The Sky Glow Comparison Tool

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Introduction

► Much concern raised in recent years regarding LED street lighting conversions and perceived increases in sky glow and associated effects.

► Most projections not based on realistic assumptions for U.S. conversion projects, vis-à-vis field experience to date.

► The commonly proposed remedy of limiting CCT involves a potentially significant energy penalty among other possible tradeoffs, while being of limited or no effectiveness.

► The DOE SSL Program therefore conducted its own investigation of street lighting and sky glow in 2016-2017.

► The investigation created a limited "universe" of results from 215,000+ runs of a well-known sky glow model.

► Those results in turn led to the development of this _simple_ tool.

Purpose of the Sky Glow Comparison Tool

► Up to now the outdoor lighting community has had:

- No simple means of evaluating their impact on sky glow, positive or negative.
- No way to test the validity of assertions by others.
- No real means of working with SPD.

► The sky glow tool is a first-order approach to addressing these gaps, using standard inputs and outputs familiar to a lighting audience.

► The tool enables relative comparisons between impacts of different lighting system characteristics, specifically: uplight, lumen output, and spectral content (SPD), under a limited set of input conditions.

► Intended to help identify the most effective means for addressing sky glow associated with an individual system or design.

► The outputs are provided in terms relative to the selected baseline, and are *not absolute*.

Derived from 215,000+ runs of *Skyglow Simulator*

▶ Variable parameters investigated include:

- ■ 3 cities of varying population (3,500 to 500,000)
- ■ 2 lumen output levels
- ■ 2 emission functions (Garstang or cosine)
- ■ 5 atmospheric conditions (4 clear with increased loading, 1 cloudy)
- ■ 11 SPDs
- ■ 4 uplight percentages (0%, 2%, 5%, 10%)
- ■ 2 observer locations
- ■ 2 output types (non-weighted irradiance or scotopic illuminance)
- ■ full visible spectrum in 80 increments (5 nm each)
- ■ => ~215,000 runs

Scattering functions drive the spreadsheet

► 48 separate scattering functions were derived from the results, one for each of the different possible combinations of input conditions

► Any SPD can now be input and results are calculated by interpolating among the 5 nm results for the given scattering function (i.e., the selected set of input conditions)

INPUT CONDITIONS

1. Scenario Parameters

Observer location	near
Atmospheric condition	clear low particulate
Weighting function	scotopic

2. Baseline Light Source Characteristics

Percent uplight	0%
Baseline source	1. HPS Example

3. Comparison Light Source(s) Characteristics

Percent uplight	0%
Lumen output (% of baseline)	100%

Clear   Calculate

The Sky Glow Comparison Tool

► Simple inputs/outputs familiar to the lighting community.

Different tabs for different steps

Procedure

1. Select or input Spectral Power Distributions (SPDs) of products to be compared

"SPD Input" Tab

CCT Calculator

Input Wavelength &
Value in any increments

The tool interpolates/averages to 5 nm
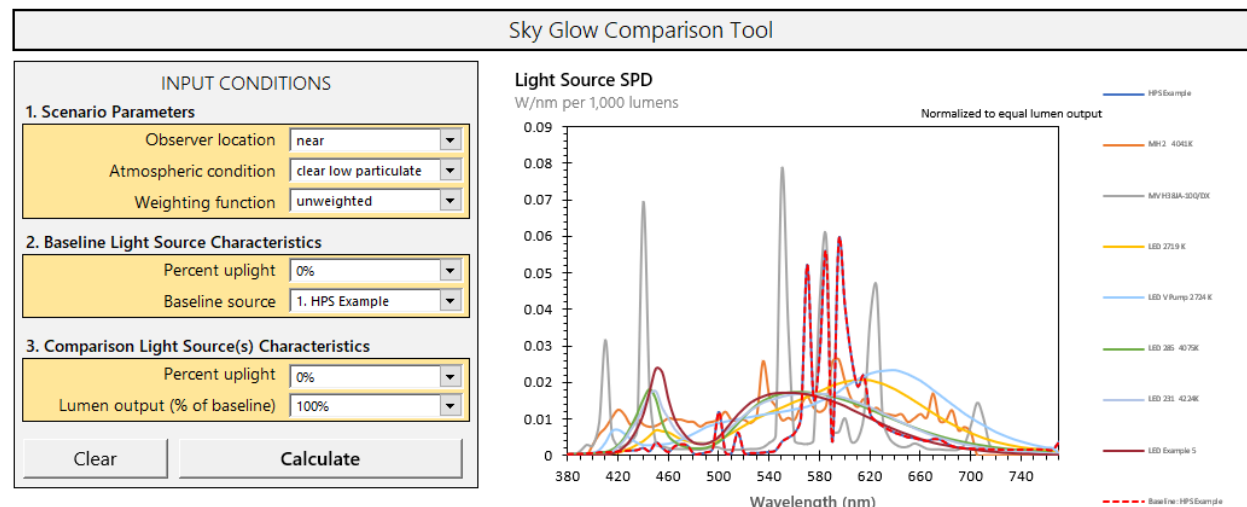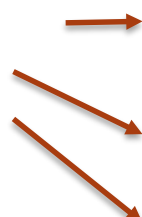increments and then normalizes to 1000 lumens

Procedure

2. Choose parameters / characteristics and click "Calculate"
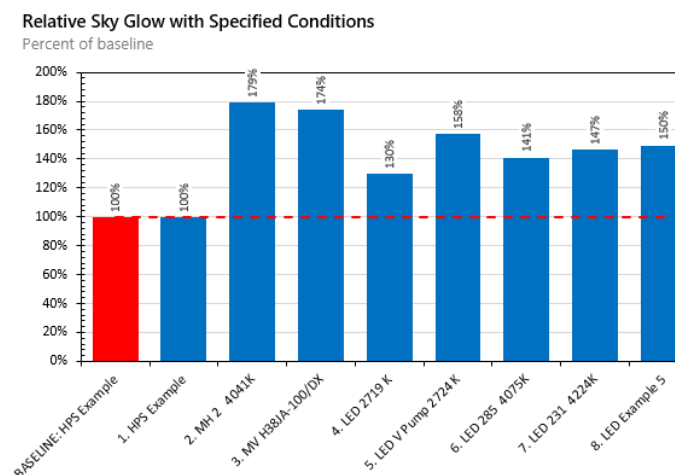
"Calculate" Tab

Drop-down menus

Graphs of Source SPDs

The SPDs being compared show a relative sky glow "score," compared to the baseline
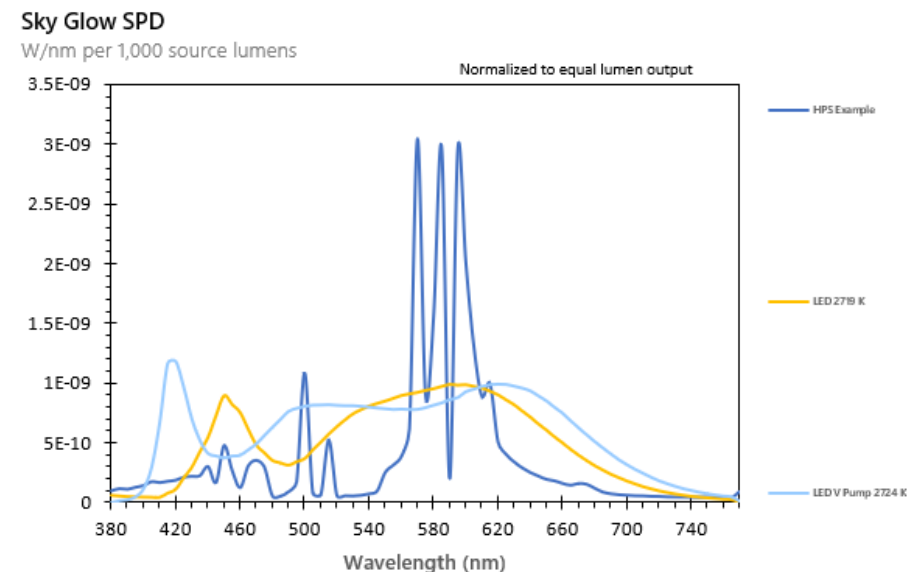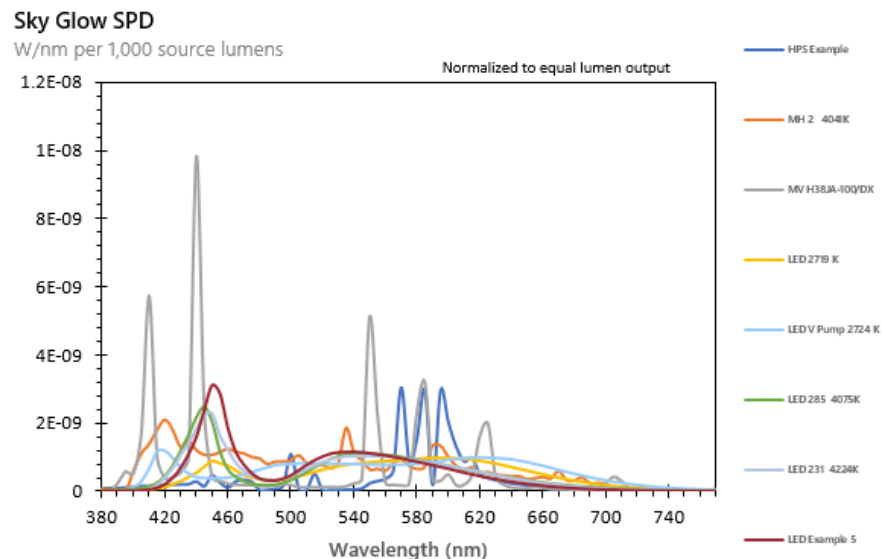
Relative sky glow score displayed graphically

Procedure

► Graphics of both Source SPDs and Sky Glow SPDs are displayed

Calculate Tab

All SPDs that were evaluated in this run

Can be filtered to only display selected sources of interest (click on chart, then press "Filter" button, make selections and press "Apply")

Live Demo

Inherent Limitations of the Comparison Tool

▶ The universe of results is "fixed," e.g.,

- 3 sets of atmospheric conditions are substituting for virtually infinite variability in reality

- Results only modeled at two observer locations, at edge of city and 40 km distant from city center

- Light output characteristics of luminaires are only approximate, e.g., 0%, 2%, 5%, 10% uplight

- *It's not a model!* Best used for comparison between scenarios to investigate *relative* effects rather than absolute

▶ Original investigation focused on street and area lighting; other significant contributors to sky glow (e.g., buildings, signage) are <u>probably not represented</u>

▶ The results reflect the state of the model in early 2017; ongoing updates are continuous
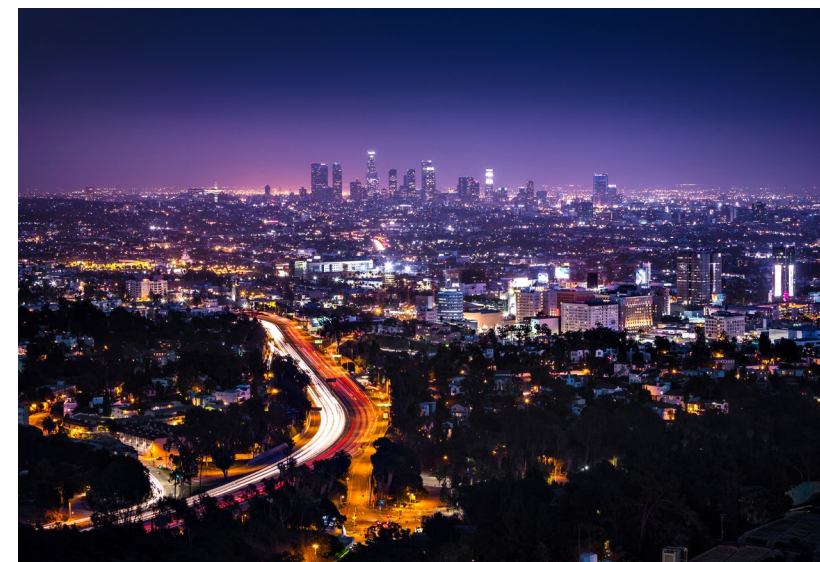
Thank you

▶ The Sky Glow Comparison Tool can be requested from the DOE Solid-State Lighting Website (https://www.energy.gov/eere/ssl/potential-impacts-led-street-lighting-sky-glow)

▶ Questions, bug reports, etc. can be sent to skyglowtool@pnnl.gov

Sky Glow SPD
W/nm per 1,000 source lumens
Normalized to equal lumen output

Legend:
- HPS Example
- MH 2 4041K
- MV H38JA-100/DX
- LED 2719 K
- LED V Pump 2724 K
- LED 285 4075K
- LED 231 4224K
- LED Example 5