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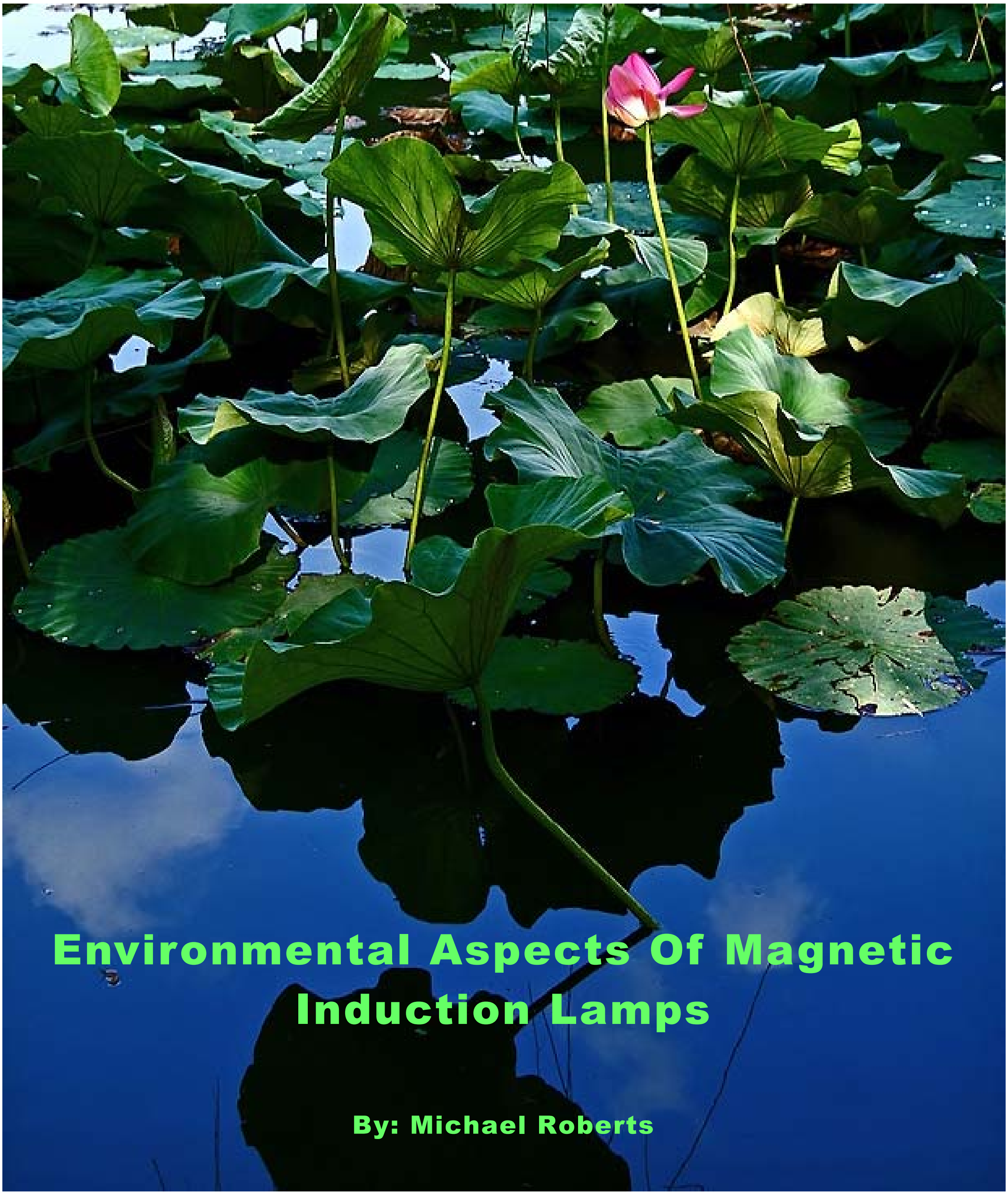

Environmental Aspects Of Magnetic Induction Lamps

By: Michael Roberts

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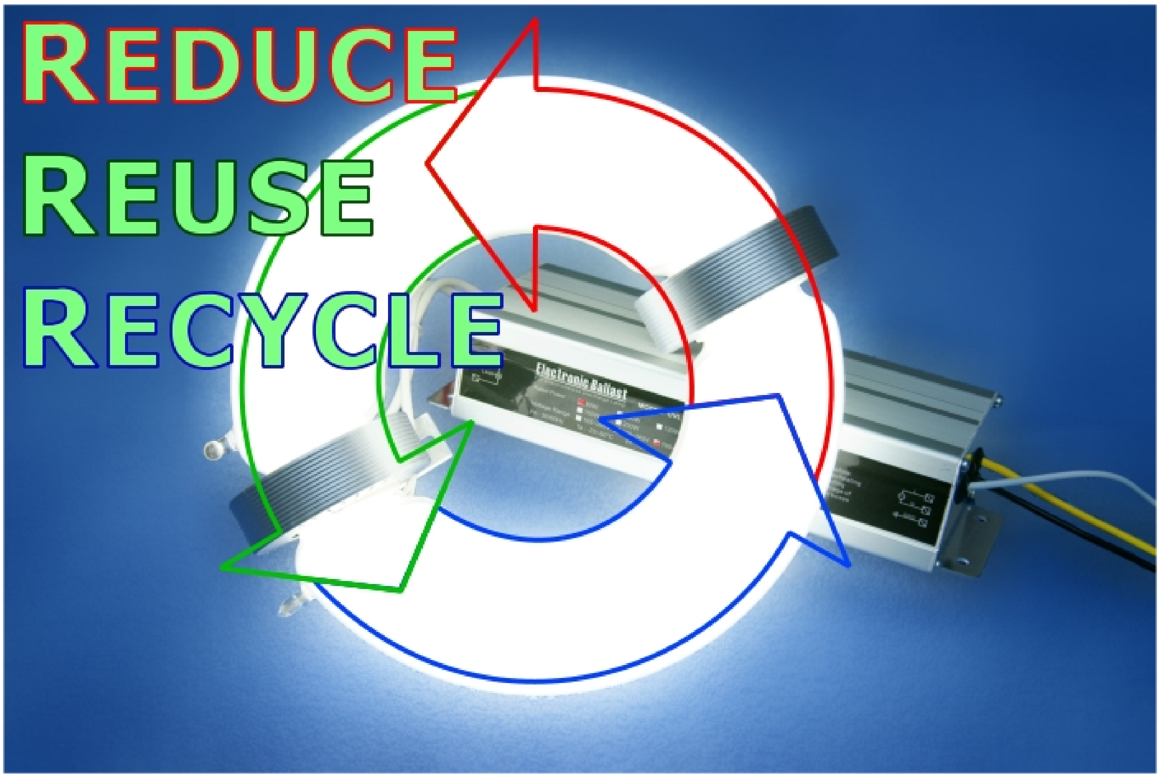
Abstract:

In an time when there is **growing concern about Global Warming** and Climate Change, and a **desire to reduce our environmental footprint**, individuals and business are seeking ways to **reduce their environmental impact**… to "Go Green".

This paper considers **energy efficient lighting**, particularly **Magnetic Induction Lighting***, as a way to implement an **environmentally friendly green lighting technology**. Magnetic Induction Lamps can reduce impact in several areas such as **saving energy, reducing CO_2 emissions, reducing materials consumption, reducing Mercury consumption**, and recycling issues.

Reducing the environmental impact and "carbon footprint" of your operations may be more feasible when implemented as a series of small incremental steps rather than as a large project. One of the often overlooked areas, where it is both simple and financially feasible, to make improvements is in your lighting systems. Magnetic Induction Lighting is one of the most environmentally friendly options available for commercial and industrial lighting applications available today.

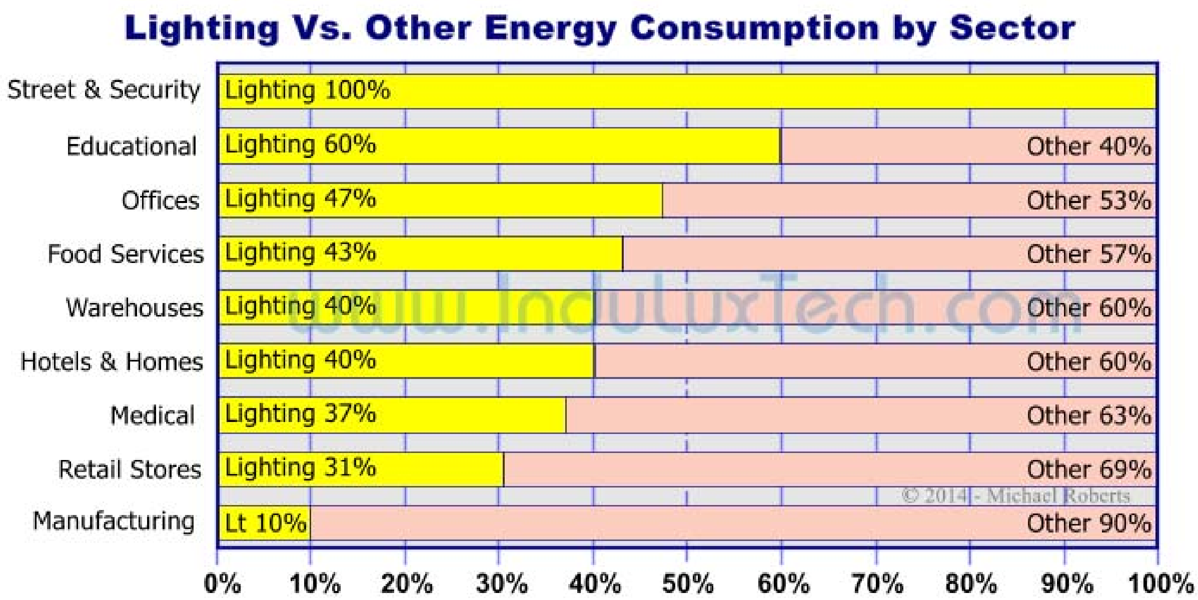
* **NOTE:** For those unfamiliar with Magnetic Induction Lighting, please see "The Science Behind Magnetic Induction Lighting" and "How Magnetic Induction Lamps Work " available in our on-line Library at http://www.induluxtech.com/Library.html



Introduction:

In an era when there is growing concern about Global Warming, and a desire to reduce our environmental footprint, individuals and corporations are seeking ways in which to reduce environmental impact. In many cases, the technology to do so is readily available but expensive to implement. For example, pollution "scrubbing" technology for factory smokestacks is available, but it is costly, disruptive to install, and in some cases may consume more energy (adding to carbon output from energy production) than the environmental remediation benefits which it provides.

This paper considers energy efficient induction lamps, as a way to implement an environmentally friendly technology which can reduce environmental impact in several areas. We will consider reducing electrical energy use in lighting and its attendant reduction of CO_2 production from power generation; secondary energy reduction through lower thermal loads in buildings; reduction of material usage and manufacturing energy; and reduction of mercury content and its impact on the environment.



Energy for Lighting:

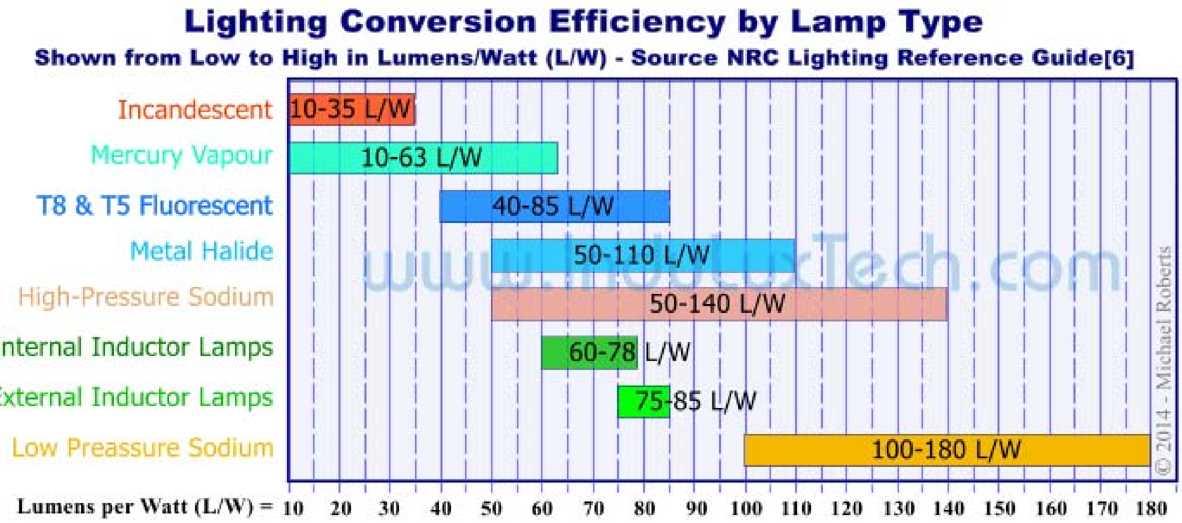
The total amount of energy used in the industrial and commercial sector in, for example, Canada varies by different building types, with a high of 34% in offices to a low of 6% in warehouses[1] Taking NAFTA and EU lighting energy figures into consideration, the variation is from 47% in offices to 10% in manufacturing and heavy industry.

Estimates for the percentage of energy used in lighting in the commercial and industrial sector range from 13%[2] to 15%[3] of total energy consumption. Reducing the amount of energy used for lighting by 40% to 75% would offer considerably savings both in energy costs and the associated environmental impact.

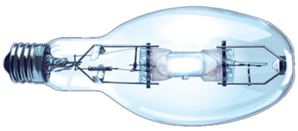
When considering energy consumption in lighting applications, one should look at two aspects of the proposed "green" lighting technology; electrical conversion efficiency and the amount of light a particular type of lamp produces that is useful to the human eye - Visually Effective Lumens (VEL), [sometimes called "Pupil Lumens" (PL)].

Electrical Conversion Efficiency:

Electrical conversion efficiency (sometimes stated as conversion efficiency) is a measure of how well a lamp converts the provided electrical energy into light. The conversion efficiency is usually stated in Lumens per Watt (L/W) and is generally in a range since there is some "economy of scale" where higher wattage lamps tend to have better conversion efficiencies.



For example, the common incandescent lamps we are all used to (pictured at right), generally have a conversion efficiency of between 12.5 and 19 lumens per watt. Induction Lamps have conversion efficiencies in the 70 to 85 Lumens/Watt (L/W) range. This means you get more light output for the same amount of energy input, or, stated another way, the same amount of light (when comparing lumen output) for less energy input.



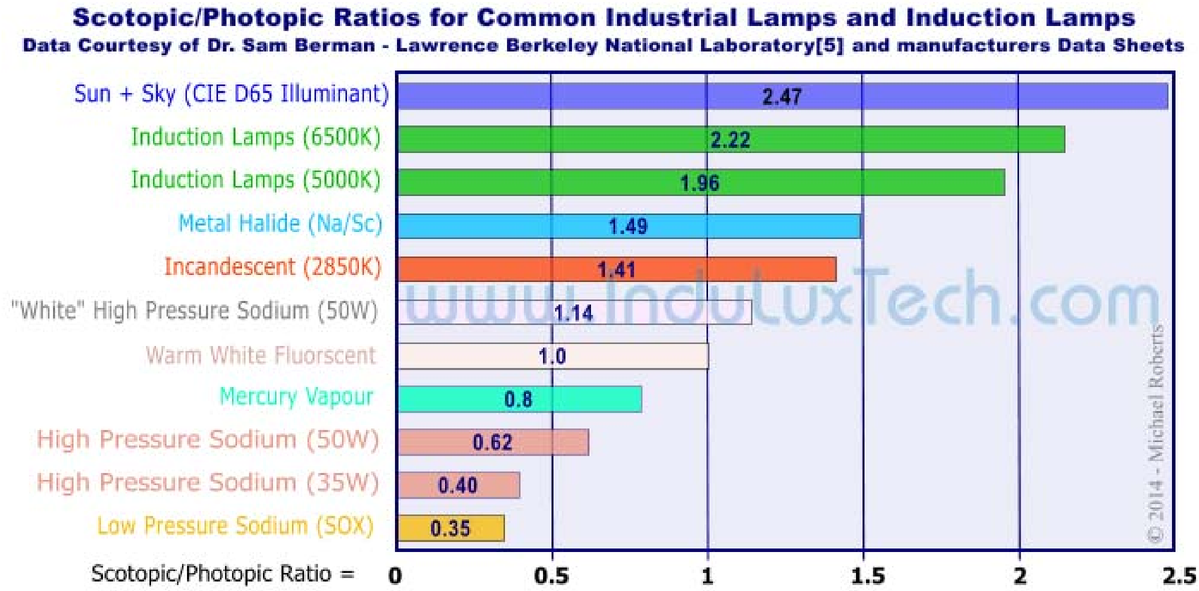
As another example, a 150W Metal halide lamp (pictured at left), with a conversion efficiency of 65 Lumens/Watt (L/W), produces 9,750 lumens. It could be replaced with a 120W Induction Lamp with a conversion efficiency of 80 L/W and an output of 9,600 lumens saving 30 watts of energy per fixture.

Visually Effective Lumens or Pupil Lumens:

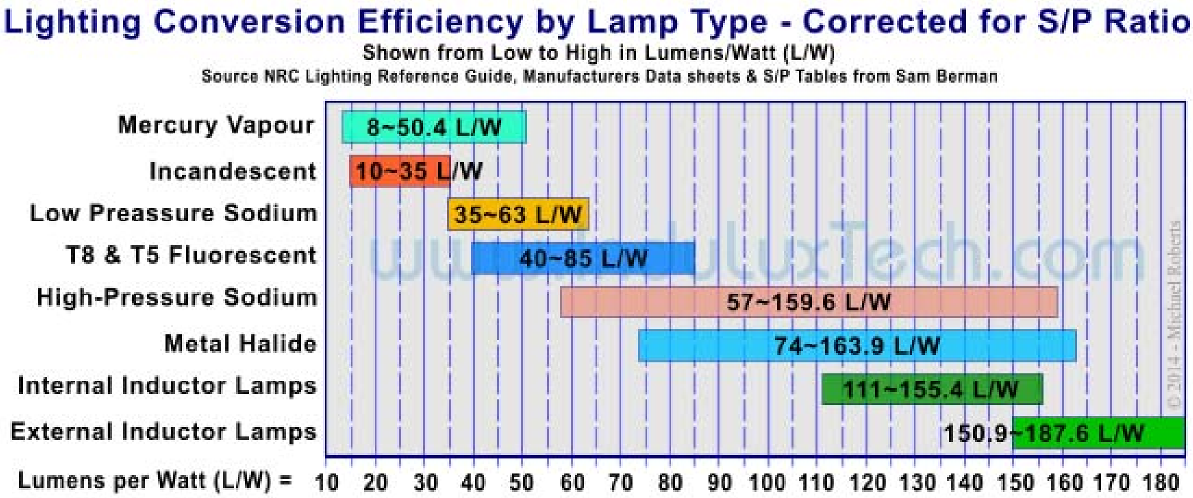
There is wide agreement and scientific data[4,5] to show that the spectral distribution of the light produced by a particular lamp affects human vision. Higher blue output, sometimes referred to as "High Scotopic Output", lamps appear brighter to the human eye than the same wattage of lamp, with the 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 of the lighting.

There is presently no scientific, or industry wide, consensus for a terminology to describe this phenomenon as yet. InduLux Technologies (and others) use the term Visually Effective Lumens, or Visually Effective Lux (VEL) while others have used the term Pupil Lumens (PL).

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 (see the chart below). The S/P ratio measures the amount of light being output in the Photopic sensitivity region of the human eye, and in the Scotopic sensitivity region of the human eye, and then derives the ratio of the two.



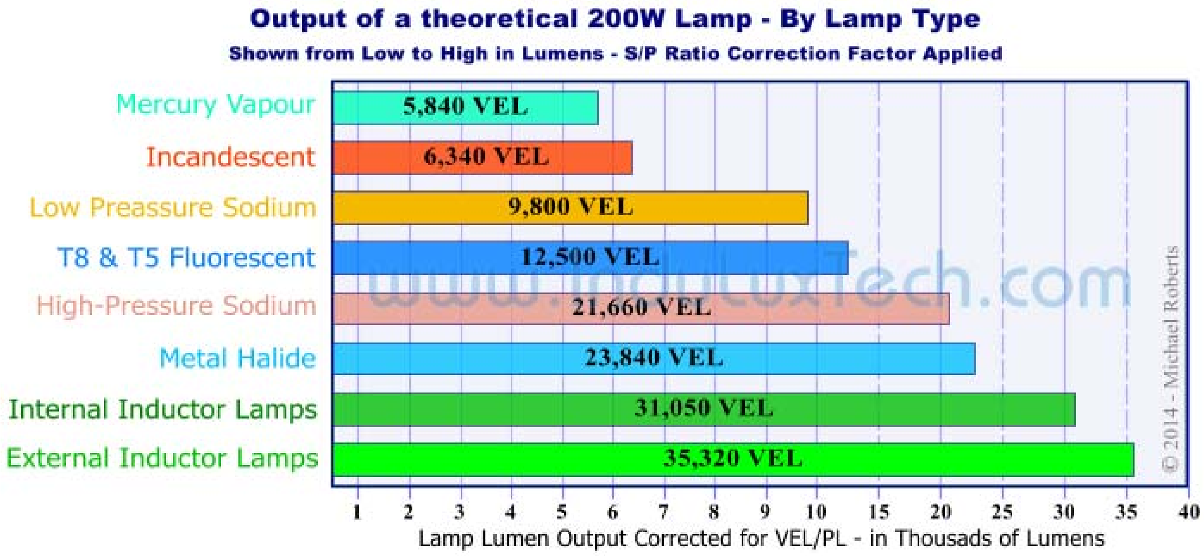
When the ratio is used as a multiplier of the actual light output in lumens (or Lux) measured, the amount of light useful to the human eye (VEL) can be determined. This correction factor drastically changes the conversion efficiency of the lamps (shown in the graph on the previous page) to that shown in the graph below.



You will note that the lamp type which had the highest conversion efficiency in the first chart, Low Pressure Sodium (LPS/SOX) at 100~180 L/W, is now one of the least efficient light sources at 35~63 L/W when corrected for it's S/P ratio. This is because the SOX lamps produce nearly monochromatic yellow light. While they score high on the Photopic curve (where conversion efficiencies are measured) they score low when corrected for VEL due to lack of blue. Since SOX lamps are nearly monochromatic, they do not produce a lot of light useful to human vision.

Magnetic Induction Lamps have the highest energy conversion efficiency once the S/P correction factor is applied (as they have a high S/P ratio of 1.96 or 2.22). Induction lamps are therefore a better choice as they produce more light useful to the human eye while using less electrical energy.

Using the S/P ratio, we can compare light sources, based on the actual amount of light useful to human vision, which they produce. The graph below shows the amount of light produced by various lamp types using a theoretical 200W version of the lamp (as not all lamp types come in 200 watt models) and applying the VEL correction factor (S/P ratio).

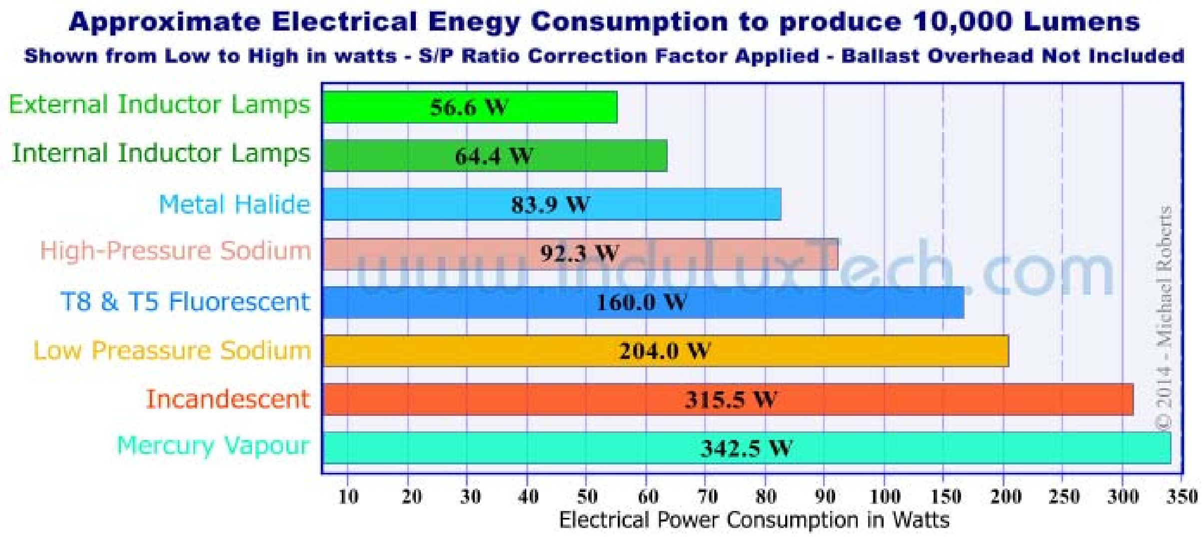


For the purposes of the graph above, the Lumens/Watt range of the theoretical 200W lamp type was averaged from the previous conversion efficiency graph. This is not scientifically accurate as higher wattages lamps tend to be more efficient, but it is used here for illustrative purposes.

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 using particular type of lighting technology.

In the chart (previous page), we have set an arbitrary number of 10,000 lumens as an example. By using the average lumens per watt figures, corrected for VEL from the previous chart, we can now approximate how much electrical power it takes to produce the desired light level of 10,000 Lumens (energy wasted in the ballasts is *not* included).



Ballast Overhead:

A further factor which must be taken into account, when considering lighting fixture energy consumption, is "ballast overhead". Almost all modern, high output lighting systems, use some form of ballast to control the energy provided to the lamp. The two most common types of ballast are the so-called "core & coil" ballasts and electronic ballasts.

- The core and coil ballasts use coils of copper wire wound around an iron core to form a special purpose current limiting transformer which controls the electrical energy provided to the lamp. The ballast may have additional components to perform other functions such as a circuit to produce a start pulse. These core and coil ballasts typically consume between 10% and 17.5% of the energy fed to the lighting fixture. This is wasted energy that is usually manifest as heat and detracts from the overall efficiency of the lighting fixtures.
- Electronic ballasts perform the same function of controlling the energy fed to the lamp and providing a start pulse if required, but they do this using electronic components rather then a transformer type ballast. As a result, they are very efficient since they can use active feedback control and a microprocessor to keep the lamp within correct operating parameters. In the case of the electronic ballasts used for Induction Lamps, only between 1% and 5% of the total energy supplied to the lighting is lost in the ballast. When we take ballast overhead into account, the Induction Lamps have significantly lower losses than most conventional lighting.

Looking at a real-world example, we can replace a 250W metal halide fixture with an 200W Magnetic Induction Lamp type fixture, or even a 120W Induction Lamp fixture, thereby reaping a considerable saving in energy costs, while maintaining a similar light level.

As we can see from the table (top of next page), we can successfully replace 275W of energy consumed by the Metal Halide fixture, with 204W of energy consumed by the Induction Lamp fixture (an energy 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, then this area would be "over lit". Accordingly, the second replacement option, 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 Lighting 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 (and does not take into account the steep lumen decline of MH lamps). The energy cost saving would be $1.90 per 100 hours of operation (at $0.125/kWh). If the area in question was adequately lit, or even over lit by the MH lamp, this would be the best option.

This example considers only one light fixture and does not take the high rate of lumen depreciation in Metal Halide lamps into account. 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.

Electricity production and CO_2 emissions:

In North America, average electrical power generation is 71% from fossil fuels [coal and gas] in the USA and 26% from fossil fuels in Canada[10]. 20.4% of all CO_2 emissions in Canada are from the generation of electricity[11] (see graph at the top of the next page). Carbon Dioxide (CO_2) is a "greenhouse gas" which traps solar radiation (heat) in the Earth's atmosphere increasing global warming and speeding climate change.

Burning fossil fuels to generate electricity emits CO2 into the atmosphere. Figures for the amount of CO_2 emitted per Kilowatt hour of electricity generated vary from .612 Kg/KWh (1.35 Lbs/KWh) [12] in the USA, to .227 Kg/KWh (0.5 Lbs/KWh) in Canada [11] These figures can vary widely depending on the mix of fossil fuel. and other types. of generating plants in use.

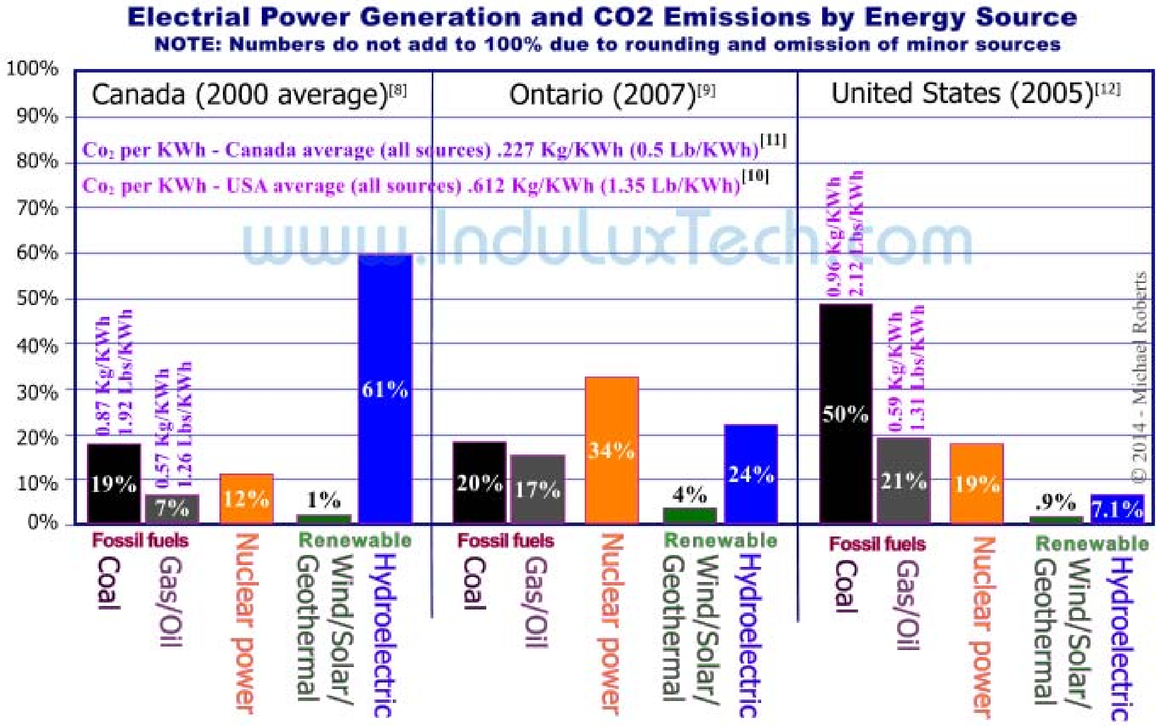
Comparison of Electrical Energy Consumption and Light Output			
Lighting Fixture Type:	**Metal Halide**	**200W Induction**	**120W Induction**
Lamp Type:	**M250 [6]**	**200R [7]**	**120R [7]**
Nominal wattage (Watts):	**250 W**	**200 W**	**120 W**
Total actual wattage (Ballast included):	**275 W[6]**	**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**	**2.22**	**2.22**
Output corrected for VEL (Lumens):	**23,020 L**	**35,964 L**	**21,312 L**
Approximate light output increase/decrease (%):	**0% (Base)**	**+ 56.2%***	**- 7.4%***
Energy savings (Watts - %):	**0W - 0%**	**71W - 25.5%**	**152.6W - 55.5%**
Energy cost for 100 hours operation (at $0.125/kWh $):	**$3.43**	**$2.55**	**$1.53**
* **Note:** A difference of +/- 10 to 15% in light levels is barely perceptible to the human eye - % figures rounded up/down to one decimal place.			

For the purpose of this paper, we will use an average figure of 0.43 Kg/KWh (0.95 Lbs/KWh) of CO_2 emitted in our discussions although the reader should bear in mind that this figure will be higher in the USA and lower in Canada due to differences in the fossil fuels used - and different again in other countries/regions according to the mix of electrical generating sources.

While energy conservation is not considered as "sexy" as renewable and "green" energy, by reducing electrical power consumption, we not only save money, but we also reduce the emission of carbon dioxide into the atmosphere from power generating stations. Energy conservation not only mitigates greenhouse gasses, but by reducing power demand and the need to build additional "dirty" power generation facilities, we gain some breathing room while more renewable/green energy sources such as wind, solar, geothermal and hydroelectric come on-line.

Using the figures from the comparison of a 250W Metal Halide fixture with a replacement by a 120W Induction Lamp fixture in the table on page 7, we can calculate the CO_2 reduction from installing energy efficient green Induction Lighting. The table below provides figures for CO_2 reduction based on 100 hours of operation and 1 year of 24/7 operation (8,760 hours) as follows:

Based on operating the fixtures 24/7 for one year, replacing the Metal Halide lamp fixture with an Induction Lighting fixture, will reduce CO_2 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 Lighting fixtures, can contribute to significant energy consumption savings and CO_2 emissions reduction.



Carbon Credits:

In many countries and territories, there are ways in which to trade "Carbon Credits". Organizations that are producing more than allowed levels of CO_2 can purchase carbon credits or carbon offsets. Those organizations or companies, who have reduced carbon output through improvements in processes, or energy consumption reduction, can sell carbon credits.

Comparison of Energy Consumption, Light Output and CO_2 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**	**2.22**
Output corrected for VEL (Lumens):	**23,020 L**	**21,600 L**
Energy savings (Watts - %):	**0W - 0%**	**152.6W - 55.5%**
Energy cost for 100 hours operation (at $0.125/KwHr $):	**$3.43**	**$1.53**
CO_2 emitted per 100 hours operation #	**11.83 Kg -** 26.13 Lbs	**5.26 Kg -** 11.63 Lbs
CO_2 emitted by one year of 24/7 operation #	**1,035.9 Kg -** 2,288.6 Lbs	**461.1 Kg -** 1,018.6 Lbs
Note: # CO_2 Emissions based on 0.43 Kg/KWh (0.95 Lbs/KWh)		

In some territories, replacing older lighting technologies with Induction Lamps may be eligible for Carbon Credits, or may be used as an offset against other carbon emissions. The sale of Carbon Credits, or their use to offset other carbon emissions, may contribute to the reduction of the cost of the Induction lighting purchase, and/or the reduction of the costs of ongoing business operations.

Secondary Energy Consumption Reduction Factors:

The primary mode of energy reduction from replacing conventional lighting with energy efficient green lighting fixtures is the energy savings on the electricity used. There are also other ways in which energy efficient Induction Lamps can reduce energy consumption and its attendant environmental impact.

Thermal loads:

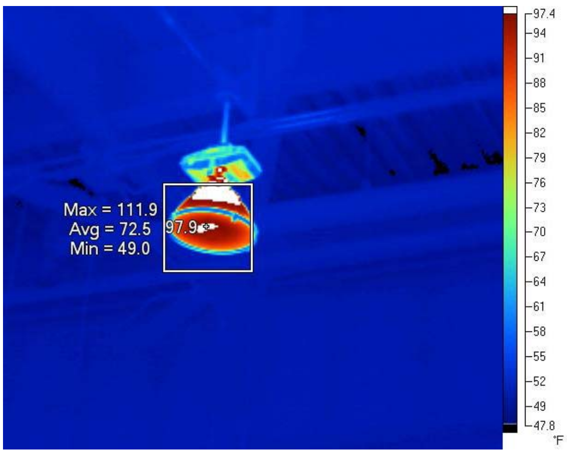
The Ballast overhead, which was discussed before, represents the loss of electrical energy in the ballast of the lighting fixture. This lost energy manifests primarily as heat, which is added to the heat output by the lamp itself. This heat output is the "thermal load" of the fixture or the amount of heat it contributes to the space in which it is operating.

The 250W Metal Halide lamp we have been using as an example, will contribute 25W or more of heat (for each fixture) to the space it is operating in. In effect, each lighting fixture becomes a 25 (or more depending on the heat output from the lamp itself) radiant heater.

In winter conditions, when the space must be heated, this is a welcome contribution and represents energy that can be used. In spaces which are air-conditioned, the thermal load of the lighting represents additional heat that must be removed by the HVAC system which adds to overall energy consumption. While this is, generally speaking a small amount of heat, in applications such as cold-storage facilities or commercial/industrial freezers, the thermal load from lighting can represent a significant percentage of cooling costs.

By installing Induction Lighting fixtures with efficient electronic ballasts, where both the ballasts and the lamps operate at lower temperatures than other HID (Mercury Vapour, Metal Halide or High Pressure Sodium) fixtures, there are secondary energy savings to be gained from the reduced heat load produced by the more efficient Induction Lighting fixtures.

Thermogram:



This image (left) is a thermo-gram (infrared photograph) of a typical, conventional technology, High Intensity Discharge, Highbay lighting fixture in an industrial cold-storage warehouse facility.

While the ambient temperature in the space is around 9.4°C (49°F) the area above the fixture is slightly warmer due to radiated heat. The "gear box" (ballast housing above the reflector portion of the fixture) is operating at a temperature of around 28°C (82.5°F) due to the wasted energy from ballast overhead, while the overall fixture is showing temperatures as high as 44.4°C (111.9°F) with an average temperature of 22.5°C (72.5°F).

On-demand Usage:

In some applications, for example an infrequently visited section of a warehouse or storage facility, the management must keep Mercury Vapour, Metal Halide and High Pressure Sodium fixtures operating continuously. These types of fixtures (and almost all other high-light-output/ HID fixtures) are not "instant-on" and require some time to warm up to full light output. It is therefore inconvenient to turn them off in applications where the lighting usage is predicated on staff activity, since people entering the area will have to wait 5 to 10 minutes for this type of lighting to reach full output.

Induction lamps are considered "instant-on" since they typically start operating at around 80% of maximum light output, and reach 100% of output in a very short time (90 to 240 seconds depending on the model). The initial light output of the Induction Lamps is usually sufficient for staff to start work in the area immediately without waiting for the lights to come to full output. Induction lamps are also "hot re-strike" meaning that they come back on instantly after a power interruption or after being switched off, then back on, by a sensor.

The use of occupancy or motion sensors with Induction Lamps is therefore practical compared to their use with MH or HPS fixtures. The facility operator can thus achieve additional energy savings by having the sensors turn the light on only when needed. Using a motion/occupancy sensor, the Induction Lighting fixtures are triggered by the sensor to provide full illumination levels, as needed, when staff enter, or are present, in the area.

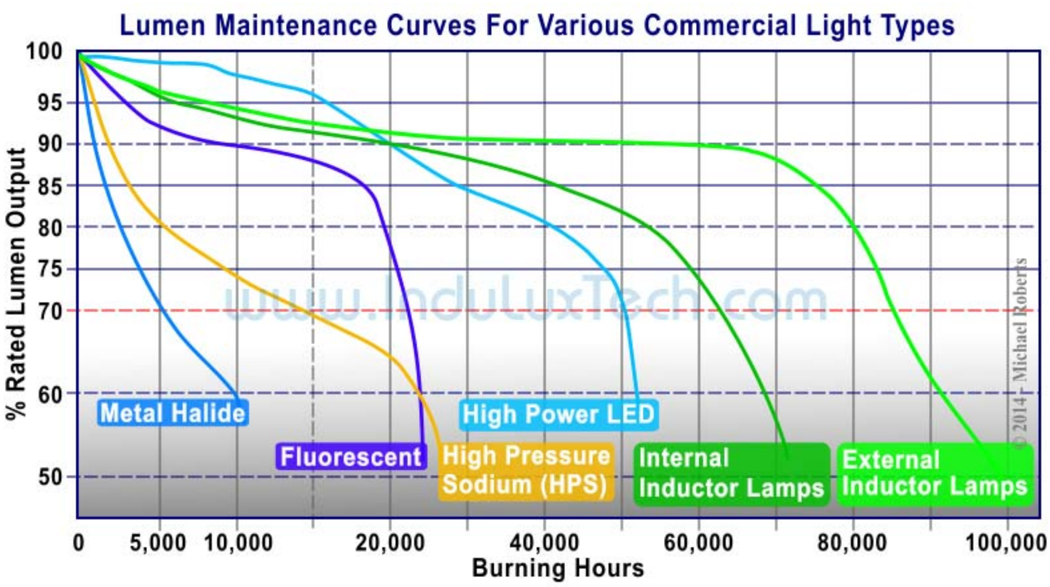
These energy savings can be even more significant in cold storage facilities. Since the Induction Lamps can be switched off when staff are not in the facility, they not only reduce the energy consumption from electricity used by the lights, they also reduce the thermal load as the lights are only operated as needed. This can be a significant energy and cooling savings when compared to MH or HPS fixtures operating continuously in a similar application.

Resource Consumption Considerations:

All lighting fixtures require resources of material and energy to manufacture. Since it is almost impossible to find figures for the resources and energy required to manufacture lamps and lighting fixtures, let us consider only the resources entailed in manufacturing replacement lamps.

Initially, we must consider "Lumen maintenance" which is a measure of how well a lamp type maintains its light output over time. All lamps produce less light output as they age which is known as "Lumen depreciation". The information for Lumen depreciation is usually published as "Lumen maintenance" curves. The lumen depreciation of a lamp type will determine how often it must be replaced.

The graph below shows the lumen maintenance curves for various types of lighting technology based on averages of figures from manufacturer's data sheets.



Experts recommend that lamps should be replaced once they have depreciated to 70% of their initial output level[14] (dashed red line in the graph above). While a drop in light output from a lamp of up to 15% is almost imperceptible to the human eye, a drop in light output of between

15% and 30% is quite noticeable to the human eye. In addition, some jurisdictions have regulations requiring certain minimum lighting levels be maintained for various kinds of tasks. Once the light output from any lamp falls below 70% of initial output, it may also fall below minimum output levels required by regulations.

The following table is extrapolated from the information in the graph (above) and 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%

Fixture Type >	Metal Halide	High Pressure Sodium	200W Induction
Lamp Type:	**M250** [6]	**S250** [6]	**200R** [7]
Total actual wattage (Ballast included):	**275 W** [6]	**305 W** [6]	**204 W**
Conversion efficiency (Lumens/Watt):	**61.8 L/W**	**81 L/W**	**81 L/W**
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:** Rounded up/down to one decimal place

As we can see from the table, MH and HPS lamps will require far more frequent lamp replacement than the Induction Lamps. If, for the sake of simplifying the example, we presume that the amount of energy and materials needed to manufacture one of each kind of lamp is the same, then we can see that using MH lamps consumes 8.7 times the resources, while the HPS lamp consume 5.8 times the resources, compared to the materials and manufacturing resources for an Induction Lamp. Induction Lamps therefore conserve resources and reduce waste due to their long lifespan.

Those materials have to go somewhere once any lamp reaches end of life. While expired lamps used in industrial/commercial applications typically end up in the landfills, much of the materials in the lamps, such as the glass and metals, can be recovered and recycled.

In the case of HID lighting with electrodes embedded in the walls of the envelope/bulb, higher temperatures and additional procedures must be used to reclaim the materials. In the case of induction lamps, the glass and metal components are very easily separated allowing for efficient recycling with less energy used in the reclamation process.

One of the components of these types of lamps, mercury, does pose a problem for disposal and recycling due to its toxicity - especially liquid mercury (pictured at right) and found in HID type lighting. Mercury, like dioxins and furans, is a toxic, persistent, bioaccumulative substance. Bioaccumulation is the process by which living organisms (including humans) can absorb contaminants more rapidly than their bodies can eliminate them, thus the amount of mercury in the body slowly accumulates over time.

Mercury Utilization:

Almost all modern light sources depend on using mercury inside the lamps for operation. When considering the environmental impact of the mercury in lighting, we must take three factors into consideration:

- The type of mercury (solid or liquid) which is present in the lamps,
- The amount of mercury present in a particular type of lamp, and
- The lifespan of the lamp which will determine the amount of mercury used per hour of operation.

Liquid mercury, which is the most common form of mercury used in lighting, represents the greatest hazard. If a lamp is broken, the liquid mercury can find its way into cracks in concrete flooring 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 that is present in a lamp, the longer the resulting contamination will last.

Mercury can be compounded with other metals, into a solid form called an amalgam - this is the type of mercury used in Magnetic Induction Lighting lamps. This is similar to the once widely used dental amalgam in fillings. The solid form of mercury poses much less of an environmental problem than liquid mercury. The small slug of amalgam can easily be recovered (wear disposable gloves) in the case of Induction Lamp breakage; and therefore can be disposed of properly with little or no risk of creating a locally contaminated area. The solid mercury amalgam is also simpler to recover for recycling at the end of lamp life.

"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]

The amount of mercury by lamp type and manufacturer varies as shown in the table below:

Comparison of Mercury Utilization for Typical Commercial Light Sources

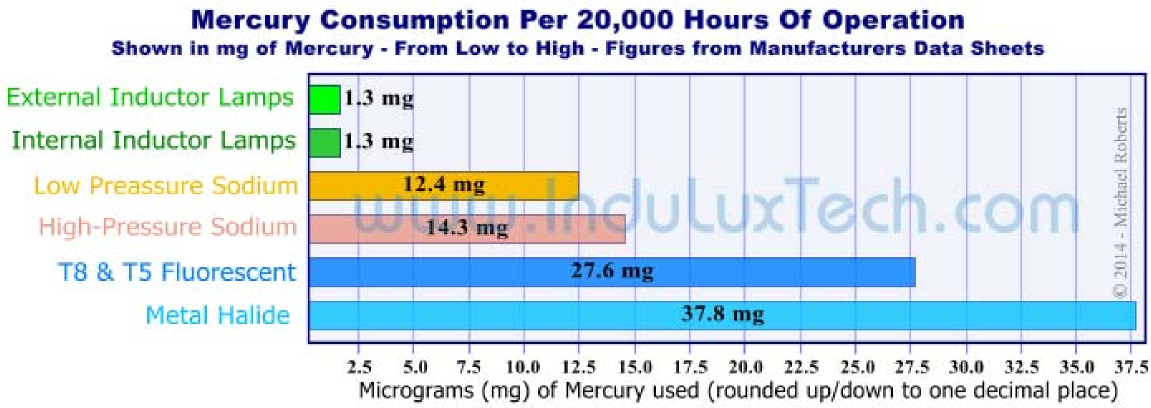
Lamp / Mercury	Low Pressure Sodium (SOX)	High Pressure Sodium (HPS)	Metal Halide	48" Fluorescent Tube	Induction Lamps
Average Mercury (Hg) Content (in Micrograms [mg]*)	GE LPS: 6~8 Phillips LPS: 12~16	Osram HPS: 13~20 Sylvania HPS: 12~15	GE : 11~30 Phillips: 12~15	Sylvania: 40~43 Phillips low Hg: 10~12	6.4 mg
Mercury use per 20,000 hours#	**12.4 mg Hg**	**14.3 mg Hg**	**37.8 mg Hg**	**27.6 mg Hg**	**1.3 mg Hg**

NOTES: * Mercury content taken from manufacturers data sheets and http://www.informinc.org/fact_P3mercury_lamps.php then adjusted as if comparing 100W lamps.

The usage figure is calculated from average Mercury content and average lifespan figures given above [rounded up/down to one decimal place]

As we can see from the table above, Induction Lamps use the least amount of mercury of any lamp technology, when considered based on both initial quantity, and amount used per 20,000 hours of lamp life. Induction lamps are therefore much more environmentally friendly since they use very little mercury over their lifespan. Further, the mercury used in induction lamps is in solid amalgam form, reducing contamination in the case of accidental breakage, and making recovery for recycling simpler.

The chart below puts this information into visual form for the most common types of industrial, commercial and retail lighting technologies:



Environmental Facts Relating to Mercury and Light Bulb Recycling:

Each year, an estimated 600 million fluorescent lamps are disposed of in U.S. landfills amounting to 30,000 pounds of mercury waste.

In 1992, mercury-containing lamps were added to the United States' Environmental Protection Agency's (EPA) list of hazardous substances. (The EPA's regulatory threshold of 2 mg./litre is usually exceeded by mercury-containing lamps).

The Mercury from one fluorescent bulb can pollute 6,000 gallons of water beyond safe levels for drinking.

"Mercury Study Report to Congress" - US Environmental Protection Agency (EPA); December 1997

Recycling considerations:

As mentioned above, Induction Lighting lamps require much less resources, in terms of the raw materials for manufacturing, than other lamp technologies considering the long lifespan of the lamps, and the number of replacement lamps required by competing technologies.

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.

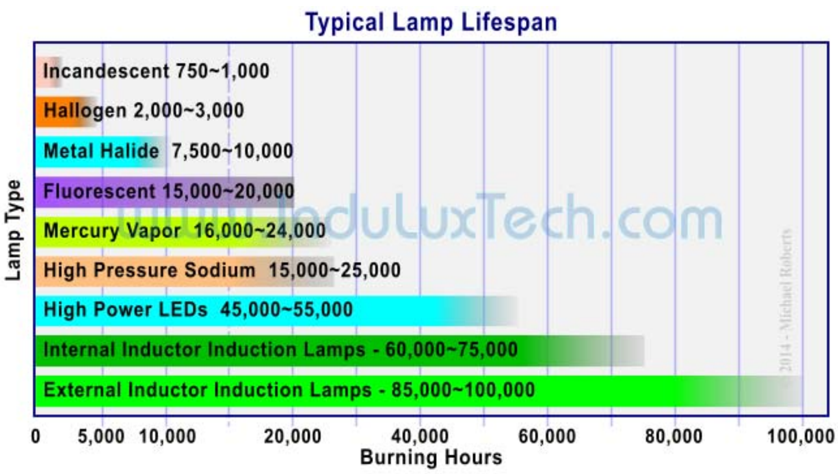
Summary:

Reducing our environmental impact and carbon footprint are worthy goals which can make a difference in limiting global warming (climate change). Lighting consumes a significant fraction of energy production (see graph, page 2) and its attendant CO_2 emissions. By installing energy efficient Magnetic Induction Lighting systems, you can not only reduce energy costs and expenditures, but also reduce environmental impact through reduced CO_2 emissions from electricity generation, reduced waste, and improved recycling.

When comparing various lighting technologies used in industrial, commercial, manufacturing and retail applications, it becomes clear that Induction lamps and fixtures offer the best environmental characteristics - they are "green lighting" compared to conventional lighting technology.

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

- **Significant reduction of** electrical **energy consumption** while producing **equivalent light levels;**
- **More light output** when corrected for **Visually Effective Lumens** (VEL/PL);
- **Significant reduction in CO_2 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, MV and SOX lighting technology;



- **Low mercury consumption** over the Induction Lamp's **long 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 requires less energy**.

Induction Lighting fixtures & 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.

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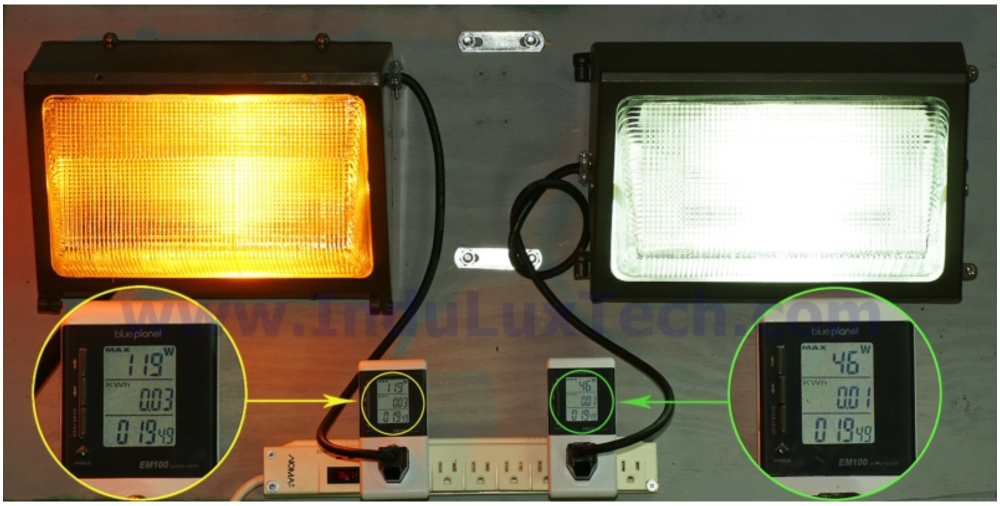
Dramatic Energy Savings - Wallpacks



Left: A 70W High Pressure Sodium Wallpack fixture (used for perimeter/security lighting). The insert photo of the watt meter shows that it is consuming 119W of energy (ballast Included) while producing 4,389 Visually Effective Lumens (VEL) of light.

Right: A 40W magnetic induction light Wallpack. The insert photo of the watt meter shows it is only consuming 46W of energy (ballast included) while producing 5,994 Visually Effective Lumens (VEL) of light. Note the more natural and pleasant colour produced by this Wallpack fixture.

The magnetic induction lighting technology Wallpack produces over 26% more light while using 62.2% less energy!

About the Author - Michael Roberts

Michael Roberts is the Chief Technology Officer for InduLux Technologies Inc., an R&D and intellectual property company focusing on energy efficient technologies. Michael is presently working on advanced, high efficiency, magnetic induction lamp light sources.

Michael travels to China frequently and visits all of the major induction lighting factories. He has worked with a number of Chinese induction lamp manufacturers on improvements to the technology as well as fixture designs optimized for use with magnetic induction lamps. He has also licensed some of his technology to Chinese manufacturers.

Michael is an inventor with two granted patents in UV water treatment technology. He invented the world's first UVC induction lamp. He has applied for patents for an induction lighting "Daylight Harvesting" system, streetlights and other applications using induction lamps. He presently has various patents pending on induction lighting technology, and speciality induction lighting fixtures. He works as a consultant to manufacturers and distributors of magnetic induction lighting products world-wide, some of whom are also licensees of his Intellectual Property.

InduLux Technologies Inc.