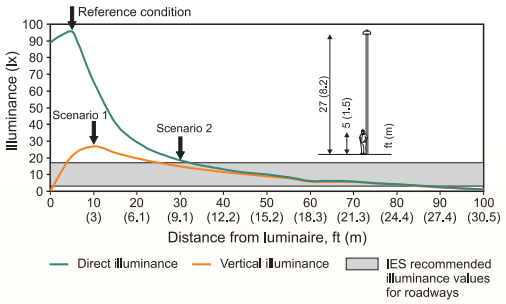
Does outdoor lighting affect the human circadian system?

Every species exhibits circadian rhythms that repeat daily. These rhythms are set primarily by the natural 24-hour light-dark cycle. But civilization, through electric lighting, has changed the natural light-dark cycle that humans experience. Medical researchers have expressed concern over electric lighting as a potential disruptor of the natural light-dark cycle; a wide range of maladies from insomnia to breast cancer have been statistically associated with disruption of this cycle.

Concerns have been raised over light at night as it affects human health through stimulation of the circadian system, with specific attention drawn to the spectral compositions of different outdoor light sources, particularly “cool white” light sources. In response, the LRC, through the ASSIST program, sought to provide a quantitative analysis of the impact of light at night, particularly from streetlights of different spectral power distributions, on the human circadian system.

Analytical Approach

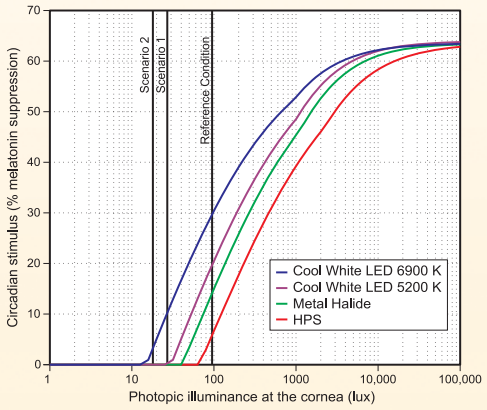
A published model of circadian phototransduction (the conversion of optical radiation to neural signals) was used to estimate levels of circadian stimulation from four typical outdoor light sources under different realistic scenarios. Two commercial “cool-white” LEDs, a sodium-scandium metal halide (MH) lamp, and a high-pressure sodium (HPS) lamp were considered for three conditions: a reference condition similar to what has been employed in controlled laboratory experiments, and two realistic scenarios that could occur with an outdoor lighting installation. Those irradiances for a one-hour exposure with natural pupils were used to calculate the degree to which the circadian system of a 20-year old would be stimulated, defined operationally in terms of the percentage of melatonin suppression.



Reference condition (direct view of the luminaire) and two lighting scenarios used to calculate effective circadian light stimulation for four light sources.

Results

Under the two realistic scenarios, three of the four sources would not meaningfully stimulate the human circadian system after one hour of exposure, while one source (a 6900 K LED) is predicted to have a small stimulating effect (corresponding to 3–10% melatonin suppression). Although this represents a state-of-the-art analysis of light-induced melatonin suppression, there are several limitations to this analysis including uncertainty as to how light exposure at night might affect human health through the circadian system.



Melatonin suppression (%) in response to two “cool-white” LEDs, metal halide, and high-pressure sodium sources plotted for a range of corneal photopic illuminance levels.

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