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As we delve further into the effects of light on human and animal biology, some regions of the visible spectrum are being found to have specific effects on animal and insect behaviour, even at fairly low intensities. Therefore, light sources such as incandes-

cent, fluorescent, or LED lamps, must now be considered as more than just a light source, because of their potential control over important bio-functions, depending on the relative spectral intensities of the activating wavelengths.

Biofunctional LED roles



Horse power and oil lamps can be at risk in bad road conditions. But wind & solar powered LEDs could provide safer lighting ethically.

Factors such as melatonin output and the related circadian rhythms (the natural 24.2 hour cycle of behaviour and metabolic changes exhibited by all plants and animals) are mostly influenced by the light-dark cycle. However, it has been recently shown that melatonin output can alter cancer growth rates and colour related wavelengths are showing evidence of physiological activity that may affect both behaviour and/or health.

It is already known that exposure to light is at least a partial cure for a seasonal form of depression (Winter blues [not LED related] or Seasonal Affective Disorder), which is common in Northern winter climates (due to the long nights). Exposure

to bright light can cure this condition and can also assist night shift workers. In the latter case, 15 minute exposures to bright lighting at the beginning, middle and end of the shifts is found to improve worker performance and well being. These effects are observed from either sunlight or artificial lighting. However, beneficial wavelength-specific effects from LED sources have been sought after and, to the potential benefit of LED demand, are now being discovered.

Red (white) & blue for health!

In a recent report, Mariana Figueiro et al, from the Lighting Research Center at Rensselaer Polytechnic Institute, described the results of a pilot study where patients suffering from Alzheimer's disease (AD), with ambient fluorescent lighting levels of 300 lux at the table top, were also exposed to relatively low intensity levels (30 lux at the eye) of 470nm (blue) and/or red (630nm) light from LED sources. The LEDs were arranged along the vertical sides of rectangular frames near to the patients to provide the required LED intensities. When the patients received blue LED exposure, their sleep behaviour became more normal, approaching daytime wake ness and 6-8 hours of sleep rather than the erratic sleep behaviour of short periods of sleep and wake ness common for AD patients.

Additional studies are planned with larger sample sizes and optimistically, light sources for this therapy are being

designed. What will the blue LEDs do next? It is hoped that other LED therapies can be developed, such as LED exposure in the morning to help teenagers ward off their late morning awakenings. Red LED exposure appeared to cause little behaviour change for AD patients, but it has been shown to improve the rate of wound healing, a useful aid for the submariner. What other health related uses for LEDs lie in store for us? Acne treatment and rosacea are both skin problems where the FDA has given clearance for blue LED use [III-Vs Review, August 2003 page 20].

LED safety for the Amish

In the ever widening panorama of application categories for high brightness LEDs, one of the most novel must be the acceptance of LED illumination for their transportation vehicles by the deeply religious Amish group. This historic sect of Pennsylvanian farmers, part of the Anabaptist group, (Mennonites, Quakers et al) have long believed that a simple and devout lifestyle will ease the way to heaven. The Amish have existed on the meager livelihood of a simple farmer relying on horse power, oil lamps and a simple lifestyle with horse drawn buggies (see Figure 1.) providing the essence of their transportation system, especially for religious duties. A characteristic that tends to restrict long distance travel and maintain their tightly knit, self-sufficient communities. Thus, they have long eschewed many of the trappings of

modern day civilization, including automobiles, tractors, telephones, electricity, street lighting etc.

Present in several states and Ontario, Canada, the total population of the Amish community in North America now exceeds one million and they are providing unique market opportunities and novel outlets for high brightness LEDs. They may not constitute the largest market opportunities in the world, but they are leading to the development of advanced lighting concepts that have the potential to fulfill lighting needs in the less developed regions of the world, for other religious groups that do not accept all the modernities of the 21st Century and for those that have to work in remote geographic locations.

In this new application, the white LED headlight units were found to be more effective than the high intensity discharge lamps (the hated blue tinted ones!), which draw six to eight amps per lamp at 12V.

However, the high and directed luminance efficiency of the LED enables the use of (smaller) batteries that can be charged by solar or wind power and that provide about a 15 fold increase in the time between charges. The new LED headlight, which contains eight of the latest Luxeon LEDs per unit (from Lumileds, San Jose, California), each modified with individual optics, is made by SunLine Solar, a partially Amish owned alternative energy business, located in Gordonville, PA, deep in the Pennsylvania Dutch Countryside.

According to Jerry Stern from SunLine, their white-LED headlight design provides wider beam coverage and about 50% extra viewing range, yet only draws 0.6 amps. As part of the total LED solution SunLine also manufactures tail lamps [red LEDs] and yellow/amber running light/turn signals [amber LEDs], both of which have the ability to operate in the flashing mode. Thus, SunLine Solar is the front runner (excuse the pun) in the buggy light-generation race. One up for the Amish in transportation applications! The car manufacturers come second,

with LED-headlight introduction, not expected for three or four more years. The armed forces also have requirements for LED headlights. But the present MIL Spec. design uses 300 to 400 small LEDs, yet having a performance comparable to the SunLine product.

The only negative factor for the LED headlights appears to be cost. At about \$100 per unit, they are two to four times as expensive as the existing buggy headlights, but as usual, external factors such as longer bulb and battery life and the related safety issues are winning the day for the LED system. The total cost for the full LED buggy lighting system, including two to four marker or running lights and tail lamps, is about \$300. The extended battery life, which improves from 6 to 100 hours, greatly increases safety margins by reducing the chances of lighting failure — at the same time increasing the life expectancy of the horse and the buggy passengers on dark country-nights. Just think, the latest high brightness LEDs could become standard equipment on the new buggy — back in your 1hp power unit and off you go!

In spite of the new LED-headlight advantages, life can be even more difficult for some of the stricter religious sects, because they still do not allow the use of headlights. However, in a meeting of the ancient and exceedingly modern, SunLine has recently provided a different LED solution for these travelers by developing new tail lamp units that contain one forward facing white LED per unit, providing some forward illumination and recognition, while still meeting their more stringent group regulations.

Other specialty LED products

In the 'thanks to the government' category, Pennsylvania introduced a law that will soon require all milking houses in the state to have lighting, a service not normally demanded by Amish cows. Again, SunLine came to the rescue with another LED product. The Dairy-Farm special is based on an eight D-battery format and uses 21 x 5mm white LEDs

(this time from Nichia). It provides adequate lighting, meets the legal and religious requirement, lasts for hundreds of hours and from the state's point of view, makes for happier, more productive cows.

Stern also mentioned an additional new product soon to be released, a Personal Security Light, suitable for most emergency applications. Also based on dry batteries and 21 x 5mm LEDs, this portable light will provide many hundreds of hours of useful light in disaster and other emergency situations, for an anticipated cost of \$59 retail.

Steve Mellinger, also from SunLine, mentioned another recent and unique local application for their dry battery lights. In the Amish communities, where midwives often have to assist in child birth by flashlight or candle light and the flashlight batteries are known to run down, one of these boxed LED lights has been evaluated and requests from other midwives are pouring in.

Obviously, either in the D-battery or solar-rechargeable format, all of these LED products developed in Pennsylvania will have wider market appeal to missionaries, residents and professionals in underdeveloped regions of the world, where electricity is not available or is an irregular commodity.

But, the biggest hurdle to their market growth will probably be spreading their gospel around to all these remote locations!



*\$300 for full LED buggy lighting system
A fine tailpiece for greater safety*