
# Street lighting projects

# Rouyn-Noranda

André Laperrière, ing. M.Sc.A.

Laboratoire des technologies de l'énergie d'Hydro-Québec

October 2-4 2011, Ottawa

*2011 Joint CNC/CIE and CIE/USA*

Hydro Québec

# Abstract

**Paper #6**

**Advanced Lighting Technologies: LED Street Lighting in Rouyn-Noranda**

**André Laperrière**

**Laboratoire des technologies de l'énergie d'Hydro-Québec**

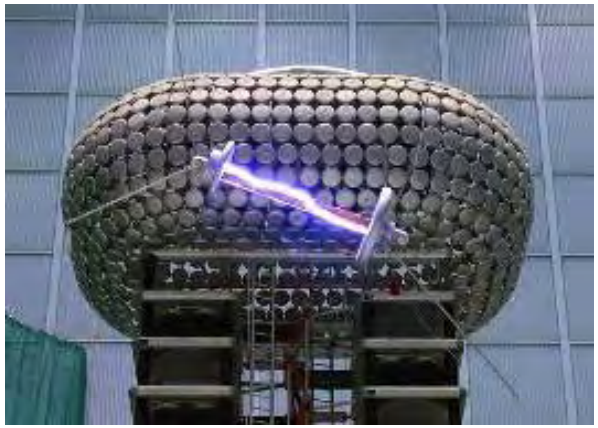
***laperriere.andre@lte.ireq.ca***

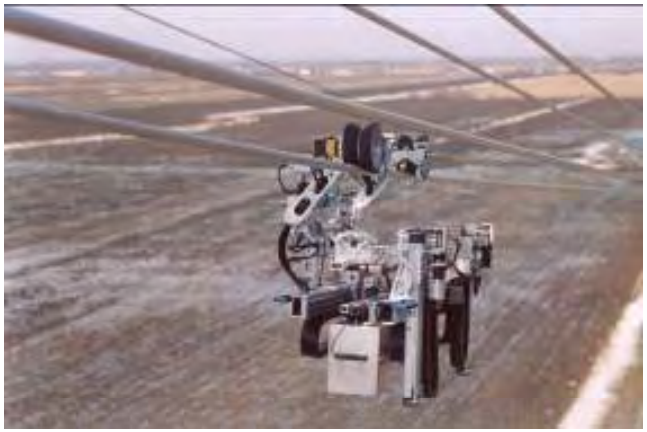
**In the field of lighting technologies, LED technology is beginning to offer energy saving opportunities in some applications. But as with any new technology, we need to know how it works, its physical underpinnings and its limitations, among other things. The US Department of Energy and other bodies have started to promote use of the technology for street lighting. Some studies, however, have shown that caution should be used and that the energy savings are not as impressive as claimed in all cases.**

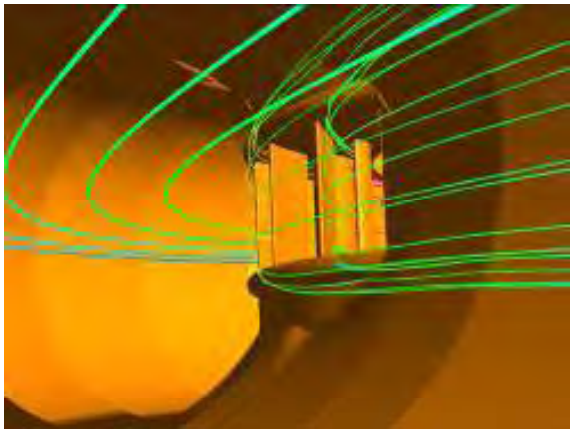
**Concurrent with a pilot project in the city of Rouyn-Noranda, a laboratory test campaign was conducted including measurements of photometric, colorimetric and electrical factors, including mesopic correction and nighttime vision, for both LED and conventional high pressure sodium (HPS) technologies. The City of Rouyn-Noranda conducted a survey regarding the pilot project. The analysis showed that it is possible to reduce electricity consumption from 130 watts (100 watt HPS lamp) to 55 watts with LED technology. However, illuminance levels diminish in comparison with previous levels. Nonetheless, luminosity levels in local streets were satisfactory. As for collector roads, i.e., roads that "collect" traffic flowing from local streets, illuminance levels were low. The laboratory tests, including numerical simulations, confirmed the performance observed in the field.**

**Thus LED technology provides adequate performance in some applications. With this rapidly evolving technology, new applications will become feasible. Caution is in order, requiring that findings be formulated with great care. This presentation will outline the issues that need to be taken into account in order to make informed decisions regarding the new technologies for street lighting.**

# L'IREQ (Institut de recherche électrique du Québec) at Varenne







# L'IREQ (Institut de recherche électrique du Québec)

- **IREQ created in 1970.**

- **During a visit to Manic construction site in 1964 , Dr. Lionel Boulet, Director from the Electrical Engineering Department at Laval University decides to present to the top management from Hydro-Québec his vision for a Research Center**

**L'Institut de recherche d'Hydro-Québec was inaugurated September 29 1970**

# Laboratoire des technologies de l’énergie (LTE)

Created in 1988.

**GOAL** : Help customer (residential, commercial and industrial) to be more efficient in the energy use and develop new applications of electricity.

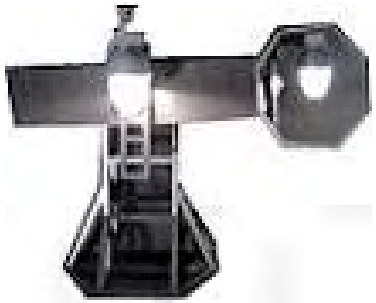
# Public lighting in Québec

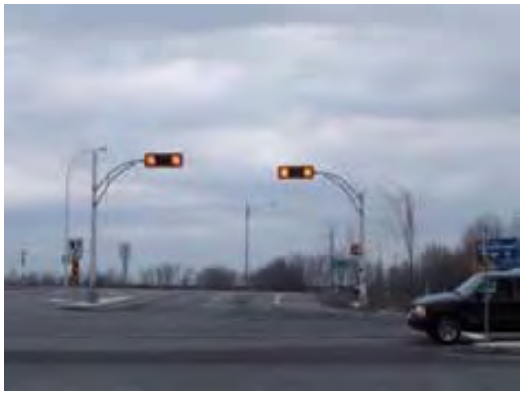
- 800 000 luminaires
- 572 GWh in 2008, growth 0.85% per year
- Mainly « cobra heads » *High Pressure sodium* (HPS) 70 and 100 W
- Typical spacing : 2 houses lot or 4 houses (120 and 240 feet)

# ROAD BLOCKS…

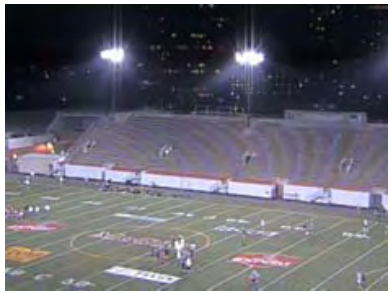
1) High cost of DEL
2) Lack of standardisation for DEL (IES working on it with DOE)
3) Spectral distribution of DEL (mesopic lighting)
4) Reliability of DEL luminaires
5) Lack of knowledge from municipalities for DEL luminaires
6) Public acceptability

# & Spectralux





SPECTRALUX
LIGHTING AND TESTING LABORATORY



# METHODOLOGY
# Laboratory and Field study

United States Department of Commerce
National Institute of Standards and Technology

NVLAP®

## Certificate of Accreditation to ISO/IEC 17025:2005

**NVLAP LAB CODE: 200899-0**

**Spectralux Laboratory**
Montreal, Quebec H4S 1M2
CANADA

*is accredited by the National Voluntary Laboratory Accreditation Program for specific services, listed on the Scope of Accreditation, for:*

**ENERGY EFFICIENT LIGHTING PRODUCTS**

*This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communique dated January 2009).*

2010-10-26 through 2011-09-30
*Effective dates*

Sally S. Bruce
*For the National Institute of Standards and Technology*

NVLAP-01C (REV. 2009-01-28)

# How to save energy ?

1) Light pollution

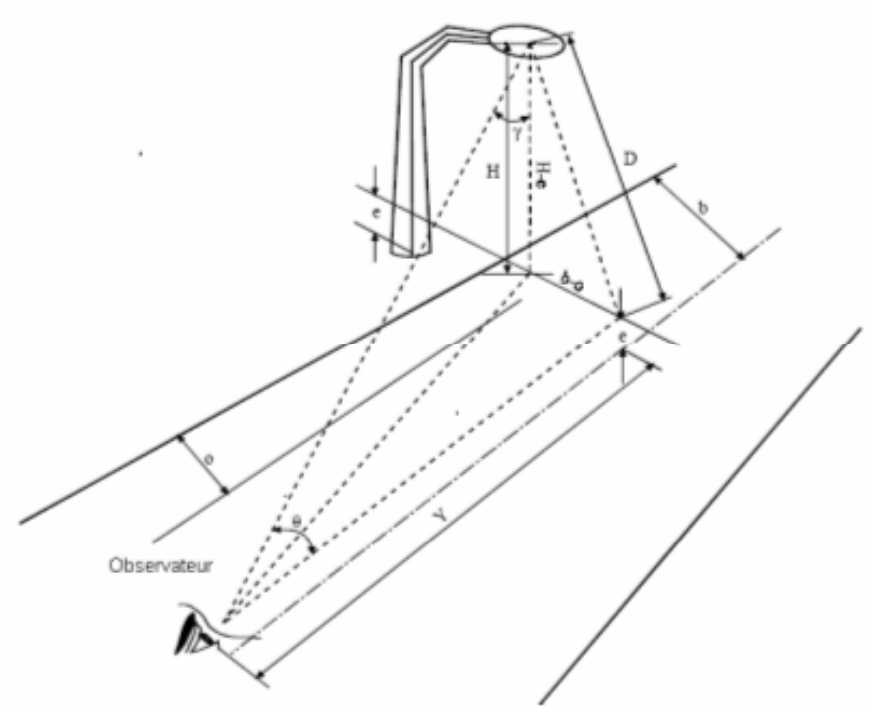
2) Spectral sensitivity of eyes
(Mesopic lighting)

3) Lumens efficacy of light source

# Principle of street lighting

**Luminance*:**

**Luminance represents the amount of lights reflected on a surface and reaching the eye of an observer (cd/m²).**




*** Method used in the study**

# Principle of street lighting

## Recommended values for street lighting / IES RP-8

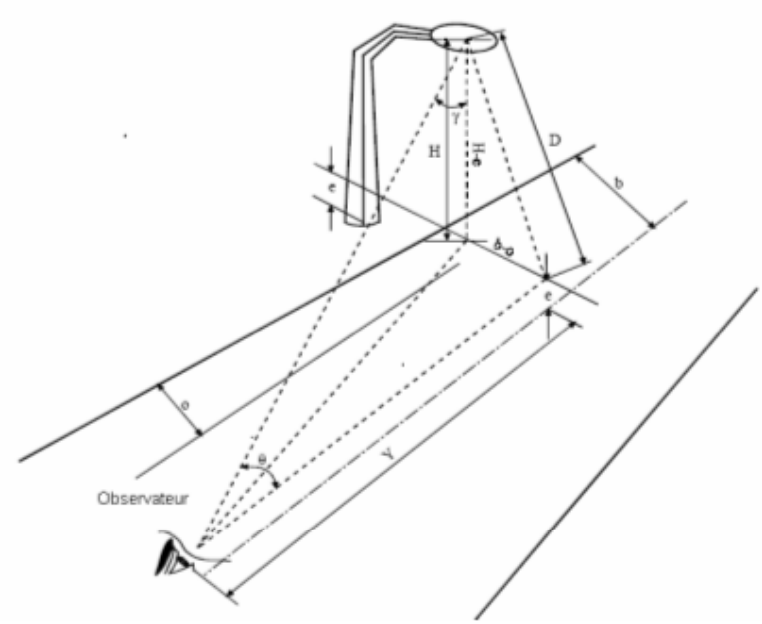
ANSI/IES RP-8-00 Luminance Method - Recommended Values

| Road and Pedestrian Conflict Area | | Average Luminance $L_{avg}$ (cd/m$^2$) | Uniformitiy Ratio $L_{avg}/L_{min}$ (Maximum Allowed) | Uniformity Ratio $L_{max}/L_{min}$ (Maximum Allowed) | Veiling Luminance Ratio $L_{Vmax}/L_{avg}$ (Maximum Allowed) |
|---|---|---|---|---|---|
| Road | Pedestrian Conflict Area | | | | |
| Freeway Class A | | 0.6 | 3.5 | 6.0 | 0.3 |
| Freeway Class B | | 0.4 | 3.5 | 6.0 | 0.3 |
| Expressway | High | 1.0 | 3.0 | 5.0 | 0.3 |
| | Medium | 0.8 | 3.0 | 5.0 | 0.3 |
| | Low | 0.6 | 3.5 | 6.0 | 0.3 |
| Major | High | 1.2 | 3.0 | 5.0 | 0.3 |
| | Medium | 0.9 | 3.0 | 5.0 | 0.3 |
| | Low | 0.6 | 3.5 | 6.0 | 0.3 |
| Collector | High | 0.8 | 3.0 | 5.0 | 0.4 |
| | Medium | 0.6 | 3.5 | 6.0 | 0.4 |
| | Low | 0.4 | 4.0 | 8.0 | 0.4 |
| Local | High | 0.6 | 6.0 | 10.0 | 0.4 |
| | Medium | 0.5 | 6.0 | 10.0 | 0.4 |
| | Low | 0.3 | 6.0 | 10.0 | 0.4 |

**Critère 1 2 3 4**

Asphalt classification R3

# Principle of street lighting




1) CRITERIA 1 : > 0,3 cd/m$^2$ mean

**Obtain mimimum value of luminance**

2) CRITERIA 2 : < 6,0 mean / min

**Reach good uniformity**

3) CRITERIA 3 : < 10,0 max / min

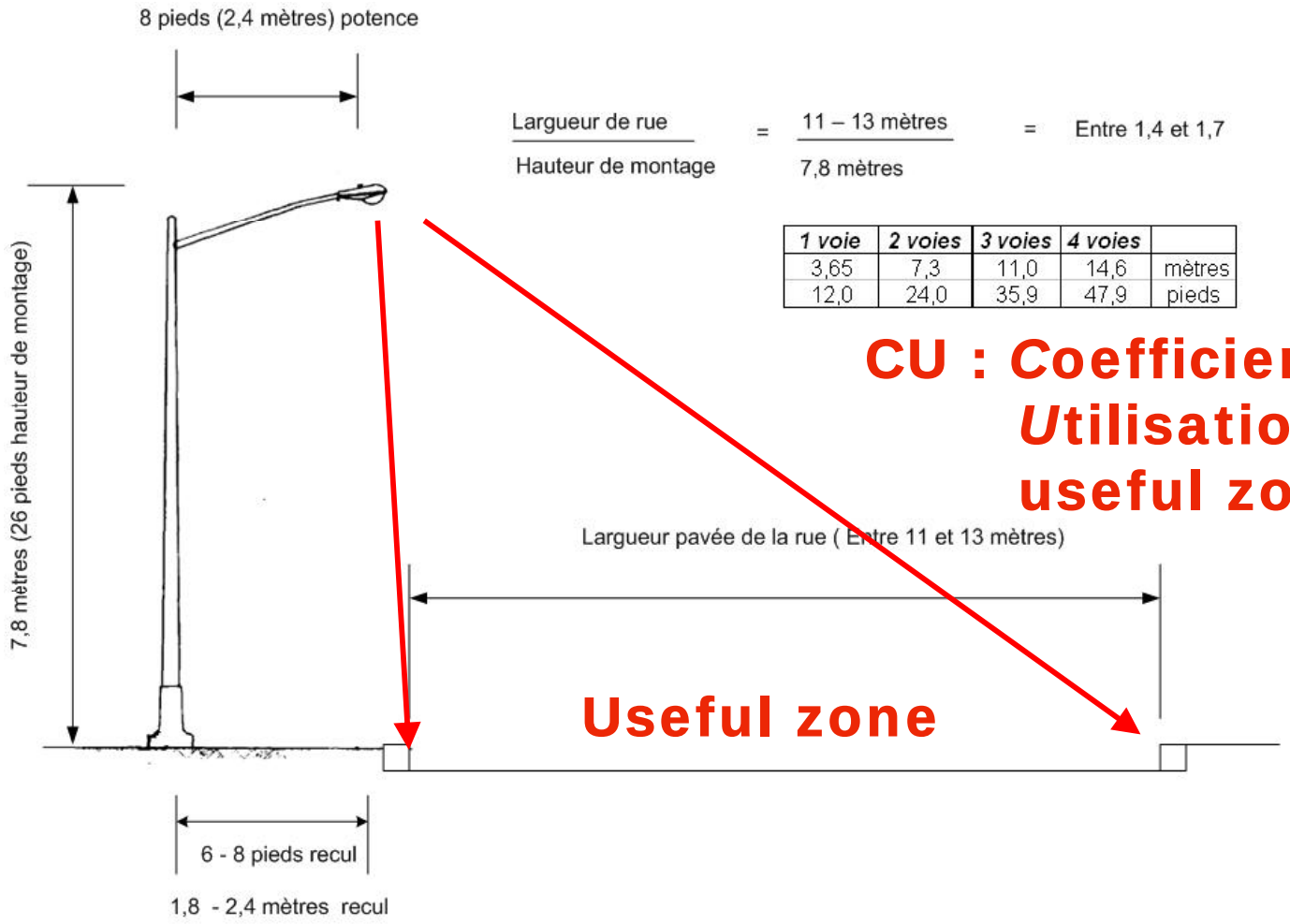
**Reach good uniformity**

**4)** CRITÈRE 4 : < 0,4

**Veiling luminance or glare..**

**Four (4) criteria to be considered in street lighting . Look not only at uniformity and minimum but also at GLARE**

# Method 1 : Light pollution



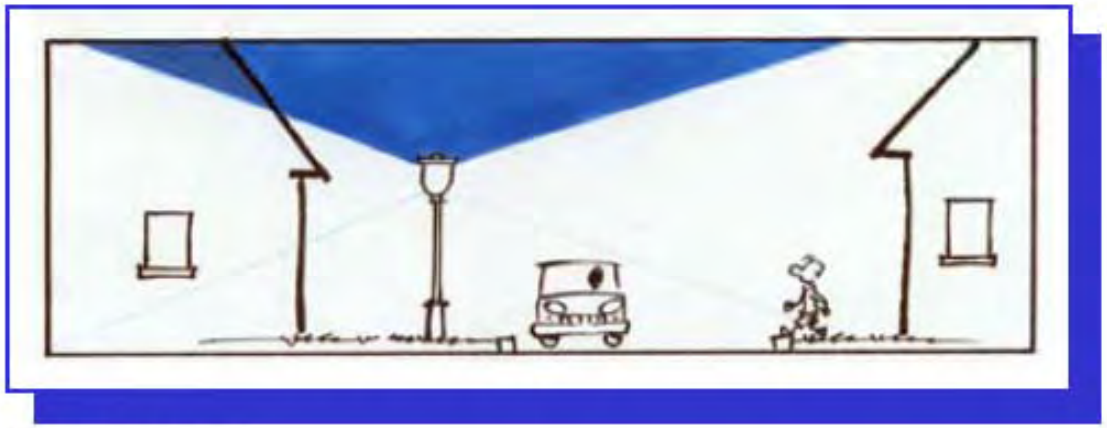

| *1 voie* | *2 voies* | *3 voies* | *4 voies* | |
|---|---|---|---|---|
| 3,65 | 7,3 | 11,0 | 14,6 | mètres |
| 12,0 | 24,0 | 35,9 | 47,9 | pieds |

**CU : *C*oefficient of *U*tilisation (CU) on useful zone**

Figure 1 : Schéma typique de rue – TYPE A

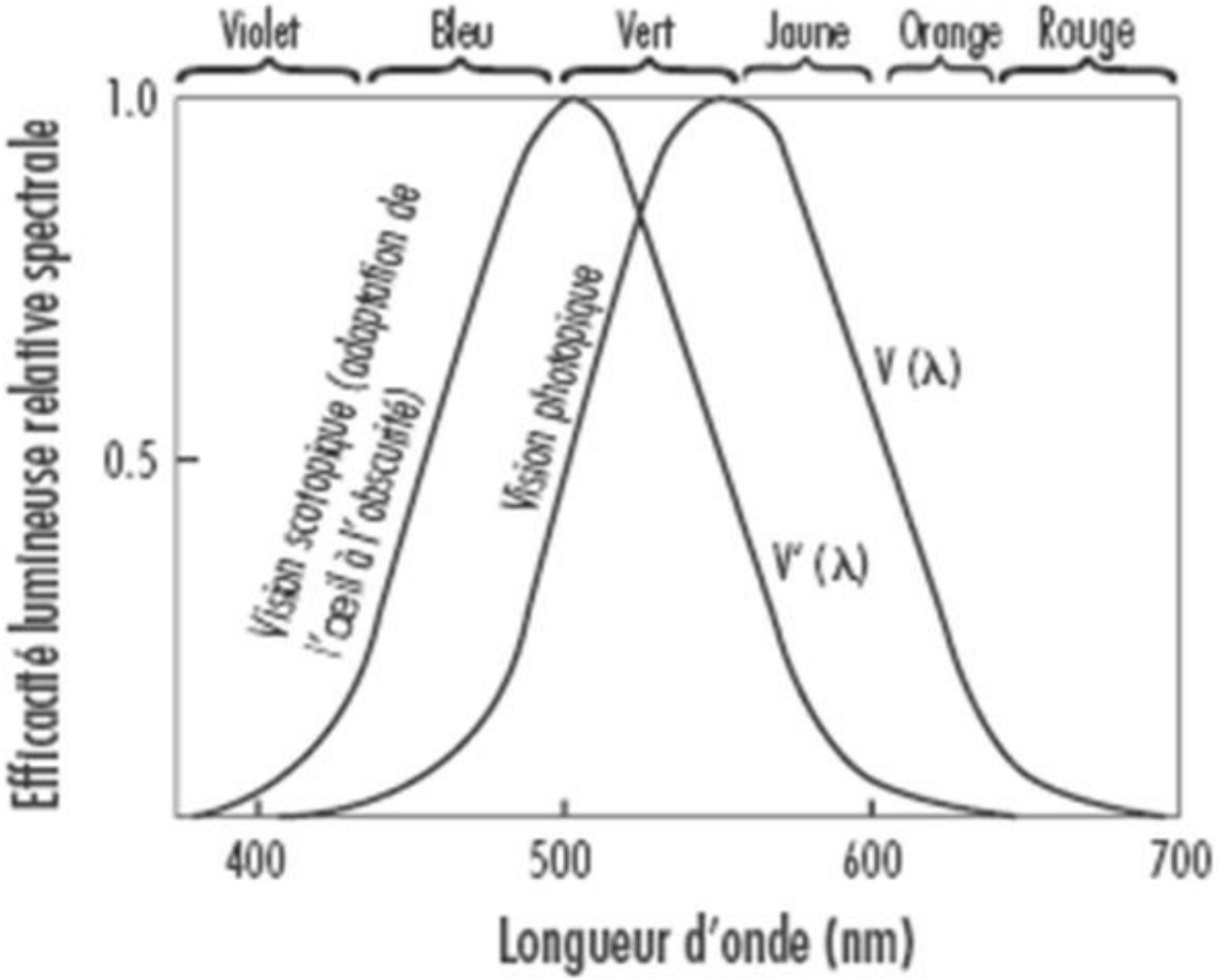
# Method 1 : Light pollution

Source : Lumec

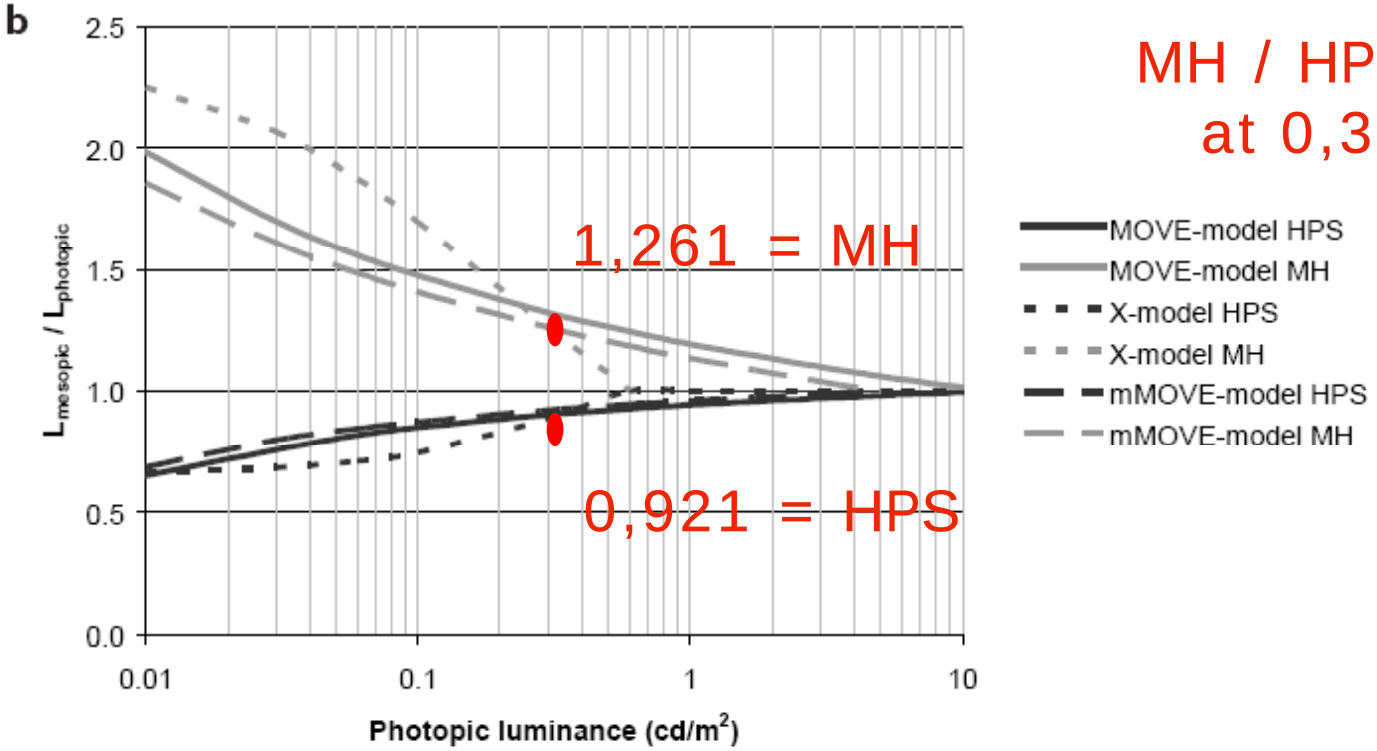


Source : Lumec

# Method 2 : Spectral sensitivity of eyes (Mesopic lighting)



# Method 2 : Spectral sensitivity of eyes




MH / HPS = 1,36
at 0,3 cd/m²

Figure 2 a) Coefficients *x* of MOVE- and modified MOVE-model, and coefficient *X* of X-model as a function of photopic luminance for HPS (S/P = 0.65) and MH (S/P = 2.35) lamps. b) The ratio of mesopic luminance (calculated using the MOVE-, modified MOVE-, and X-models) to photopic luminance as a function of photopic luminance for HPS (S/P = 0.65) and MH (S/P = 2.35) lamps.

***Modeling spectral sensitivity at low light level based on mesopic visual performance***

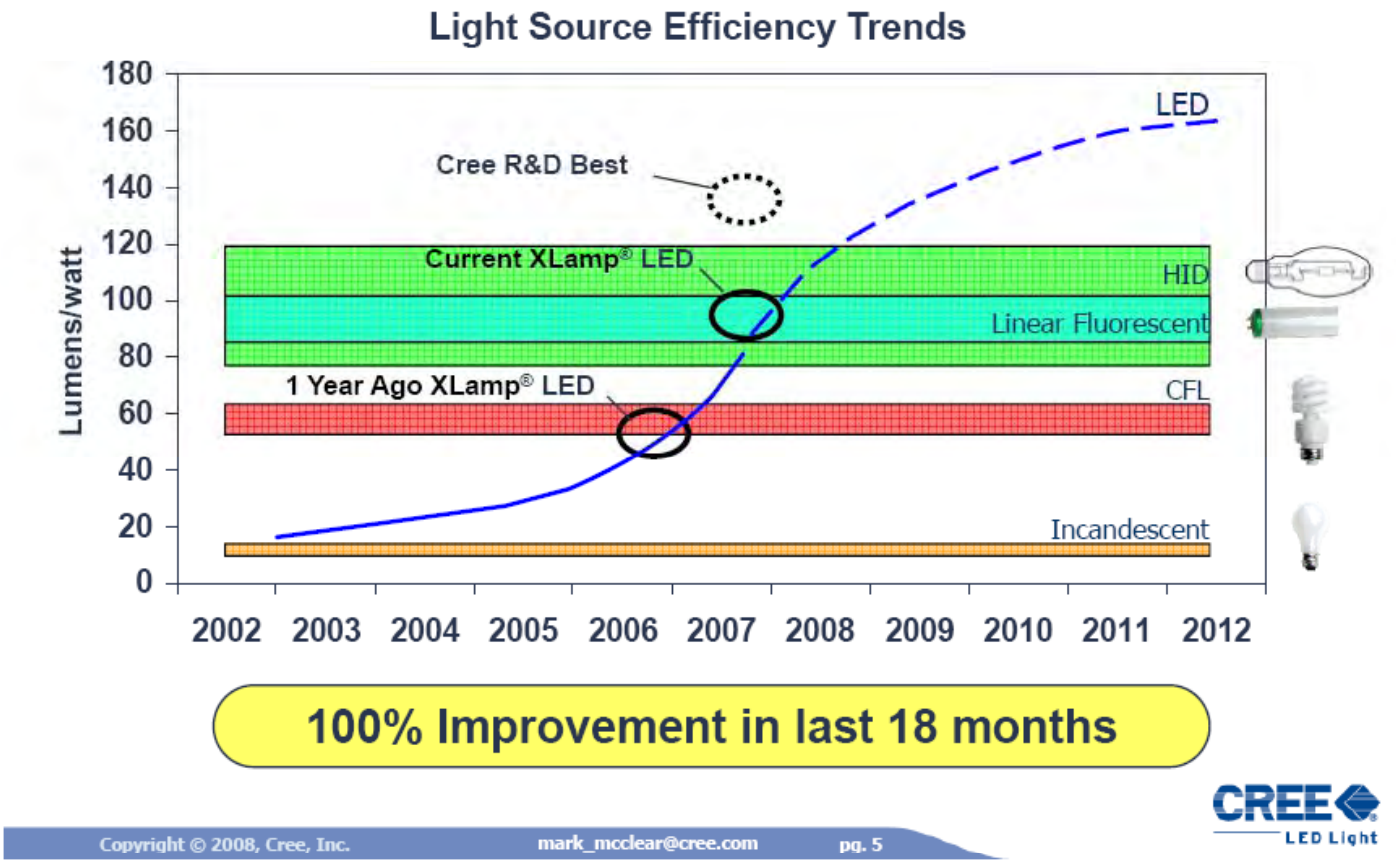
Meri Viikari, Aleksanteri Ekrias, Marjukka Eloholma, Liisa HalonenLighting Laboratory, Helsinki University of Technology, Finland, Clinical Ophthalmology 2008:2(1) 1–1

# CNN News update

- **CIE TC 1-58 “Visual Performance in the Mesopic Range” and MOVE - Mesopic Optimisation of Visual Efficiency.**
- **Recommended System for Mesopic Photometry Based on Visual Performance *Commission Internationale de L'Eclairage* / 01-Sep-2010 / 81 pages ISBN: 9783901906886**

# Method 3 : LED technology moving fast (lumens per Watt)

## LED Performance Continues To Increase



# METHODOLOGY TO EVALUATE THE TECHNOLOGY

1. Integrating sphere for lumens and color aspect

2. Goniophotometer for light distribution of the luminaire

3. Computer Simulations

4. Field evaluation

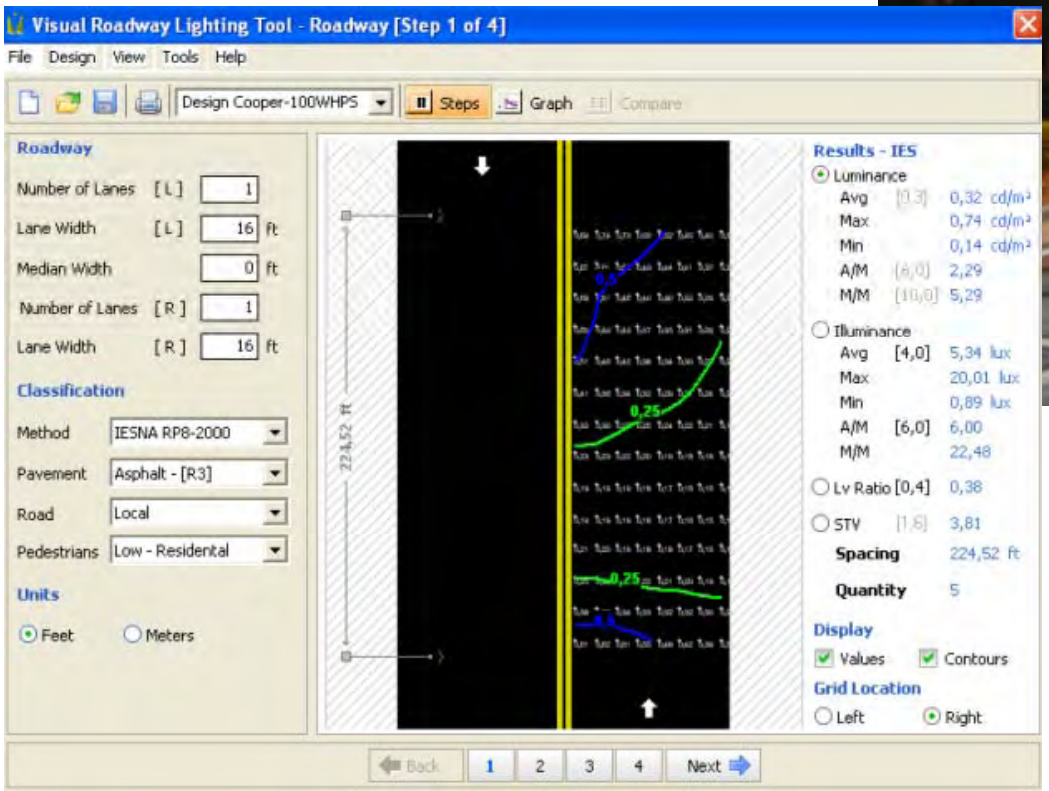
# Integrating sphere (lamp  ballast)

# Luminaire in integrating sphere

# Goniophotometer to evaluate light distribution

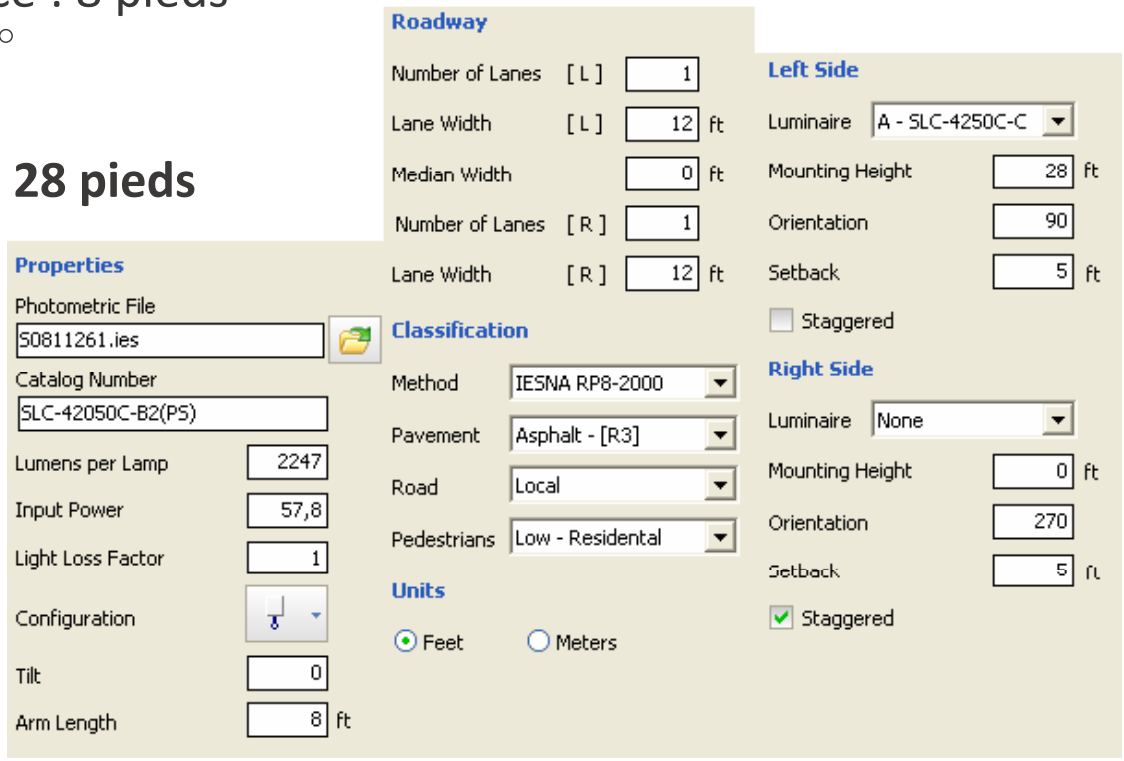
# Results – simulations

## Calculate criteria of design

# Results – parameters of simulation

Nombre de voies : 2
Largeur par voie : **12 pieds**
Asphalte de type R3
Route : Local de type Pedestrians « *Low-residential* »
Longueur de la potence : 8 pieds
Angle d'inclinaison : 0°
Recul arrière : 5 pieds
Hauteur de montage : **28 pieds**



# LED – Rouyn-Noranda (Luminaire OLD version BEFORE the Test Pilot)

# Methodology of the study

## Old HPS luminaires *c.* LED luminaires

1) Laboratory testing
   - i) As it is
   - ii) New lamps

2) Computer simulation

1) Laboratory testing

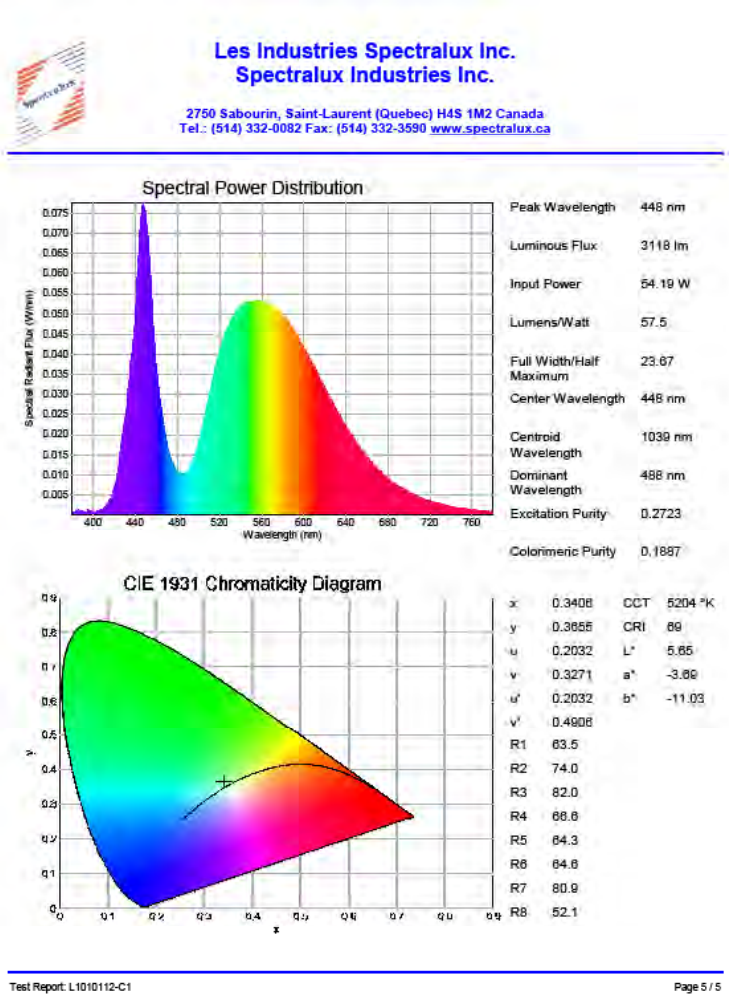
2) Field testing

3) Computer simulation

4) Public survey among people

# Spectral sensitivity of eyes – Results from Rouyn-Noranda Test Pilot

## DEL



Les Industries Spectralux Inc.
Spectralux Industries Inc.

2750 Sabourin, Saint-Laurent (Quebec) H4S 1M2 Canada
Tel.: (514) 332-0082 Fax: (514) 332-3590 www.spectralux.ca

Spectral Power Distribution

Spectral Radiant Flux (W/nm)

Wavelength (nm)

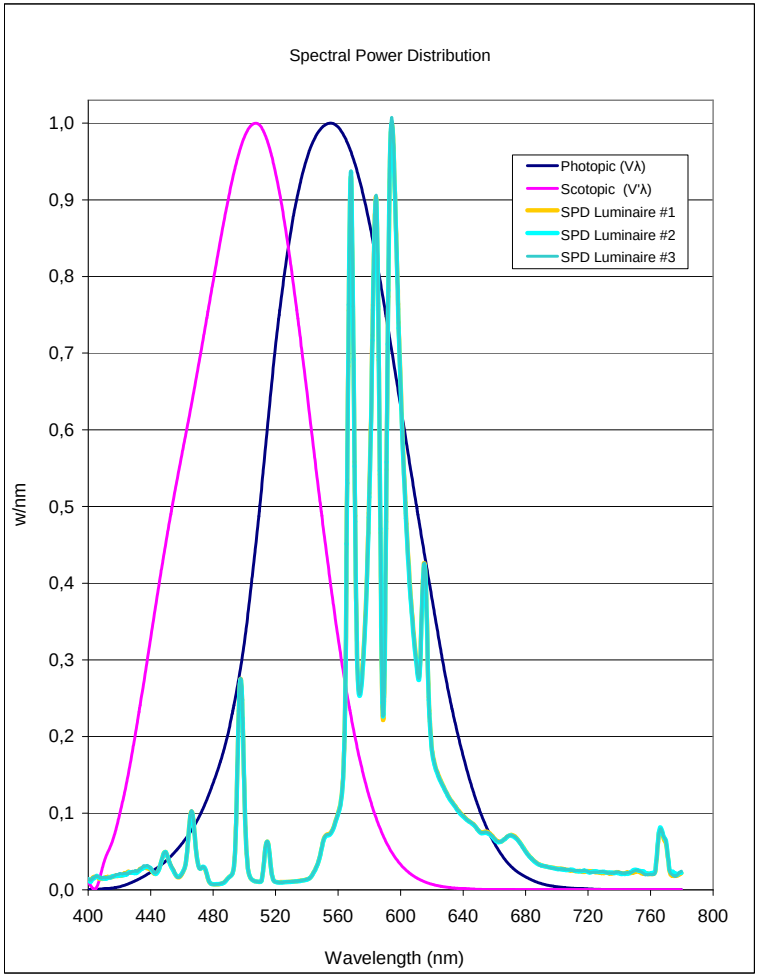
| | |
|---|---|
| Peak Wavelength | 448 nm |
| Luminous Flux | 3118 lm |
| Input Power | 54.19 W |
| Lumens/Watt | 57.5 |
| Full Width/Half Maximum | 23.67 |
| Center Wavelength | 448 nm |
| Centroid Wavelength | 1039 nm |
| Dominant Wavelength | 488 nm |
| Excitation Purity | 0.2723 |
| Colorimetric Purity | 0.1887 |

CIE 1931 Chromaticity Diagram

| | | | |
|---|---|---|---|
| x | 0.3408 | CCT | 5204 °K |
| y | 0.3655 | CRI | 89 |
| u | 0.2032 | L* | 5.65 |
| v | 0.3271 | a* | -3.89 |
| u' | 0.2032 | b* | -11.03 |
| v' | 0.4908 | | |
| R1 | 83.5 | | |
| R2 | 74.0 | | |
| R3 | 82.0 | | |
| R4 | 66.6 | | |
| R5 | 84.3 | | |
| R6 | 64.6 | | |
| R7 | 80.9 | | |
| R8 | 52.1 | | |

Test Report: L1010112-C1 Page 5 / 5

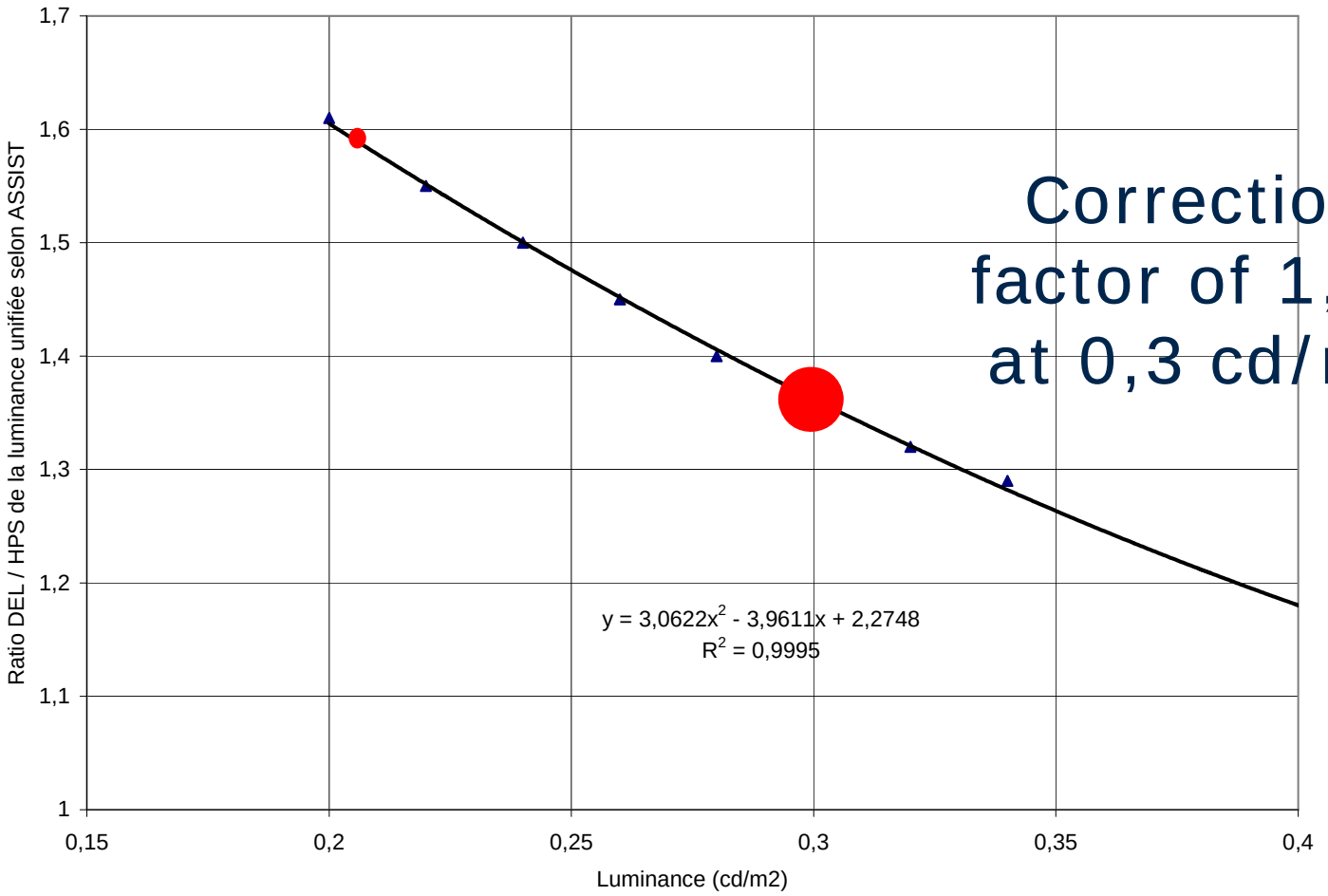
## HPS



# Spectral sensitivity of eyes – Results from Rouyn-Noranda Test Pilot

| | Photopic (DAY VISION) « OLD FASHION WAY » | Scotopic (NIGHT VISION) | Ratio S/P |
|---|---|---|---|
| DEL Luminaire | 3 143 | 5 686 | 1,81 |
| HPS luminaire (Ballast factor of 1) | 6 603 | 4 043 | 0,61 |

# Spectral sensitivity of eyes




Correction factor of 1,36 at 0,3 cd/m$^2$

# Rouyn-Noranda Pilot Project
# HPS

# Rouyn-Noranda Pilot Project
# LED

# Rouyn-Noranda Pilot Project
# LED

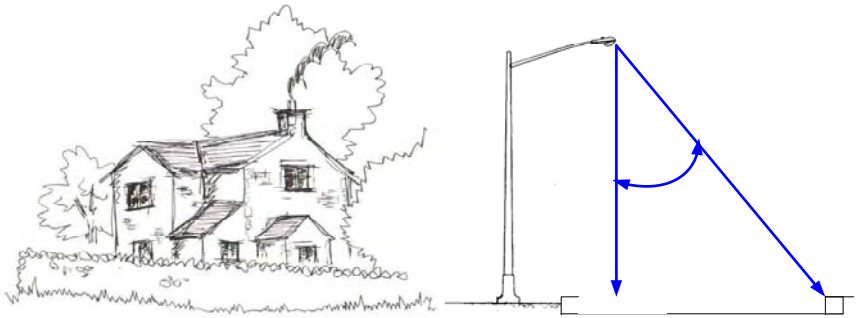
**New lamp on reference ballast : 9 516 lumens**

**Luminaire output (BF = 0,9) :**

**5 567 lumens ( luminaire efficacy: 58,5 %)**

**Downward : 5 346 lumens**

**Upward lumens : 221 lumens**



**HOUSE side lumens**

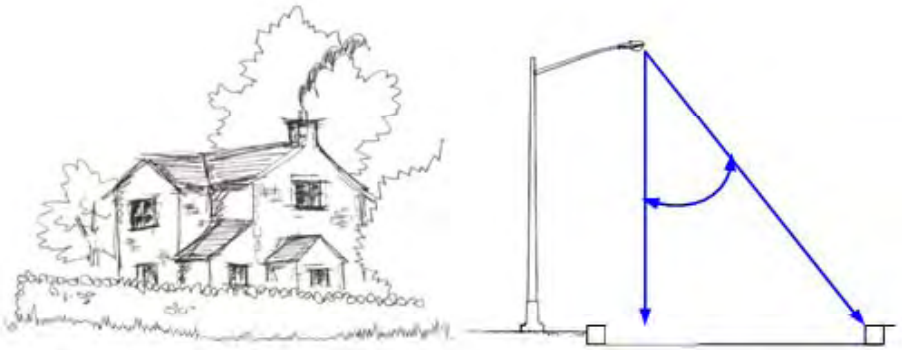
**1 592 lumens**

**STREET side lumens**

**3 754 lumens**

## HPS

Lumens total: 3 084 lumens



HOUSE side lumens

1 018 lumens

STREET side lumens

2 066 lumens

## LED

HPS

DEL

0,82 cd/m$^2$ left lane

0,67 cd/m$^2$ right lane

0,35 cd/m$^2$ left lane

0,21 cd/m$^2$ right lane

Mesopic correction

$y = 3{,}0622\ x^2 - 3{,}9611\ x + 2{,}2748$

MULTIPLICATION FACTOR = 1,27

Mesopic correction

$y = 3{,}0622\ x^2 - 3{,}9611\ x + 2{,}2748$

MULTIPLICATION FACTOR = 1,58

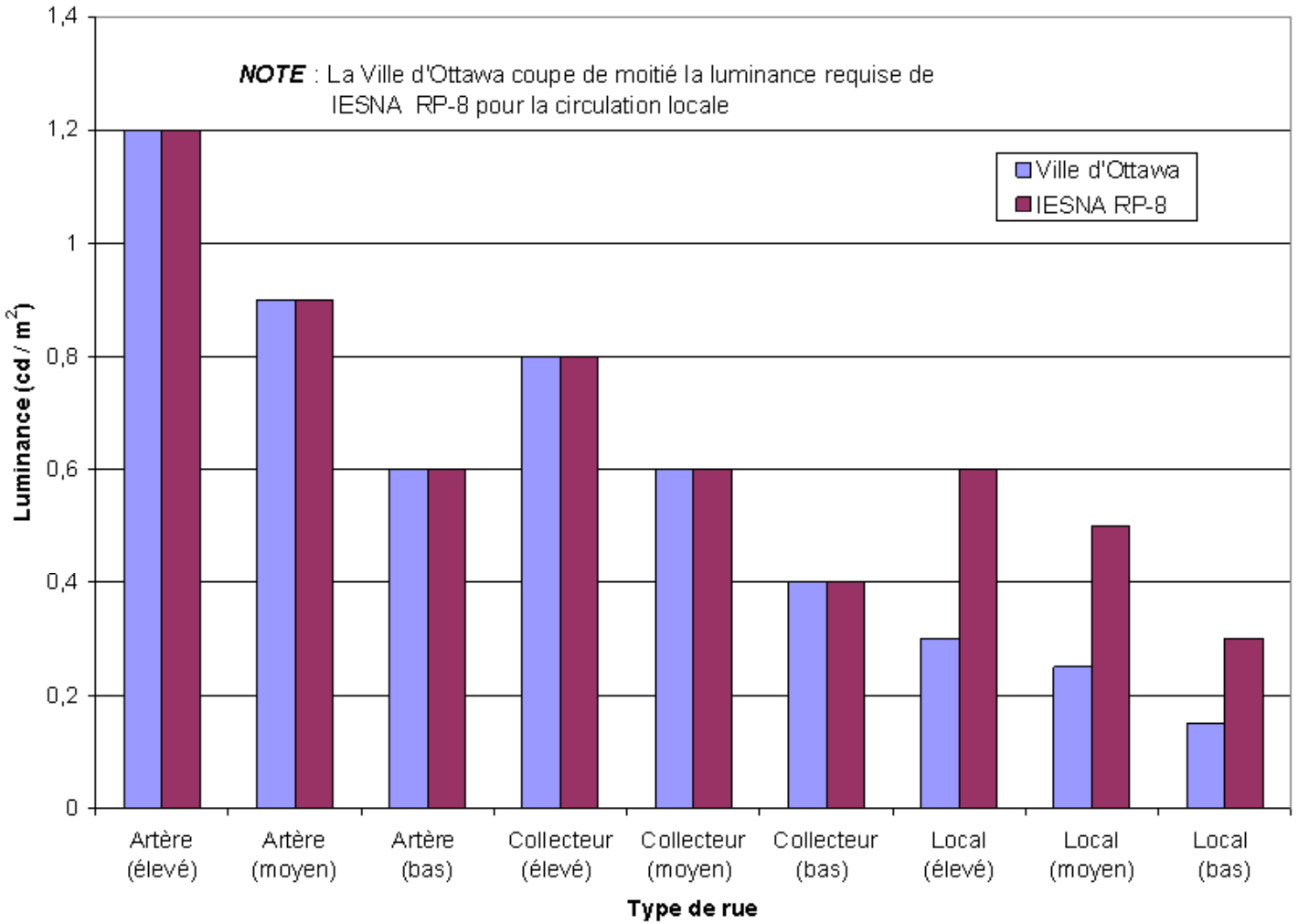
0,44 cd/m$^2$ left lane

0,33 cd/m$^2$ right lane

**Initial luminance 2 lanes *local street***

**i) 24 feet wide**
**ii) 140 feet spacing**
**iii) 30 feet mounting height**

# Acceptable luminance levels




Required levels of luminance in Ottawa versus RP-8

# CNN news update PART 2

## IES (Illuminating Engineering Society) – RP8

| Road and Pedestrian Conflict Area | | Pavement Classification (Minimum Maintained Average Values) | | | Uniformity Ratio | Veiling Luminance Ratio |
|---|---|---|---|---|---|---|
| Road | Pedestrian Conflict Area | R1 lux/fc | R2 & R3 lux/fc | R4 lux/fc | $E_{avg}/E_{min}$ | $L_{vmax}/L_{avg}$ |
| Freeway Class A | | 6.0/0.6 | 9.0/0.9 | 8.0/0.8 | 3.0 | 0.3 |
| Freeway Class B | | 4.0/0.4 | 6.0/0.6 | 5.0/0.5 | 3.0 | 0.3 |
| Expressway | High | 10.0/1.0 | 14.0/1.4 | 13.0/1.3 | 3.0 | 0.3 |
| | Medium | 8.0/0.8 | 12.0/1.2 | 10.0/1.0 | 3.0 | 0.3 |
| | Low | 6.0/0.6 | 9.0/0.9 | 8.0/0.8 | 3.0 | 0.3 |
| Major | High | 12.0/1.2 | 17.0/1.7 | 15.0/1.5 | 3.0 | 0.3 |
| | Medium | 9.0/0.9 | 13.0/1.3 | 11.0/1.1 | 3.0 | 0.3 |
| | Low | 6.0/0.6 | 9.0/0.9 | 8.0/0.8 | 3.0 | 0.3 |
| Collector | High | 8.0/0.8 | 12.0/1.2 | 10.0/1.0 | 4.0 | 0.4 |
| | Medium | 6.0/0.6 | 9.0/0.9 | 8.0/0.8 | 4.0 | 0.4 |
| | Low | 4.0/0.4 | 6.0/0.6 | 5.0/0.5 | 4.0 | 0.4 |
| Local | High | 6.0/0.6 | 9.0/0.9 | 8.0/0.8 | 6.0 | 0.4 |
| | Medium | 5.0/0.5 | 7.0/0.7 | 6.0/0.6 | 6.0 | 0.4 |
| | Low | 3.0/0.3 | 4.0/0.4 | 4.0/0.4 | 6.0 | 0.4 |

# CNN news update PART 2

## > CIE 115 :2010 *Lighting of roads for motor and pedestrian Traffic*

| Cat. | Éclairement moyen horizontal $E_{h,av}$ (lux) | Éclairement minimum horizontal $E_{h,\min}$ (lux) | Critères additionnels si la reconnaissance faciale est nécessaire | |
|---|---|---|---|---|
| | | | Éclairement minimum Vertical $E_{v,\min}$ (lux) | Éclairement semi-cylindrique minimum Vertical $E_{sc,\min}$ (lux) |
| P1 | 15 | 3,0 | 5,0 | 3,0 |
| P2 | 10 | 2,0 | 3,0 | 2,0 |
| P3 | 7,5 | 1,5 | 2,5 | 1,5 |
| P4 | 5,0 | 1,0 | 1,5 | 1,0 |
| P5 | 3,0 | 0,6 | 1,0 | 0,6 |
| P6 | 2,0 | 0,4 | 0,6 | 0,4 |

**2 lux CIE < 4 lux RP-8**

# Concept of local street lighting

**Convert HPS 100 Watts**

**(130 Watts total with ballast loss)**

**to**

**LED 58 Watts**

# Energy and $ calculation

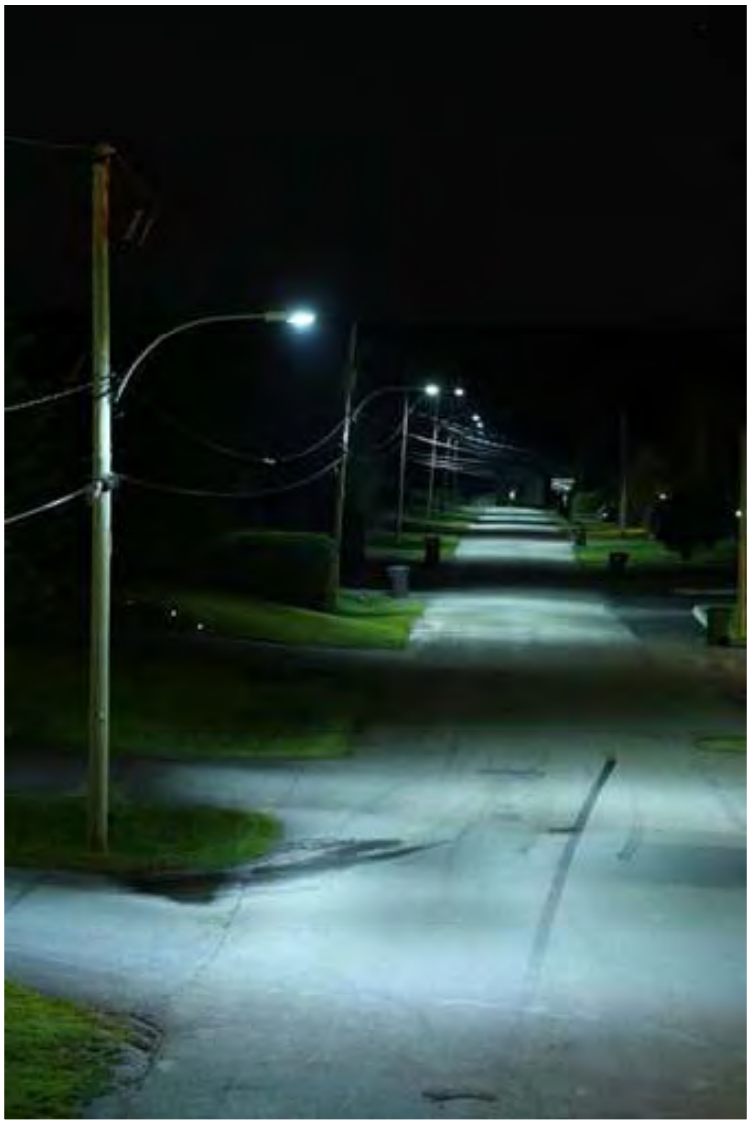
- 345 hours monthly and in most case not measured
- 4 140 hours annually
- 8,82 ¢/ kWh = 0,0882 $/kWh
- Power reduction of 130 – 58 = 72 Watts or 0,072 kW

***Annual savings*** :

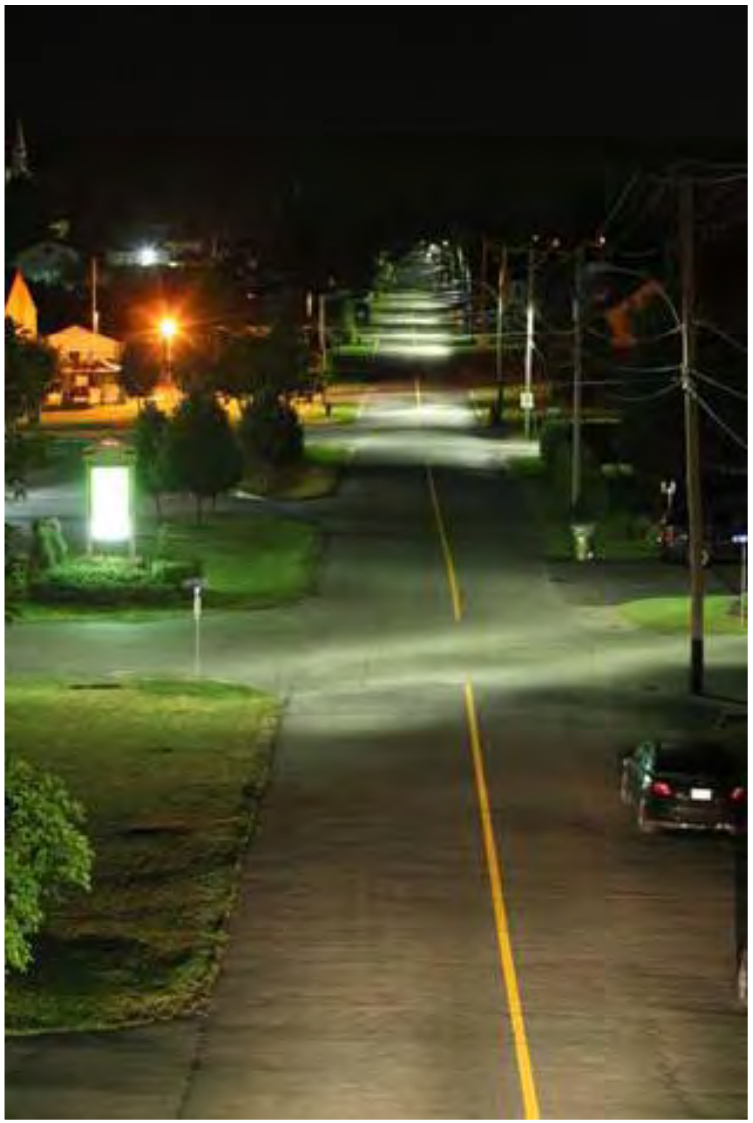
**0,072 kW x 4140 hr x 0,0882 $/kWh**

**26,3 $ of annual energy saving**

# Saint-Gédéon-de-Beauce



# Saint-Gédéon-de-Beauce



# IF … THEN …

- Decision should not be made only on the aspect of energy saving

- Ex: light pollution
- light trespass
- lifetime,…


Natural Resources Canada
Ressources naturelles Canada
UTILITIES to HELP customers to understand product application and build confidence that new lighting products will meet their needs
Hydro Québec

**MERCI**

**THANKS**

**André Laperrière, ing. M.Sc.A.**

**Laboratoire des technologies de l'Énergie d'Hydro-Québec**

Hydro Québec