U.S. DEPARTMENT OF
ENERGY

*Office of*
ENERGY EFFICIENCY &
RENEWABLE ENERGY

# U.S. Department of Energy Headquarters Lighting Retrofit

The James Forrestal Building in Washington D.C. serves as headquarters for the U.S. Department of Energy (DOE). The nearly 1.7 million square foot building recently implemented a lighting upgrade project through an energy savings performance contract (ESPC). An ESPC allows federal agencies to implement facility improvements that save energy with no up-front capital costs or special appropriations from Congress. The project was completed using FEMP's ESPC ENABLE process, which is designed to permit a standardized and streamlined procurement process for small federal projects to install energy conservation measures in six months or less. The project cut lighting energy use by about 50% and is expected to save 2.4 million kilowatt-hours (kWh) annually, amounting to nearly $258,000 in annual energy cost savings.

## Background

In early 2016, after considering a number of options, the DOE settled on replacing the existing fluorescent lamps with tubular light-emitting diodes (TLEDs), retrofitting roughly 35,000 troffers (most containing one lamp).


James Forrestal Building is the Department of Energy Headquarters. *Photo credit Pacific Northwest National Laboratory.*

Of the anticipated annual energy savings about 2.1 million kWh is directly attributed to the new lighting and 300,000 kWh is related to a reduction in the heating, ventilation, and air conditioning (HVAC) usage. HVAC is reduced because less heat is generated by the lighting system. This is a standard calculation within the FEMP ENABLE tools.

## Project Drivers and Successes

Federal buildings are required to decrease energy use intensity by 30% in 2015 compared to 2003. Additional federal goals include a 25% reduction in 2025 from a 2015 baseline.

**Table 1. Project at a Glance**

| | |
|---|---|
| Project Location | Washington, DC |
| Total Area of Project | 1,700,000 ft$^2$ |
| Troffers Upgraded | 35,000 |
| Annual Energy Savings (includes lighting and HVAC) | 2,400,000 kWh |
| Energy Use Reduction | 50% |
| Annual Energy Cost Savings (2017) | $258,000 |
| Initial Investment | $2,318,000 |

Because lighting use constitutes approximately 15 – 20% of the total source electrical consumption in commercial buildings, the use of lighting-related energy conservation measures has the potential to help significantly in meeting legislative targets.

A payback of less than 10 years was required for the project since the Forrestal Building is slated for replacement in the relative future. The target project timeline was 12 months. Four retrofit options were considered:

1. Reduced wattage fluorescent – Replace the lamp with a 25 or 28 Watt (W) 4-foot T8 fluorescent lamp. This option would have saved roughly 15 – 20% and required no other modifications to the fixtures.
2. Lamp only – Replace the lamp with TLEDs. Savings estimates ranged from 30 – 60% due to uncertainties related to the existing equipment and the new equipment needs. Three options for TLEDs exist: Underwriters Laboratory (UL) Type A, B, and C.
3. Retrofit Kit – Replace the fluorescent lamps and other luminaire components with an LED retrofit kit. Initial savings estimated were 40% – 70%.
4. Luminaire – Replace the entire fluorescent luminaire, including the housing, with a new LED luminaire. Initial savings estimated were 40% – 70%.

### Learn More

U.S. Department of Energy (DOE) Forrestal Building lighting retrofit lessons learned report

Schedule and labor costs also drove the project. The work had to be completed within a certain timeframe, and the labor required to convert the fixtures had to occur in the off hours. UL Type A TLEDs were selected because they are designed to use the existing fluorescent ballast, therefore reducing labor time and associated costs.

Verifying compatibility of existing ballasts to the TLEDs was critical. Ballast compatibility issues that can occur when replacing only the lamps is a common project challenge. A given ballast may operate properly with some, but not all, wattage TLEDs. TLEDs may work with a ballast at one voltage, but not another. Also, the standard ballast may be compatible with the TLEDs, but the emergency lighting ballast may not be compatible.

## Federal Guidance

The Forrestal Building is owned by the General Services Administration (GSA) and is operated by DOE; in 2016, GSA guidance did not allow TLED retrofits in existing luminaires. DOE had more confidence in the readiness of TLEDs and wanted to apply them in the Forrestal project. As a result, a Memorandum of Understanding between DOE and GSA was completed allowing the installation of UL Type A TLEDs to proceed.

The 2016 GSA PBS-P100 Facilities Standards for Public Buildings Service (GSA P100) document did not have TLED requirements. Therefore, a TLED specification was developed prior to the solicitation to the Notice of Opportunity (NOO). At the time, FEMP-designated energy efficient product requirements existed for fluorescent ballasts, fluorescent lamps, fluorescent troffers, and LED troffers, but did not exist for TLEDs.

The Department of Defense's Unified Facilities Criteria (UFC), which does not apply to Forrestal, included TLED requirements that served as a reference in the specification development. It should be noted that the April 2017 GSA P100 does include text related to TLEDs. However, as a general rule, both GSA P100 and UFC are updated on different schedules. Federal projects should verify that the organization is using the current version of either document at the start of each project.

Electricity costs at the site were $0.104/kWh and $0.93/therm (natural gas is applicable when accounting for HVAC savings). A large scale analysis was conducted as part of FEMP's ESPC ENABLE process to determine cost effectiveness. Table 2 provides an analysis of different material costs, operating hours, and the simple payback period. Table 3 provides a summary of the lighting upgrade details and results.

**Table 2. Simple Payback Based on Material Costs Only**

| | Assuming 48% energy savings | |
|---|---|---|
| **Cost per Lamp** | 8 hours/day | 12 hours/day |
| $15 | 4.6 years | 3.1 years |
| $16 | 4.9 years | 3.3 years |
| $17 | 5.2 years | 3.5 years |
| $18 | 5.5 years | 3.7 years |
| $19 | 5.8 years | 3.9 years |

Based on $0.104 / kWh

## Lessons Learned

- At the time of the project, there was a need for more information on successfully upgrading troffers to LEDs. FEMP has since released *LED Troffer Retrofit Lighting and Controls Best Practices*[1]. Soon after the completion of the Forrestal project GSA PBS-P100 Facilitates Standards for the Public Buildings Service (April 2017)[2] was published allowing retrofit LED lamps.
- The release of a clear and detailed NOO that included a TLED performance specification and specific measurement and verification requirements and protocols[3] garnered a number of high quality responses.
- If funding shift is a concern, a tight completion schedule could benefit the project by reducing the chances of funding insecurity.
- Thorough review of existing conditions and systems as well as product selection reduces, but does not eliminate, occasional incompatibility with existing equipment or systems. The majority of ballasts were compatible with the TLEDs, but a few outliers were not.
- LED luminaires are not compatible with all dimmer switches; compatibility should be verified.

**Table 3. Before and After**

| | Before | After |
|---|---|---|
| **Number of Troffers** | 35,000 | 35,000 |
| **Technology** | Fluorescent | TLED |
| **Lamp Rated Wattage** | 32-W | 13-W |
| **Wattage per Troffer** | 29.4-W | 14.4-W |
| **Light out per lamp on ballast** | 2,550 lumens | 1,600 lumens |
| **Annual Lighting Energy Use** | 4,200,000 kWh[a] | 2,100,000 kWh |

[a] The office areas were over lighted as a result of a significant quantity of fixtures. Newer buildings are designed with fewer light fixtures.

[1] https://energy.gov/sites/prod/files/2017/03/f34/led_troffer_retrofit_guide.pdf
[2] https://www.gsa.gov/real-estate/design-construction/architecture-engineering/facilities-standards-p100-overview
[3] https://energy.gov/eere/femp/downloads/espc-enable-measurement-and-verification-protocol

## Federal Energy Efficiency Requirements for Interior Lighting

Although every site, whether federal, private, commercial, or industrial, can benefit from the energy savings, maintenance savings, and lighting quality improvements offered by energy-efficient lighting, federal sites have another motivator. They must ensure compliance with the multiple laws, executive orders, and Federal Acquisition Regulations, which mandate that federal agencies meet efficiency requirements in all procurement and acquisition actions that are not specifically exempted by law.

### ENERGY STAR® Lighting

Federal laws and requirements mandate that agencies purchase ENERGY STAR® qualified products. To find ENERGY STAR qualified lighting products, see www.energystar.gov/productfinder/.

### Federal Efficiency Requirements

In cases where there is no ENERGY STAR product category, the agency must comply with FEMP-designated efficiency requirements.

The table below lists the minimum federal efficiency requirements that various categories of interior LED lighting must meet to be eligible for purchase by federal agencies.

### FEMP LED Purchasing Guidance

For more information on high-efficiency lighting technologies and information for federal agencies, including lighting requirements language for contracts, visit energy.gov/eere/femp/purchasing-energy-efficient-commercial-and-industrial-led-luminaires.

FEMP and the DOE LED Lighting Facts® program have partnered to offer a tool that allows federal users to identify LED lighting products that meet the minimum federal efficiency requirements.

The FEMP Acquisition Guidance Product List allows users to search for interior lighting products in the six categories in the table below that meet federal requirements. The tool provides a pre-screened list of products and federal users can screen on a large range of other product metrics, including color temperature, power factor, and beam angle. Find qualifying products at www.lightingfacts.com/LFPowered/FEMP.

### Helpful Guides

*LED Retrofit Kits, TLEDs, and Lighting Controls: An Application Guide* — This document provides guidance for retrofitting existing fluorescent troffers including the LED and associated control options available, the pro/cons and costs/benefits of each option, and agency specific requirements (where applicable). www.energy.gov/eere/femp/downloads/led-retrofit-kits-tleds-and-lighting-controls-application-guide

*Forrestal Tubular LED Demonstration Project: Lessons Learned* — This document provides lessons learned from the relighting project at the James V. Forrestal Building. Project consisted of replacing the existing fluorescent lamps with TLEDs. www.interiorlightingcampaign.org/sites/default/files/FEMP-LessonsLearnedForrestal-TLED.pdf

*Wireless Occupancy Sensors for Lighting Controls: An Applications Guide for Federal Facility Managers* — This guide describes the different types of sensors, appropriate applications, and expected energy savings. www.energy.gov/eere/femp/downloads/wireless-occupancy-sensors-lighting-controls-applications-guide-federal-facility.

*Measurement and Verification of Energy Savings and Performance from Advanced Lighting Controls* — This document provides a framework for measurement and verification. www.energy.gov/sites/prod/files/2016/03/f30/mv_lighting_control_wireless.pdf

### Proven Specifications

Use these specifications, developed by DOE's Better Buildings Alliance and the DesignLights Consortium, to specify performance expectations, warranty, and testing requirements for your lighting projects.

*Better Buildings Alliance Model Technical Specification: High-Efficiency Troffers* www.betterbuildingssolutioncenter.energy.gov/resources/high-efficiency-troffer-performance-specification

*Designlights Consortium Networked Lighting Control Systems Specification* www.designlights.org/content/CALC/SpecificationAndQPL

### FEMP SSL Solutions Website

Solid-state lighting (SSL) technology has the potential to reduce U.S. lighting energy use by 75% by 2035 and contribute significantly to our nation's energy security. FEMP offers a unique opportunity for the federal sector to lead large-scale implementation efforts focused on applications ripe for near-term implementation through a process that recognizes the technology's potential and challenges to adoption. Visit the FEMP website for a wealth of information on both interior and exterior LED lighting and controls solutions. www.energy.gov/eere/femp/solid-state-lighting-solutions

**Efficiency Requirements for Commercial and Industrial LED Luminaires**

| Luminaire Type | Light Output | Luminaire Efficiency (LE) |
|---|---|---|
| Commercial: Linear Ambient[a] | ≥375 lm/ft | ≥119 lm/W |
| Commercial: 1-Foot by 4-Foot Troffers | ≥1,500 lm | ≥119 lm/W |
| Commercial: 2-Foot by 2-Foot Troffers | ≥2,000 lm | ≥111 lm/W |
| Commercial: 2-Foot by 4-Foot Troffers | ≥3,000 lm | ≥115 lm/W |
| Industrial: Low Bay | ≥5,000 to <10,000 lm | ≥109 lm/W |
| Industrial: High Bay | ≥10,000 lm | ≥128 lm/W |

[a] Includes luminaires with both direct and indirect lighting components

## Interior Lighting Campaign

FEMP encourages federal facilities to join the Interior Lighting Campaign (ILC), a recognition and guidance initiative. The ILC encourages facilities to install energy-efficient lighting as well as lighting occupancy or daylight controls to cut energy use and deliver occupant satisfaction. By adopting more efficient lighting, such as systems that meet the Better Buildings Alliance specification for troffers, building owners can save up to 50% on a one-for-one basis, and up to 80% with the use of controls.

The ILC's overall goal is to achieve the replacement of 2 million planned or installed high-efficiency interior lighting solutions (troffer, high-bay, low-bay, and suspended linear lighting systems and controls) by April 2018.

### Join the ILC

Federal sites are encouraged to join the ILC. The ILC will provide you with:

- technical assistance
- information on financing and incentives
- lighting savings calculators.

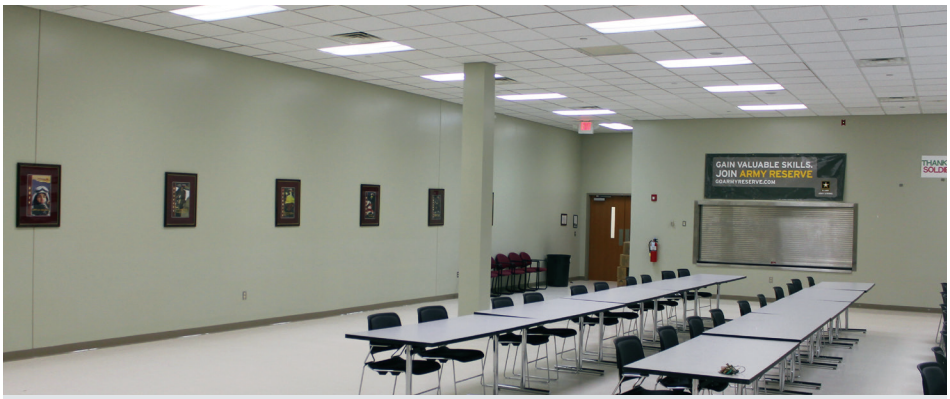
Federal sites commit to:

- building or retrofitting at least one building space with high-efficiency lighting. (Sites built or retrofitted with complying fixtures any time after January 1, 2013, are eligible to compete.)
- Share your results.

Report your actual savings by April 2018 for a chance to be recognized at the ILC recognition event at the Illuminating Engineering Society 2018 Annual Conference, August 2018, Boston, Massachusetts.

### ILC Recognition Categories

ILC Recognition spans four application categories including troffers, high-bay, low-bay, and suspended linear. There are also special recognition categories including best use of lighting controls, largest number of facility projects, largest portfolio-wide energy savings, and sector recognition, including a category for federal agencies.




Through the Better Buildings Alliance, members in different market sectors work with the U.S. Department of Energy's exceptional network of research and technical experts to develop and deploy innovative, cost-effective and energy-saving solutions that lead to better technologies, more profitable businesses, and better buildings in which we work, shop, eat, stay, and learn. Join today to start saving energy in your commercial buildings through programs like the Interior Lighting Campaign, www.interiorlightingcampaign.org. *Photo courtesy of Pacific Northwest National Laboratory.*

The award categories for the interior lighting campaign include the following:

- Highest Annual Energy Savings for Lighting Retrofits
- Highest Percentage of Annual Energy Savings for Lighting Retrofits
- Highest Annual Energy Savings for Lighting New Construction
- Highest Percentage of Annual Energy Savings for Lighting New Construction
- Special Recognition Categories:
  - Best Use of Lighting Controls in a Single Building
  - Largest Number of Facility Projects
  - Largest Portfolio-wide Annual Energy Savings
- Exemplary Performance Recognition may also be presented to participants in the federal sector. ■

"The adoption of advanced interior lighting technologies continues to bring U.S. businesses and other organizations significant energy savings," said the Energy Department's Deputy Assistant Secretary for Energy Efficiency Kathleen Hogan. "By investing in more efficient lighting, ILC partners demonstrate how cost-effective measures can make a big difference in a building's energy consumption."

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FEMP Federal Energy Management Program

**For more information, visit:**
energy.gov/eere/femp

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