



STREET LIGHTING AND TRAFFIC SIGNALS REPLACEMENT PROGRAM

Discussion Paper C3 - 07

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EXECUTIVE SUMMARY

Climate Change Central engaged an external contractor to conduct research to determine the viability and economics of a province-wide street light replacement program. The primary objective was to reduce the amount of energy consumed by a minimum of 30% from current levels to reduce the impact of street lighting on greenhouse gas (GHG) emissions. The second area to be researched was traffic signals.

For street lights, there are currently two different technologies available that could achieve the goal according to the manufacturers. One would see the physical replacement of the head of the light while the other technology provides reductions on long-dedicated lighting circuits.

There are two significant drawbacks to implementing a street light conversion program at this time using these technologies. The Illuminating Engineers Society of North America (ISNEA) is participating in a study to develop visibility recommendations for the design of traffic routes. This study was initiated approximately two years ago (2000) and was expected to be completed in three to five years. The intent of the study is to review light level requirements on all classifications for roadways utilizing a new method of measuring visibility. The secondary purpose is to drive the lighting manufacturers to perform research and development into new products that will achieve these light levels using alternate technologies. It is expected these alternate technologies will be more energy efficient.

Therefore, in our opinion it is premature to initiate a province-wide street light conversion program until the work of ISNEA is complete and the new recommendations are in place. Any work done in advance of those standards being adopted could well need to be replaced to meet the new standards with more energy efficient technologies.

For traffic signals there is well proven technology that significantly reduces the energy consumption by greater than the 30% target. In fact, this new technology has been demonstrated to use about 15% of the energy of current technology. It is recommended the following program be implemented immediately to reduce energy consumption to clearly show Alberta's commitment to reducing GHGs through voluntary efforts.

Recommendations

Traffic Signals

- That the Province of Alberta establish a dedicated Green Fund of \$8,000,000 per year for three years to a maximum investment of \$24,000,000.00 to implement a province-wide traffic signal replacement program. The funds will to be loaned to municipalities with repayment to the fund from electrical energy cost savings generated by the program. It is expected that by the year 2010 all funds borrowed from the province will be repaid. Significant greenhouse gas reductions will have occurred at no net cost to the provincial or municipal governments. The only direct cost would be to the electrical utilities. It is anticipated the utility companies would be able to resell this existing generation, thus delaying the need for additional electrical generation in the province. Using the 2001 grid average of 0.991 Tonnes of GHG per Mwhr, the amount of

greenhouse gas reductions available through this program would be in the order of 30,000 tonnes.

- That the Province of Alberta review the debt level and debt service requirements of the municipalities to allow the special funding of this program to exceed either of those criteria as they are at worst, revenue neutral.

Street Lights

- That the Province of Alberta participate in, or perhaps lead, a research and development (R&D) program with lighting manufacturers to encourage the development of new technologies to achieve significant energy reductions that provide proper lighting levels. Those manufacturers contacted during the preparation of this report indicated a strong desire to participate in such a co-venture.
- Proceed with demonstration projects utilizing current state-of-the art technologies to measure the effects of light levels and visibility. The demonstration projects, coupled with the anticipated IESNA standards, could quickly establish Alberta at the forefront of voluntary GHG reductions. A budget of \$1,000,000.00 should be established to participate in this program.
- Once the R&D work is completed, it is anticipated that, beginning in 2004, a fund of \$30,000,000 per year for five years, to a maximum investment of \$150,000,000.00 will be required to implement a provincial street light replacement program. As with the traffic signal program, the funds will be loaned to municipalities with repayment to the fund from the electrical energy cost savings generated. It is expected that by the year 2014 all funds borrowed from the province would be repaid. Again, significant greenhouse gas reductions will have occurred at no net cost to the provincial or municipal governments. Assuming a 30% reduction in energy consumption and using the 2001 grid average of 0.991 tonnes of GHG per Mwhr, the amount of greenhouse gas reductions available through this program would be in the order of 55,000 tonnes.

Background

Street Lighting

The principal purpose of roadway lighting is to produce quick, accurate, and comfortable visibility at night. The qualities of visibility may safeguard, facilitate and encourage vehicular and pedestrian traffic. It is very important to make streets and highways useful during hours of darkness as well as during the day. The proper use of roadway lighting provides economic and social benefits to the public including:

- 1) reduction in night accidents, human misery and economic loss,
- 2) aid to police protection and personal security,
- 3) traffic flow, and
- 4) promotion of business and the use of public facilities during night hours.

Darkness brings increased hazards to users of streets and highways because it reduces the distance they can see. The nighttime fatal accident rate on unlighted roadways is

about three times the daytime rate. This ratio can be reduced when proper fixed lighting is installed due to increased visibility in the environment beyond the range of vehicle headlights. Therefore, any street lighting program that proposes to reduce light levels must be implemented very cautiously so that visibility is maintained.

A literature search was completed to understand both the pros and cons of reduced street lighting levels. Shaflik Engineering, a firm with expertise in the area of street lighting, researched this issue for Calgary Roads. Their findings are summarized as follows:

- *Visibility of Objects in Roadway*

It is perceived by many that the brighter an area is, the better the visibility is in the area. This is not necessarily true. It has been found that the absolute amount of light on an area is not directly related to the visibility of objects in the area. It is quite conceivable that an area of lower illumination may have better visibility than an area of brighter illumination. Therefore, it should not be pre-supposed that the reduction of street lighting will degrade the visibility. It is highly likely that the reduction of street lighting will actually increase the visibility.

Similarly, the visibility of objects is increased if the background glare from the lighting source can be reduced. By changing from dropped lens luminaires to low-glare flat lens luminaires, the lighting source glare is significantly reduced thereby increasing the visibility in the area.

- *Street lighting and Impacts on Crime and Safety*

The link between lighting and crime is a controversial one with no proper scientific study done that we know of (although IES may be doing a study that may provide more answers). At best, the opinion of lighting experts is that increasing lighting will not reduce crime.

Lighting, in most cases, does not reduce vandalism. For vandalism to be effective to the vandals they must see what they are doing. There is however, the possibility that lighting reduces the fear of crime without actually reducing the level of crime itself. It is common for people to feel safer in a well-lit area even though this is only a perception. The reduction in lighting levels may initially have an impact on public perceptions of safety. However, this is not likely to last, as people get accustomed to the new lighting levels. The main reason complaints will be received at this time is because of the noticeable change from the original state. If a new subdivision was illuminated to the lower level from the beginning, it is almost certain that no complaints would be received.

The reduction of glare by using flat lens luminaires is sometimes interpreted by individuals as a significant reduction in lighting levels. This is a psychological effect and is a perception only. It does not relate to the actual lighting levels or the visibility level in the area.

Aging Population – Elderly people need a higher level of lighting for driving and identification of objects in the area surrounding the road. It is true that the older one gets the more light is needed by the eye to produce the same level of

visibility. This situation, however, has been taken into account in the development of the IES roadway lighting standards.

Night Blindness - This physiological problem with the eye is thought to be either genetic or a result of a Vitamin A deficiency. It affects a small segment of the population and is usually not considered in determining lighting levels in general areas.

Ability to See Street Signs - Street signs do not rely on street lighting for their visibility. Signs are produced using retro-reflective materials (materials that reflect light back to the originating source). Therefore signs rely on headlights for their illumination. In fact, most signs are more visible at night in areas with low or no street lighting due to the increase in contrast. If some signs require special illumination (like overhead signs) then specific sign lighting should be used.

Flat lens versus Dropped lens Fixtures - The use of dropped lens fixtures will not produce better lighting. By using properly designed flat glass luminaires the luminance (overall brightness) of the roadway will not be affected significantly. What will be affected is the uniformity with flat glass luminaires being more sensitive to the maximum spacing (not as much beam pattern overlap). However, for this project the new Small Target Visibility method for the roadway lighting should be used. With this design method high uniformity is not as important, in fact, non-uniform lighting has proven to be better for visibility by increasing the contrast. In short, with flat glass luminaires, the result is lower uniformity, which provides better visibility.

There are two primary customers of utilities for street lights and traffic signals. Alberta Transportation through the highway network and Alberta municipalities. There are isolated instances where roadway street lighting systems are owned independently.

The two major cities in Alberta roughly account for one-third each of the total street lights and traffic signals in the province. For the purposes of this report it is assumed that the rest of the jurisdiction, shared by Alberta Transportation and all other municipalities, contributes the remaining one-third of the total provincial electrical load for street lights and traffic signals.

The following table identifies the physical numbers of street lights and traffic signals in Alberta. The chart indicates the number of intersections that do not have LED traffic signals. Both Edmonton and Calgary employ this technology as standard practice for new intersections. The traffic signals number represents intersections, not individual traffic signals.

	Edmonton	Calgary	Rest of Province	Total
Traffic Signals	823	725	775	2,323
Street Lights	90,000	72,000	81,000	243,000

The approximate existing energy demand/consumptions are represented in the following table. These numbers were provided by the City of Calgary and Edmonton with the Rest of Province numbers being assumed as one-third of the provincial total.

	Edmonton	Calgary	Rest of Province	Total
Traffic Signals	9 MW	10 MW	9.5 MW	28.5 MW
Street Lights	66,000 Mwhrs	80,000 Mwhrs	73,000 Mwhrs	219,000 Mwhrs

Based on the information in the above tables, the approximate GHG for street lighting and traffic signals in Alberta is:

	Edmonton	Calgary	Rest of Province	Total
Traffic Signals	9,685 tonnes	10,762 tonnes	10,224 tonnes	30,672.4 tonnes
Street Lights	60,315 tonnes	61,416 tonnes	60,865 tonnes	182,596 tonnes
Total	70,000	72,178.5	69,205.1	213,268.4

Technology

Existing

The majority of street lights in use today are High Intensity Discharge (HID) and are predominately High Pressure Sodium (HPS). HPS lamps are among the most efficient HID lamps available. The major drawback of these lamps is their orange color, which affects color rendition.

Retrofits to Date

According to the publication compiled by the Office of Energy Efficiency, "Energy Efficiency Trends in Canada 1990 – 2000" energy consumption for street lighting has decreased considerably between 1990 and 2000 from 8.9 to 7.3 petajoules (PJ), a reduction of 18%. This reduction has primarily been caused by replacing Mercury Vapour (MV) lights with HPS. One common retrofit is to replace a 175 watt MV lamp with a 100 watt HPS lamp. Due to the superior efficacy of HPS lights, there is no appreciable loss of light levels. The typical retrofit includes changing the ballast as well as the lamp, which increases installation and replacement costs. Replacement therefore is normally spread over a long period of time. In Alberta, most utilities offered municipalities this retrofit in the late 1980s and early 1990s.

Current street light design maintains the 100W HPS light for most residential streets. One significant change is the adoption of a flat lens as opposed to a pear shaped lens. While not reducing the energy consumption of the fixture, this lens accomplishes other important goals, reducing glare and light trespass.

Calgary Roads has undertaken a study of the city's street light system to determine whether the existing lighting levels in residential areas are excessive and if operating efficiencies and improvements can be achieved in the system. The study concluded that the lighting provided by the majority of residential street lights exceeds recommended lighting levels and that energy cost savings can be realized by retrofitting the street lights to lower wattage, flat lens luminaires. In addition to the energy and cost reductions, there are significant environmental benefits to retrofitting street lights, including reduction in CO₂ emissions, reduction in light glare, light trespass, and light pollution.

Light pollution is a major concern in most metropolitan areas across North America. Light pollution, which includes unnecessary glare, light trespass onto adjacent properties, and urban sky glow, detracts from the use and enjoyment of the night sky and degrades the environment by wasting energy.

The City of Calgary is widely recognized as one of the most overlit cities in North America. The city is retrofitting approximately 49,000 street lights to flat lens technology and reducing wattage from 200W HPS to 100W HPS. Calgary is targeting acceptable light levels in accordance with recommended practice as set forth by the IESNA RP 8 00, as revised in April 2000. The city will achieve a 50% energy consumption reduction with this retrofit.

New Technology

High Pressure Sodium technology may soon be outdated by more energy efficient lamps and fixtures. Philips Lighting developed a lamp/ballast combination, known as QL, that has been in use in Europe for 12 years. One-hundred-fifty-watt HPS lights can be replaced with an 85-watt QL. Similarly, a 100-W HPS can be replaced with a 65-W QL. At this time the 85- and 65-W QL lamps are the only wattages that Philips Lighting have adapted to North American voltages. The QL lamp is a white light as opposed to the

orange of HPS. As discussed earlier in this report, it is expected that this white light with high-color rendering could result in higher visibility even at lower light levels.

TRAFFIC SIGNALS

Background

Traditional signals use incandescent lamps, typically 135 W for red, amber and green and 69 W for wait walk signals. New energy-efficient traffic signal technology is widely available and the majority of new installations use new Light Emitting Diode (LED) lamps as their standard. In conversations with both the City of Calgary and Edmonton, the only barrier to widespread replacement is the up-front capital cost. Both cities have said they would immediately retrofit to LED if finances were available.

Technology

An LED is a semiconductor device that uses solid state electronics to produce coloured light. The LEDs are more efficient than incandescent lamps for two key reasons:

- **Energy is not wasted as heat.** Unlike incandescent lamps, LED lamps do not create light through the production of heat.
- **Energy is not wasted by filtering.** Incandescent lamps produce white light; filters are needed to block all light energy except for the colour required. LEDs create coloured light directly.

An LED traffic signal module incorporates an array of coloured LED lamps assembled on an electronic board. The module is then installed into the casing of the existing traffic signal replacing the incandescent lamp and reflector assembly for the respective colour.

Advantages of LED's

While LED modules are initially more expensive than incandescent lamps, they have many benefits that result in a lower overall lifecycle cost. The advantages of LEDs include:

- Use 90% less energy compared to standard incandescent lamps
- Last 7 -10 years resulting in less labour devoted to re-lamping
- Produce colour directly without filter for greater visibility in fog, sun and rain
- Reduce emergency call-outs due to increased reliability
- Less susceptible to mechanical failure - rugged solid state construction
- Easy to retrofit - the LED module installs directly into the casing of existing traffic signals

LED Intersection Conversion Example

	300mm Red	300mm Green	200mm Red	200mm Green	Don't Walk
Number of signals replaced with LED modules	8	8	4	4	8
Incandescent Wattage	135W	135W	69W	69W	116W
LED Wattage	12W	12W	7W	7W	6W
Before LED modules installation:					
Monthly energy consumption	1,667 kWh				
Monthly cost	\$113.50*				
After LED modules installation:					
Monthly energy consumption	194 kWh				
Monthly cost	\$13.20				
MONTHLY ENERGY COST SAVINGS					
	\$100.30				
ANNUAL ENERGY COST SAVINGS					
	\$1,203.60				

*Based on electricity rate of \$0.06809 kWh. Taxes are not included.

FINANCIAL

Most of Alberta's municipalities have significant infrastructure deficits. Roadways, water and sewer systems, bridges and facilities are in desperate need of repair or replacement. Existing infrastructure programs are in place to address this need. A street light replacement program should be an attractive proposition for all municipalities but the reality is that capital dollars in most municipalities are already allocated. Therefore, a financing program for a street light/traffic signal replacement program will need to be offered to reduce a significant barrier to adoption.

Based on the City of Calgary's retrofit program, the approximate cost in 2002 dollars is \$240.00 per light fixture. Based on an estimated 243,000 street lights in Alberta the capital requirement to implement a retrofit program, using existing technology, would be in the order of 59 million dollars. Adding a 20% contingency for inflation and allowance for actual numbers of street lights would require 70 million dollars. The new QL fixtures discussed earlier in the report require an additional \$240.00 per fixture. However, it is expected with a program of this magnitude and widespread commercialization of the technology, that this price would be reduced. For the purposes of this report, the entire \$240.00 is used as the price increase to reflect a worst-case scenario. Therefore, a capital budget of 140 million dollars would be required.

Information received from the City of Edmonton indicates that the cost to perform a retrofit of a single intersection is in the order of \$7,000-10,000. Using the worst-case scenario of \$10,000 per intersection results in a capital requirement of 23 million dollars. Combined with the street light program an approximate capital investment of 163 million dollars is required.

Financing Options

There are two principal sources of funding available to municipalities to implement this program.

- 1.) Internal
- 2.) External

The internal options for municipalities include using existing reserves to pay outright for the street light energy reduction program. This method would be the most financially attractive to municipalities as the cost savings from the energy reductions would result in immediate positive free cash flow that the municipality could then use for other pressing capital or operating requirements. Unfortunately, most municipalities do not have the available reserves to allocate to a project of this magnitude.

The second internal option is for the municipality to borrow funds from the Alberta Municipal Finance Corporation (AMFC). At current interest rates this is an attractive option. At an interest rate of approximately 6.5% for five years, the municipalities could repay the cost of the lighting retrofit from the energy savings and could generate some positive free cash flow. Again, some municipalities may be at or near their debt limits or debt service levels as established by the province and may be unable to utilize this option.

One option the province could consider to eliminate this barrier is to allow municipalities the option of exceeding their debt levels or debt service ratios to implement a street light replacement program. Energy cost savings derived from the program would generate

the free cash flow to pay for the upgrades. This type of funding could be attractive to most municipalities. Again the positive free cash flow generated by the energy savings would repay the debt and could easily service any excess debt service ratios caused by this program.

The second primary source of funding for municipalities is external funding. There are three sources of external funding that could be made available to municipalities for this program.

- 1) The Province of Alberta
- 2) Utilities
- 3) Third Party Financing

Provincial Government

Green Fund Loan Program – The Province of Alberta could establish a fund to provide loans to municipalities to implement the program. It is estimated that there is a \$23,000,000.00 financial requirement for the traffic signal conversion. It is further estimated an additional \$140,000,000.00 would be required to implement a street light conversion program.

The funds will to be loaned to municipalities with repayment to the Green Fund from the electrical energy cost savings generated by the program. All funds borrowed from the province will be repaid by the year 2014. Significant greenhouse gas reductions will have occurred at no net cost to the provincial or municipal governments. Participating municipal governments would be required to use the energy cost reductions to repay the loan from the province.

The only direct cost would be to the utilities. It is anticipated the utility companies would be able to resell this existing generation delaying the need for additional electrical generation in the province.

Third Party

Third party financing is one option that is available to implement this program. Utilizing a third party financial institution is unlikely to appeal to a municipality as the interest rates would be higher than what would be available from AMFC unless the deal could be structured as “off balance sheet.” Given the transparency of most municipalities, “off-balance” sheet financing is an unlikely option. Using “on-balance” sheet financing would increase the municipal debt levels and as discussed earlier, may result in municipalities exceeding their allowable borrowing limits or debt service ratios as established by the province of Alberta.

Utilities

One external source of funding that may be extremely viable and attractive to municipalities is to have their electrical energy supplier or wires utility advance the capital costs up-front and charge them back over the repayment term on their utility bills. The utility would continue to charge the municipalities the same amounts as currently on their utility bills. Once the capital and interest charges are recovered, the municipality would benefit from the reduced energy charges. This is the format that was primarily used during the previously mentioned Mercury Vapor to High Pressure Sodium retrofit in the late-1980s. As utilities compete in a deregulated energy market this option could prove valuable to those suppliers looking to secure long-term energy contracts with their customers. Initial conversations with the two primary energy suppliers in the province, ENMAX and EPCOR, have produced favorable responses. Initial conversations with a wires only company Aquila also produced a favorable response. This type of program would result in an “off-balance” sheet type of borrowing except the municipality would not be borrowing the funds.