



# Energy Efficiency - Halogen Lighting

An Online Continuing Education Course for Engineers

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**Credit: 4 Hours / 4 PDH / 4 CPD**

# Energy Efficiency – Halogen Lighting

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## Introduction

In traditional incandescent lamps, vaporized gaseous tungsten from the filament is transported through the vapor phase and continuously deposited on the inside walls of the glass bulb. This artifact serves to blacken the inner walls of the bulb and gradually reduces light output. In order to maintain light loss at the lowest possible levels, conventional tungsten lamp filaments are housed in large bulbs having sufficient surface area to minimize the thickness of deposited tungsten that builds up over the life span of the lamp. Eventually, when a sufficient amount of tungsten is depleted, the lamp fails.

A halogen lamp, also known as a tungsten halogen or quartz lamp, is a form of incandescent lamp that has a small amount of a halogen such as iodine or bromine added. The combination of the halogen gas and the tungsten filament produces a halogen cycle chemical reaction which re-deposits evaporated tungsten back onto the filament, increasing its life and maintaining the clarity of the envelope. In order for the chemical reaction to take place, the filament needs to be hotter than that needed for incandescent bulbs. This hotter filament produces a brilliant white light and is more efficient than an incandescent lamp.



The filament is composed of ductile tungsten and located in a gas filled bulb just like a standard tungsten bulb, however the gas in a halogen bulb is at a higher pressure. The bulb must be stronger than standard glass in order to contain the high pressure. The glass bulb is typically made of fused quartz or some other special compound.

The first halogen type lamp was developed by General Electric in the 1950's. Previously, others had tried to build halogen lamps, however they could not determine how to stop the blackening of the lamp. General Electric determined that using a small amount of iodine surrounding the tungsten filament, would allow the lamp to burn at elevated temperatures. Philips Lighting developed a lamp that used halogen bromine instead of iodine. This lamp was more efficient than iodine at the time and became the standard form of halogen lamp.

In this course, starting with Chapter One, we will review the overall lighting market to get a sense of how halogen lamps are participating in the marketplace. Chapter Two reviews the fundamentals of lighting and Chapter Three covers the basic characteristics of all halogen

lamps, including construction and operation. Chapter Four explains the predominate uses of halogen lighting.

## Chapter 1: The Lighting Market

This chapter discusses the size of the U.S. lighting market, recent changes in the market and describes lighting intensities by sector (residential, commercial, industrial, and outdoor lighting).

In 2010, the total energy consumption in the United States was 97.8 quadrillion BTUs (quads) of primary energy. Roughly 40 quads (or 41 percent) of this energy was consumed for electricity use.

For the purposes of this course, the lighting industry is divided into four sections:

1. Residential
2. Commercial
3. Industrial
4. Outdoor Lighting

The total amount of electricity consumed by lighting technologies is estimated to be 700,000 GWh of site energy, or 7.5 quads of primary energy. Thus, lighting accounts for 7 percent of the total energy and 18 percent of the total electricity consumed in the U.S.

The residential sector accounts for the overwhelming majority of installed lamps, at 71 percent of installed base of lighting. However, in terms of electricity consumption, the sector only consumes 175,000 GWh, or 25 percent of the total. Due to the relatively low efficacy of residential light sources (primarily incandescent), the residential sector only accounts for 8 percent of the lumens produced.

The commercial sector is the greatest energy consumer, accounting for half of the total lighting electricity consumption. In addition, the commercial sector represents the sector in which the greatest number of lumens is produced. This is largely due to the longer operating hours found in the commercial sector as compared to the residential sector. Both the industrial and outdoor sectors make up a relatively small portion of the total installed stock of lamps, each approximately two percent. However, the use of high lumen output lamps and high operating hours result in these sectors consisting of greater shares of total electricity consumption and lumen production.

Residences account for 71 percent of all lamp installations nationwide, at 5.8 billion lamps. The commercial buildings sector is the second largest sector with 25 percent of all installations and

2.1 billion lamps. The outdoor and industrial sectors are significantly smaller, each accounting for roughly 2 percent of all lamps installed, 180 million and 140 million lamps, respectively.

With regard to average daily operating hours, while lamps in the commercial, industrial, and outdoor sectors typically are used for half the day (working hours for commercial and industrial sector lamps and night time hours for outdoor lamps) residential lamps are only used a couple hours a day on average. As for the average wattage characteristics of the residential sector, the average wattage of 46 watts per lamp represents a mix of low wattage, high efficacy CFLs and higher wattage, lower efficacy incandescent lamps. The commercial, industrial and outdoor sectors are dominated by the high installed base of linear fluorescent lamps and high wattage, lower efficacy incandescent lamps. These inputs combined result in a total annual lighting electricity consumption of approximately 18 percent of total U.S. electricity.

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**Figure 1**

See Figure 1, nearly half of the lighting electricity is consumed in the commercial sector, which also represents the sector in which the majority of lumens are produced. This sector is dominated by linear fluorescent area lighting. The residential sector’s large installed base of low efficacy lighting causes the sector to be the second largest lighting energy consumer, at 175,000