



# SEAD Street Lighting Tool

## Reference Manual

The SEAD Street Lighting tool is an Excel-based tool for calculating the expected energy use, light performance, and lifecycle cost of street lighting upgrades for the most common road configurations. This document describes the inputs, calculations, and operation of the tool. It is intended to be used as a reference manual, answering specific questions about the inputs required by the tool and how the calculations are performed. If you have additional questions, please email [stoolkit@superefficient.org](mailto:stoolkit@superefficient.org).



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## 1 Overview

The SEAD Street Lighting Tool provides the capability to quickly calculate the expected energy use, light quality, and lifecycle cost of street lighting upgrades.

The inputs for the tool are spread across five steps, as outlined in each of the following sections. Broadly speaking, the tool:

- Allows for inputs describing the road and light fixtures along it. The tool assumes uniform pole placement and lane configuration for straight road sections only.
- Uses photometric data from .ies files to calculate light quality on the road surface for multiple fixtures at once.
- Determines whether these fixtures pass or fail light quality criteria, as input by the user and described in relevant lighting standards.
- Performs lifecycle cost analysis for fixtures compared to a single baseline fixture.

### 1.1 Tool Requirements

- Windows operating system or virtual machine
- Excel 2003 or later
- Macros enabled (use a search engine for your Excel version to determine how to enable macros).
- After downloading the tool, the user needs to save it to their hard drive

## 2 Define Road

Road geometry inputs describe the size and shape of the road section, as well as the placement and size of poles. This page is used to provide the tool with the basic layout of the road to be analyzed.

The road geometry tab has two columns for inputs, one for baseline and one for upgrade. Two columns are provided so that, if desired, the road configuration of the baseline calculation can be different from that of the upgrade. However, the tool always performs both calculations; therefore, values must be provided for both baseline and upgrade columns. If any of the values in either column are blank, the tool will not perform the calculations.



Description:	Baseline	Upgrade	Units	
<b>Road Geometry</b>				
Number of Lanes	6	5	Lanes	?
Lane Width	3.3	3.3	meters	?
Median Width	4	4	meters	?
<b>Light Geometry:</b>				
Pole Placement	Median mounted	Median mounted		?
Luminaire Mounting Height	8	8	meters	?
Pole Spacing	28	28	meters	?
Pole Setback	0	0	meters	?
Arm length	3	3	meters	?
<b>Pavement Type (only required for luminance calculations)</b>				
Road Surface Type	R3	Standard Surface		?

Figure 1: Inputs for the “Describe Road” input page

## 2.1 Road Geometry

The three inputs for the road geometry describe the size and shape of the road surface. These are shown in Figure 1 above.

### 2.1.1 Number of lanes

#### What it is:

The number of lanes is the total number of lanes in the road section being analyzed. Enter the number of lanes for which you want the analysis to be performed, regardless of the number of lanes on the road itself. For example, if you only want to perform analysis for one travel direction, only enter the number of lanes in that direction.

#### How it’s used:

Combined with the lane width and calculation method ([see the ‘Lighting Standards’ section](#) for definitions of the two methods, CIE and IES), the tool calculates the location and number of grid calculation points for the light on the road. For the CIE method, there are three grid points per lane across the road; for the IES method, there are two.

The tool calculates results for any reasonable number of lanes (20 or less).

### 2.1.2 Lane width

#### What it is:

The lane width is the lateral distance (across the road) of a single lane.

#### How it’s used:

The lane width is used to calculate the spacing of the grid points across the road. For example, in the CIE calculation method (see the ‘Lighting Standards’ section for a definition of the CIE and IES methods), the



measurement grid points are located at 1/6, 1/2, and 5/6 of the lane width. The tool assumes that all lanes being analyzed are the same width.

### 2.1.3 Median width

#### **What it is:**

In roads with an even number of lanes, the median is the space in the road between the two travel directions.

#### **How it's used:**

The input for number of lanes accounts for all travel lanes to be studied. When there is an even number of lanes, the tool assumes that the median occurs half way between the total number of lanes. The lane width increases the distance from the side of the road to the second half of the lanes (i.e. lane 3 and 4 of a 4 lane road).

As of version 1.7.0, if you enter a median width but select an odd number of lanes, the median width will be ignored.

## 2.2 Light Geometry

This section describes where the fixture is located in relation to the roadway.

### 2.2.1 Pole Placement

#### **What it is:**

This input describes the arrangement of the poles along the road. The tool assumes that the pole arrangement is the same along the entire section of road to be analyzed.

#### **How it's used:**

There are four arrangement options to select from. When performing the calculation, the tool assumes several cycles of fixtures occurring before and after the measurement grid, placing them in relation to each other and to the road based on the pole placement choice. These are:

**Single-side:** Assumes poles are only on one side of the road, at an even pole spacing which is the same as the pole spacing entered.

**Staggered:** Assumes poles are placed on both sides of the road. The poles on side A are identical to the placement of those in the single-side arrangement. Half-way in between each pole on side A, there is a pole on side B.

When choosing a staggered configuration, it is important that the 'pole spacing' input reflects the distance between the poles on a single side of the road. The distance between pole 1 on side A and pole 1 on side B will be half the pole spacing.

**Median-mounted:** In this arrangement, two fixtures are mounted on the same pole, located in the center of the road, facing opposite directions. The distance between the first pole (with fixtures 1 and 2) and the second pole (with fixtures 3 and 4) is the 'pole spacing' input.

In this configuration, the 'pole setback' input is ignored. However, the arm length value is used. With an arm length of zero, the fixtures are assumed to be in the same location in the center of the road but facing towards opposite sides of the road.



**Opposite:** In this configuration, there are poles on both sides of the road, but they are directly across the road from each other. On both sides of the road, the distance between fixture 1 and fixture 2 is the pole spacing.

### 2.2.2 Luminaire Mounting Height

**What it is:**

This is the distance above the road surface that the fixture is located.

**How it's used:**

The tool uses this input to determine the vertical distance from the surface of the road to the fixture. In many cases, this is close to the pole height; however, things like arm curvature, road shoulder, and pole base that are above or below the road grade, etc. can mean that the pole itself is longer or shorter than the actual mounting height. Be sure to enter the actual value of the fixture's location directly above the roadway.

### 2.2.3 Pole Spacing

**What it is:**

The distance between any two fixtures along the road.

**How it's used:**

In all cases, this is the distance between two poles that are on the same side of the road. Be careful when entering this value for some pole configurations, such as the staggered configuration; for more information, see the pole configuration definitions above.

### 2.2.4 Pole Setback

**What it is:**

This is the distance from the edge of the road to the base of the pole. Some countries may refer to this as "clearance".

**How it's used:**

The distance from the edge of the road to the fixture in the x-direction (across the road) is calculated as:

$$\text{Edge of road} - \text{Pole Setback} + \text{Arm Length}$$

### 2.2.5 Arm Length

**What it is:**

Horizontal distance from the center-line of the pole to the center point of the fixture.

**How it's used:**

The tool calculates the x-direction location of the fixture above the road per the equation shown under Pole Setback. It's important to note that this is only the distance in the x-direction, i.e. across the road – in cases where the arm is mounted at an angle, the length entered should only be the projection of that arm onto the x-axis.

## 2.3 Road Surface Type

**What it is:**

Luminance is the amount of light reflected off the road surface as seen by an observer standing a set distance away from a point on the road. In addition to the relevant distances, angles, and fixture



brightness, luminance is influenced by how reflective the road surface is. Road Surface Type is the input defining which standard road surface type the tool will use in calculating the luminance of the scenario described.

**How it's used:**

Both CIE and IES calculation methods (see the 'Lighting Standards' section for a definition of CIE and IES methods) share the same 4 standard pavement types. The tab 'Rtables' contains the assumptions used for each road type. If the user does not enter a road type, the R2 road type is assumed.

**R1 (mostly diffuse)** - Portland cement concrete road surface. Asphalt road surface with a minimum of 12 percent of the aggregates composed of artificial brightener (e.g. Synopal) aggregates (e.g., labradorite, quartzite).

**R2 (mixed diffuse and specular)** - Asphalt road surface with an aggregate composed of a minimum 60 percent gravel (size greater than 1 cm). Asphalt road surface with 10 -15 percent artificial brightener in aggregate mix.

**R3 (slightly specular)** - Asphalt road surface (regular and carpet seal) with dark aggregates (e.g. trap rock, blast furnace slag); rough texture after some months of use.

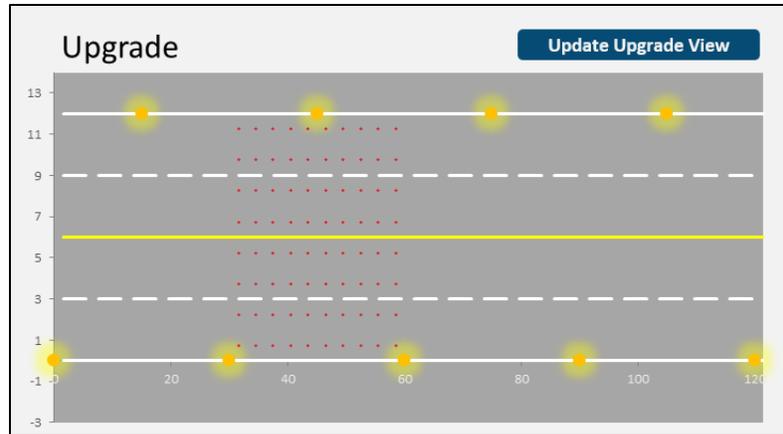
**R4 (mostly specular)** - Asphalt road surface with very smooth texture.

## 2.4 Road Layout Graphs

The tool provides graphs showing how the tool interprets the inputs provided to help the user understand and visualize the layout selected. These graphs do not influence the calculations or update automatically.

There are two graphs, one for the Baseline input column (i.e. inputs in Column C) and one for the upgrade column (Column D). Clicking the 'Update view' button after inputting data will refresh each graph.

There are slight variations in the assumptions for the CIE and IES calculation methods, specifically (1) in the placement and number of grid points where calculations will be performed and (2) in the number of fixtures that must be included for the calculations. The user is prompted to select which calculation method they would like to see visualized; however, since in the next section users can choose to perform calculations for one method or for both methods, this choice does not affect the assumptions used in the actual calculations. See the Lighting Standards section for more information about the differences between the CIE and IES methods.



### 3 Set Lighting Targets

There are two measurement properties that describe light quality of a road - illuminance (light hitting the road) or luminance (light seen by an observer). The tool performs calculations for both properties - you may enter targets for either or both.

The first input in this section determines which set of calculation assumptions will be used – those defined by the IES standard or those defined by the CIE standard. However, the rest of the assumptions on this page do not affect the calculated light levels on the road; they are only used for determining whether a specific fixture passes or fails the user selected targets. Regardless of whether a specific fixture passes or fails, all of the results relevant to that fixture will be presented in the output file.

#### 3.1 Lighting Standard

##### What it is:

This input tells the tool whether to use the assumptions relevant to lighting standards defined by Illumination Engineering Society of North America Standard RP-8-00 (IES) or the Commission Internationale de L'Eclairage Standard 115:2010 (CIE). Users can select IES, CIE, or choose to repeat the calculations for both methods. If users select 'both,' two separate output files are created. This only specifies the way the inputs for illuminance and luminance are calculated, users can enter target values from the standard of their respective country.

##### How it's used:

While based on the same fundamental formulas, the CIE and IES methods differ in several specific inputs including:

- **Measurement grid:** To calculate the light level, the tool performs calculations at specific points along the roadway, and then uses these values to calculate average light levels and uniformity; this array of points on the road is referred to as the measurement grid. In the CIE method, there are three grid points per lane across the x-direction of the lane (located at 1/6, 1/2, and 5/6 of the lane width); In the IES method there are only two grid points (at 1/4 and 3/4 of the lane width).
- **Number of fixtures:** At each measurement grid point, the tool calculates the light level resulting from the light output of several nearby fixtures – including both those before and after the grid under consideration – and then sums the light output of all fixtures that are taken into account.



The CIE method includes the light contribution from additional fixtures that are located further away from the grid point than those taken into account by the IES method.

- **Distance of the observer:** When calculating luminance, the observer is located 83 meters away from the first luminaire in the IES method, and 60 meters away from the first luminaire in the CIE method.
- **Alignment of the observer:** For luminance calculations in the IES method, the observer is aligned with each measurement grid point. In the CIE method, the observer is placed in the center of each lane, and luminance calculations are performed for each grid point relative to this center position; the value used is the lowest of each of these iterations.

### 3.2 Targets and uniformity

After calculating the luminance or illuminance level for each fixture, the average lighting levels and uniformity ratios are compared to the targets provided by the user, determining whether the fixture passes or fails the criteria. Whether the fixture passes or fails is indicated in the outputs, and denoted with a different color in the output graphs, as shown in Figure 2 below. These targets don't affect the calculation of light levels – if they are left blank calculations will be performed and the fixtures will be marked as passing or failing based on a target of 'zero' for each input.

## Illuminance vs Wattage

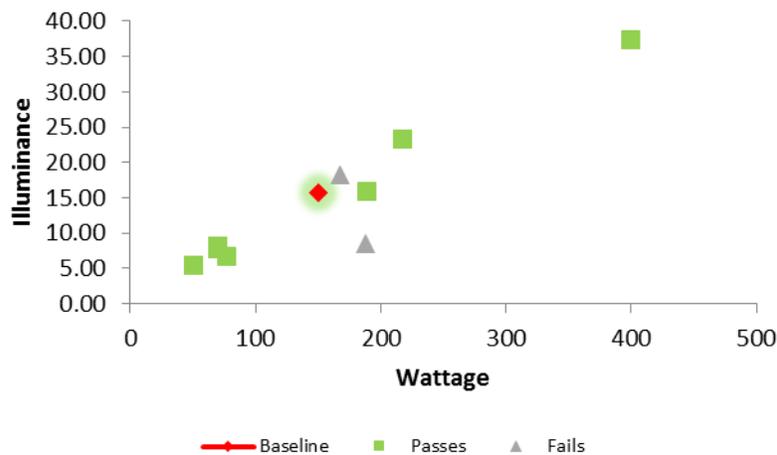


Figure 2: Example Output

The tool performs calculations for both the illuminance and luminance properties; however, these results are independent of each other and are presented separately. The user chooses whether to calculate luminance and illuminance properties using the CIE assumptions, IES assumptions, or both.

#### Determining targets:

Users can find target lighting levels for their road in the relevant lighting standards, which present minimum required light quality levels that vary based on road size, traffic volume, and pedestrian volume. These minimum standard levels, along with the calculation methods, are defined in Illumination Engineering Society of North America Standard RP-8-00 (IES) or the Commission Internationale de L'Eclairage Standard 115:2010 (CIE). However, it is important to note that target levels do not need to



come from these standards – many local and national standards are based on these but set different targets. In addition, you can use the ‘IES’ or ‘CIE’ method for the calculation assumptions used (see previous input), but still assign targets that do not match the targets in the standard.

When choosing a lighting target, you should also consider how you would like your results to be displayed. Any fixture that does not meet the target, even by a small margin, will be marked as failing.

### 3.2.1 Average Illuminance

The average illuminance is calculated as the average across all grid points. Fixtures that have an average illuminance greater than the target level indicated are assumed to pass this criterion.

### 3.2.2 Uniformity Ratio (Illuminance)

The uniformity ratio used for the illuminance calculations is the ratio of the illuminance level of the grid point with the lowest individual value to the average illuminance level across all grid points. In the IES method, this is the ratio of the average illuminance divided by the minimum illuminance, and should therefore be a value greater than 1. In the CIE method, the ratio is inverted, with minimum illuminance divided by average illuminance, and should be a value that is less than one.

In the IES method, a fixture meets this criteria when the calculated value for that fixture is less than the entered target (i.e. calculated value is closer to 1). In the CIE method, a fixture meets the criteria when the calculated value is greater than entered target (i.e. calculated value, again, is closer to 1).

### 3.2.3 Illuminance Pass/Fail Criteria

A fixture is marked as pass only if it meets both the average and uniformity criteria.

### 3.2.4 Average Luminance

The average luminance is calculated as the average across all grid points. Fixtures that have an average luminance greater than the entered value are assumed to pass this criterion.

### 3.2.5 Uniformity Ratio (Luminance)

The luminance calculations have two types of uniformity – the ratio of the average to minimum level and the ratio of the maximum to the minimum level. The average level indicates the mean value of all points in the measurement grid. Minimum and maximum levels are the levels of individual grid points.

In the IES method, these ratios place the minimum in the denominator, i.e. they should be values that are greater than 1. In the CIE method, the minimum is in the numerator, i.e. the value should be less than 1.

In the IES method, a fixture meets each of these criteria when the calculated value for that fixture is less than the entered target (i.e. calculated value is closer to 1). In the CIE method, a fixture meets the criteria when the calculated value is greater than the entered target (i.e. calculated value, again, is closer to 1).

### 3.2.6 Luminance Pass/Fail Criteria

A fixture is marked as pass if and only if it meets all three criteria for that method (average and both uniformity methods).



## 4 Choose Fixtures

The tool takes inputs related to the fixture's light output, energy use, and costs to perform analysis of how each fixture will perform on a specific road. The tool provides the ability to store a library of data about different fixtures, and then select which of these fixtures will be included in a particular analysis.

The tool can analyze one single baseline fixture and an unlimited number of upgrade fixtures in each analysis batch. For some calculations, such as light level, these results are presented side-by-side. For other calculations, such as the return on investment, all upgrade fixtures are compared to the single baseline fixture.

Fixture assumptions come from a variety of sources:

**Light output:** Extracted from the photometric data contained in the .ies file corresponding to the individual fixture, supplied by the fixture manufacturer. This data is extracted from the file once, and then saved to a library of fixture data, which is stored on the FixtureData tab. This tab does not need to be used or modified by the user; all necessary changes can be made through the Fixtures tab.

**Fixture costs:** Default fixture costs are provided for each technology type (i.e. high pressure sodium, metal halide, and LED), and are automatically added by the tool. However, default fixture costs are only rough estimates, and any time the user has more realistic data these should be used instead.

**Light depreciation factors:** The tool also provides default values for the light depreciation factors to be used. These can be overridden or changed by the user as desired.

The tool provides a selection of default fixtures that can be used while learning to use the tool; however, these are not comprehensive and any analysis of actual road segments should rely on additional fixtures added by the user.

Fixtures are assumed to include the effect of both the lamp and the ballast, when relevant; see the note in the 'Watts' assumption below for information on this. In addition, the tool assumes that the same fixture is used on each of the poles that contribute to the light in the measurement grid (including several fixtures before and after the grid section, as shown in the graphs in the 'Describe Road' section.

### 4.1 Add a Fixture

When using the Fixture tab, the first step is to add the appropriate fixture data from the .ies files relevant to your analysis. You can get .ies files directly from the manufacturers for each of the fixtures you are considering using; you can also use resources like the Design Lights Consortium Qualified Products List (<https://www.designlights.org/QPL>) to find a list of possible fixtures and manufacturers that make quality LED lighting fixtures.

By clicking the 'Add a fixture' button, you are taken to the 'Add IES Files' tab. This tab lists eight steps, which are explained in more detail below:

**Step 1: Save the IES files you would like to upload to the tool into a folder on your hard drive.**

**Step 2: Select "Add files to list below."**



**Step 3: Use the dialog box to find the folder where the files are saved on your hard drive. Select one of the files in the folder and click “Open.”** You only need to select one file, but the tool will populate the list below with all .ies files it finds in that folder. You can delete any row below Row 20 (right click the row number and then click ‘Delete’) if you do not want that fixture included. You can also copy/paste to rearrange the order of the files.

**Step 4: Enter a name for the fixture that you can use to identify the fixture in the tool analysis (the default will be the file name).** The tool automatically enters the file name here, but you can change this text to be anything you want. You must enter a unique name for each fixture, so make sure the name you use only occurs once, taking into account other fixtures already listed on the ‘Fixtures’ tab. The tool will automatically add “\_#” to the name if it finds a duplicate, where # is a sequential number for each instance of a non-unique fixture name the tool finds.

**Step 5: Enter the Fixture Type (HPS, MH, or LED).** The tool does not populate this field automatically, but the field must have a value before the tool will upload an .ies file. The Fixture Type field is used to determine which set of default assumptions should be populated for the fixture described in the .ies file under consideration. You can override any of these assumptions in step 6, or after uploading the .ies by editing these values directly on the Fixtures tab. If all default assumptions are overridden, this field has no effect, but it still requires a value during this step.

Acronyms are translated to the relevant language – see the ‘Assumptions’ tab to view the translated acronyms.

**Step 6: If desired, enter data for optional inputs found in Columns D-K.** If you leave any of these fields blank, the default value for the selected fixture type will be used. See the sections of this document corresponding to each of these inputs in the “Choose Fixtures” section for definitions of how these values are used in the calculations.

**Step 7: Select “Begin upload of IES files listed below.”** Each .ies file will be read, and its data will be added to the ‘FixtureData’ tab and a new fixture will be added to the ‘Fixtures’ tab on a new row. A message box will inform you that the process is complete.

**Step 8: Return to “Fixtures” tab and select the fixtures that you want to include in this analysis.** After uploading data on a fixture, that fixture can be used in any future analysis. However, for each analysis you have to select which fixtures you want to include (which can be done on the Fixtures tab).

After adding new fixtures, you can select the ‘Fixtures’ tab or click the ‘Back’ button to return to the main Fixtures page.

## 4.2 Delete a fixture

Deleting fixtures makes the list of fixture choices easier to read, and can reduce the file size of the tool. Deleting fixtures is optional - the tool can still run with as many fixtures as you’d like in the library, as long as you don’t exceed Excel’s data limits (approx. 1,000+ fixtures for Excel 2003, depending on their complexity, and much higher for Excel 2007 and above. The limit on data pertains to the number of rows available on the ‘FixtureData’ tab.



Clicking on the 'Delete a fixture' button takes you to the 'Delete IES' tab. To delete a fixture, simply select the fixture name from the list and click 'Delete Fixture Data.' Note, after deleting a fixture, you cannot undo the deletion. You will need to re-add deleted fixtures using the original .ies file.

After deleting a fixture, you may see a calculation error in the 'Selected file' box – simply re-select another file from the list to fix this error.

After deleting fixtures, you can select the 'Fixtures' tab or click the 'Back' button to return to the main Fixtures page.

### 4.3 Choose Baseline Fixture

Since only one baseline fixture is included as part of any calculation, only one fixture can be selected. Simply click on the fixture name from the list in the box shown in Figure 1. When you select a fixture, its assumptions are shown in the table to the right. These assumptions are for reference only – they cannot be edited here.

This list draws directly from the table featured in the 'Choose Upgrade Fixture(s)' section. To edit any assumptions about the baseline fixture, you can change any of the yellow fields in this table starting at Row 36.

#### 4.3.1 Set Installation Cost to Zero

If the fixture is already installed, the 'Equipment Cost,' 'Installation Cost,' and 'One-time Rebate or Subsidy' will most likely be zero. You can change these costs (and other relevant costs) in the Fixture table starting on Row 36. However, to make it easier to set these installation costs to zero without editing or losing the values in the main table, you can use the entry in Row 23 to override the value used in the main fixture table (found in the 'Choose Upgrade Fixture(s)' section). To do this, simply enter an 'x' (without quotation marks) in cell B23. The cost values actually used by the tool will be displayed in the Baseline Fixture Summary table in Column F.



## Choose Baseline Fixture

Select one of the fixtures from the list below. To edit the fixture assumptions, find the fixture in the table below

**Baseline Fixture**

<No Fixture>

A - HPS 70W Type II

B - HPS 100W Type II Short

C - HPS 100W Type III Med

D - HPS 150W Type II

E - HPS 150W Type IV

F - HPS 150W Type IV

Set installation cost to zero?

Fixture already installed (mark with 'x')

*If the fixture is already installed, installation cost will be zero. Instead of editing this in the large table below, you can override the values for just the baseline fixture here.*

### Baseline Fixture Summary

Fixture Name	0
Manufacturer	0
Type	?
Model #	0
Distribution Type	0
Comments	
Watts	?
Equipment Cost (\$/fixture)	?
Installation Cost (\$/fixture)	?
One-time Rebate or Subsidy (\$/fixture)	?
Annual Maintenance Cost (\$/year)	?
Maintenance inflation rate (%/year)	?
Total Light Loss Factor	?

Figure 3: Baseline Fixture Choices

### 4.4 Choose Upgrade Fixture(s)

You can select as many upgrade fixtures as you would like to be included in a single analysis. Note that selecting a large number of fixtures may result in the analysis taking some time to calculate, depending on your computer's processing power.

To indicate that a specific fixture should be included in the analysis, place an 'x' or 'X' (without quotation marks) in Column B beside the fixture you would like to include. The row for that fixture will then be highlighted in blue, indicating that the fixture is selected. The total number of fixtures selected is shown on Row 32.

### 4.5 Fixture Assumptions

All of the assumptions for each fixture are stored on the 'Fixtures' tab or the 'FixtureData' tab. Each row of the table at the bottom of the 'Fixtures' tab is an individual fixture. Except for the values featured in Column D, all fixture assumptions are read either from the .ies file when it is uploaded, from the default assumptions based on the fixture type, or from user inputs during the upload process. Sections 4.5.1 to 4.5.18 include detailed descriptions of each assumption type included in the table.

#### 4.5.1 Include?

**What it is:**



Use this column to indicate whether a fixture should be included in the current calculation. Use an 'x' or 'X' to indicate which fixtures should be included.

#### 4.5.2 Fixture Name

**What it is:**

The unique identifier for each individual fixture whose information is stored in the tool.

**How it's used:**

The Fixture Name links the assumptions listed the 'Fixtures' tab to the data from .ies files, which are stored on the 'FixtureData' tab. This name can be any value you choose, but you cannot change the name once you've added the fixture to the tool. Instead, you should delete and re-add the fixture with the new name.

Note to advanced users – if you do need to change the name, you can do so by changing the name to the exact same string on both the 'Fixtures' and 'FixtureData' tabs. You must also make certain that the name is not the same as any other name currently in use, or the tool may use incorrect values in calculations.

#### 4.5.3 Fixture Data Row

**What it is:**

The row on the 'FixtureData' tab where the .ies photometric data for a specific fixture begins.

**How it's used:**

The tool searches the 'FixtureData' tab for the Fixture Name in Column C, and identifies the first instance where the Fixture Name appears. It is for reference only.

#### 4.5.4 Manufacturer

**What it is:**

The company that makes the specific fixture.

**How it's used:**

This data is read from the .ies file when the fixture data is uploaded to the tool. It is for reference only.

#### 4.5.5 Type

**What it is:**

The technology used in the fixture – high pressure sodium (HPS), metal halide (MH), or light emitting diode (LED). This is provided by the user when the fixture is first added to the tool.

**How it's used:**

This is used for determining the default assumptions used in the other fields, such as cost and lumen depreciation.

#### 4.5.6 Model Number

**What it is:**

The specific fixture model assigned by the company that makes the fixture.

**How it's used:**

This data is read from the .ies file when the fixture data is uploaded to the tool. It is for reference only.



#### 4.5.7 Distribution Type

**What it is:**

The category of the pattern of light intensity that comes from the fixture. The fixture types defined by the Illumination Engineering Society of North America are referenced.

**How it's used:**

This data is read from the .ies file when the fixture data is uploaded to the tool. It is for reference only.

#### 4.5.8 Comments

**What it is:**

Any user specific comments on the fixture.

**How it's used:**

It is for reference only.

#### 4.5.9 Watts

**What it is:**

The total power consumption of the fixture, including ballast and bulb, in the operation mode to be analyzed.

**How it's used:**

This data is read from the .ies file when the fixture data is uploaded to the tool. The user should check that this value is accurate, particularly for HPS and MH fixtures. Some manufacturers (incorrectly) use the nominal wattage in this field, while the tool assumes that it will be the operational wattage. The user can change this value, if needed, after data on a particular fixture has been uploaded from an .ies file.

This value is multiplied by the operating hours to obtain the annual energy use for the cost calculations performed by the tool. The value does not affect light output – if the user wishes to change the drive current of a specific fixture, you must change both the wattage and one of the light depreciation factors (such as the ballast factor).

#### 4.5.10 Equipment Cost

**What it is:**

This cost should be the all-in equipment cost for the fixture, including the fixture purchase cost, new mounting arm and pole if needed, and any other miscellaneous wiring or ballast costs. If this is your baseline fixture (i.e. already installed), the fixture cost should be zero.

**How it's used:**

This cost is added to the fixture installation cost to calculate the cost of ownership in year zero for all cost calculations.

#### 4.5.11 Installation Cost

**What it is:**

The installation cost should be the all-in cost for installing the fixture, including street closure costs, labor costs, etc. as relevant. If this is your baseline fixture (i.e. already installed), this cost should be zero.

**How it's used:**



This cost is added to the fixture installation cost to calculate the cost of ownership in year zero for all cost calculations.

#### 4.5.12 One-time Rebate or Subsidy

**What it is:**

Enter any rebates or subsidies to be subtracted from the overall equipment cost on a per fixture basis.

**How it's used:**

The rebate or subsidy value is subtracted from the sum of equipment and installation costs to calculate the cost of ownership in year zero.

#### 4.5.13 Annual Maintenance Cost

**What it is:**

The annual maintenance cost should reflect the cost of maintaining the fixtures and poles. This should include the cost of periodic relamping, cleaning (washing of LED fixtures), and repairs. It should include estimates of street or lane closures when relevant, on an average per fixture basis. For example, if 10% of your fixtures must be replaced every year, the maintenance cost would be 1/10 of the cost of replacing a single fixture.

**How it's used:**

The annual maintenance cost is multiplied by the maintenance inflation rate to determine the cost of maintenance each year. The equation for total cost of ownership each year is shown in Equation 1 below, in section 4.6.

#### 4.5.14 Maintenance Inflation Rate

**What it is:**

The estimated inflation rate of maintenance rates due to increased labor costs, etc. This value should be just the percentage rate above 0%.

**How it's used:**

The equation for total cost of ownership each year is shown in Equation 1 below, in section 4.6.

It's assumed that the maintenance costs increase by the same percentage every year, compounded annually.

#### 4.5.15 Lamp Lumen Depreciation

**What it is:**

This value reflects the depreciation in light output due to fixture degradation as it ages.

**How it's used:**

This factor should represent the percent of light that is still output at the end of the fixture life. This contributes to the total light loss factor.

For LED fixtures, the default LLD is 0.7. This represents the level that is commonly agreed to be too low for the fixture to continue to be used (i.e. the point at which the fixture has reached the end of its useful life). If your analysis assumes a specific life that is shorter than when the fixture reaches L70 life, you should refer to manufacturer data to determine the appropriate LLD for that life.



LLD is influenced by operating temperature and drive current, as well as fixture design, so check that the manufacturer estimates take into account these considerations. For countries that use the IESNA standards, LLD is best determined using the methodology outlined in IES TM-21.

#### 4.5.16 Luminaire Dirt Depreciation

**What it is:**

The fraction of light output that actually leaves the fixture when dirty. Fixture output can be reduced due to dirt, soot, etc. Typical values can be found in appropriate lighting standards based on the cleanliness of the air and environment, such as in IES RP-8.

**How it's used:**

The LDD contributes to the total light loss factor.

#### 4.5.17 Ballast Factor

**What it is:**

The ballast factor is the ratio of an actual light's output to the light output of that fixture using a reference ballast.

**How it's used:**

The ballast factor contributes to the total light loss factor. For LED fixtures, this will typically be 1 – LED fixtures are tested using absolute photometry, where the light output is measured using the actual ballast. In conventional fixtures, a single test can be used for a fixture that can use multiple ballasts; the ballast factor is used to correct the data in the .ies file when a different ballast is used than the one that the fixture was tested with.

#### 4.5.18 Total Light Loss Factor

**What it is:**

The cumulative effect of the LLD, LDD, and BF in the previous three inputs.

**How it's used:**

A total light loss factor of less than 1 reduces the estimated light levels output by the tool to those needed for design on the future performance of the fixture, ensuring that the fixture still meets your lighting criteria at end-of-life.

The tool multiplies the light output of the fixture (as supplied by the .ies file data) by the total light loss factor. This reduced value is used in determining the luminance and illuminance on the road. Therefore, all light quality values reported by the tool include the effect of light loss factors.

Total Light Loss Factor is calculated as the product of the three contributing light loss factors.

### 4.6 Identify Costs

The tool performs several cost calculations:

Simple payback: this calculation ignores all inflation and discount rates, and simply divides the difference between the baseline and upgrade cost by the annual savings. This value depends on the baseline cost.

Net Present Value: Calculates the annual cost in each year of ownership using the appropriate installation, equipment, energy and maintenance costs, including inflation rates. This annual cost stream



is then converted to present-value currency using the discount rate, and is represented as the total cost of ownership. This value is independent of the baseline cost.

**Return on Investment:** This uses the same annual cost stream as the net present value calculation, but instead presents the results as the return on investment in each year in relation to the baseline cost. This value depends on the baseline cost. The Return on Investment is presented as a percent value in each year. The value in each year should be read as “if we keep these fixtures for X years, we will earn Y% return on investment each year.”

The equations for these calculations can be seen on the ‘Cost Calcs’ tab.

*Equation 1: Cost of Ownership*

$$Cost\ of\ Ownership_{year} = C_{maint} * (1 + I_{maint})^{year} + C_{energy} * Hours * Watts * (1 + I_{energy})^{year}$$

C = cost

I = inflation rate

Hours = annual operating hours

Year = number of years that inflation is compounded

## 4.7 Cost inputs

Some inputs used for cost calculations are fixture specific, while others are used for all fixtures in an analysis. The input of fixture-specific costs occurs during the same step as all other fixture data, and as such those inputs are described in the “Choose Fixtures” section above. The following costs are input in the “Identify Costs” section and are used for all fixtures in a given analysis.

### 4.7.1 Operating Hours

**What it is:**

The total hours per year that the fixture operates.

**How it’s used:**

This is multiplied by the energy cost and the fixture wattage to determine the operating cost.

### 4.7.2 Energy Cost (\$/kWh)

**What it is:**

The price of electricity.

**How it’s used:**

This is multiplied by the operating hours and the fixture wattage to determine operating cost.

The tool assumes that there is a fixed cost for energy on a metered basis. In reality, many utilities and jurisdictions don’t meter the electricity usage of street lights, and instead have a per-fixture or per-pole cost, which may or may not vary by fixture type. Some utilities have a tiered schedule. In these cases, if you want to show the impact of these alternate pricing structures, you can modify the wattage of the fixture, in combination with the operating hours and energy cost, to reflect the actual annual cost of that fixture. Alternately, you can use the tool just to calculate the light output, and perform cost analysis separately.



### 4.7.3 Energy Inflation Rate (%/year)

**What it is:**

The amount that the energy cost increases each year.

**How it's used:**

The cost of ownership, and how the inflation rate is used in this calculation, is shown in Equation 1 above.

### 4.7.4 Discount Rate

**What it is:**

The discount rate is used to calculate the net present value and return on investment.

**How it's used:**

The annual operating cost is calculated for each year of ownership using the inflation rates, and then is brought into equivalent today's-currency using the discount rate. For a full definition of discount rates, it is best to refer to economic theory resources.

## 5 Confirm Inputs

The final step of the process in using the tool is to perform all calculations. Before doing so, the 'Quick Check' provides some information on what you have entered, to make sure your inputs are as expected. In addition, under 'Review All Inputs,' the information on all inputs and fixtures are listed.

Once you have verified that all inputs are correct, clicking the 'Calculate Scenario Results' button will begin the calculations.

### 5.1 Quick Check

The tool performs the following informational checks, and flags any errors that it finds:

**Road configuration:** It is not necessary for the baseline and upgrade to use the same inputs for the road geometry; however, most users performing analysis (particularly for retrofit) will use the same inputs. This flag is triggered if there is any difference between the inputs in the two Road Geometry columns.

**Calculation Method:** Makes sure the user knows whether they are using the IES or CIE assumptions for the calculations. A method must be selected for the calculations to occur.

**Lighting Targets:** There are separate flags for the CIE and IES lighting targets. It is not necessary to enter lighting targets, but most users will prefer to do so. In addition, if you are performing calculations in one methodology only (i.e. CIE or IES), there is no reason to enter targets for the methodology not used. These flags are just to make sure the user is aware of whether values have been entered for these inputs.

**Baseline fixture:** At least one baseline fixture must be selected. If you do not need baseline calculations, select any fixture – the tool will not run without a baseline fixture selected.

**Upgrade Fixtures:** Provides a count of the number of fixtures that have been selected in the upgrade category. These are all those that are marked with an 'x' in column B of the 'Fixtures' tab, beginning at Row 36.



## 5.2 Review All Inputs

This section uses formulas to pull in the input values from all the previous steps. Only data for the fixtures actually selected for inclusion in calculations are shown.

## 5.3 Calculate Scenario Results

After finalizing all inputs, the 'Calculate Scenario Results' button begins the calculation process. There are several pop-up boxes you will see:

- **Calculation notification:** The tool calculates the light level at each grid point for all fixtures contributing to the light level, and as such calculations can take some time to complete. As of version 1.6.9, the calculation for each fixture typically takes between 3-20 seconds, depending on your computer's processing power. The first pop-up box notifies you that calculations will begin.
- **Group Name:** This name is added next to the results for all the fixtures in the calculation. If you do not delete results between analyses, you can use the "Group Name" to differentiate the results from different analyses. This is useful if, for example, you wish to compare the results of analyses using two different pole spacing values.
- **Clear Results:** After each analysis, the results are saved in the tool as well as in the output file. If you do not clear results, results from previous analyses will be added to the output file in addition to those from the current analysis. This can be a useful way to compare different scenarios, such as two different pole spacing options.
- **Output File Generated:** The output file is saved in the same folder as the tool, with a date stamp reflecting the time that calculations were run. The output file will remain open when calculations complete.
- **Repeat for second calculation method:** If you selected 'both' calculation methods (IES and CIE), the process will repeat, and a second output file will be generated.