give the viewer zero ability to distinguish colours (an example is yellow low-pressure sodium light, as used for streetlighting, with 585nm wavelength and CCT of 1700K).

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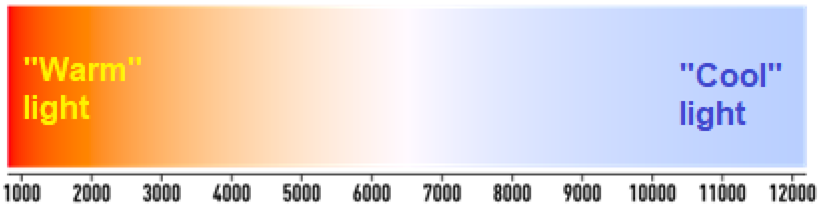
Whilst there is no direct relationship between wavelength and CCT, we can say that "cool" (blue-ish) light with a higher CCT will contain more light of short wavelength than "warm" (red-ish) light which will lean towards longer wavelengths.



Correlated Colour Temperature, Kelvin

The spectrum of daylight is best enumerated as 6500K. A tungsten lamp emits "warm" light at 2500K; halogen, 3000K. Fluorescent lamps range between 2700K…6500K, or higher for specialist lamps; high-pressure sodium is 2000K, and metal halide 4000K.

Manufacturers may also specify a Colour Rendering Index (CRI) rating on the Ra scale, which indicates what percentage of the visible spectrum is represented, i.e. how well the light permits colour discrimination. Generally, modern sources all exceed Ra80. This parameter is less important for cows.

Dutch manufacturer Hato claims that cows perceive red light in greyscale, which would allow them to manoeuvre under red light but not to be stimulated by it. Furthermore, they cannot perceive depth, and are therefore startled by shadows. Its lighting products for cows use correlated colour temperature (CCT) of 4000-5000K, a balance of green and blue light to give an approximation to daylight.

Yield Increase

Unlike the photoperiod science, daylight spectrum lighting has not been proven to lead to a yield increase. There is anecdotal evidence of improved herd welfare, but as lighting upgrades tend to accompany other alterations it is difficult to attribute any yield increase to the lighting spectrum with certainty. The recommendation remains that cool-white light or daylight should be provided in preference to "warm" (longer wavelength) sodium light.

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5. Manufacturers

A number of manufacturers offer tailored spectrum LED lighting products aimed at dairy applications. It is evident that many products with a "daylight" output are widely available in this market, but some are more specialised. All suitable lights offer high ingress protection ratings e.g. IP65 or IP67, permitting easy cleaning from below by pressure washer.

Form Factor and Lighting Design

LED lighting appropriate to dairies may come in a variety of forms:

Highbay: Compact, high-wattage fixtures (typically 100-150W) intended for mounting or suspending above 5m, with high lumen output for wider spacing. A wide, downwards beam.

Vapourproof batten: Linear fixtures similar to traditional fluorescent types. Low intensity opal or frosted cover, for mounting within eyesight. Some types are sealed and prewired with linkable cables and stainless mounting clips.

Festoon: Waterproof lampholders mounted at intervals on a cable, for suspension at any height. Mostly 230V, for users to fit their own lamps. Some are low voltage, or preassembled with non-replaceable lamps.

Retrofit tube: Glass or plastic LED tubes intended to replace fluorescent lamps in existing fixtures. May give narrower light beam than fluorescent. Beware electrical compatibility issues. A compromise.

Corn lamp: LED assemblies intended to retrofit directly into sodium or metal halide HID lampholders. May suffer from disappointing lifespan, or poor optical performance, in an existing fixture. Another compromise.

To ensure the intended light levels and uniformity are achieved by the new scheme, a light plan is recommended. An insufficient quantity of the best light fittings will still provide a bad scheme, whereas too many lights could waste energy. To provide better uniformity without shadow, it is better to use numerous lights at lower height, than a few high-output sources at roof height. Light planning puts luminaire-specific photometric data into widely available software to calculate the lux level and uniformity that will result in your shed, given its dimensions, surfaces, and obstacles. Note that light plans are not available for retrofit products, as these fit into existing luminaires: any photometric data will relate only to the originally intended lamp.

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Manufacturer	Product	Spectrum	Wattage. Control, Dimming	Lifespan	Light plans	Comments
Hato hato.lighting	Rudax	CCT 4000-5000K, green / blue approximation to daylight	Ensures higher intensity blue light after evening milking. Zoning down to individual lights		Every time	Plug-and-play, replaceable, optimised light distribution. Dutch, origins 1974 in poultry, now expanded into cattle
UniLight uni-lightled.com/our-products/livestock/	IP65T8B sealed batten prewired with linkable cabling	6000K	35W, 65W 3,500 or 6,500 lumens Fully dimmable with low flicker	L70 = 50k hours		Constant Lux system extends L70 to 100k hours
	T8HP retrofit tubes	3000K - 6000K	600mm 18W, 1200mm 36W, dimmable	5 year warranty		
	Highbay	-	200W, 300W			
Meltron meltron.com/product/mll/	Meltron Livestock Lights	As UniLight batten				Patented technology for livestock wellbeing
Dairylight www.dairylight.co.uk	Smart Linear batten	White, blue460nm, red LEDs 9000K - 10000K	Day mode 65W, night mode 5W Selected by switching control unit with daylight option	50k hours 5 year warranty	Yes	Originally part of UniLight, now a separate company with its own distinct product
Philips Lighting lighting.philips.com/main/products/naturedynamics	NatureDynamics linkable sealed tubes	Multi spectrum tuneable colour	Various lengths and wattages. Dimming via analogue controller	L70 = 50k hours		NatureDynamics adjusts and adapts light wavelengths that positively influence animals' comfort and health
Feirme Lights feirmelights.ie/dairy-livestock-led-lighting/	IP67 Tubular housings with LED Tubes	Not stated	600mm 10W, 1200mm 18W, 1500mm 25W			Irish company
Intershape www.intershape.com/Lights-ventilation/dairy-lighting.htm	Highbay, 120° beam	5000K	100W, 150W. Timer and dimming controls available	50k hours	Yes (free)	Rather than provide 200 Lux in all areas, designs concentrate on feed passages, with lower levels around cubicles
Cowcare Systems www.cowcaresystems.com/luxum-led/	Luxum LED: sealed tubes, corn lamps, highbays	Plug & Play sealed tubes 6000K	Corn lamps 24W-125W, sealed tubes 28W,	5 year warranty		N. Ireland supplier known for its Agrilight dairy shed sodium fixtures

Hato recommends a standard 16-hour day for optimum yield and melatonin suppression for sleep. It claims that improvements in milk yield may be seen within 2 weeks of upgrade. Tests in China have shown improvements from 9.5t to 10.5t yield per lactation season – an increase of 5-10%, equivalent to 500-1000kg per year, 3.27kg per day per cow. Feed intake also increased during the hot season, leading to higher yield. Stress is said to be lower, and fertility to be increased; clearly these improvements will depend on availability of daylight and the type of lighting being replaced.

Many lighting installations' benefits are inseparable from those brought by other improvements made at the same time. An installation of Dairylight battens was audited by agricultural sustainability measurement experts Alltech E-CO2 and found to have achieved a 9% yield improvement. This was in a scenario where no other factors were altered, even down to feed batch, during the before-and-after trial period.

Intershape finds that clients' existing lighting usually provides insufficient light, and that in all cases, fundamental improvements are therefore possible. One obstacle they encounter is persuading customers that dry cows need a shorter photoperiod and would therefore benefit from a zoning system to separate dry and lactating cows.

Five Key Questions

Prospective suppliers will not always provide comparable data on their products, so we have compiled a list of five questions, and the answers you might hope to receive.

1. **Can you provide spectrum data for your lights? If not, what is the CCT?**

   Manufacturers should know what wavelengths their LEDs emit. They should provide a graph (similar to those in Section 2) of relative output against wavelength. There should be a strong emphasis on the 460nm blue region which is linked to the suppression of Melatonin.

   If not, then the next best thing is to know the CCT, which should be at least 5000K (cool white) but preferably 6500K (daylight). This is a reasonable indicator of high blue content.

2. **Are your lights dimmable?**

   This is a simple yes-no question, but it conceals complexity. If the lights are dimmable, how do you propose to control this – manually, or automatically from a timer or sensor? Who will design and install the controls?

3. **What is your product lifespan? How long is the warranty?**

   Although manufacturers may tell you that LEDs last for tens of thousands of hours, this may not be the case with cheaper products. LED chips require good heat dissipation, or they will fail or fade rapidly. Their electronic drivers are also a key point of failure, with some cheaper units failing to a very annoying flashing state. Ask for the "L70" lifetime – this is the industry yardstick, the point at which light output will have fallen to 70% of its output when new. A good LED product will have been tested to give L70 at ~50,000 hours.

4. **Do you provide a light planning service?**

   This will separate the volume sellers from the solution experts. A good vendor trades on reputation and they will want to ensure their lights are applied correctly to achieve the desired result.

   Never install without a plan.

5. **Do you have testimonials from recent installs similar to mine?**

   The experience of other users is invaluable.

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6. Users' experiences

Ed Towers

Mr Towers runs a dairy in Lancashire, consisting of 260 Holstein-Friesians, and 160-170 Jersey cows. He milks twice per day using a 24/48 herringbone setup. Historically the two breeds performed similarly over a season, where the Holstein-Friesians would produce on average 30 litres per day per cow, with Jerseys producing 22 litres.

The cows are split into different sheds based on their breed. The Jerseys were housed in a shed lit particularly poorly by only two high-pressure sodium lights that were permanently on. The farmer knew he needed to address this issue and was also aware of some of the reported benefits lighting could have on milk production. He decided to experiment with upgrading the lighting system in the Jersey shed to see what effects could be observed.

Rather than approaching specialist dairy lighting suppliers, Mr Towers designed and installed his own system using equipment obtained from wholesalers and other retail outlets, which he saw as a more cost-effective option.

Based on published reports, Mr Towers had a clear aim to achieve a light level of 200 Lux at cows' eye-level. Rather than install high-output fixtures at ceiling height, he instead opted for a festoon system along the stalls and feed passage, with 25-30 lamps spaced approximately 0.75m apart, on each of three rows. Lux levels were measured using an iPhone App.

Mr Towers initially tried to control this system with a light sensor, however, this did not work as intended, so was replaced by simpler On/Off time switch control set to provide 16 hours of operation per day with 8 hours of darkness. No dimming feature was included. The total cost of the installation was approximately £600.

The new lamps make no net energy saving but provide a higher lux level than the sodium lights previously in use. It could be argued that an LED system replicating the lux level from existing SON would save energy.

Mr Towers' opinion is that for the first winter after installing the new lighting system in the Jersey cow shed, they performed better, each producing on average up to 24 l/day, an increase of 2 l/day and an all-time high for the herd. There was no noticeable change in the Holstein-Friesian herd that did not receive a new lighting system, remaining at around 30l/day/cow; he now plans to carry out a similar upgrade in the Holstein-Friesian shed based on his results.

Mr Towers did not observe and noticeable increase in herd fertility but did state that they generally have an average to good conception rate regardless of the lighting system anyway, so changes may have gone undetected.

One observation from the pictures sent is the mix of colour temperatures within the lighting system. This was due to buying lamps from multiple manufacturers, as no single supplier had enough stock for the volume of lights needed at the time of install.

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John Booth

Mr Booth's dairy in north Wales has 340 cows in one shed. Like Ed Towers, he identified that his existing lighting was unsuitable, consisting of 4 sodium lights on manual switches. A few years ago, quotes were sought for an upgrade, ranging from £5,000 up to £15,000; the £5,000 quote was chosen.

The new highbay LED lights provide higher illumination levels than the old system for approximately 16 hours a day; they then gradually dim over a couple of hours before switching off completely for 4 hours. The lights then gradually brighten as morning approaches, simulating sunrise and sunset. This system is entirely automated and has a light sensor that will switch the lights off if there is enough natural daylight. The light output is simply described as "5000K" or Daylight; it will likely contain a higher level of blue wavelengths than red due to the LED fitting.

Initially a wiring problem left the lights on all night, which caused significant stress to the herd. Once rectified, within two weeks Mr Booth noticed improvements in fertility, welfare, and calmness amongst the herd.

Mr Booth enjoys that when he arrives in the morning to milk the lights are already on, providing a noticeable improvement to his working environment. However, he could not attribute any increase in milk yield to the lighting upgrade specifically as he feels there are too many factors that could influenced this.

Energy reduction was not a primary driver for carrying out the upgrade. Four sodium fixtures (probably 400W SON lamps, but possibly 250W) were replaced by 21× 100W LED lights, which consume more energy but provides a much higher level of illumination within the housing. Without knowing load and light levels of the two systems, the improvement in efficiency cannot be quantified, but it is certain that if the old lighting system provided as much light as the new, it would do so by using more electricity.

Mr Booth would have no hesitation in installing similar lighting at another dairy, as he is very happy with the effects on cow welfare and fertility since his upgrade.

Mark Burgess

Mr Burgess has recently upgraded his Dairy farm by erecting a new cattle housing and parlour. As part of this upgrade, he opted to install LED lighting at a cost of £6,000, provided by a local dairy lighting specialist. This choice was influenced by the hope that it would improve herd fertility. Since operating out of this new Dairy unit, Mr Burgess has confirmed that fertility rates have greatly improved and is overall happy with the lighting system. He acknowledges that other factors may have contributed to this, with improved ventilation and cow welfare facilities, but would not hesitate to use a similar lighting system again.

In line with the other testimonials presented here, the upgraded lighting system provides far higher levels of illumination when compared to his old cattle shed. This appears to be a consistent observation of dairy farms across the UK.

Any impact on milk yield cannot be justified as so many improvements have occurred at once, however, Mr Burgess currently adopts a 24-hour lighting regime to try and encourage dry matter intake and improve milk yield. Based on the results of this study, we recommend a trial of the LDPP regime by using simple time switches, and to monitor if this has an impact on milk production.

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7. Review Conclusions

There is clear and well documented correlation between photoperiod length and dairy herd performance. Farms should adopt an LDPP lighting regime during production, consisting of 16-18 hours of light, followed by 6-8 hours of darkness. Conversely, a SDPP regime of 8 hours of light with 16 hours of darkness is recommended for cattle in the dry period. This will maximise milk production in the following lactation.

Illuminance levels in dairy housing should consist of 50-100 Lux in passageways, and 100-200 Lux in feed areas Further study is required in UK Dairies to define this range more accurately. A minimum of 200 Lux should be made available for the cow standing area in the milking parlour.

Observation lighting during overnight periods should be limited to <10 Lux. Providing this with red light may provide less risk of triggering a hormonal response during the cattle's period of rest.

Light uniformity across the housing area and passageways plays a critical role in eliminating shadows, leading to lower stress for the herd, and is an important consideration when upgrading a lighting system.

There is limited evidence that a tailored spectral output provided by specialised light fixtures is necessary in a dairy environment. Light fixtures should be selected for what best facilitates the operatives working environment (cool-white light), and focus should remain on illuminance levels and photoperiod length until conclusive evidence is published.

Lighting specialists should be able to assist in designing bespoke systems, taking into account the physical constraints of each building, and providing suitable control systems.

Sophisticated LED lighting systems can accommodate zonal control, allowing LDPP and SDPP regimes to be adopted within the same shed if necessary.

More elaborate systems will include features such as dimming, to simulate sunset and sunrise and to save energy when natural daylight is available. Energy savings here are difficult to quantify and may vary on an individual basis based on shed design, orientation, and geographical location. There is little evidence to support that such a complex system improves production.

As for the economic benefit, LEDs clearly still bring a saving – it is for the user to decide whether they require a lower energy bill than with their existing system, or a higher light level, or a combination of both. Sodium lamps are highly efficient, as their published data will suggest, but when placed into a reflector, and operated from a magnetic ballast, system efficiency falls; LEDs are easily driven from efficient electronics and are directional sources, so these drawbacks do not apply. With LEDs, light output (in lumens) and circuit wattages are usually quoted for a complete fitting.

A further justification for owners of fluorescent lighting to upgrade to LED lighting is the UK's forthcoming (September 2023) removal from sale of most types of fluorescent tube (excluding T5 types). This is part of the rolling programme of bans on less efficient lighting technologies once suitable alternatives have become widely available.

Energy Technology List

Until 2020, the Energy Technology List[1] functioned as the definitive list of energy saving products that attracted the Enhanced Capital Allowance, which has now been withdrawn. However, inclusion on this list remains a firm indication of a product's low energy credentials. Not all LED products offer the same efficiency, although most should out-perform older technologies.

[1] https://etl.beis.gov.uk/

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