Seattle City Light
LED Streetlight Program Case Study
July 15, 2011

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DKS Associates

2011 Northwest Region Workshop – Seattle, WA
Keys to Successful LED Program

1. Ability to Identify Good Engineering
2. Vision for the Possibilities Embodied in a Strategic Program Lead
3. Executive and Political Support – Must Have!
4. Experienced External Partnerships (The Consortium | PNNL | Your Local Utility)
Program Goals

• Reduce energy use by 40% - Actual 48%+
• Lower maintenance costs (only cleaning during fixture life)
• Improve Customer Service (no lamp change over fixture life - 12+ years)
• Improve operation on Bridges
• Select reliable fixture (5 Step Process)
SCL Street Lighting System Background
Types by Use
84,000 Total Fixtures

- Residential Cobra Head Lighting: 40,783 (49%)
- Arterial Cobra Head Lighting: 31,447 (37%)
- Pedestrian and Special Lighting: 11,705 (14%)

Pilot Evaluations in 2011
Current SL System Energy Use by Category

- Arterial Cobra Heads 52,827,180 kWh (59%)
- Residential Cobra Head 22,693,382 kWh (25%)
- Pedestrian and Special 14,334,629 kWh (16%)

After 6000 LED Streetlights installed Energy Usage decreased 90,000 kWh
Why LED Street Lighting for Seattle?

For the first time in history a singular light source appears to show maximum potential to fill the three main desires for lighting: Illumination Performance, Controllability, and Operational Efficiency

1. Illumination Performance - Quality and Volume Desired where Desired, Color Rendition, CCT, Uniformity, etc.
Historical Acceptance of Poor Quality Light...
Why LED Street Lighting for Seattle?

Continued...

2. Controllability (Passive and adaptive controls for dimming and lumen maintenance, event and time of day scene setting, etc.)

3. Operational Efficiency - >50% energy savings over HPS, Reduced maintenance cost = $avings!
Challenges

1. Community Acceptance
   - Quality of Light
   - Light Trespass

2. Lack of Standards – No ones ever done this before...

3. Funding
   – Down economy
   – Competing resources

4. Historical Design Practices
The Plan

• **Stage 1** - Replace 41,000 Streetlights on existing poles in Residential areas beginning in 2010

• **Projected Cost**: $24,000,000

• **Acquire Funding**:
  • Utility funding | Customer billed
  • $1m ARRA EECBG Grant
Phase 1 - 2010
Replaced 6k of the 41,000 Residential Streetlights w/in LED – Zone 3
Phase 2 - 2011
Replace Additional 12k Residential Streetlights w/in LED – Zone 4

(18,000 Total by end of year)
The Research and Engineering...
Review Typical Seattle Roadway Compositions

GIS Base mapping of luminaire locations

- Typical 32 foot cross-section
- Luminaire mounting height (25’ to 30’)
- Light pole spacing (150 feet)
- Tree Conflicts
Luminaire Selection

- Internet Research & Phone Calls
- Manufacture Questionnaire
  - Photometric performance
  - “Made in America” status
- Manufacturers’ production capabilities
- Manufacturers’ Specification
- LM 79 & LM 80 Reports
- Pricing
LM-79 vs. LM-80 Reports for SSL Products

•IES LM-79-08
  •Electrical characteristics
  •Light output
  •Luminous intensity distribution
  •Color Characteristics

•IES LM-80-08
  •Lumen maintenance
QUESTIONNAIRE

- Material specification
- IES files based on the IESNA LM-79-08 test procedure from an approved laboratory. Preferred laboratories include:
  - ITL in Boulder, CO
  - LTL in Allentown, PA
- Light Loss Depreciation (LLD)
- Recommended Light Loss Factor (LLF)
- Available correlated color temperatures in Kelvin (CCT)
- Available Color Rendering Index (CRI) rating
- Available Watts for fixtures
- Luminaire Classification System Rating (BUG Rating) per IESNA TM-15: Assessment of glare, with the luminaire at intended mounting height and under typical nighttime viewing conditions, compared to incumbent technology
- Power quality and electromagnetic compatibility data. This should include grounding requirements

☞ Address the questionnaire by May 26, 2009.
☞ Sample product shipped to SCL by June 23, 2009 for mockup test at Lighting Lab.
Luminaire Selection Outcome

- Initial Phone Contact
- Internet Research

- From Questionnaire
- Specifications Review

- Manuf. Experience
  - Price
  - Availability

150 Manufacturers

40 Manufacturers

5 Manufacturers
Photometric Analysis

Computer Simulation

• Based on the IES RP-8-00, Table 2

(American National Standard Practice for Roadway Lighting)

  – Average maintained illuminance values.
    • 0.4 foot candles (Seattle 0.7 foot-candles)
  – Uniformity ratios (average/minimum).
    • 6:1 with a minimum of 0.2 foot-candles allowed.
Photometric Analysis

Computer Simulation

• Luminaire Characteristics
  • Type II & III distributions
    Type II - greater pole spacing less light trespass
    (New BUG rating has come out – Backlight, Uplight, Glare)
  • Multiple Wattages tested
Photometric Analysis

Computer Simulation

- Color temperature 4000°K to 6000°K
  - Keyed in on 4000°K to 4300°K
    (Based on input from Stage 1 & Lighting Lab install)
- 350 to 525 milliamps operating current
  - Cooler operation to extend life of fixture
Photometric Analysis
Light Loss Factors (LLF) – 0.77

- Luminaire Dirt Depreciation factor (LDD) based on:
  - Clean/very clean environment
    (Based on *IESNA Lighting Handbook, 9th Edition*)
  - 7 year maintenance cycle.
  - LDD of 0.90 used in evaluation

- Lamp Lumen Depreciation factor (LLD):
  - Luminaire manufacturers claims
  - Review of LM-80 test data.
  - LLD of 0.85 utilized for most fixtures

- Dana Beckwith will have further discussion on this topic.
Photometric Analysis

RP-8-00, Figure A5. Luminaire Dirt Depreciation (LDD) factors
Photometric Analysis Outcome

- 5 Manufacturers
- 2 Manufacturers
  - 2 Luminaires Each

- Luminaire Selection
- Photometric Performance
- Further Price Review
Field Evaluation

Methodology

• Before and after comparison
• Field Testing Methodology based on RP-8-00
• Field measurements made with sled mounted light meter for efficient and fast data collection
• Testing conducted on clear nights with no clouds or moon
Field Evaluation

SITE 11C
- Manufacturer: Vendor 1
- Model: System A
- Removed: 4
  - 100W HPS COBRAHEAD (142W)
- Installed: 4
  - Wattage: 105W LED
  - Color Temp: 4100K
  - CRI: 75

SITE 11B
- Manufacturer: Vendor 6
- Model: System D
- Removed: 4
  - 100W HPS COBRAHEAD (142W)
- Installed: 4
  - Wattage: 137W LED
  - Color Temp: 4100K
  - CRI: 75

SITE 11A
- Manufacturer: Vendor 1
- Model: System B
- Removed: 4
  - 100W HPS COBRAHEAD (142W)
- Installed: 4
  - Wattage: 142W LED
  - Color Temp: 4300K
  - CRI: 75

SITE 12
- Manufacturer: Vendor 6
- Model: System C
- Removed: 2
  - 100W HPS COBRAHEAD (142W)
  - Induction Lamp
- Installed: 4
  - Wattage: 75W LED
  - Color Temp: 4100K
  - CRI: 75
# Field Evaluation

**Test Location**: 11-A (HPS)

<table>
<thead>
<tr>
<th>Line #</th>
<th>Test point 1</th>
<th>Test point 2</th>
<th>Test point 3</th>
<th>Test point 4</th>
<th>Test point 5</th>
<th>Test point 6</th>
<th>Test point 7</th>
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<td>5.57</td>
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<td>2.60</td>
<td>1.21</td>
<td>0.56</td>
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<td>0.84</td>
<td>0.84</td>
<td>0.84</td>
<td>0.84</td>
</tr>
</tbody>
</table>

**Average**: 1.208  
**Maximum**: 5.574  
**Minimum**: 0.093  
**Avg/Min**: 13  
**Max/Min**: 60
# Field Evaluation

A detailed summary of South Park field data

## 11-A S. Donovan St. between St. 14th Ave S. to 12th Ave S.

<table>
<thead>
<tr>
<th>Description</th>
<th>11-A (HPS)</th>
<th>11-A (beta) (LED)</th>
<th>11-A Sidewalks (HPS)</th>
<th>11-A Sidewalks (beta) (LED)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average</strong></td>
<td>1.21</td>
<td>1.14</td>
<td>0.36</td>
<td>0.52</td>
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<tr>
<td><strong>Maximum</strong></td>
<td>5.57</td>
<td>2.51</td>
<td>1.21</td>
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<tr>
<td><strong>Minimum</strong></td>
<td>0.09</td>
<td>0.28</td>
<td>0.09</td>
<td>0.09</td>
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<tr>
<td><strong>Avg/Min</strong></td>
<td>13.00</td>
<td>4.10</td>
<td>3.77</td>
<td>5.64</td>
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<tr>
<td><strong>Max/Min</strong></td>
<td>60.00</td>
<td>9.00</td>
<td>13.00</td>
<td>13.00</td>
</tr>
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</table>

## 11-B S. Donovan St. between St. 12th Ave S to 10th Ave S.

<table>
<thead>
<tr>
<th>Description</th>
<th>11-B (HPS)</th>
<th>11-B (LSI) (LED)</th>
<th>11-B Sidewalks (HPS)</th>
<th>11-B Sidewalks (LSI) (LED)</th>
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</thead>
<tbody>
<tr>
<td><strong>Average</strong></td>
<td>1.15</td>
<td>1.75</td>
<td>0.39</td>
<td>0.46</td>
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<td><strong>Maximum</strong></td>
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<td>4.46</td>
<td>1.67</td>
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<td><strong>Minimum</strong></td>
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<tr>
<td><strong>Avg/Min</strong></td>
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<td>18.88</td>
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<tr>
<td><strong>Max/Min</strong></td>
<td>18.50</td>
<td>48.00</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

## 11-A S. Donovan between St. 10th Ave S to 8th Ave S.

<table>
<thead>
<tr>
<th>Description</th>
<th>11-C (HPS)</th>
<th>11-C (beta small) (LED)</th>
<th>11-C Sidewalks (HPS)</th>
<th>11-C Sidewalks (beta) (LED)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average</strong></td>
<td>0.42</td>
<td>0.81</td>
<td>0.42</td>
<td>0.29</td>
</tr>
<tr>
<td><strong>Maximum</strong></td>
<td>3.25</td>
<td>1.77</td>
<td>3.25</td>
<td>1.11</td>
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<tr>
<td><strong>Minimum</strong></td>
<td>0.00</td>
<td>0.09</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Avg/Min</strong></td>
<td>-</td>
<td>8.68</td>
<td>-</td>
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<tr>
<td><strong>Max/Min</strong></td>
<td>-</td>
<td>19.00</td>
<td>-</td>
<td>-</td>
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</tbody>
</table>
Field Evaluation

Photometrics

Before (HPS)
- Illuminance levels of existing HPS system exceeded RP-8-00 minimums
- Uniformity for HPS did not meet RP-8-00

After (LED)
- Illuminance levels exceeded RP-8-00 minimums
- Illuminance levels of the LED fixtures exceeded HPS system levels
- Uniformity for LED did not meet RP-8-00
Field Evaluation Outcome

- **2 Manufacturers**
  - Field Deployment

- **1 Manufacturer Failed**
  - Water inside housing
Economic Analysis

Base luminaire: 100 W HPS Cobra Head
- 25% failure rate
- 30,000 hour lamp life
- Maintenance cycle 4 years

Comparison Luminaires: 39 to 142 Watt LED
- 10% failure rate
- 50,000 hour LED life
- Maintenance cycle 7 years

Life Cycle - 15 years (assumed)
Energy Rate - $0.053/kWh
Rebate - $0.23/kWh saved
Economic Analysis

Payback (compared with 100 W HPS)

Also met photometric requirements

- Medium LED array luminaires
  - Luminaire C2 (75 watts) – 4.7 years
  - Luminaire A2 (109 watts) – 6.1 years

- Large LED array luminaires
  - Luminaire C3 (137 Watts) – 13.8 years
  - Luminaire A3 (142 Watts) – 14.6 years

85 Watts or less required to meet 40% Energy Savings
Economic Analysis Outcome

- Field Performance

2 Manufactures
2 Luminaire Each

- Economic Payback

2 Manufactures
1 Luminaire Each
Recommendations

Luminaire

60LED-Type II Distribution-4300K-525mA

Only one luminaire made the final cut.

Note: Since the report was published, technology has advanced and more products are available.
Pilots

• Capital Hill
• South Park
• West Seattle
Community Outreach

• Pilots in Specific Neighborhoods
• Questionnaire to Every Household
• Noted Major concerns and adjusted fixture selection
Create Fixture Standard

• At the end of all of this 5-Step evaluation process came the SCL LED Streetlight Standard...
Implementation

• Jorge Carrasco, SCL Superintendent, Approval
• Mayors Office Support and Approval
• City Council Budget Approval
LED SL Program Savings - Residential Streets

<table>
<thead>
<tr>
<th>Residentail LED Installations</th>
<th>Units Converted</th>
<th>Savings Per LED</th>
<th>Monthly Savings</th>
<th>Annual Savings at end of period</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010 Installations</td>
<td>5000</td>
<td>$4.90</td>
<td>$24,500.00</td>
<td>$294,000.00</td>
</tr>
<tr>
<td>All Residential Streets Installed: 41000</td>
<td>$200,900.00</td>
<td>$2,410,800.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual System Management &amp; Cleaning Costs</td>
<td>$ (520,000.00)</td>
<td></td>
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</tbody>
</table>

Total Projected Savings at end of 2014: $1,890,800.00
2010 LED Expenditures

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>$665,000</td>
</tr>
<tr>
<td>Materials – City Funded</td>
<td>$800,000</td>
</tr>
<tr>
<td>Materials – ARRA Funded</td>
<td>$1,000,000</td>
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<tr>
<td>Total Project Cost</td>
<td>$2,465,000</td>
</tr>
</tbody>
</table>
Investment and Savings on Residential System
Updated 2011

Total Residential Capital Costs = $20,500,000
LED Next Steps

• 2011 – Residential LED Conversion – 12,000 units
• Arterial Pilots
  • West Seattle Bridge – I-5 to 35th Ave SW
    (SCL | SDOT | Consortium | PNNL Partnership)
  • Other Major Arterials
• Arterial Fixture Selection – Fall 2011
• Arterial Conversion Target - Begin Year 201X
New Technology Goals

• Remote Monitoring
  – Ability to get real time/ metered power usage for each light
  – Immediate notification of streetlight malfunctioning
  – Quicker response time for repair

• Lumen Maintenance - Light loss management

• Adaptive Controls
  – Ability to dim or brighten streetlights to meet vehicular and pedestrian demands
  – Set scenes for events and time of day
  – 20%+ Additional energy savings
Goals for Lumen Maintenance

- Power Consumption w/ Lumen Maintenance Applied
- Typical Constant Power Use
- LED Streetlight
- Standard HPS Streetlight

Graph showing lumen output and energy consumption over time:

- 100% lumen output at 0 years.
- 70% lumen output at 5 years (50% burned out).
- 100% lumen output at 10 years (no projected failures).
- Decrease in lumen output and energy consumption over time.
Adaptive Controls Next Steps

• 2011 - Consultant System Evaluation
• Pilots on Arterial and Residential Streets
• Economic Evaluation
Why LED Street Lighting for Seattle?

“LED street lighting has proven to be a significantly better light source in terms of expected maintenance, energy efficiency, and quality of light.”

Edward Smalley, Seattle City Light
Why LED Street Lighting for Seattle...
It's simply better lighting!

Before (HPS)

After (LED)
Seattle City Light – LED Street Lighting Program
July 13, 2011

Thank You…! Questions?

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