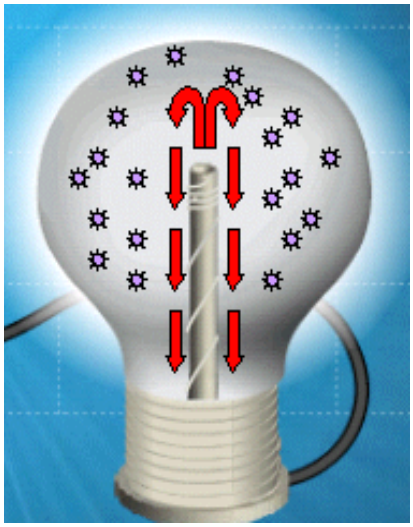
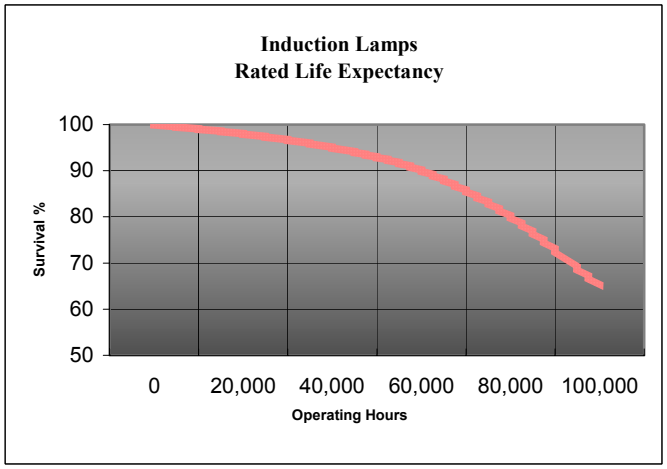
Customer Advanced Technologies Program

Induction Lighting Systems





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Customer Advanced Technologies Program

SMUD's Customer Advanced Technologies (C.A.T.) program works with customers to evaluate new or underutilized technologies. The program provides funding for customers in exchange for monitoring rights. Completed demonstration projects include lighting technologies, light emitting diodes (LEDs), residential building shell construction, geothermal heat pumps, indirect / direct evaporative cooling, non-chemical water treatment, solar powered lighting systems and a wide variety of other technologies.

For more program information, please visit: http://www.smud.org/community/cat/

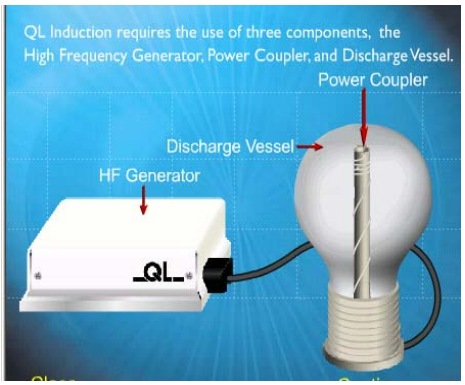
Introduction

Almost every type of lighting system has a common weakness – the lamp filament. Most lamp failures are due to degradation of the filament or electrodes. About ten years ago, lighting manufacturers introduced a product that did not require electrodes: the induction lighting system. According to manufacturers, some of these lamps will last over 100,000 hours - over 25 years for most users! Today SMUD customers are finding new energy saving applications for this technology.

This evaluation report focuses on induction lighting systems and attempts to address the following questions: How do these systems work? Are they cost effective? What are some of the applications and challenges associated with using this technology?

Technology Description: How Do They Work?

Although induction lighting systems come in different shapes and sizes, the operating principles are essentially the same. They all include a high frequency generator, a power coupling and a glass lamp housing which is called the **discharge bulb**. To understand how these systems operate, we first need to take a closer look at some of the components.



Phillips QL System
Source: www.lighting.philips.com

High Frequency Generator

The high frequency (HF) generator is essentially a type of ballast. As the name implies, it produces a high frequency electronic current that flows through the power coupler.

Power Coupler

The power coupler is a specialized type of induction coil. It converts the current from the HF generator into a magnetic field within the discharge bulb.

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Discharge Bulb

The power coupling is encased within a glass housing known as the discharge bulb. The bulb is filled with a mixture of gases including mercury. The inside of the bulb is coated with rare earth phosphors.

Sequence of Operation

1) The high frequency generator produces a high-frequency electrical current and sends it to the power coupler (induction coil).

2) The current passing through the induction coil generates a fluctuating electromagnetic field within the lamp. This fluctuating field excites and ionizes the mercury atoms in the gas fill. The ionized mercury atoms emit ultraviolet radiation.

3) When the ultraviolet radiation strikes the phosphor coating on the inside of the glass bulb, the phosphors produce visible light.

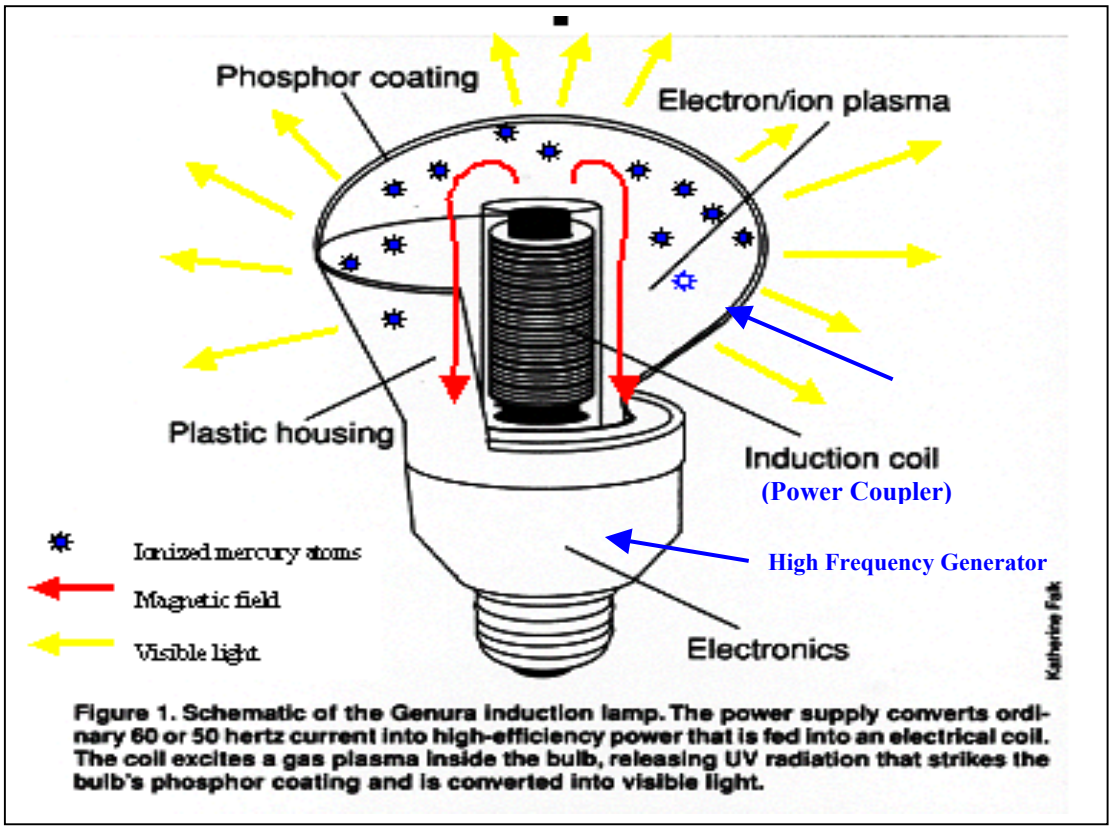

Figure 1. Schematic of the Genura induction lamp. The power supply converts ordinary 60 or 50 hertz current into high-efficiency power that is fed into an electrical coil. The coil excites a gas plasma inside the bulb, releasing UV radiation that strikes the bulb's phosphor coating and is converted into visible light.

General Electric's Genura Lamp

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Are Induction Lighting Systems Cost Effective?

Induction lighting systems usually cost more than other types of lighting systems. However, they are energy efficient and last a long time. Induction lighting systems are a very attractive option for:

- Locations where access to the lighting fixtures is difficult, inconvenient or dangerous. Examples: street lights, tunnels, and 24-hour facilities with high ceilings. Since the rated life of some induction lighting systems is 100,000 hours, customers may reap significant benefits from reduced lamp replacement costs. This is especially true when compared to standard metal halide lamps, which are typically only rated for a maximum of 15,000 hours.

- Low temperature environments such as walk-in freezers. Most lighting systems perform very poorly in applications with ambient temperatures of less than 32°F. See ***Showcase Projects*** for more information.

- Applications with high ceilings that require high color rendition and maintained illumination levels. Since induction lighting systems have good lumen maintenance characteristics (over 80%), it may be possible to use fewer or lower wattage fixtures (compared to metal halide systems).

- Applications that require instant-on capability. The re-strike period requirements associated with using metal halide systems in public gathering places often require the installation of additional equipment (e.g. quartz re-strike) or additional lighting systems (e.g. incandescent fixtures).

- Interior applications usually reserved for incandescent floodlights. Customers may want to consider using lamps such as the Genura as an energy efficient alternative.

General Observations

- The efficacy of induction lighting systems varies significantly depending on the product. Please refer to the system comparison table on the next page for more information.

- Most induction lamps require fixtures specifically designed for induction lighting systems. Consequently, retrofit options may presently be somewhat limited.

- Induction lamps run much hotter than other types of fluorescents. According to the lamp manufacturers, the surface temperature of the lamps typically reaches 150°F. Consequently, care must me taken when servicing the lamps to avoid possible skin burns.

- Some products may interfere with radios, cordless telephones, remote control devices, pacemakers and computers. Customers should check with the manufacturer of the product for any particular application.

- Inductions lighting systems are not dimmable and may not be compatible with certain types of lighting controls (e.g. dimmers, occupancy sensors)

System Performance Comparison

Performance Comparison	*Standard T8 Lamps*	*T5HO (linear)*	*T5HO (biax)*	*250 Watt Metal Halide*	*Phillips QL 165 Watt*	*Genura 23 Watt*	*ICETRON 150-Watt*
Lamp Data							
Lamp Lumens (initial)	2,950	4,450	4,800	23,000	12,000	1,100	12,000
Rated Life (hours)	20,000	20,000	12,000	10,000	100,000	15,000	100,000
Color Rendering Index (CRI)	82	82	82	65	80	82	80
Mean Lumens	2,714	4,136	4,128	17,000	9,600	935	8,880
Lumen Maintenance (40% life)	92%	93%	86%	74%	80%	85%	74%
Re-strike time requirement	None	None	None	10 min	None	None	None
System Data							
Number of Lamps	4	4	4	1	1	1	1
Ballast Factor	90%	100%	100%	94%	100%	100%	100%
Initial System Lumens	10,620	17,800	19,200	21,620	12,000	1,100	12,000
Nominal System Watts	114	234	234	289	165	23	150
Initial System Efficacy (lpw)	93	76	82	75	73	48	80
Mean System Lumens	9,770	16,544	16,512	15,980	9,600	935	8,880
Maintained System Efficacy (lpw)	86	71	71	55	58	41	59

All values were based upon manufacturer's published data

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Showcase Project

Project: Ralph's Grocery Stores
Sacramento Area Locations

Basecase:

Ralph's was experiencing problems with the lighting systems in their walk-in freezers. The Illumination levels were very poor and many of the lamps needed to be replaced on a weekly basis due to the extreme cold (-5°F). Most of the freezers originally had two or three surface-mounted 150-Watt incandescent lights. Staff was often forced to leave the lights on 24 hours per day to prevent them from freezing (photo at right).

New System:

The original lights were replaced with surface mounted fixtures featuring the Phillips 85 watt QL induction lighting system.

Results:

The illumination levels have improved dramatically. Since the QL system has a minimum starting temperature of –40°F, staff should now be able to turn off the lights when they are not in the walk in freezer. This will save a significant amount of energy.

- Customer Advanced Technologies Program grant = $12,175
- Savings: lighting costs were reduced by 40%
- Simple payback = 1.98 years

"Induction lighting provides an efficient long-term solution to a problematic lighting application. Historically, fluorescent or HID lights were either left on all the time or required an extended warm up period. If incandescent lights were turned off, they were frequently subject to premature failure due to the rapid temperature change when switched on. The energy savings achieved by the induction system and the virtual elimination of maintenance costs, combine to create an attractive technology. "

- Mike Toman, Manager-Energy Utilization

Showcase Project

Project: City of Sacramento
William Land Park

Basecase:

Street lighting retrofit kit
www.1stsourcelight.com

The Land Park area of Sacramento is well known for its well-kept old-fashioned homes and charm. However, the streetlights were antiquated and presented serious safety and maintenance challenges. Since the City had adopted high-pressure sodium (HPS) lamps as a standard for street lighting, they were preparing to replace the 100-Watt mercury vapor lamps with HPS. The residents objected to the proposed retrofit since they did not like the color of the light produced by HPS lamps. They asked the City to attempt to find a suitable white light source.

New System:

After investigating induction lighting, Wesley Hiratsuka, the City's Traffic Control and Lighting Supervisor, worked closely with SMUD to develop a prototype retrofit kit. The retrofit kit was based upon the Phillips 85-Watt QL induction lighting system (photos at right). The design included a heat sink for the HF generator and the power coupling. A local fixture manufacturer was hired to produce 183 retrofit kits.

Results:

The illumination levels have improved dramatically and the residents are very satisfied with the retrofit. Since the rated life of the QL system is 100,000 hours, the City's maintenance costs have been dramatically reduced. The new system also saves energy.

- Project cost = $41,013
- C.A.T. Program grant and efficiency rebates = $23,000
- Net project cost = $18,013
- Estimated annual energy savings = 26,357 kWh
- Estimated annual energy cost savings = $1,755
- Estimated annual maintenance savings: $750
- Simple payback = 7.2 years

"The QL-85 inductive lamp appears to offer the solution to many issues brought up in residential lighting. The light color is "white", 100,000-hour lamp life, eliminates four to five relamp cycles, and saves energy. The latest research into light color quality at night also seems to make the QL-85 the ideal light source for residential roadway lighting."

- Wesley Hiratsuka, Traffic Control and Lighting Supervisor

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Conclusions

Market Potential and Barriers

The main benefit from using induction lighting systems may be the potential for significant maintenance savings. This technology appears to be well suited for street lighting and interior applications where fixture access is problematic or expensive. The white light, good color rendition, lumen maintenance, instant on capabilities are qualities favorable for interior applications.

Induction lamps such as the Genura are an energy efficient alternative for interior applications usually reserved for incandescent floodlights. The efficacy of induction lighting systems is on par with metal halide systems, but is less than high-efficiency fluorescent systems.

Challenges for this technology include:

- ☐ **Cost:** induction lighting systems typically cost more than comparable metal halide or fluorescent lighting systems.

- ☐ **Difficulty with Retrofits:** generally speaking, these systems usually require specifically designed lighting fixtures. Consequently, customers may need to replace their existing fixtures or fabricate custom retrofit kits. Either of these options may significantly increase the project costs.

- ☐ **Limited Fixture Selection:** although lamp manufacturers have made significant progress in working with lighting fixture manufacturers, choices may still be somewhat limited compared to other types of lighting systems such as metal halide.

Technology Transfer and Recommendations

Although this technology is commercially viable and is presently available from at least three major lamp manufacturers, sales volumes are low since the lamps are more expensive than competing lighting technologies. Since increasing the sales volume may yield cost reductions, electric utilities and lighting industry advocates may want to promote this technology through consumer education and outreach.

Sample Products

Philips QL System

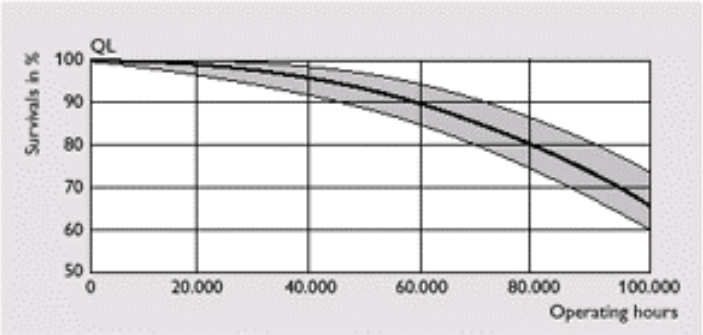
General Description: "A" shaped lamp with separate discharge vessel (bulb), high frequency generator and power coupling. Users must specify and order all three components. The HF generator is connected to the power coupler via a coaxial cable

Color Temperature: 2700K*, 3000K and 4000K
* Not available in North America
Color Rendering Index: 80
Base: Proprietary
Require dedicated fixtures? Yes
Lumens: *see table below*
Rated life: 100,000 hours (see graph)
Burn position: universal
Efficacy: *see table below*

Phillips QL System
Source: www.lighting.philips.com

Features

- Long life
- Excellent lumen maintenance
- White light / good color rendition (80)
- Instant on (no re-strike period)
- Suitable for low temperature environments (minimum staring temperature is - 40°F)
- No color shift
- No flicker
- No noise
- No stroboscopic effect



Life expectancy Graph

QL System	System Power	Lamp Efficacy (Initial /Mean)	Initial Lumens (@ 25°C)	Mean Lumens (@ 25°C)	Color rendering index (CRI)	Lumen maintenance
	W	lm/W		lm		%
QL 55W	55	63 / 51	3,500	2,800	80	80%
QL 85W	85	70 / 56	6,000	4,800	80	80%
QL 165W	165	73 / 58	12,000	9,600	80	80%
*Note: *Typical values for I827, I830, I840*						

For more information, please visit: www.lighting.philips.com/feature/ql/intro

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Osram/Sylvania Icetron System

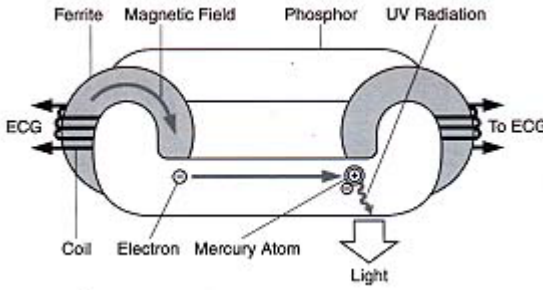
General Description: "O" shaped lamp with separate discharge vessel (bulb), and electric current generator (ECG). The induction coils are incorporated into the lamp mounting brackets and are connected to the ECG via 24" leads with two pin connectors.

Color Temperature: 3000K, 3500K and 4000K
Color Rendering Index: 80
Base: Proprietary mounting brackets
Bulb: T17
Require dedicated fixtures? Yes
Lumens: *see table below*
Rated life: 100,000 hours
Burn position: universal
Efficacy: *see table below*

OSRAM ICETRON
Source: www.sylvania.com

Features

- Long life
- Excellent lumen maintenance
- White light / good color rendition (80)
- Instant on (no re-strike period)
- Suitable for low temperature environments (minimum staring temperature is - 40°F)
- No color shift
- No flicker
- No noise
- No stroboscopic effect



Life expectancy Graph

ICETRON System	System Power	Lamp Efficacy (Initial /Mean)	Initial Lumens (@ 25°C)	Mean Lumens (@ 25°C)	Color rendering index (CRI)	Lumen maintenance
	W	lm/W	lm			%
ICE70/835	70	93 / 65	6,500	4,588	80	71%
ICE100/835	100	80 / 59	8,000	5,920	80	74%
ICE150/841	150	80 / 59	12,000	8,880	80	74%

For more information, please refer to: www.sylvania.com

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G.E. Genura Lamps

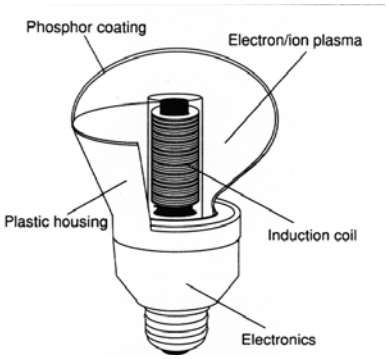
General Description: R25 lamp with integrated HF generator and power coupling. The lamp is capable of being screwed into a standard Edison socket.

Color Temperature: 2700K and 3000K
Color Rendering Index: 80
Base: E26 (screw-in)
Bulb: R25
Require dedicated fixtures? No
Lumens: *see table below*
Rated life: 15,000 hours
Burn position: universal
Efficacy: *see table below*

G.E. Genura
Source: www.gelighting.com

Features

- 50% Longer life than comparable compact fluorescent lamps
- Excellent lumen maintenance (85%)
- White light / good color rendition (82)
- Instant on (no re-strike period)
- Suitable for temperatures above 32°F **(indoor use only)**
- No color shift
- No flicker
- No noise
- No stroboscopic effect



Genura	System Power	Lamp Efficacy (Initial /Mean)	Initial Lumens	Mean Lumens	Color rendering index (CRI)	Lumen maintenance
	W	lm/W		lm		%
EL23/R25/27	23	48 / 41	1,100	935	82	85%
EL23/R25/30	23	48 / 41	1,100	935	82	85%

For more information, please refer to: ***www.gelighting.com***

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