DOCUMENT IN SUPPORT OF LED STREET LIGHT RECOMMENDATION, 2/9/2009
BILLINGS ENERGY & CONSERVATION COMMISSION

TITLE: LED Outdoor Lighting

Guess which side is LED light?
Which side uses 53% less energy at Prairie School in Racine, Wisconsin?
http://www.betaled.com/docs/BetaLEDPB-Prairie.pdf

Source: http://www.netl.doe.gov/ssl/PDFs/Portland_2008/Day2_Ruud.pdf

INTRODUCTION - PROBLEM/ISSUE STATEMENT

The LEDs were on the left side in the first picture above, the side with the white light. Recent technology advances in solid state lighting (SSL) (aka.LED (light emitting diode)) lighting make it possible for us to reduce the energy used for street, parking lot & garage, and airport walkway lighting by between 50% and 70% depending on the technology being replaced. Payback periods vary from 3.7 to 6.3 years for new installations in a DOE demonstration project in San Francisco, depending on the type of new light installed, old light replaced, and maintenance costs. Those costs and payback periods have come down rapidly. Payback periods are also affected by rising energy prices and may not be the same in Billings. NorthWestern Energy believes the payback periods would be more like 4.7 to 7.9 years. City staff is developing some economic data.

LEDs can have a maintenance free life longer than the payback period. Many have five or more year warranties. Some manufacturer make free demonstration fixtures available. DOE offers demonstration assistance (i.e., "in-kind" technical support, research on demonstration projects, illumination measurements, report writing, and product testing. but not funding). Rather than casting the issue as a problem, we see LED's as a significant opportunity to significantly reduce energy use in outdoor lighting while saving money for Billings's taxpayers.

- A study in the 1970's found that if financing for energy conservation measures can be obtained for the payback period, one creates an immediate positive cash flow in the budget. That happens when we finance the project and pay to amortize the principle and interest with what would have been spent to continue wasting energy. Simply put, if we do not seize this opportunity, we will pay more to waste energy than to save it. That is true in both the short and long run.

RECOMMENDATION

Therefore we are recommending that you:

- consider requiring that city-owned street lighting in all new lighting districts under city jurisdiction be LED lighting (partially adopting the policy of Welland, Ontario Canada which directed "LED lighting installations for all new developments" on July 15, 2008)[1]
- participate in further cost-effectiveness analyses specific to Billings' situation to support your decision.

BACKGROUND

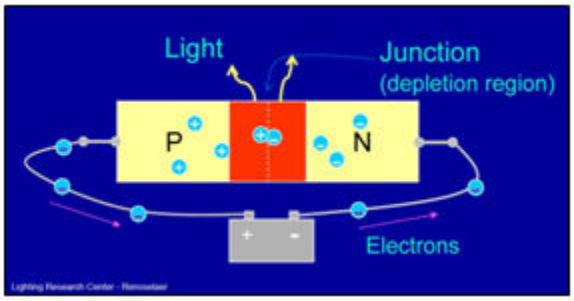
What Are LEDs?

LEDs (light-emitting diodes) have been around since the 1960s. You've probably seen them used as indicator lights in consumer products, car tail lights, or traffic signals. Recently, however, they have become practical for general lighting purposes. Although they cost more upfront than the bulbs they replace, LED lights use half the energy (or less) and last longer than conventional bulbs, resulting in sufficient savings and reasonable payback periods. One specific advantage of LEDs is that they produce directional light. This gives us more control over what

[1] See page 7 at http://www.welland.ca/Council/c2008/CM20080715.pdf#search="led" Welland City Council directs staff to amend the City of Welland Municipal Standards and the section pertaining to street lighting to accommodate LED lighting installations for all new developments.

we light (i.e. the street) and what we don't (the night sky), reducing light pollution and wasted energy.

How LEDs Work



LEDs differ from traditional light sources in the way they produce light. In an incandescent lamp, a tungsten filament is heated by electric current until it glows or emits light. In a fluorescent lamp, an electric arc excites mercury atoms, which emit ultraviolet (UV) radiation. After striking the phosphor coating on the inside of glass tubes, the UV radiation is converted and emitted as visible light.

An LED, in contrast, is a semiconductor diode. It consists of a chip of semiconducting material treated to create a structure called a p-n (positive-negative) junction. When connected to a power source, current flows from the p-side or anode to the n-side, or cathode, but not in the reverse direction. Charge-carriers (electrons and electron holes) flow into the junction from electrodes. When an electron meets a hole, it falls into a lower energy level, and releases energy in the form of a photon (light).

The specific wavelength or color emitted by the LED depends on the materials used to make the diode.

"White" light is created by combining the light from red, green, and blue (RGB) LEDs or by coating a blue LED with yellow phosphor. See "Color Quality" section for more information. http://www.netl.doe.gov/ssl/usingLeds/general_illumination_color.htm

Where are LEDs being used for Outdoor Lighting?[2]

Anchorage, Alaska, recently announced it will begin installing 16,000 LED street lights.

Ann Arbor, Michigan, a city the size of Billings, recently contracted for 1000 LEDs for $630,000 to replace existing metal halide (MH) decorative street lights. The contract was awarded following a 25-fixture evaluation from five manufacturers. It showed a 50 percent energy savings and 3.8 to 4.4 year payback on initial investment. The Mayor of Ann Arbor told NBC that after the payback period, the ongoing savings would be $100,000 a year. LEDs are designed to last at least 10 years, in some pathway lighting applications, 23 years. [3]

The vast majority of savings in Ann Arbor's project were due to avoided maintenance. DOE does not expect most sites to see these kinds of maintenance savings, because Ann Arbor

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2 For more information than listed in this section on the places using LEDs, see "Attachments …" link at http://www.newworldwindpower.com/LED%20MENU.htm .

3 For technical report on Ann Arbor's LED program see http://www.a2gov.org/government/publicservices/systems_planning/energy/Documents/LED_Summary.pdf .
To see NBC or Fox reports that include quotes from Ann Arbor's mayor:
http://www.msnbc.msn.com/id/21134540/#22247015 .
http://www.lumecon.com/uploaded_files/LED_Street_Lights_Ann_Arbor.wmv

employs a spot lamp replacement approach. It is more common for communities to use a group lamp replacement process. Maintenance savings in group replacement cities are less.

Made in America, each LED fixture in Ann Arbor draws only 56 watts replacing bulbs that use more than 120 watts. [4] There is no lead or mercury in these fully recyclable LEDs. In terms of eliminating CO2, it was like taking 400 cars off the road.

San Francisco, CA The DOE and Pacific Gas & Electric have studied 4 LED "cobrahead" fixtures (more commonly seen in many cities for use in residential areas).[5] Payback periods for new construction ranged from 3.7 to 6.3 years for the two most energy efficient and best lighting pattern luminaires. For retrofits the payback range for these two fixtures was from 7.4 to 10.8 years.

Welland, Ontario, Canada (50,000 pop.) experienced similar test run savings. It now plans to replace all 6,500 of its street lights in 3 to 5 years with Relume LED luminaires. [6]

Benton Harbor, MI (10,500 pop.) installed 46 LEDs in its historic downtown area.

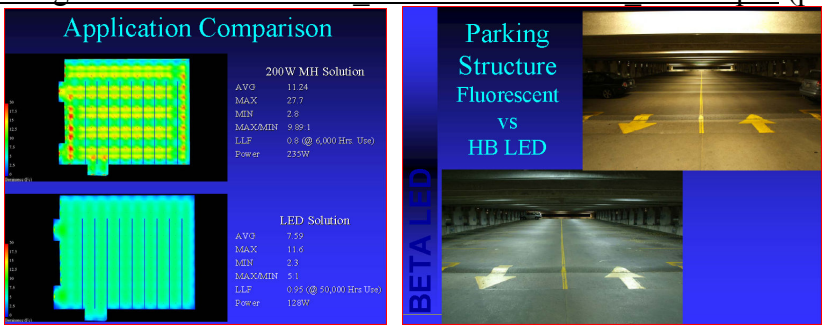
Other Cities: See for information on several other cities that are installing LED street lights, see "Attachments …" and "Update" links at http://www.newworldwindpower.com/LED%20MENU.htm.

ALTERNATIVES ANALYZED

For outdoor lighting, four technologies have been used to replace general incandescent lights. Mercury Vapor lighting is considered the most inefficient. Metal halide and high pressure sodium (HPS) were the next technological advances. Several years ago, Northwestern Energy (then called Montana Power) was required by the Montana Public Service Commission to replace mercury vapor and incandescent fixtures in most of the areas where it owned outdoor lighting with HPS. The most recent technological advance has been to light emitting diodes (LED).

The pros and cons of LEDs are discussed in the various reports at http://www.netl.doe.gov/ssl/materials_2008.html The DOE testing through its CALiPER program is the most credible. http://www.netl.doe.gov/ssl/comm_testing.htm

On the left below are light distribution comparisons between MH & one brand of LEDs for a parking lot found at http://www.netl.doe.gov/ssl/PDFs/Materials_2008/HAUGAARD_SSL08.pdf (p. 30)



Source: http://www.netl.doe.gov/ssl/PDFs/Portland_2008/Day2_Ruud.pdf

In the above pictures you see an application of LED (white light) in a parking ramp. The patterns for LEDs are more uniform (on the left, the bottom (green pattern).

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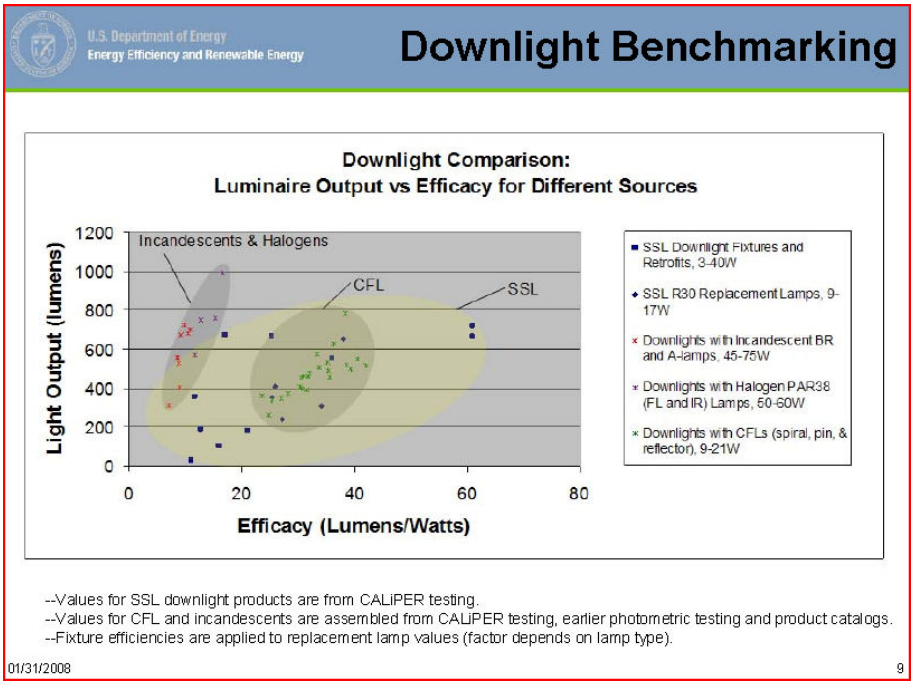
4 Source: http://www.lumecon.com/uploaded_files/Lumecon_wins_AA_contract.pdf .

5 http://www.netl.doe.gov/ssl/PDFs/gateway_sf-streetlighting.pdf

6 Source: http://www.lumecon.com/uploaded_files/LED_Magazine_Article_12_7_2007.pdf



Source: http://www.netl.doe.gov/ssl/PDFs/Materials_2008/PAGET_SSL08.pdf

The above screen print indicates different lumen/watts outputs for LEDs (otherwise known as SSL). The better performers are at the top right hand corner of the graph. However the LED squares are all over the map and also include some very poor performers.

Not shown in the above comparison is the LED from Universal Display Corporation, a Ewing, New Jersey Company specializing in innovative organic light - emitting diode (LED) technologies. In the summer of 2008 it announced the **successful demonstration of a world record-breaking white OLED with a power efficacy of 102 Lumens per Watt (lm/W)**. This marked the first time that white OLEDs have surpassed the power efficacy of incandescent bulbs with less than 15 lm/W and most fluorescent lamps, which are rated at 60 - 90 lm/W. OLEDs are organic light emitting diodes. A short time later **Cree successfully created a cool white LED prototype that delivers 107 lm/W at 350mA**.

Please note the recognition that some Solid State Lighting (LED or SSL) products in the outdoor and down lighting category now exceed traditional sources.

Source: http://www.netl.doe.gov/ssl/PDFs/Portland_2008/Day2_Paget.pdf

What we learn from seeing the range of LED (SSL) (includes other than street light) performance is to not generalize. The specific Solid State Light (LED) in question might be quite adequate. Product testing is available on the DOE web site.

LEGAL, REGULATORY OR CONTRACTUAL REQUIREMENTS

Energy policies vary by state. Montana's Energy Policy is found in:

90-4-1001. State energy policy goal statement. (1) It is the policy of the state of Montana to promote energy conservation, production, and consumption of a reliable and efficient mix of energy sources that represent the least social, environmental, and economic costs and the greatest long-term benefits to Montana citizens.

(2) In pursuing this goal, it is the policy of the state of Montana to:

(a) recognize that the state's energy system operates within the larger context of and is influenced by regional, national, and international energy markets;

(b) maintain a continual process to review this energy policy statement and any future changes so that Montana's energy strategy will provide for a balance between a sustainable environment and a viable economy; and

(c) adopt a state transportation energy policy as provided in 90-4-1010 and an alternative fuels policy and implementing guidelines as provided in 90-4-1011.

Other legal considerations may come into play if bonds have to be issued to finance replacement of existing outdoor lighting with LEDs.

HUMAN CAPITAL REQUIREMENTS

For new installations, labor costs are the same as they would be for installing a traditional outdoor luminaire.

Since LEDs are long lasting with virtually no maintenance, maintenance costs will go down, largely because bulbs will not have to be replaced as often.

Ann Arbor's workers' compensation rates went down 20% for some workers because they were not in bucket trucks as much fixing Metal Halide lights that lasted only two years. Some cities have experienced casualties involving traffic hitting the bucket trucks while workers were maintaining lights. Ann Arbor also was able to free up workers who had been keeping the old lights operable for other maintenance projects.

STAKEHOLDERS

Four main groups of stakeholders are affected by this recommendation.

Citizen Concerns: The public has received the quality of LED lighting favorably (with rare exception) when polled during trials of the products. This surprised the engineer who advised Benton Harbor, who changed from not favoring these lights to favoring them after the trial. The media and public have also reacted well to projected savings resulting from outdoor LED installations. Architects have preferred the white LED light because it showed their buildings in a more favorable light.[7]

Governmental Concerns: When citizens are happy with the light quality, governmental concerns turn to whether the implementation makes financial sense. The total savings varies on the fixture used, its price, costs of maintaining existing lights and costs of switching to LEDs.

[7] See http://www.ledsmagazine.com/news/5/8/27

In Billings, the Montana Highway Department is trying two Leotek LEDs streetlights on the south side of where Gabel Road intersects with Zoo Drive. Also, two Leotek luminaires have been installed to the north and south of Newman School, north of the freeway on S. Billings Boulevard. And the new transit center in downtown Billings will be lit with Ledway LEDs.

Utility Concerns: Utility responses to LEDs have been mixed. AVISTA is apparently testing LEDs in Spokane. PG&E participated in a DOE outdoor lighting fixture test in Oakland, and San Francisco, California and is moving ahead according to the Company's Mary Matteson Bryan, P.E (marymattesonbryan@pacbell.net Phone: (415) 305-5445). Ms. Bryan updated the rather long payback periods in the Oakland study of the RUUD Lighting BETALED with new data using RUUD's LEDway at the October 2008 Engineering Illuminating Society conference in Denver. She also is a prime mover in a conference at UC Davis to discuss the need to modify lighting standards for LEDs because the white light produced by them does not require as many lumens to be satisfactory as some traditional light.

Utilities will lose sales if this recommendation is implemented. On the other hand they will be better able to meet demand side management goals and will have a reduced need to find additional energy sources as demand for electricity grows.

Since the US is moving toward the use of electric hybrid vehicles, the energy needed at night to charge batteries in those vehicles could come from the savings in reduced energy needed for outdoor lighting if LEDs were installed on a wide scale. That cannot happen if we do not act now to put the LED infrastructure in place to make the offset a reality.

LED Manufacturers: Product manufacturers undoubtedly have an interest in selling what they make. Be cautious when listening to manufacturer's claims and testing labs. Look for independent labs certified to test Outdoor LED lighting under the DOE CALiPER testing program.[8]

The Northwest National Laboratories (US Department of Energy) has engaged in six rounds of LED testing (some of which included outdoor lighting).

CONSISTENCY WITH ADOPTED POLICIES OR PLANS

Western Governors' Goals: The nation is moving in the direction of more energy conservation and using renewable energy. The Western Governor's Association (WGA) estimates that its 19 states will need 43,500 MW of additional generation by 2015. It finds that more than 2 times that goal can be achieved from conservation and non-fossil fuel, non-nuclear power generation. It has set a goal of 20% increase in energy efficiency by 2020. This LED recommendation will help the Western Governors meet its conservation target. http://www.westgov.org/wga/initiatives/cdeac/index.htm By the end of 2008, the 19 WGA states will have installed at least 12,000 MW of wind electric generation since the 2004 WGA assessment. Charley Grist indicates that the excess capacity from new renewable generating sources is slowing the energy price cost growth curve in the Northwest.

U.S. Mayors' Goals: As of February 3, 2009, mayors of 911 cities had taken Seattle Mayor Greg Nickels' challenge to reduce green house gases to comply with the Kyoto Protocol. These mayors from all 50 states, Washington DC & Puerto Rico represent more than 80.9 million citizens. Seattle has cut its greenhouse gas emissions by more than 60% compared to 1990 levels. This recommendation will help the cities that have taken this pledge to achieve reductions they have pledged to reach. http://www.seattle.gov/mayor/climate/default.htm#cities

[8] See http://www.netl.doe.gov/ssl/comm_testing-labs.htm

Montana Climate Change Advisory Committee (CCAC) Goals: The CCAC recommended policy options in two areas that would be well served by this Commission's LED rule. They are RCII-1 (Demand Side Management Programs, Efficiency Funds and Requirements (and Financial Incentives)); and RCII-2 (Market Transformation and Technology Development Programs). This recommendation also is consistent with Montana Energy Policy statutes quoted in the legal section.

Northwestern Energy Demand Side Management Goal: is to achieve 90-95 aMW of DSM savings over 20 years—5.0 aMW/year beginning in 2003 (http://www.northwesternenergy.com/documents/defaultsupply/plan07/volume1/chapter3.pdf). Progress toward meeting that goal is being made without the benefit of savings accruing from implementation of LED street lighting. Whether or not such lighting would facilitate a more aggressive goal has not yet been measured. The "… forecast annual growth rate for the Supply is 0.7% including DSM energy conservation impacts. If DSM impacts are excluded, the average annual growth rate increases to 1.3% for the 20-year period." Estimating from graphs in its 2007 Default Supply plan, Northwestern supplied DSM reduced 2008 Load by about 15 MW; and displaced less than a million MWh in 2008. [Figures 6-1 & 6.2] http://www.northwesternenergy.com/documents/defaultsupply/plan07/volume1/chapter6.pdf .

LEDs brighten new I-35W Bridge (Minneapolis)