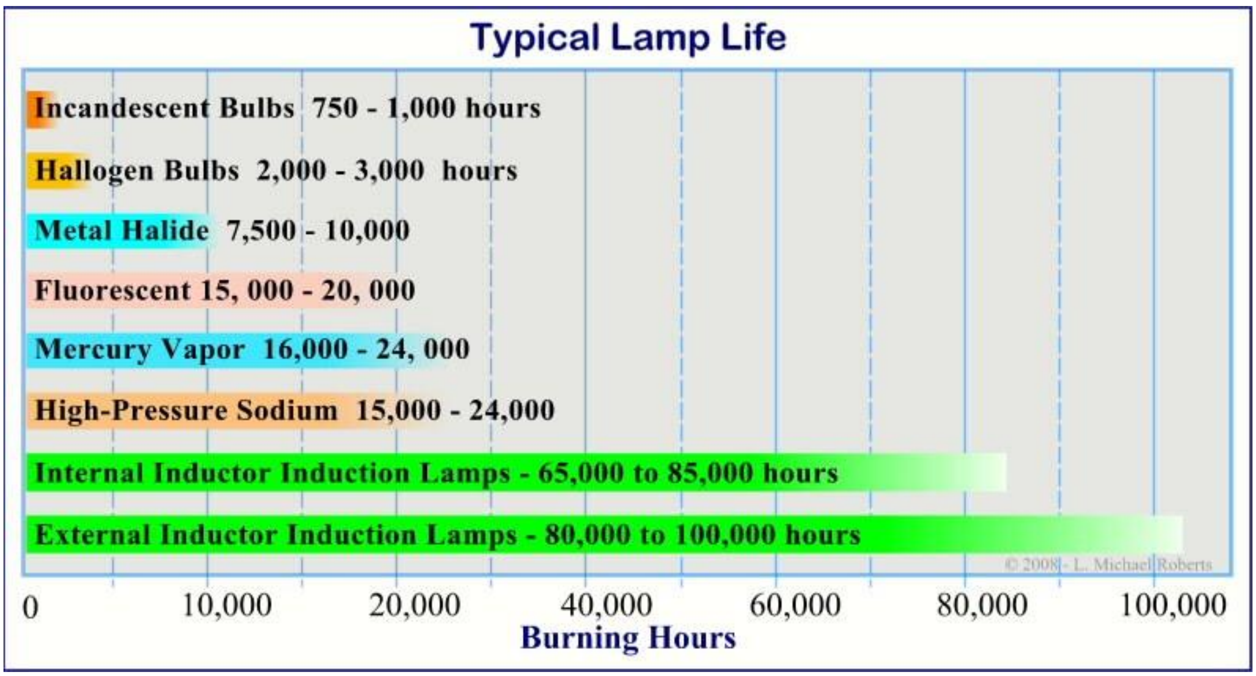
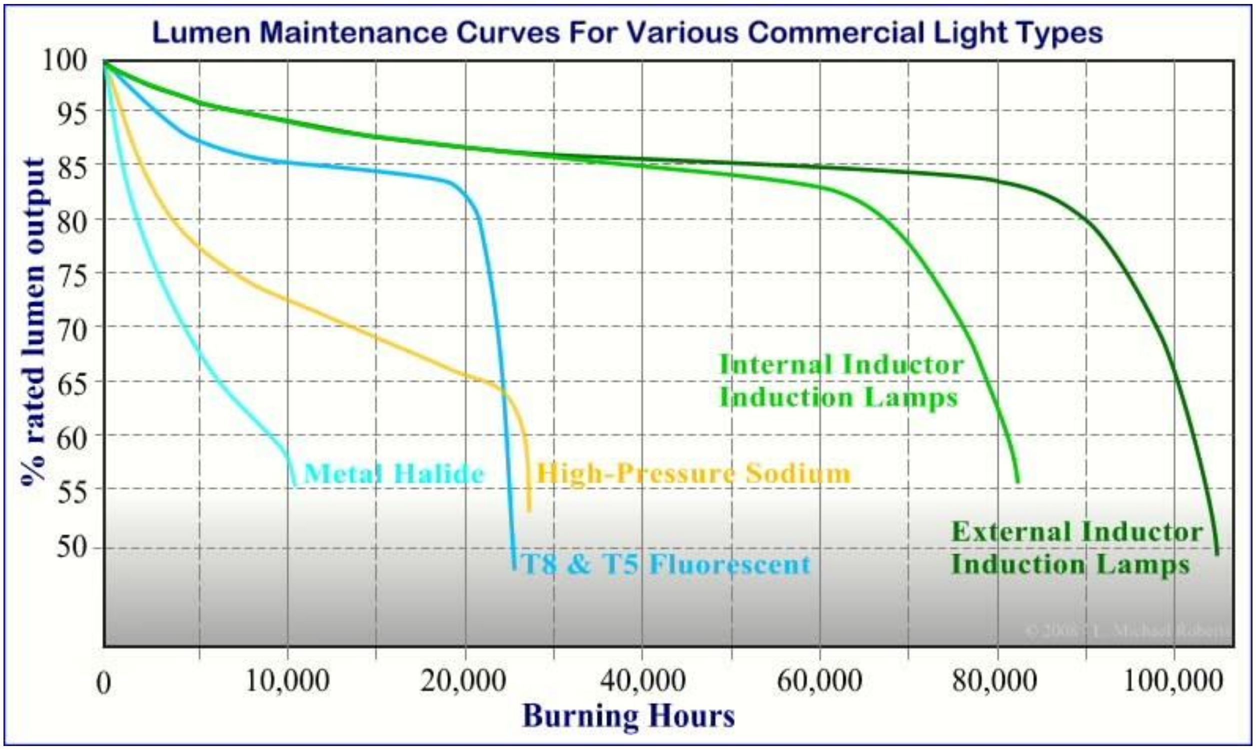
When comparing various lighting technologies used in industrial, manufacturing and retail applications, it becomes clear that induction based lighting fixtures offer the best environmental characteristics. This study surveys the advantages of Magnetic Induction lighting versus traditional lighting technologies.



The Advantages of Magnetic Induction Lamps:

- Long lifespan due to the lack of electrodes - between 65,000 and 100,000 hours depending on the lamp model;
- Very high energy conversion efficiency of between 62 and 90 Lumens/watt [higher wattage lamps are more energy efficient];
- High power factor due to the low loss in high frequency electronic ballasts which are between 95% and 98% efficient;
- Minimal Lumen depreciation (declining light output with age) compared to other lamp types as filament evaporation and depletion are absent;
- “Instant-on” and hot re-strike, unlike most conventional lamps used in commercial/industrial lighting applications (Sodium vapor and Metal Halide);
- Environmentally friendly as induction lamps use far less energy, and almost no mercury per hour of operation than conventional lighting. The mercury is in a solid amalgam and can easily be easily recovered if the lamp is broken, or for recycling at end-of-life.

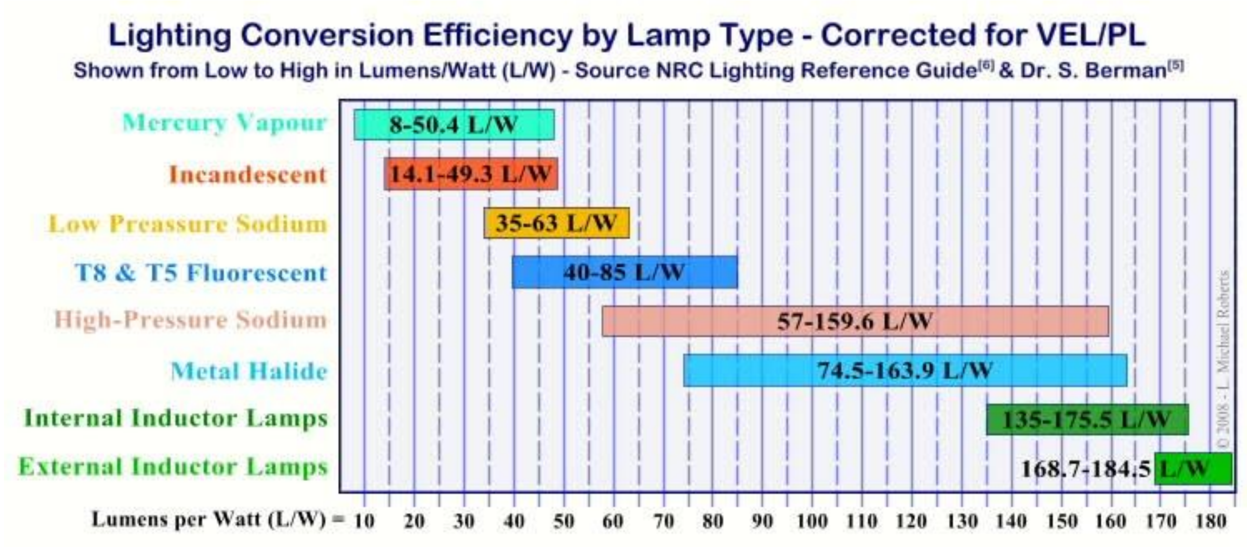
These benefits offer a considerable cost savings of between 35% and 65% in energy and maintenance costs for induction lamps compared to other types of lamps that they replace. In some applications, advanced energy savings technologies incorporated into the fixtures can provide energy savings as high as 75%.



Visually Effective Lumens or Pupil Lumens:

There is wide agreement, and scientific data, to show that the spectral distribution of the light produced by a particular lamp affects human vision. Higher blue output, sometimes referred to as “High Scotopic Output” lamps, appear brighter to the eye than the same wattage of lamp, with the same conversion efficiency, but with little or no blue output. Thus the lamp’s spectral output of light that is useful to the human eye is also a factor in perceived light quality and brightness.

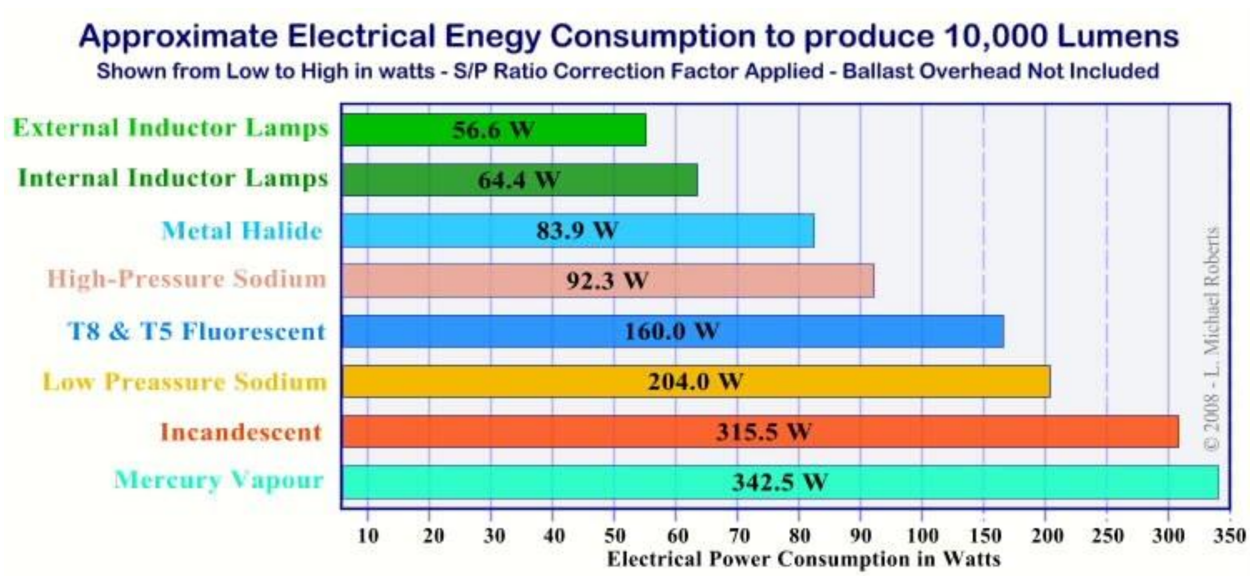
The VEL or PL of a lamp can be determined by multiplying the output in lumens by a conversion factor. The conversion factors are derived from the Scotopic/Photopic Ratio (S/P ratio) of a lamp. When the ratio is used as a multiplier of the actual output lumens, the amount of light useful to the human eye (VEL or PL) can be determined. The S/P ratio correction factor drastically changes the conversion efficiency of the lamps (Fig. 1 above) as shown in Fig. 3 below.



Induction lamps have the highest energy conversion efficiency once the correction factor is applied (as they have a high S/P ratio of 1.96 or 2.25 depending on model). Induction lamps are therefore a better choice as they produce more light useful to the human eye (VEL/PL) while using less electrical energy.

Lighting Energy Consumption:

If we look at this another way, we can determine how much electrical energy it takes to create a certain level of light for a particular type of lamp. In the chart below, we have set an arbitrary number of 10,000 lumens as an example. By using the average lumens per watt figures, corrected for VEL/PL from the previous chart, we can now approximate how much electrical power it takes to produce the desired light level of 10,000 Lumens.



Looking at a real-world example, we can replace a 250W metal halide fixture with a 200W induction lamp based fixture, or even a 120W induction lamp fixture, thereby reaping a considerable saving in energy costs.

Comparison of Electrical Energy Consumption and Light Output

Fixture Type	Metal Halide	200W Induction	120W Induction
Lamp Type	M250 [6]	200R [7]	120R [7]
Nominal Wattage (Watts)	250 W	200 W	120 W
Total actual wattage (ballast included)	275 W [6]	204 W [7]	122.4 W [7]
Ballast overhead (Watts)	25 W	4 W	2.4 W
Conversion efficiency (Lumens/Watt)	61.8 L/W [6]	81 L/W [7]	80 L/W [7]
Light output (Lumens)	15,450 L	16,200 L	9,600 L
S/P Ratio (from Dr. Berman's table)	1.49	2.25	2.25
Output corrected for VEL/PL (Lumens)	23,020 L	36,450 L	21,600 L
Approximate light output increase/decrease (%)	0%	+ 58%*	- 6.5%*
Energy savings (Watts - %)	0W - 0%	71W - 25.5%	152.6W - 55.5%
Energy cost for 100 hours operation (at $0.125 per Kw/Hr $)	$3.43	$2.55	$1.53

* **Note:** A difference of +/- 10 to 15% in light levels is barely perceptible to the human eye - % figure rounded up/down to one decimal place.

As we can see from the above table, we can successfully replace 275W of energy consumed by the Metal Halide fixture, with 204W of energy consumed by the Induction lamp fixture [a decrease of around 25%]. At the same time, we can increase light levels by approximately 58% and save $ 0.88 in energy costs per 100 hours of operation. Such a large increase in light levels will be quite noticeable to the human eye, thus if the area in question was adequately lit before, this would be "overkill" and the second replacement option, a 120W induction lamp, would be the better choice.

The second option replaces 275W of energy consumed by the Metal Halide fixture with 122.4W of power consumed by the 120W Induction Lamp Fixture [a decrease of over 55% in energy consumption]. Light levels would decrease by only around 7% - a difference that is barely perceptible to the human eye. The energy cost saving would be $1.90 per 100 hours of operation (at $0.125/KwHr). If the area in question was adequately lit, or even over lit by the Metal Halide lamp to be replaced, this would be the best option.

This example considers only one light fixture. Typically there will be dozens, and in some cases hundreds, of light fixtures, thus the overall energy savings, and consequent reduction in environmental impact, can be substantial.

Environmental Impact.

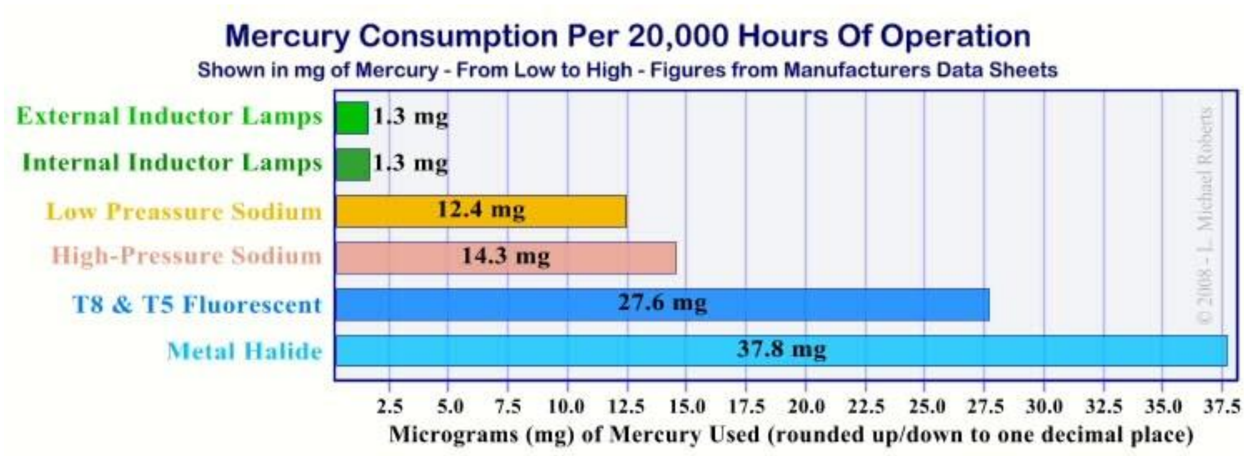
Comparison of Electrical Energy Consumption, Light Output and Co2 Emissions		
Fixture Type	Metal Halide	120W Induction
Lamp Type	M250 [6]	120R [7]
Total actual wattage (ballast included)	275 W [6]	122.4 W [7]
Conversion efficiency (Lumens/Watt)	61.8 L/W [6]	80 L/W [7]
S/P Ratio (from table)	1.49	2.25
Output corrected for VEL/PL (Lumens)	23,020 L	21,600 L
Energy savings (Watts - %)	0W - 0%	152.6W - 55.5%
Co2 emitted per 100 hours operation #	11.83 Kg 26.13 Lbs	5.26 Kg 11.63 Lbs
Co2 emitted by one year of 24/7 #	1,035.9 Kg 2,288.6 Lbs	461.1 Kg 1,018.6 Lbs
# Note: C02 emissions based on 0.43 Kg/KWh (0.95 Lbs/KWh) - figures rounded up/down to one decimal place. © 2008 - L. Michael Roberts		

Based on operating the lighting fixtures 24/7 for one year, replacing the Metal Halide lamp fixture with an induction lamp fixture will reduce Co2 emissions from electrical power generation by 574.8 KG (1,270 Lbs) or about 55%. Again, this is the figure for one fixture and typically there will be dozens or even hundreds of fixtures in a facility… thousands when considering a city or region. Replacing inefficient lighting technologies with energy efficient Induction lamps, can contribute to significant energy consumption savings and Co2 emissions reduction.

Liquid mercury, which is the most common form of mercury used in lighting, represents the greatest environmental hazard. If a lamp is broken, the liquid mercury can find its way into cracks in concrete flooring, the fibers of carpets, or into spaces in other floor coverings. Over time, the mercury will evaporate into the atmosphere causing a local “hot spot” of low level contamination. The more liquid mercury present in a lamp, the longer the resulting contamination will last.

> *“If the total amount of mercury contained in a typical fluorescent tube (approximately 20 milligrams), were to mix completely and evenly in a body of water, it would be enough to contaminate around 20,000 litres of water beyond Health Canada limits for safe drinking water (0.001 milligrams of mercury per litre of water)”* **- Environment Canada** [15]

Mercury can be compounded with other metals, into a solid form called an amalgam - this is the type of mercury used in induction lamps. It is similar to the once widely used dental amalgam in tooth fillings. The solid form of mercury poses much less of an environmental problem than liquid mercury.



Further, induction lamps are simpler and cheaper to recycle. The solid mercury amalgam is easily removed and can be recycled with less chance of environmental contamination. The external or internal inductors can be removed (for metal recovery) leaving a glass envelope free of metal parts which takes less energy to recycle. Competing lamp technologies have a significant amount of metal embedded in the lamp envelopes, thus higher temperatures and more energy must be expended to recycle the components.

Maintenance/ Bulb Replacement

The following table shows the lifespan of various lamps, and the number of replacements required based on re-lamping when the lamps reach 70% of initial output (30% lumen depreciation).

Replacement Lamps Required by Type When Output Falls Below 70%

Lamp Type	Metal Halide	High Pressure Sodium	200W Induction
Lamp Type	M250 [6]	S250 [6]	200R [7]
Nominal Wattage (Watts)	250 W	250 W	200 W
Total actual wattage (ballast included)	275 W [6]	305 W [6]	204 W [7]
Ballast overhead (Watts)	25 W	55 W	4 W
Conversion efficiency (Lumens/Watt)	61.8 L/W [6]	81 L/W [6]	81 L/W [7]
Initial Light output (Lumens)	20,500 L [6]	27,500 L [6]	16,200 L [7]
Mean (average over lifespan) light output	17,000 L [6]	24,750 L [6]	14,740 L [7]
Rated lifespan (Hours)	10,000 H [6]	24,000 H [6]	100,000 H [7]
Lifespan to 70% lumen depreciation (Hours Approx.)	5,000 H [6]	15,000 H [6]	85,000 H [7]
Number of lamps to be replaced over 10 years of 24/7 operation (87,600 hours)	8.7*	5.8*	1.0*

* **Note:** Figures rounded up/down to one decimal place.

Summary:

Reducing our environmental impact and carbon footprint are worthy goals which can make a difference in limiting global warming and climate change. Lighting consumes a significant fraction of energy production with its attendant Co2 emissions. By installing energy efficient lighting systems, you can not only reduce energy costs and expenditures, but also reduce environmental impact through reduced Co2 emissions from electricity generation, reduced waste and improved recycling.

When comparing various lighting technologies used in industrial, manufacturing and retail applications, it becomes clear that induction lamp based lighting fixtures offer the best environmental characteristics when compared to the most commonly used lighting technologies.

When compared to the two most commonly used lighting technologies in commercial and industrial applications (Metal Halide and High Pressure Sodium lamps), Induction lamps offer the following benefits:

- Significant reduction of electrical energy consumption;
- More light output when corrected for Visually Effective Lumens/Pupil Lumens;
- Significant reduction in Co2 emissions from electrical power generation due to reduced energy consumption;
- Secondary energy consumption reduction through reduced thermal loads thereby saving HVAC costs and energy, and the ability to use on-demand technologies such as occupancy sensors due to the "instant on" feature of induction lamps;
- Extended lifespan which reduces the materials needed for replacement lamps compared to MH, HPS and SOX lighting technology;
- Low mercury consumption over the induction lamp lifespan compared to competing lighting technologies;
- Induction lamps use a solid mercury amalgam which produces significantly less environmental contamination than other technologies, if accidentally broken. The sold mercury amalgam is also easy to recover and recycle at end of lamp life; and
- End of life de-construction for recycling and materials recovery requires less energy.

Magnetic Induction Lamps represent not only a breakthrough in energy efficient lighting, but also a sound environmental choice, when all aspects of the lamp technology are considered.

Information accumulated from ***knol****.google.com*