
City of Palo Alto LED Streetlight Pilot Project

Christine Tam
May 6, 2010

Overview of Palo Alto's Present Street Lights

- The City of Palo Alto owns, operates and maintains all of its utility services, including electric, natural gas, water and wastewater collection services.
- The Utilities Department operates and maintains the City's street lights.
- Total number of High Pressure Sodium (HPS) fixtures: 6,300
 - Type of HPS fixtures: 70, 100, 150 and 250 Watts
 - Accounts for ~0.4% of community-wide electric use
 - HPS bulbs on group replacement every 5 years
- The City Council adopted a Climate Protection Plan in December 2007 that identified the prospective use of light-emitting diode (LED) technology for street lighting as a cost-effective means to reduce greenhouse gas (GHG) emissions.

Pilot Project Objectives

- Evaluate the energy savings and illumination levels of alternative street lighting technologies compared to HPS.
 - Light Emitting Diode (LED)
 - Induction technology
- Seek feedback on alternative street lighting technologies from the community, police officers and operations staff.
- Assess the cost-effectiveness of converting to LED or induction streetlights

Palo Alto partnered with DOE's Pacific Northwest National Laboratory (PNNL), which provided expert assistance in luminaire selection, field measurements, and advice on cost-benefit analysis.

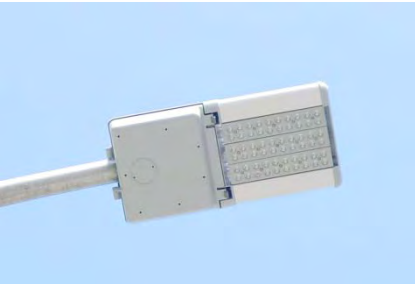
Comparison of Streetlighting Technologies

HPS



- Low Color Rendering Index (CRI = 22); i.e. light output has yellow tinge (daylight has a CRI of 100).
- Lighting tends to be less uniform with hotspots under fixtures.
- Lamps expected to last approximately 24,000 hours.
- Contains mercury.

LED



- Whiter light—High Color Rendering Index (CRI = 70 to 80).
- Given the directional capability to point multiple LEDs in a fixture, light is more uniform.
- Rated lamp life of 100,000 hours.
- Does not contain mercury.

Induction



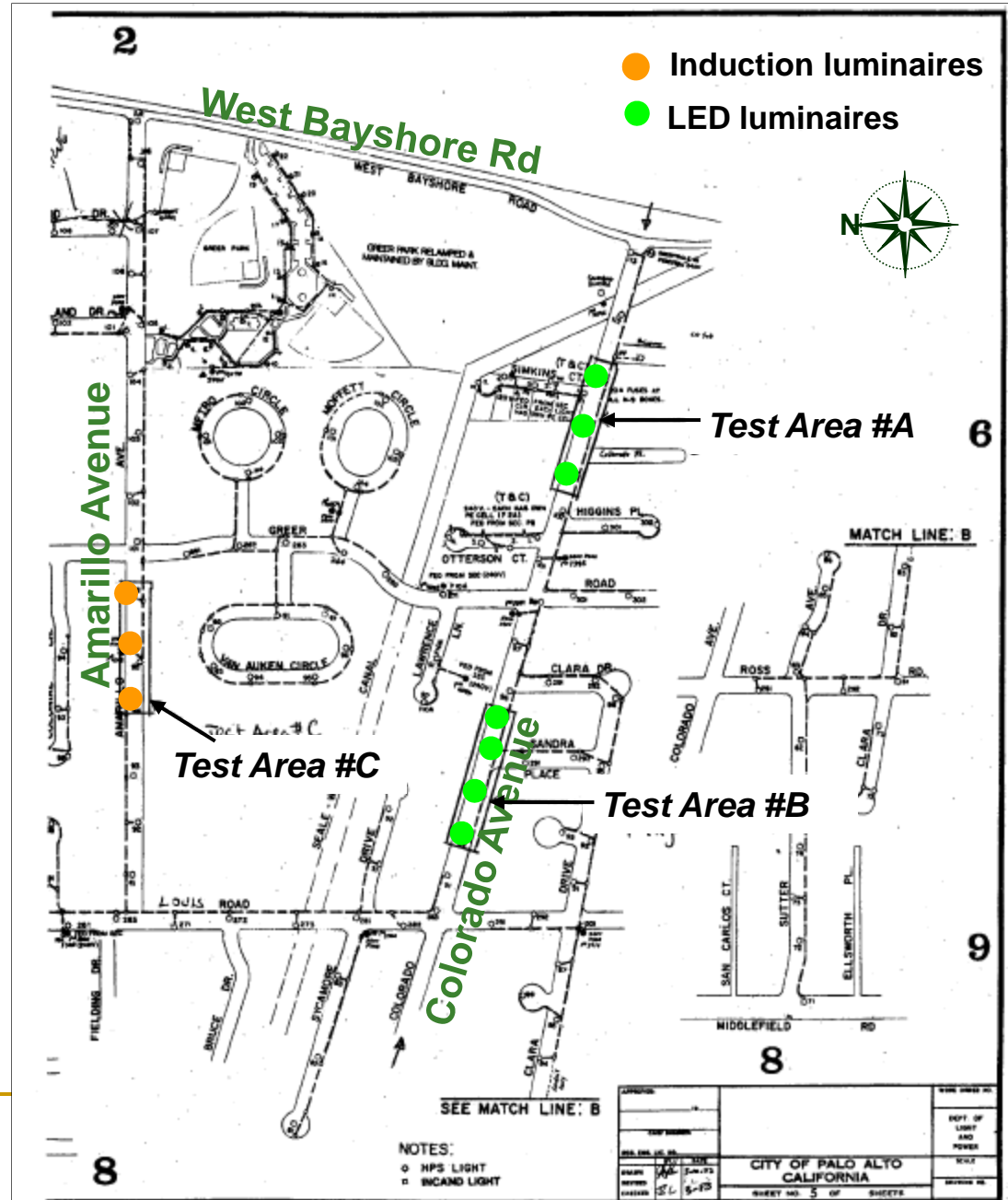
- Whiter light—High Color Rendering Index (CRI = 80).
- Lighting tends to be less uniform.
- Similar to fluorescent lamp
- Rated lamp life of 100,000 hours.
- Contains mercury.

Project Scope

- Replace selected HPS fixtures on residential streets and near City Hall with LED and induction fixtures.
- Test streetlight monitoring technology that allows for:
 - Dimming of individual fixtures based on lighting needs; and
 - Remote access and alarms to assist with maintenance.
Select one vendor each for LED and induction streetlight fixtures and one other vendor for the remote monitoring system.
- The test LED and induction fixtures were selected to match the existing illuminance levels of the HPS fixtures.

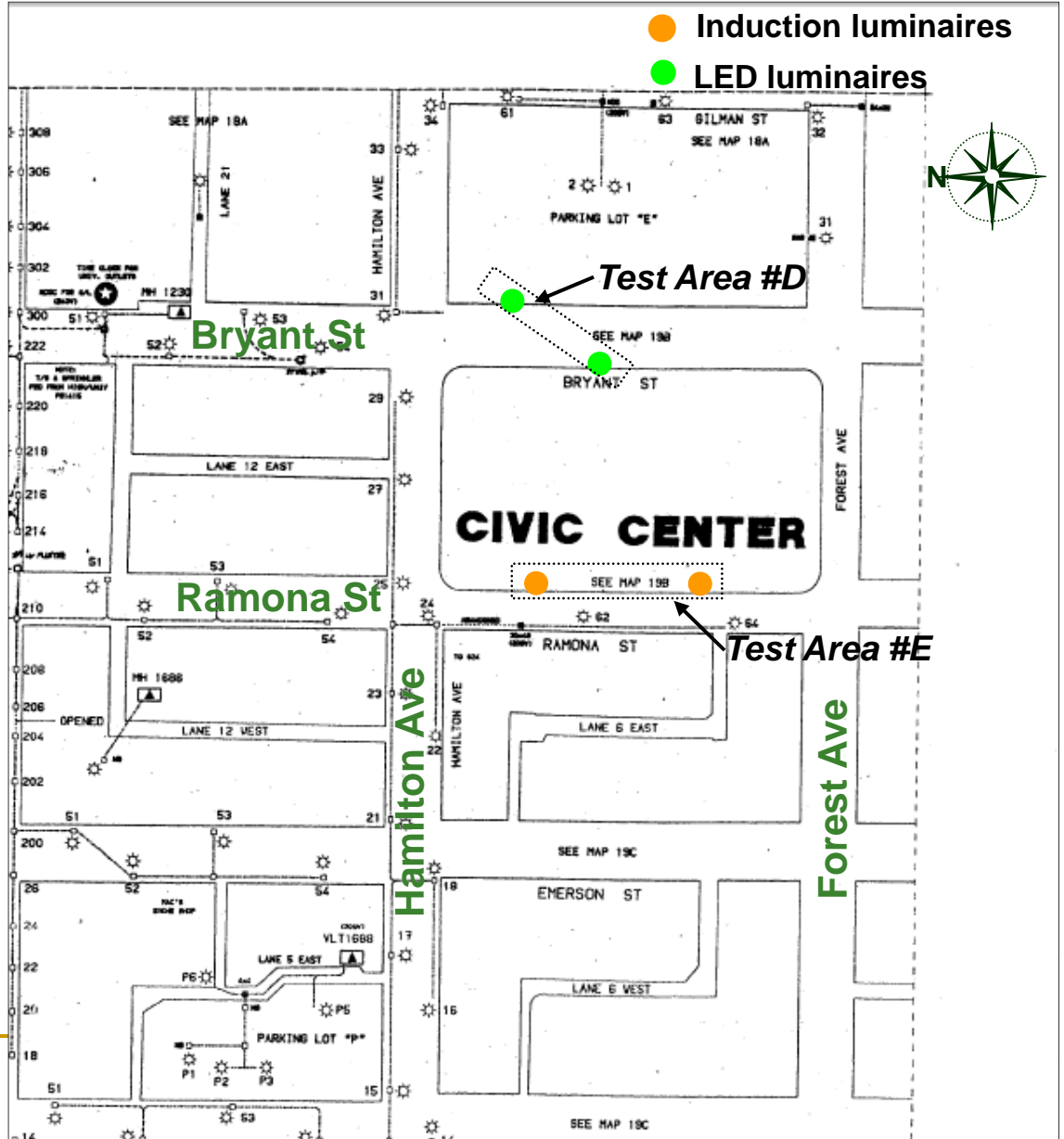
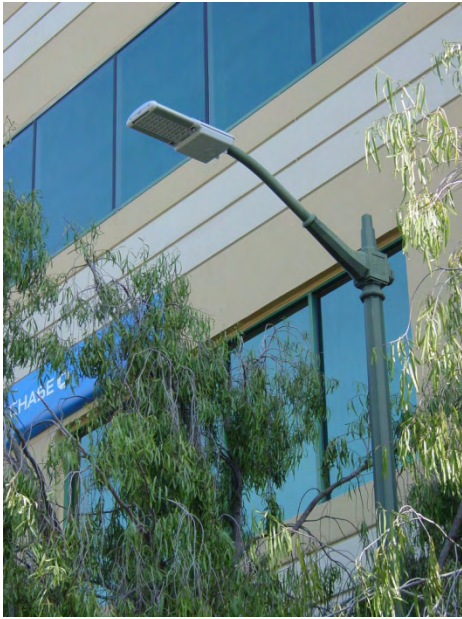
Test Sites

Residential Neighborhood



Test Sites

City Hall



Field Measurements

- Illuminance was measured at the residential sites for both the baseline and new fixtures. Measurements are taken along grids spaced approximately 16 feet by 8 feet. Around 90 measurements were taken for each residential test site.
- For the commercial street near City Hall, illuminance measurements were taken for the LED lights powered at 100%, 70% and 50%.
- Power measurements were taken for both the baseline and new fixtures.

Gathering Stakeholder Feedback

- Survey was not designed to be unbiased.
- Notification letters sent to about 200 residents living near the residential test sites.
- News page created in the City of Palo Alto website with a link to an online feedback form.
- Signs were posted on the poles of each fixture to indicate the technology deployed and to direct viewer to the online feedback form.
- Conducted an evening walk-through tour to solicit in-person feedback.
- Surveyed Palo Alto Police and Utilities Operations staff.

Pilot Results

- Illuminance measurement results show that the LED systems produce a more uniform light output than HPS .

| | Colorado 1 | | Colorado 2 | | Amarillo | |
|--------------|------------|---------|------------|---------|----------|---------|
| | HPS | 20-LED | HPS | 30-LED | HPS | IND |
| Average | 0.44 fc | 0.24 fc | 0.36 fc | 0.43 fc | 0.27 fc | 0.23 fc |
| Minimum | 0.03 fc | 0.02 fc | 0.02 fc | 0.01 fc | 0.01 fc | 0.01 fc |
| Maximum | 2.64 fc | 1.02 fc | 1.68 fc | 1.47 fc | 1.34 fc | 1.52 fc |
| Coeff of Var | 1.22 | 1.08 | 1.05 | 1.004 | 0.90 | 1.23 |

- Power measurement results show that 20-LED provides the most energy savings, while induction delivers the least energy savings .

| Source | Power (W) |
|-----------|---------------|
| HPS | 97 |
| 20-LED | 42 (57% less) |
| 30-LED | 54 (42% less) |
| Induction | 90 (7% less) |

Pilot Results

- Assumptions for the Payback Analysis:
 - Avoided energy cost of \$0.08/kWh;
 - Streetlight annual operating schedule of 4,100 hours;
 - Annual maintenance costs of the LED and induction fixtures at 30% less than the HPS system;
 - Initial cost for the 70W HPS, 20-LED, 30-LED and Induction fixtures are \$78, \$350, \$420 and \$459 respectively.
 - Expected lifespan for LEDs = 15 years; for induction = 17 years.
 - Discount factor 4.5%

| | Retrofit | | New Construction | |
|------------------|----------------------|-------------------|----------------------|-------------------|
| | Simple Payback (yrs) | Net Present Value | Simple Payback (yrs) | Net Present Value |
| 20 LEDs | 9 | \$122 | 7 | \$201 |
| 30 LEDs | 12 | -\$15 | 10 | \$64 |
| Induction | 17+ years | -\$173 | 16 | -\$105 |

Pilot Results

- Further analysis showed that the economics are highly sensitive to the years of operation, fixture cost and maintenance cost of LED fixtures.
- Base case assumes a 15-year life time for LED fixtures. Typical warranty for LED fixtures is only 5 years.
- The price of LED streetlight fixtures has been declining over the past 24 months. The City of Oakland conducted two demonstration projects with LED streetlights and found that over a 12 month period ending December 2008, cost for similar fixtures decreased by 34%.
- Base case assumes maintenance cost reduction by 30%. Actual maintenance cost of LED fixtures may deviate from this estimate.

Pilot Results

- The deployment of remote monitoring system with LED fixtures is currently not economical based on the additional system costs.

| <i>(retrofit scenario replacing 150W HPS)</i> | Without Dimming | | With Dimming | |
|---|------------------------|-------------------|------------------------|-------------------|
| | Simple Payback (years) | Net Present Value | Simple Payback (years) | Net Present Value |
| 60 LEDs | 12 | -\$63 | 15+ years | -\$358 |
| 165W Induction | 15 | -\$145 | 17+ years | -\$199 |

Pilot Results

- Results of the survey may be biased due to the information presented to survey respondents, e.g. energy efficiency and/or mercury content of the different lighting technologies.
- Overall, respondents preferred the 30-LED streetlights over HPS and induction streetlights. Increased color perception and visibility plus energy savings were given as the key advantages of LED fixtures.
- Concerns remain over the color of the LED light output, which was perceived as “too cold” and “harsh” compared to other light sources.

Next Steps

- Palo Alto is currently testing fixtures from 4 different LED vendors (Phillips, GE, LED Roadway Lighting and Beta).
- Public feedback on the new test fixtures will be taken into consideration when selecting the vendor product to replace the HPS street lights.
- Palo Alto plans to replace around 10% of its HPS streetlights by end of 2010/beginning of 2011 using ARRA funds.
- By 2015, all HPS streetlights will be replaced with more energy efficient streetlights.
- Joint PNNL report on the pilot project to be finalized in May 2010.