Solar Light Emitting Diodes (LEDs): the new standard for navigation lights

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ABSTRACT

Advances in light emitting diode (LED) technology have been remarkable in the last decade, opening up a realm of new applications. Carmanah Technologies Inc., based in Victoria, British Columbia, Canada has taken advantage of LED performance improvements to produce the first fully enclosed, solar-powered LED navigation lights. These lights are more rugged and require less maintenance than conventional marine navigation lights and they are becoming the standard technology used by coast guards, navies and other marine authorities around the world, including the Port of Hong Kong, the Indian port of Kandla, Ha Long Bay and Hai Phong Harbour of Northern Vietnam as well as the US and Canadian Coast Guards. In addition, Carmanah has expanded its core technology for land-based lighting applications that require durable, self-powered lights; the company is optimistic that these new products may become important in port safety and security on shore.

The LED revolution

LEDs are the most fundamental improvement in lighting technology since the invention of the light bulb. Light is produced by an LED when electricity is passed through a small silicon semi-conductor crystal (approximately the size of a grain of sand) causing the crystal to glow.

LEDs have long been known for their incredible efficiency, low DC voltage requirements and longevity, which led to their widespread use in electronics displays. Over the last decade, however, two advances have increased their realm of potential applications. First, experiments with new diode materials and package design have enabled ever-increasing brightness of LEDs. The speed of this development has been compared to the constant gains in computer processing power as the brightness of LEDs doubles approximately every 18–24 months. The new generation of LEDs are now bright enough for navigation lights, air traffic control signals, traffic signals, vehicle signals and outdoor security lights (Figure 2). The second advancement to LEDs was the rapid development in the mid-1990's in the range of available colours, including the most elusive, white.

Depending on colour, LEDs are conservatively estimated by Carmanah to last up to 100,000 hours in the company's solar-powered lights, or 27 years if used for 10 hours a day. This is 20 times longer than the best incandescent bulbs. In addition to their long life, LEDs are shock and vibration proof, making them ideal for marine lighting applications.

Figure 1. Today's LEDs: pure bright colour with minimal losses to heat.

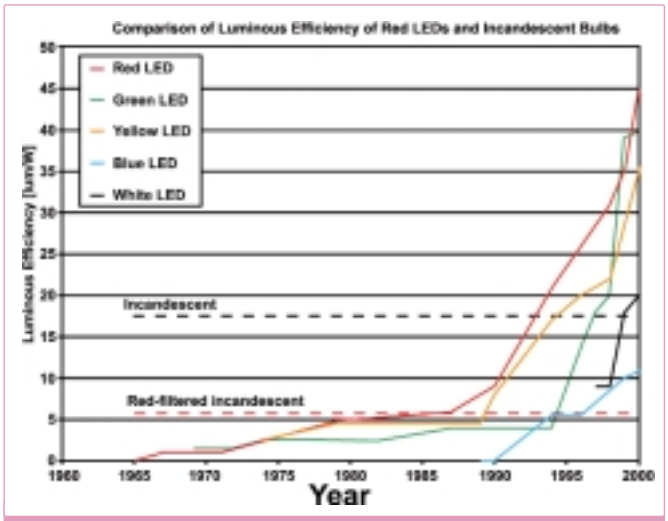

Figure 2. Rise in LED luminous efficiency – adapted from Scientific American, 2001.

Carmanah's marriage of solar power and LEDs

Photovoltaic (solar power) technology has both improved in performance and become more cost-effective over the last twenty years, making it the standard power source for incandescent navigation lights. The high efficiency of LEDs makes using solar power even more desirable for navigation buoys. Solar-powered LED lighting can dispense with large battery systems, large solar panels (usually 0.9 m by 0.6 m) and large frames to hold the panels facing south.

Carmanah's proprietary design has the solar panel, battery and LED arrays fully sealed in a compact, durable polycarbonate/

Figure 3. Carmanah's Model 700 Series, with ranges up to 5.4 km.

Figure 4. Model 701 marking a port side hazard in the Port of Singapore.

polymer housing. The lights are able to operate reliably in northern, cloudy climates, yet they weigh about 1/10th of the weight of traditional solar-powered incandescent units with similar range. Furthermore, no switches or wiring are exposed to the ravages of salt water or UV light. The resulting product is tough and maintenance free for up to five years. There have been reports of Carmanah navigation lights, being knocked free from buoys in storms and washing up on shore, still operating normally. One light was even dropped from a 20 m tower onto cement and survived unscathed. On the West Coast of Canada, a Carmanah light was submersed in 2 m of water when the barge and crane sunk. A month later, the equipment was salvaged and the light was still flashing.

The growing trend towards solar-powered LED lighting

Carmanah now has sales in 110 countries with more than 50,000 units installed. The following are some samples of ports using Carmanah light technology:

Socialist Republic of Vietnam, October 2001: Ha Long Bay and Hai Phong Harbour purchased over 400 units of Carmanah's Model 601 as part of the Government of Vietnam's commitment to invest US$84.9 million in port development and shipping infrastructure, as well as upgrading and modernisation of its current merchant vessel fleet.

China, April 2002: Hong Kong Port bought an initial order of

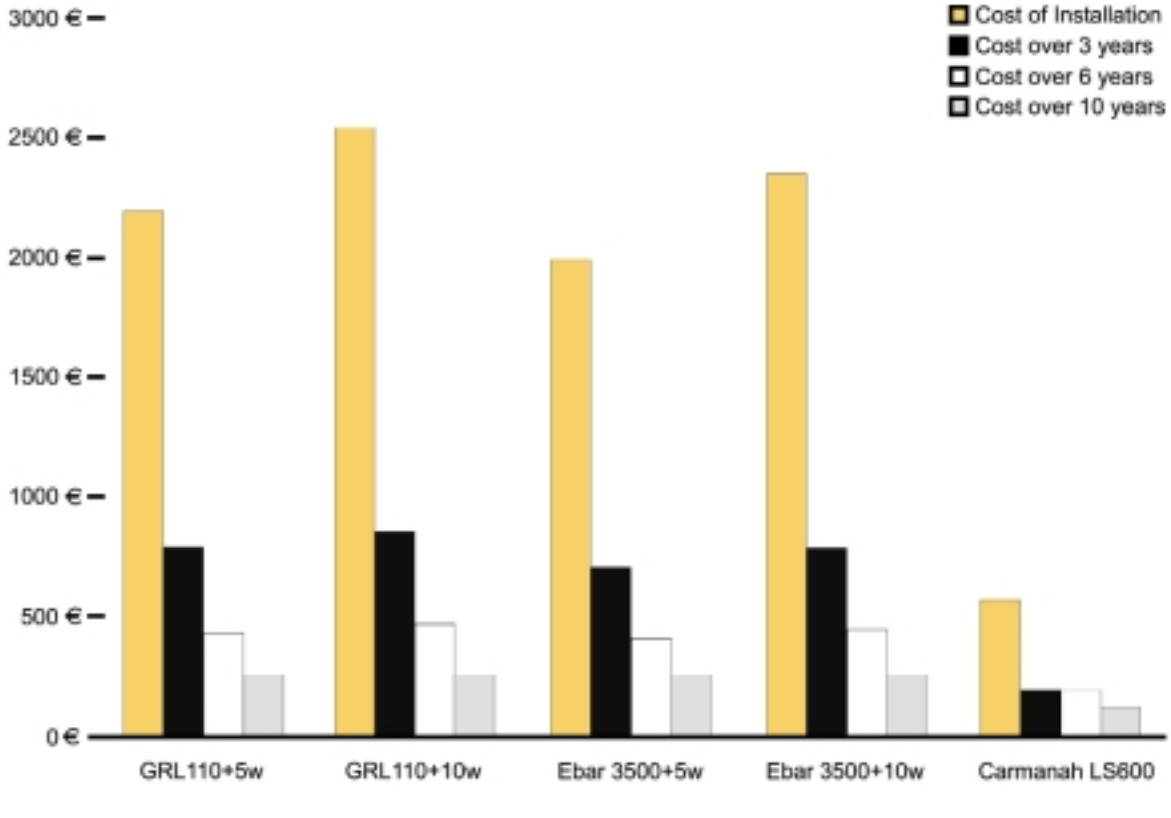

Figure 5. Comparison of acquisition, installation and maintenance costs for navigation lights in the 0-3.2 km range.
(Wallard, Jean-Pierre, XVth IALA conference, March 2002)

10 units of the Model 601 and 28 units of the Model 702-5. The Model 702-5 units will be used to mark bridges that span the main Hong Kong/Kowloon Channel. The port expects to replace all current low range (up to 5.6 km/3 nm) lighting with Carmanah's products, assuming the performance and reliability of these initial units are proven.

Canada, May 2002: Canadian Coast Guard (CCG) developed a Standard Offer Agreement with Carmanah for ongoing purchases to modernise the navigation lighting in all regions of Canada. For the CCG, the real advantage of Carmanah's solar-powered LED lights is that they allow for lighter navigation buoys: 68 kg, rather than 136 kg. The CCG instituted a programme where fishermen could retrofit the lights with minimal equipment. Mike Clements, Manager of the Aids to Navigation Programme for the CCG in Newfoundland and Labrador credits the new technology with enabling the Newfoundland region to establish the first fully lighted aids-to-navigation system in the world.

Carmanah wins tenders primarily because of the compact configuration, low power consumption, quality and performance of its products. At the XVth Conference of the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) in March 2002, Dr. Jean-Pierre Wallard of the French government's Centre for Maritime and River Technical Studies presented a comparison of navigation lights. He noted that Carmanah's Model 601 and 700 Series lights offered the lowest cost of acquisition, installation and operation for three years, compared to lights with similar ranges. The Model 601 also had the lowest cost of operation over 6-year and 10-year intervals for lanterns with a 3.6-km range (Figures 3 & 4).

United States coast guard approval

Carmanah's 700 Series solar-powered LED marine lights were originally developed to U.S. Coast Guard specifications in 1999. In August, 2002, the USCG officially approved the 700 Series models for use in the USCG Aids-to-Navigation System. Carmanah is the first company in the world to receive such an approval for LED-based marine lighting technology.

The USCG is currently performing a rigorous economic analysis of a large-scale conversion to newer LED-based lights, versus the total ownership cost of its incandescent signal lights (Figure 5). Meanwhile, all area and district commanders are officially permitted to use Carmanah's 700 Series lights on discrepancy buoys, ATON stations, small-lighted buoys and other platforms. In September, 2002, Carmanah became a Federal Supply Contractor, and is now able to provide products to all U.S. federal government agencies, including the USCG, without entering a bidding process.

The lights have been well received according to Jon Grasson, Chief of the Signal and Power Team with the Ocean Engineering Division of the USCG, who presented the USCG's experience with

Figure 6. Carmanah lights mark hazards around the world.

Carmanah's lights at the March 2002 IALA Conference. He found that the range, 6-year life and programmable flash rhythms made the lights ideal for discrepancy buoys. The acceptance and use of Carmanah's solar-powered LED lights by the USCG is expected to have international implications, as other regulatory bodies look to the USCG for guidance regarding new technologies.

Land-based port lighting

In the process of producing lights that can operate under harsh ocean conditions, Carmanah has developed a versatile platform technology that can be modified for almost any application requiring a self-sustaining, rugged, no-maintenance light.

Carmanah's enclosed power source concept makes its lights portable, enabling users to cut installation and hardwiring costs dramatically. With the recent emphasis on port security, illuminating security areas around ships and port facilities may become the next application of solar-powered LED lighting. The U.S. Office for homeland security has expressed the need to enhance protection in the U.S. around high-risk vessels, oil refineries and nuclear power plants. George Bush's 2003 budget set aside US$11 billion for border security, with US$2.9 billion allocated to help the USCG keep illegal goods and immigrants from gaining access to the US from its 95,000 miles of coast and 350 official ports of entry. Solar-powered LED lighting will allow for versatile and portable security lighting without large investments in infrastructure.

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Dr. David Green is research manager and founder of Carmanah Technologies Inc. He has an engineering physics degree from the Royal Military College, Kingston, Ontario and a Ph.D. from the University of British Columbia. He is a professional engineer with 20 years of experience. Dr. Green previously founded or was a founding member of several companies including SDL Optics (merged with JDS Uniphase), Seastar Chemicals, NxtPhase Corp. and the Axys group of companies.

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