Computer Simulations to Predict Performance of UV Energy Systems

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When new healthcare facilities are designed, engineers use product data and computer simulations to predict the performance of building systems including HVAC, electrical, lighting and structural. Product data and simulations allow the proper design with the least amount of resources. With UVGI systems, most of this design occurs as a rule of thumb or using adjustments after the space has been built to ensure the dosing is correct. Being able to perform the same types of predictive simulations used for visual lighting can help spaces be designed more efficiently to ensure adequate UVGI performance with minimal energy and fixture cost. Computer simulations can also allow fixture designers to create more efficient fixtures.

The first step is characterizing how efficient a product is at getting energy from the UV source out of the fixture and how that energy is distributed. In occupied spaces, the largest consideration is limiting the amount of UV energy that ends up in the occupied regions, effectively requiring UV energy to stay in the upper regions of the spaces. This requires fixtures that keep light directed upward and outward to adequately fill the upper region of the room uniformly for the most effective kill rate.

The product data can be simulated by raytracing software already commonly used for luminaire design, like Photopia from LTI Optics. Most software allows for wavelength specific analysis, to take into account how UV energy is attenuated in the fixture both over distance and when it intersects with reflectors, louvers or lenses. Figure 1 shows an example of two fixture types (curved reflector and louvered) that both limit the downlight into the space but with different efficiencies (86% vs 13%).

Physical fixtures can be measured in a photometric lab on a goniophotometer, as long as the photometer has sensors that are adequate for the applicable UV wavelengths. The output of these measurements will be the total UV energy out of the fixture as well as how that energy is distributed. Historically there was no standard file format for capturing this data, but it was commonly placed in an IES LM-63-2002 file, the same file used for standard lighting products. The IES has a new standard, TM-33 which will allow for including of wavelength based data.

Once the product level performance is known, the room level performance can be simulated. Metrics such a fluence in the upper room region (µW/cm3) or irradiance on surfaces like a patients bed (µW/m2) are the desired outputs of these simulations. For these simulations, a CAD model of the room is imported into raytracing software like Photopia, or application software like Visual from Acuity Brands.[1] The product level performance data is imported in the form of an IES file, and then appropriate surface properties are assigned to the room surfaces. The result is shown in Figure 2, which shows the fluence rate in the upper room and the maximum irradiance at eye level.

Having methods to measure or predict the product level performance of UV fixtures ultimately allows building engineers to predict the room level performance before construction. This allows for the design of systems that will meet requirements for the least energy and cost.

References:

[1] Rudnick S, First MW, Sears T, Vincent RL, Brickner PW, Ngai PY, Zhang J, Levin RL, Chin K, Rahn RO, Miller SL, Nardell EA, Spatial distribution of fluence rate from upper-room ultraviolet germicidal irradiation: experimental validation of computer-aided design tool. *HVAC&R Research.* 2012;18(4):1-21.
[2] T Sears, Visual 2012 UVGI Basic Tutorial (2012)

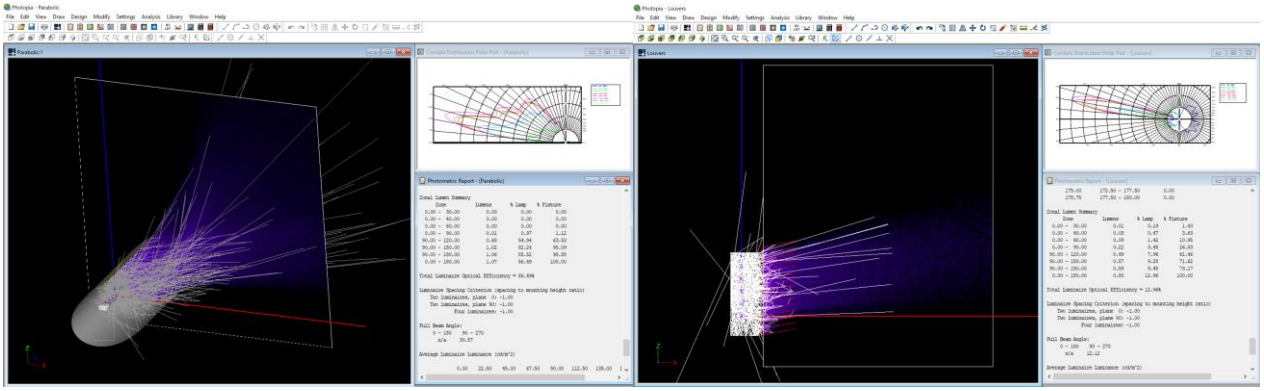

Figure 1. Image of raytraces of UV fixtures in Photopia from LTI Optics.

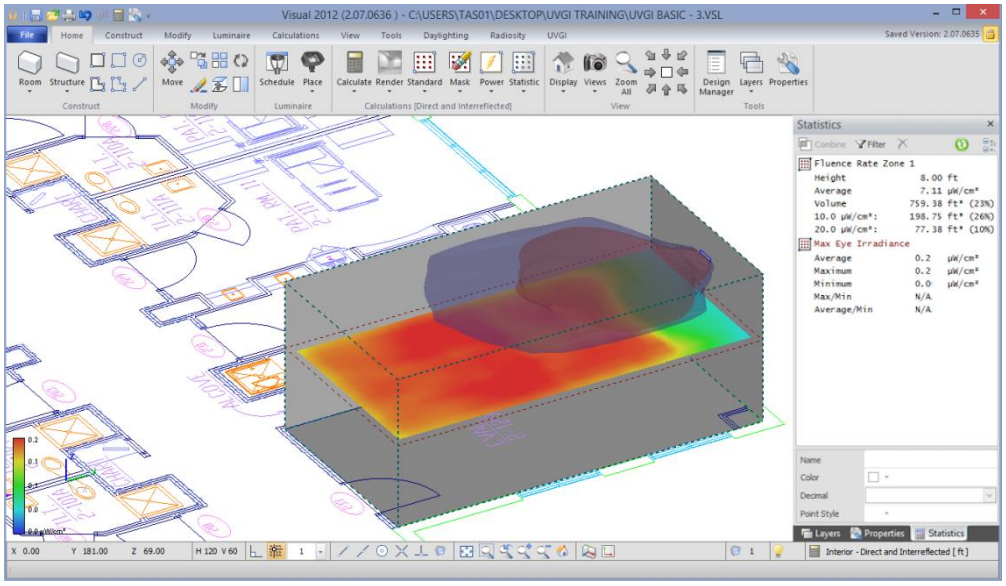

Figure 2. Image of Visual Lighting Software from Acuity Brands, with example calculation of UVGI fluence rate in upper room zone and maximum eye irradiance at eye level. [2]