

# Tennessee Valley Authority Substation Lighting Guidelines

## **For Greenfield Sites**

Permanent substation lighting should be a two-stage design. Stage 1 is operated dusk to dawn for fixtures at higher mounting heights, more than 12 feet above the ground, and Stage 2 is switch-controlled for low mounting heights at 12 feet and below.

Stage 1 will be continuous nighttime lighting turned on with a photocell and designed to meet minimum requirements for safety and security. The general purpose of Stage 1 lighting is to light the ground and general area to the fence. Designing Stage 1 continuous lighting should follow Illuminating Engineering Society of North America (IESNA) RP-33-99 recommended practices for maximum lighting at the fence and past the fence, except where National Electrical Safety Code (NESC) requirements supersede these guidelines for safety reasons or *Federal Register* requirements supersede these guidelines for spill-containment facilities. Stage 1 lighting fixtures mounted at an elevation above 12 feet should be the cutoff or full-cutoff type to reduce off-site glare.

The Stage 2 lighting will be provided for temporary operational needs and will only be turned on when required. Stage 2 lighting is intended to provide visibility of substation structures and devices, to operate switches, and to perform tasks. Design of Stage 2 lighting should follow NESC and IESNA RP-7-01 recommended practices for task lighting.

Substation structures should be utilized for mounting Stage 1 and Stage 2 lighting fixtures wherever feasible. Lighting fixtures should be mounted at the minimum elevation required to provide coverage dictated by the required vertical and horizontal light levels and uniformity. Lights may be mounted above an elevation of 40 feet when required for security reasons, such as cameras, or lighting of objects taller than 40 feet.

## **For Minor Modifications to Existing Facilities**

Additional lighting required for substation modifications will follow the basic existing lighting design. To the degree possible, substation structures should be utilized to mount light fixtures. Lighting fixtures may be mounted at an elevation above 40 feet when required for site coverage, security reasons, such as cameras, or lighting of objects taller than 40 feet. All substation lights mounted at an elevation above 12 feet should be cutoff or full-cutoff type, such that no light is emitted from the fixture at lateral angles above 90 degrees (above the horizontal plane) to reduce off-site glare, unless the light is required for operational needs, such as the operation of a disconnect switch mounted at a higher elevation. To the extent possible, lighting additions should follow *Federal Register*, NESC, IESNA RP-7-01, and IESNA RP-33-99 recommended practices for lighting.

The Stage 1 and Stage 2 lighting approach will not be considered for minor modifications because of the difficulty in rearranging wiring circuits for lighting power supply and control. These changes are more appropriately addressed when major modifications are made.

*(For major modifications to existing substations, consideration should be given to implement lighting policies for greenfield sites. This can be determined during site visits and project scoping.)*

## General Design Issues and Design Principle Definitions

- A Good Neighbor. Most of the design constraints are summed up by this principle. Thoughtful consideration of the neighbors is critical to the success of the design.
- Luminaire Optical Properties. Four designations are used for the light control of outdoor lighting fixtures: Full Cutoff (0 percent, <10 percent), Cutoff (<2.5 percent, <10 percent), Semicutoff (<5 percent, < 20 percent), and Noncutoff. These are in terms of a percentage of the lamp's intensity lateral to the fixture and at an angle 10 degrees below the horizontal plane.
- Light Levels. Light levels are determined for both horizontal and vertical surfaces by the appropriate standards. Principally American National Standards Institute (ANSI)/IESNA RP-7-01, IESNA RP-33-99, IESNA *Lighting Handbook*, 9<sup>th</sup> Edition, 2000, blue pages Safety/Security-1, IESNA G-1-03, and the NESC, Section 111.A, should be considered.
- Neighboring Property Uses. The lighting design shall consider ways to reduce light trespass in directions where neighbors are known to exist through light fixture placement and control of the fixture light output.
- Design Standards. Design standards are general engineering guides to proper application of lighting equipment to achieve lighting levels consistent with their recommended standards. Primary design standards are listed under the "Light Levels" definition.
- Physical Security Survey. If warranted, specific lighting needs can be determined through the process outlined in IESNA G-1-03, Annex B, with measurements according to Annex C.
- Television Surveillance. If required, television surveillance provides lighting compatible with the needs of camera visibility, which may or may not enhance human visibility.
- Mounting Heights. Mounting height is a key factor in determining the uniformity or evenness of the light level. For substations, mounting heights are defined as Stage 1 or Stage 2 for high and low under "Mounting Locations." Generally, mounting heights provide good uniformity on the ground or structure when lights are spaced a distance two times the mounting height or lateral distance. Aboveground structures will have decreased uniformity by the same ratio unless this design geometry is considered. For example, lights at a 12-foot mounting height typically provide uniform coverage on the ground 24 feet wide. Spacing between fixtures of 48 feet would provide good uniformity on the ground. When lighting vertical structures, the distance to the light affects the uniformity in the same way.
- Mounting Locations. Low mounting heights are defined as 12 feet and below and high mounting heights are above 12 feet.
- Terrain. Nuisance glare and light trespass are also a function of the substation height above or below the average local terrain, including land contours and vegetation height. Terrain can shield fixtures and reduce lighting control requirements.

- Temporary Lighting Systems. Systems designed for outages and limited to portable systems should have no restrictions due to their temporary nature.
- Permanent Lighting Systems. These systems require the most care due to their persistent effect on the neighbors.
- New Construction Greenfield Sites. These sites have a higher level of care due to the clean slate available to accommodate good lighting design.
- Minor Substation Modifications. Small modifications include substation component replacement and expansions of less than 50 percent of the substation capacity. Following the existing lighting design pattern in these cases is acceptable practice to expand the lighting system coverage.
- Extensive Substation Modifications. Extensive modifications involve site voltages or expansions of more than 50 percent capacity. Lighting should be evaluated by design engineers to determine feasibility of using the design approaches of new construction greenfield sites.
- Safety. Wherever unsafe conditions are present, in the judgment of design engineers, additional lighting is warranted.

#### **References**

IESNA G-1-03, *Guideline on Security Lighting for People, Property, and Public Spaces*

IESNA *Lighting Handbook*, 9<sup>th</sup> Edition, 2000, blue pages Safety/Security-1

IESNA RP-7-01, *Recommended Practice for Lighting Industrial Facilities*

IESNA RP-33-99, *Recommended Practice for Lighting for Exterior Environments*

NESC, Institute of Electrical and Electronic Engineers (IEEE), *ANSI/IEEE C2-2007*, 2007 Edition

July 2017 Revision