Presents
The Science of Lighting Snow
Using

If you run a ski resort or winter recreation area you're in the business of ***selling snow***. Snow is your number one product, and our goal is to present your product in the best light… literally. That's why Ultra-Tech™ Lighting has developed a comprehensive line of magnetic induction lighting (MIL) specifically designed to address the complexities and unique requirements of illuminating snow in all its varieties.

No other lighting company has spent as much time or resources perfecting ***the science of lighting snow***™. Until now, snow resort operators have had to use generalized industrial lighting like high intensity discharge (HID) or high pressure sodium (HPS) lamps for night skiing, tubing parks, cross country ski areas, parking lots, snow mobile tracks, and facility lighting. Unfortunately, none of these lamps is specifically designed to provide the appropriate spectrum and intensity required for proper snow illumination. From your own experience, you know that HPS lighting has a monochromatic orange hue that makes color rendition virtually impossible and does not provide adequate shadow resolution. Black ice becomes even more invisible under HPS and HID lamps. By the same measure, the blue bias of HID and LED lamps tends to make all surfaces appear flat. This disguises contours, making night skiing more difficult and subliminally stressful. Snow-Bright™ lighting solves these problems with unique LUMENTEC® spectral tuning while using up to 60% ***less power***.

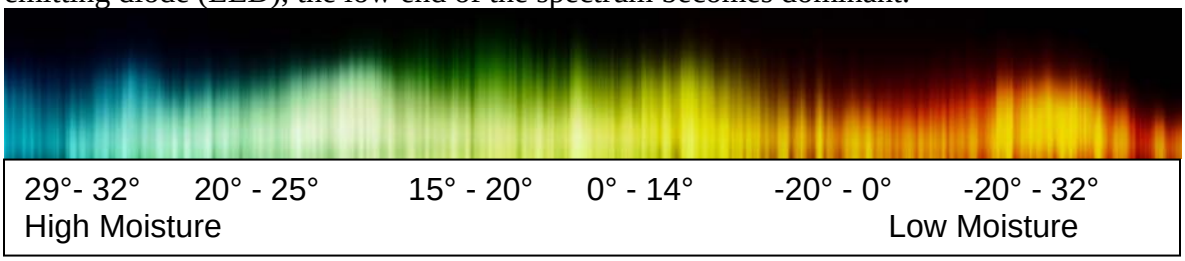
What's So Special About Snow?

As a snow professional, you know there is no such thing as generic snow. The physics and chemistry of frozen water are very complex and fascinating. Photo-reflective properties vary depending upon formation temperature, humidity, and even sunlight exposure. Manmade snow is sensitive to pressure, droplet formation and size, blow angle, latent freeze time, additives, and grooming. Natural snow ranges from "Champagne powder" and dust, to "Sierra cement" and slush. There is everything in between.

Moisture content impacts consistency and reflective properties. High moisture correlates with high freezing temperatures. Of course, moisture is the component of all snow, however high and low moisture is associated with density. A cubic yard of powder snow formed below 0°F can weigh 30 times less than snow formed at or near freezing. Powder exhibits different "settling

patterns" that will form different reflective surfaces. Mixed snow on a bump run will shadow troughs in accordance with opposing faces such as ice, hard pack, and powder.

Believe it or not, snow's light absorption and reflectivity is highly variable based upon its specific properties and how it was formed. For example, natural snow that is formed within three degrees of freezing becomes "blue hue." You have probably noticed how this snow actually appears sky blue. When blue hue is illuminated with blue bias lamps like HID or light emitting diode (LED), the low end of the spectrum becomes dominant.

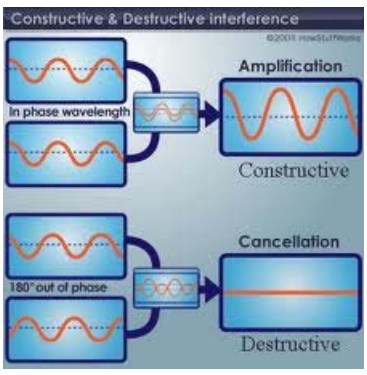


The result is a flattening effect that prevents the eye from resolving contours. Bumps, troughs, and texture blend together. Thus, the snow may appear to be well lighted, but the human eye is unable to actually ***see*** the snow's features.

As the graph illustrates, snow's photo-reflective properties carry along the full visible spectrum. Visible light falls within 400 nanometers and 780 nanometers which is actually a very small portion of the electromagnetic scale. Approximately 50% of sunlight is visible at sea level. When illuminating snow, the objective is to create the greatest intensity within the visually perceivable range (violet, indigo, blue, green, yellow, orange, and red). This is referred to as "visually effective lumens (VEL)." Given snow's unique reflective properties and the enormous variability of terrain, the science of maximizing visual acuity requires a delicate balance of spectrum, intensity, and lighting angle.

What You Can't See Can Hurt You!

Noise canceling headphones have become a popular electronic accessory. Using complementary or interfering wavelengths, it is possible to eliminate sounds within a targeted range. Noise canceling headphones can provide total silence on a jet liner or accentuate the sounds of a concert hall. The same principles apply to light. This is why proper light selection and placement is so important when illuminating snow. Many ski resort operators have experienced "black out" troughs; a confounding blank area on a seemingly well lit slope. Often, the problem stems from combining incompatible lighting such as orange hue HPS and blue hue HID within the same area, or mixing intensities such as 1,000W and 1,500W HID of different color or "Kelvin."



If the crest of one wave meets the valley of another, they cancel each other out. When two light waves cancel each other, the result is darkness called "destructive interference." If the crests of two or more waves are in phase, or almost in phase, they can combine into a larger or more intense effect. This is called "constructive interference."

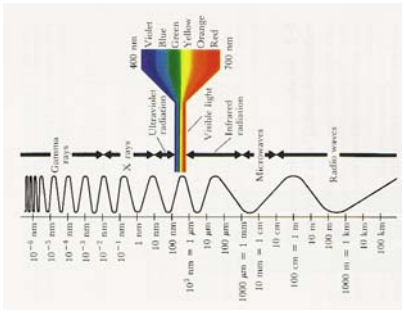
Snow-Bright™ lighting is specifically designed to create

maximum constructive interference from the original source and, equally important, from the reflection off the snow. Understand that white light is made up of all colors and all wavelengths. If one of these colors is subtracted from white light (by interference, for instance) we see the complementary color. For example, if blue light is subtracted from white light, we see yellow. As light bounces off convex and concave snow surfaces, its wavelength can be slightly altered. Depending upon the snow's consistency and surface, light harmonics can develop. Mixed or inconsistent lighting can increase negative harmonics, making it difficult to resolve the snow's surface and texture. This is why the "full spectrum" produced by Ultra-Tech lamps is so effective. Ultra-tech lighting can provide significantly more visually effective lumens using ***60% less power***.

When rays recombine they can get "out of phase" and interfere with each other. Given particular snow properties, a certain wavelength will be cancelled and its complementary color will be seen. Long wavelengths (red) are generated from low moisture, fine, ungroomed snow. When red is cancelled, it leaves a blue-green reflection. As snow becomes denser, yellow is cancelled out, leaving blue; then green is cancelled, leaving magenta; and finally blue is cancelled, leaving yellow. Sometimes lighting is so inconsistent relative to the illuminated surface that cancellation occurs for all wavelengths and the slope appears dark against a gray background. These are frequently referred to as lighting voids. Surprisingly, voids are not always corrected by adding more light. In fact, many facilities managers have been shocked to find that more lighting increases voids.

This surprising complete cancellation is due to the different way light reflects from variable surfaces. When light reflects from the outside surface of a contour (an air-to-water surface) the direction of vibration of the wave is reversed; i.e. all "up" vibrations are turned into "down" vibrations and vice versa. This phenomenon is frequently seen on freshly groomed corduroy where the grooves appear unusually dark despite being relatively shallow and well illuminated. As the slope is skied, it miraculously appears to get brighter and brighter.

The Ultra-Tech™ Snow-Bright™ Difference!



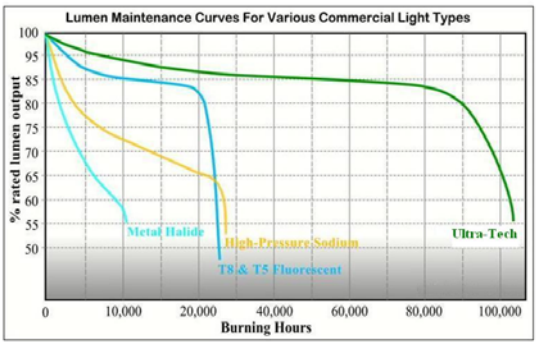
Snow-Bright™ lamps start with a "full spectrum" light using LUMENTEC® phosphorous coatings that recreate visually effective lumens in the same proportions as sunlight. Using the correct geometry, reflectors, and lenses, you can achieve optimal lighting with significant economies of scale. For example, two 300W Snow-Bright™ slope fixtures can produce 20% to 40% more visually effective lumens than a 1,000W HID lamp, saving 40% in electricity. With the right strategic lighting plan, you can reduce the electric load by up to 60% or even 80%.

Snow-Bright™ fixtures are "cool" lamps that are less affected by temperature. By comparison, metal halide (MH) and HPS lighting is very hot and can lose 20% or more in luminosity in temperatures lower than freezing (32°F/0°C). On extremely cold nights, up to 40% of the light output of MH and HPS can be lost. Snow-Bright™ fixtures have an operating range from -40°F to 120°F with little impact upon light output.

Rated at 6,500K, Snow-Bright™ gives you an exceptionally white light with color rendering index (CRI) exceeding .90. The high scotopic/photopic (S/P) ratio improves visual acuity and color rendition, reducing eye fatigue while improving perception.

Equally important, Snow-Bright™ bulbs do not use electrodes. Instead, a magnet stimulates the high energy circulation of electrons to produce light. This gives Snow-Bright fixtures an extraordinary 100,000 hour life-cycle rating; the equivalent of 11 years running 24 hours a day, 365 days per year. Since night skiing is generally less than four hours an evening for approximately 4 to 6 months per year, Snow-Bright lamps can last more than half a century! This translates into more than 600% in maintenance savings compared with conventional ski slope lighting.

Snow-Bright™ fixtures maintain more than 90% of their luminosity over their life-cycle. When compared with other lighting, Snow-Bright offers unparalleled performance. Consider that conventional MH can lose 25% of their light output within the first season! HPS is not significantly better. LED lighting lacks the photometric properties required for slope lighting. The choice is clear. Nothing beats MIL, and no other MIL comes close to Snow-Bright™ fixtures.



Technical Considerations for Minimizing "Light Pollution"

Light pollution has become a major environmental consideration for ski slope managers as we learn more about the adverse effects of artificial light on nocturnal wildlife. In addition, brightly lit slopes can be disturbing to residential areas such as slope-side housing and neighboring villages. In the natural world, the brightest light we experience at night is the full moon which is approximately 0.2 lux at sea level. Even under such extraordinarily low light, the healthy human eye can clearly resolve objects and features. However, moonlight is not sufficient in intensity or spectrum to provide color perception or to resolve writing on the page of a book. Although it is impossible to read a book under moonlight, cross-country skiers frequently venture out under a full moon for an evening trek. This raises the important question, "How much light do you *really* need for effective slope illumination?"

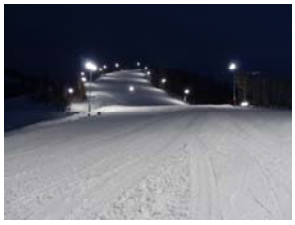
Traditionally, ski facility managers have believed that the more light you can have on the slope, the better the experience. In reality, more light can create more visual problems than it may solve. Equally important, increasing environmental considerations challenge the traditional view of slope lighting. Responsible night lighting must balance external impacts against desired objectives. Lighting a ski slope as you would a sports arena may seem like a good idea, but it is not cost effective and can have serious negative effects upon nocturnal wildlife and neighbors. In addition, excessive night lighting may actually be dangerous if it acts as a visual distraction for pedestrians and motorists.

High intensity lighting creates light pollution, making slopes stand out against surrounding areas.

The "snow-specific" spectrum of Snow-Bright™ lamps provides the ability to lower overall lumen levels by concentrating light within the visual range of the human eye. This is particularly important when considering sensitivities of night predator birds like owls which have fixed frontal eyes and rely upon vision derived from rods rather than cones. This vision is monochromatic since rods do not resolve color. A very bright slope illuminated by 1000W or greater metal halide or high pressure sodium may act like oncoming headlights that can obscure an owl's forward vision. High intensity lamps like metal halide and sodium disturb the natural cycle of insects and have been known to interrupt hibernation in some mammals.

When compared side-by-side, the Snow-Bright difference becomes obvious. Metal halide lamps produce a very bright white glare upon the snow. Skiers are effectively blinded by the contrast between the reflected light and their forward vision. Terrain appears "flat" and without contrast much the way an overcast day causes "flat light." At the same time, the entire surrounding area is subject to the intense reflected glare from the slope… the light is wasted. Orange light from sodium lamps is concentrated in a narrow visible spectrum, making colors muted and indistinguishable. Snow contour is lost and moguls can appear flat. Snow-Bright™ lighting can be configured to provide a more uniform light across the snow without the intense "spotting" produced by conventional generic outdoor lighting.

Retrofit project shows sodium on left, metal halide on right, and Snow-Bright center-right. Notice the high contrast without glare on the snow illuminated by Snow-Bright™ lamps



Snow-Bright™ light in the foreground uniformly illuminates snow with exceptionally high contrast compared with metal halide lights down the slope that produce excessive glare and flatten the snow's appearance.

Ideally, slope lighting should blend into the environment rather than contrast against it. While there may always be more intensity at the focal point of any lamp, the ability to spread light more uniformly reduces contrast. Snow-Bright™ lamps are designed to focus light onto the snow where it is needed rather than into the sky where it causes light pollution.

In many cases, local ordinances actually foreclose night lighting. In Europe, lumen restrictions are as low as "5 x moonlight;" the equivalent of just 1.0 lux. Some communities require "full cut-off" lamps that prevents extraneous light from "bleeding" away from the source. All of these issues can be addressed using Snow-Bright™ lighting.

Snow-Bright™ lamps come in a variety of configurations that can produce the correct reflective pattern for particular terrain. Consider the unique aspects of a slope's vertical geometry in comparison with roads and fields. With few exceptions, the maximum grade (incline) for a U.S. road is only 8% which is less than 10°. Fields are level at 0° pitch. By comparison, a slalom ski course can exhibit more than a 30° pitch. Thus, the typical high intensity lamps used to light roads and fields do not lend themselves to efficiently illuminating ski slopes. This is because the reflective pattern and "throw" is designed for "down-lighting." Yet, virtually all ski areas have been forced to use standard fixtures because that was all that was available. Some areas have resorted to high-mast configurations that are designed for roadways and fields. These lights

A 400-watt Snow-Bright "race-slope" lamp produces an elongated lighting pattern that can disperse light along the vertical slope contour. Unlike conventional spot lights, the light source is over 2 feet long. Lamps can be canted to accommodate specific slope incline.

can be mounted on poles ranging from 60-feet to more than 100-feet high. They produce an enormous amount of extraneous light than can be seen for miles.

For the first time, ski facility managers can actually design a lighting plan that matches the particular application. From a gentle incline in a beginner area to a race course or half-pipe… Snow-Bright™ lighting will maximize the resolution on the snow while minimizing light pollution. Intense blotches of round light are replaced with smooth spreads of uniform and non-obtrusive usable slope illumination.

A typical metal halide bulb offers a single intense point of light.

In order to have a metal halide or sodium fixture spread its light along an angular slope surface, the lamps must be directed along the slope's vertical. This means the light will be pointing downhill, putting light into the eyes of those below the beam. Pointing lamps uphill shines light directly into the eyes of descending skiers. The geometry of a conventional high intensity lamp uses a single concentrated source that is dispersed from a reflector. Snow-Bright™ fixtures use elongated bulbs that disperse light in accordance with slope angles and contours. A Snow-Bright 300W round flood lamp can frequently cover more area than a 1,000W sodium fixture. This is because the reflector works with the bulb geometry to spread light over a wider surface area. This means the lamp can be directed more toward the snow surface and less into the sky. The result is better performance without excessive light pollution.

Snow-Bright™ round wide-area flood uses a tubular circular light source for dispersion across the slope.

Economies of Scale

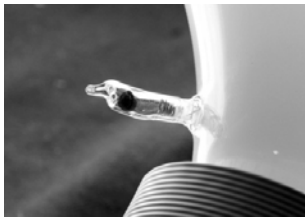
When considering a new night-lighting project, infrastructure and economies play as important a role as light selection. Since Snow-Bright™ fixtures are specifically designed for mountain terrain, they are wind resistant, moisture resistant, light weight, and multi-directional. This usually means mounting pole heights can be lowered to 20 or 30 feet for most projects. Multiple light-weight lamps can be mounted on a single pole. The "throw" of the light can reduce the number of required poles and associated electrical infrastructure. Economies of scale come into play when reducing pole counts, wiring, power, mounting casings, and engineering.

In most cases, two 300W Snow-Bright™ floods can perform better than a single 1,500W metal halide lamp, yielding over 50% in operational savings while generating better lighting performance. Ski facility managers who want to minimize light pollution can actually use lower wattage ratios while maintaining safe and comfortable night skiing or tubing experiences.

Flexibility and Fun with Lights

The "cold bulb" technology of Snow-Bright™ means facility managers can use plastic color filters to change lighting effects when desired. For example, a tubing park can display green and red Christmas lighting, green lighting for Saint Patrick's Day, and anything in between. Of course, care must be taken not to degrade the visual requirements for the illuminated environment. Still, the ability to change lighting effects provides versatility and flexibility for tubing parks, cross country tracks, and gathering areas. (Not recommended for active slopes.)

Environmentally Friendly, Too!



Magnetic induction lights are totally recyclable. This is because bulbs do not use dispersed mercury. Instead, MIL has a solid mercury amalgam "slug" that can be clipped from the lamp for recycling. The remaining glass is disposable like any other glass container. Even the magnetic rings can be recycled as metal, or returned to Ultra-Tech Lighting for reprocessing. Mercury lamps, CFLs, HID, and even LED lighting must be handled as "hazardous waste" which requires Class 3 disposal. Fees for disposing of hazardous waste are being imposed in many districts and can amount to large overheads

In our new era of "sustainability," Snow-Bright addresses all the most important goals:

- Extraordinary life-cycle
- Fully recyclable
- Low energy consumption

With fewer and fewer landfills for hazardous waste, disposal is an important consideration. Although the need to dispose of MIL bulbs is not likely to occur for at least a decade, the fact that Snow-Bright bulbs are not likely to carry a disposal fee is part of creating a "sustainable" plan for the future.

Snow-Bright™ lighting addresses carbon footprint issues as well. When you use Snow-Bright™ lamps, you are lowering your lighting-related carbon footprint by as much as 60% to 80%. This, too, is an important aspect of maintaining a sustainable business that is more "Green" and more efficient. For companies that have issued carbon footprint guidelines, retrofitting to Snow-Bright™ lights can help meet carbon reduction goals.

We invite you to consider the full line of Snow-Bright lighting and urge you to call your representative today to set up an evaluation and lighting audit. See what Snow-Bright™ can do to improve your bottom line while solving all your outdoor lighting needs.

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LUMENTEC® technology tunes bulb spectral output to produce specific light frequencies, color, and intensity. By changing a bulb's spectral output, LUMENTEC® technology can provide the exact light needed for specific purposes.

VARIBEAM™ technology changes the fixture focal length by altering the position of the Ultra-Tech™ Lighting bulb within the fixture. This allows more precise light dispersion over the desired surface areas.

SNOW-BRIGHT™

BY

ULTRA-TECH™ LIGHTING

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