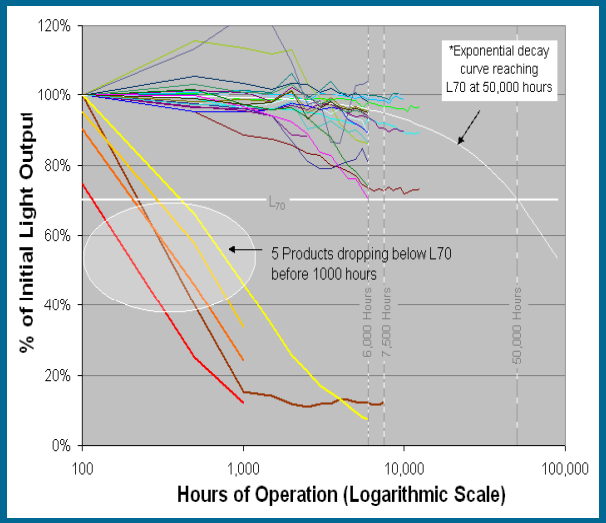
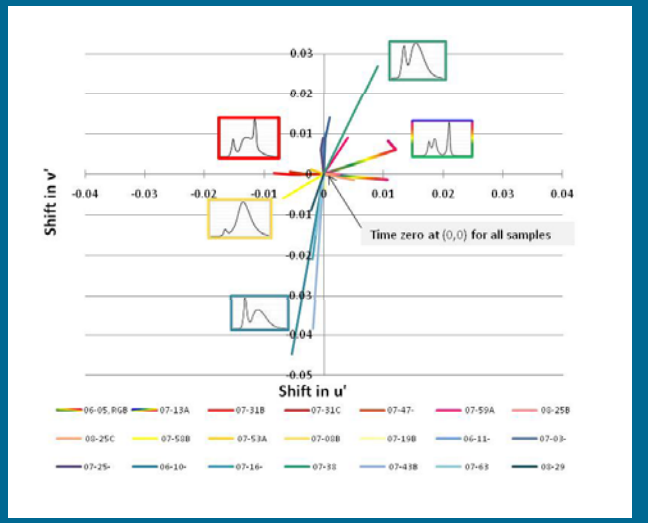
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

UPDATED CALiPER LONG-TERM TESTING: 2010





CORM Conference

Las Vegas, May 11, 2010

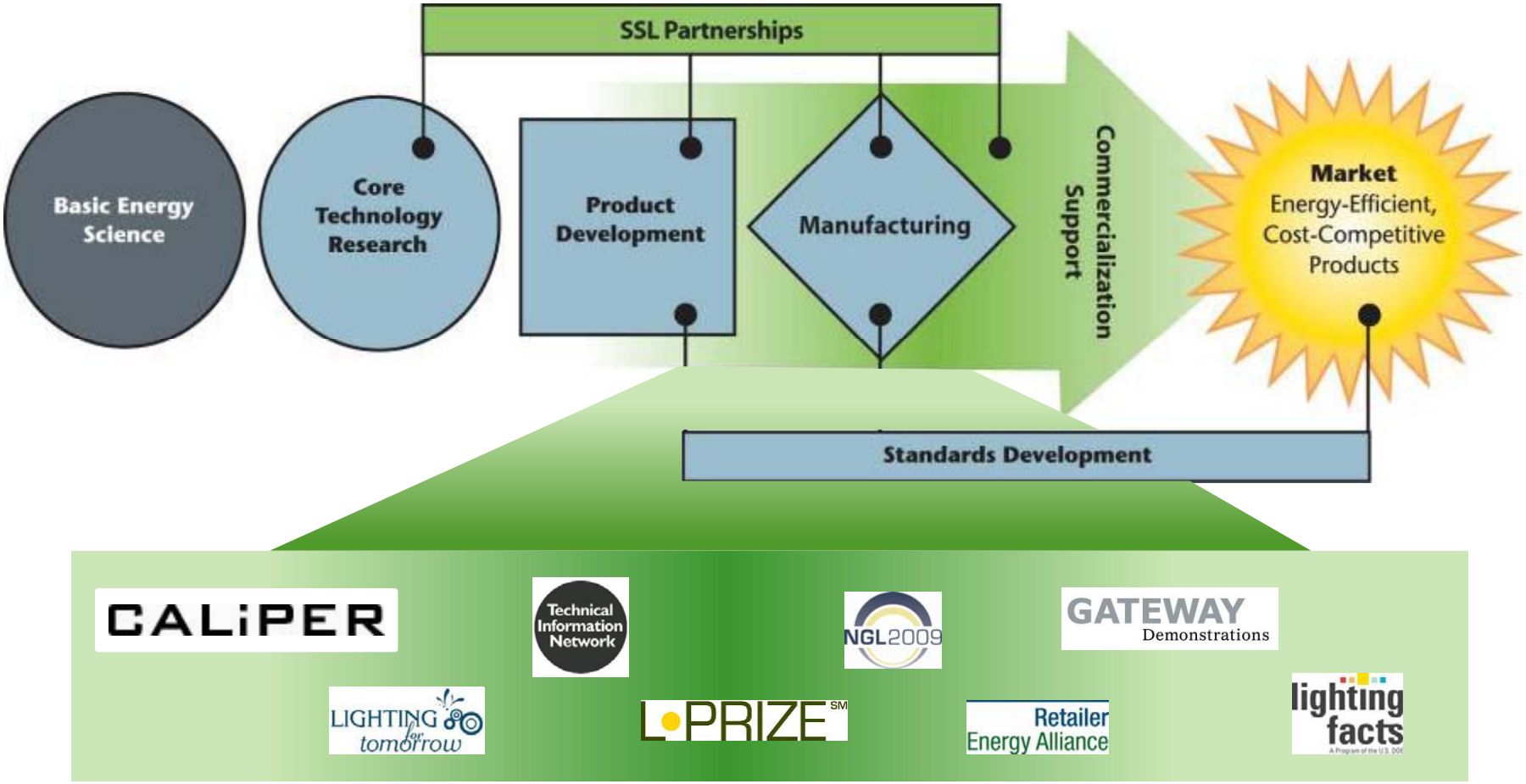
Mia Paget

Pacific Northwest National Laboratory

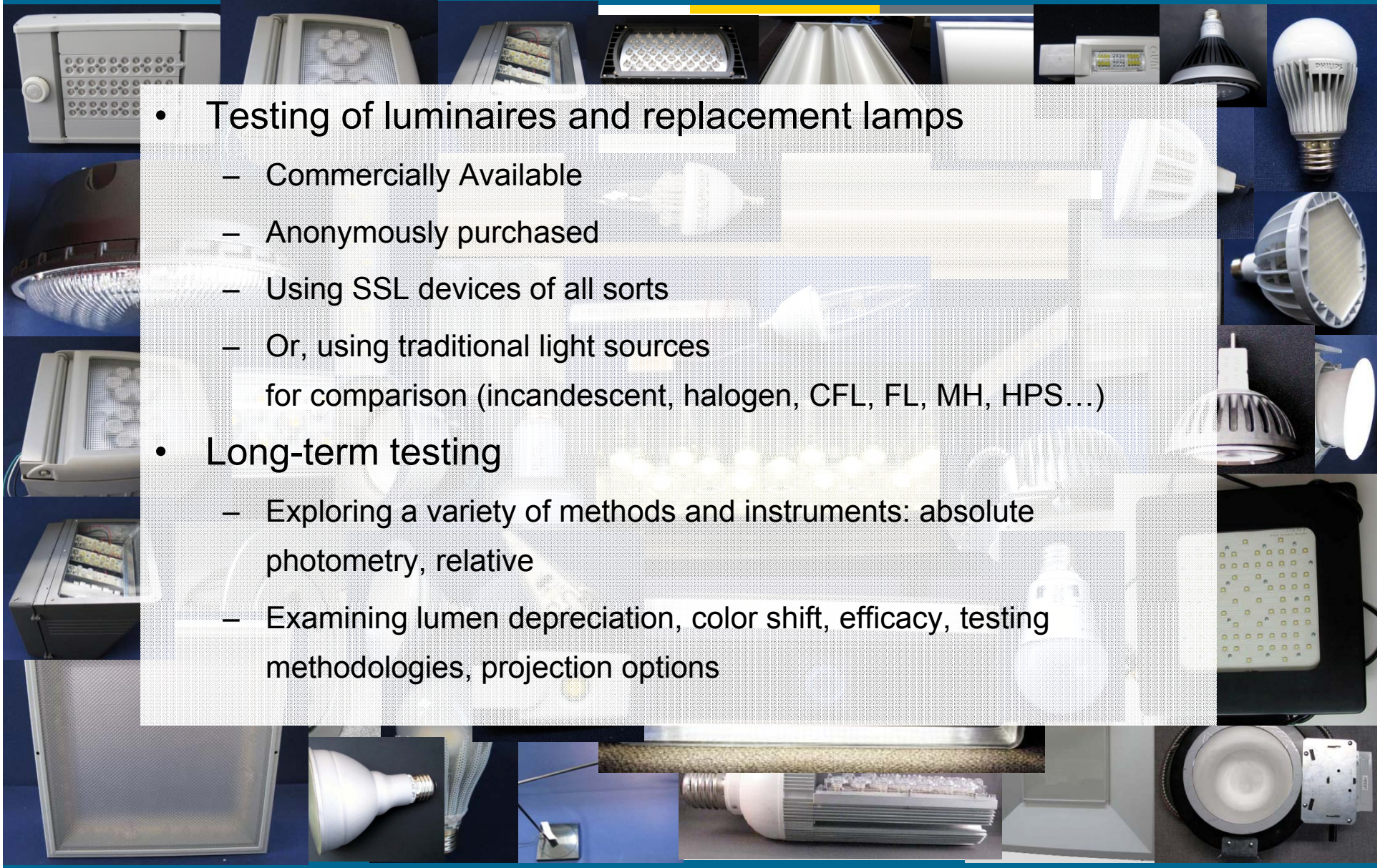
DOE Solid-State Lighting Program Strategy

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Guiding technology advances from laboratory to marketplace



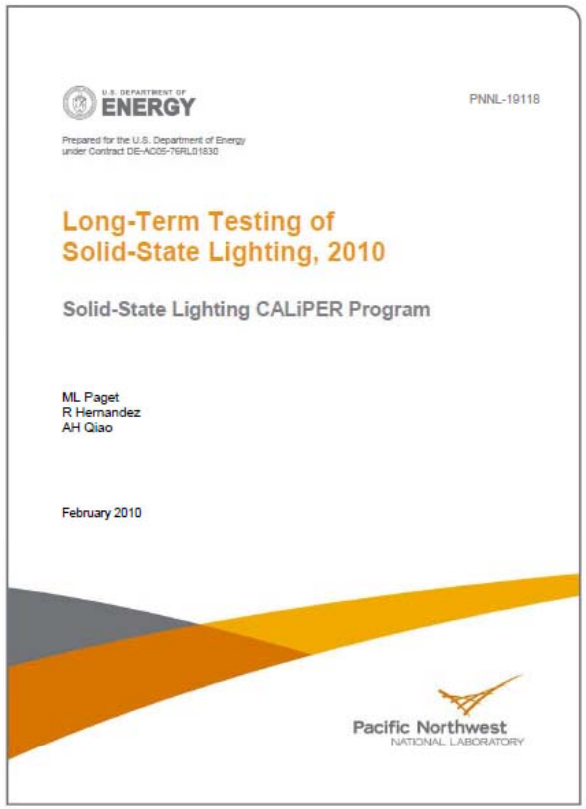
CALiPER Testing Program



- Testing of luminaires and replacement lamps
  - Commercially Available
  - Anonymously purchased
  - Using SSL devices of all sorts
  - Or, using traditional light sources for comparison (incandescent, halogen, CFL, FL, MH, HPS…)
- Long-term testing
  - Exploring a variety of methods and instruments: absolute photometry, relative
  - Examining lumen depreciation, color shift, efficacy, testing methodologies, projection options

Context of 2010 Long-Term Testing

- CALiPER exploratory studies
- Initial long-term testing report issued in January 2009
  - 13 SSL samples
  - Operated 6000-7500 hours
  - Analysis of behaviors
  - Initial observations
- Second long-term testing report issued in January 2010
  - 25 SSL samples
  - Monitored up to 13,500 hours
  - Wide range of behaviors observed

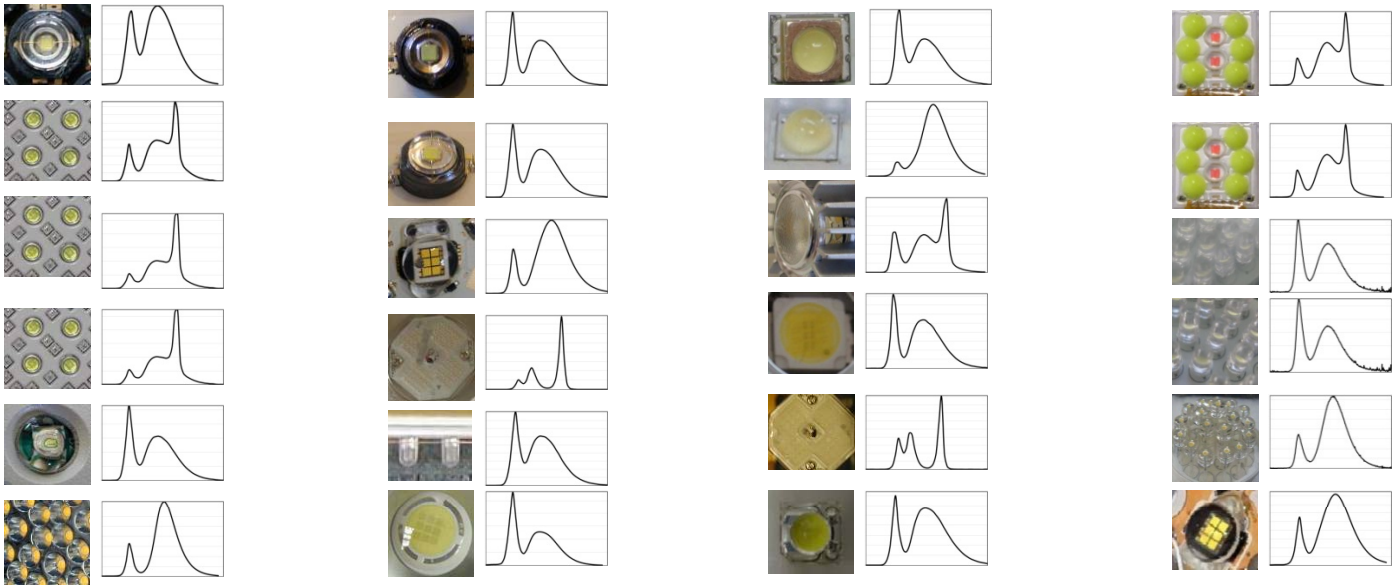


CALiPER

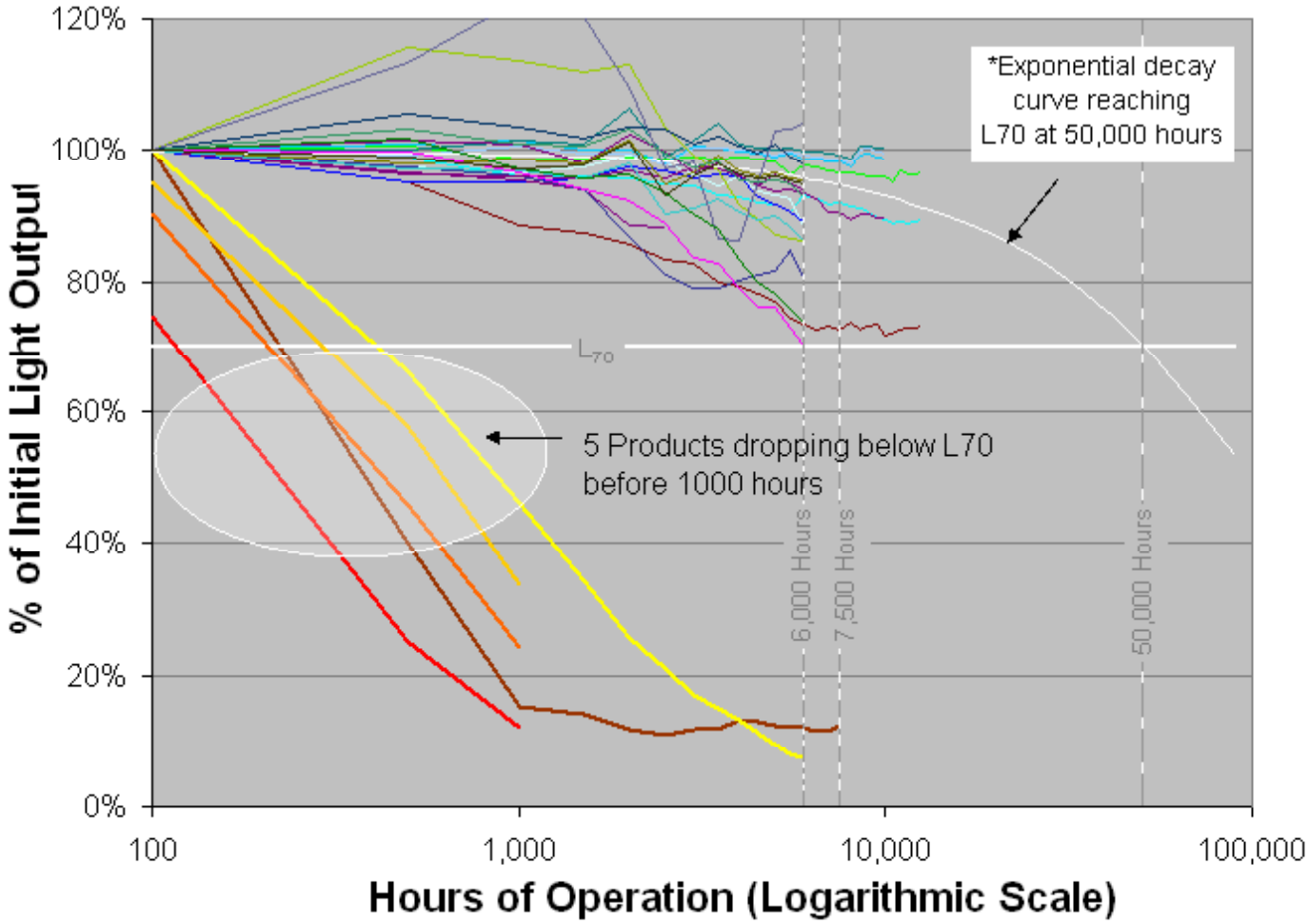
www.ssl.energy.gov/caliper.html

A Wide Variety of Samples Tested

- A range of lighting applications, sizes, shapes, optics, thermal management
- Wide range of power and light output
- Representing many different LED devices

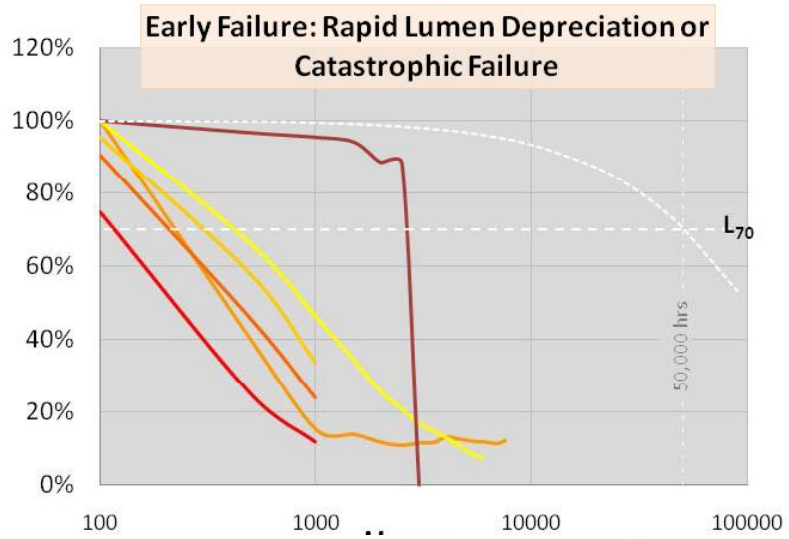


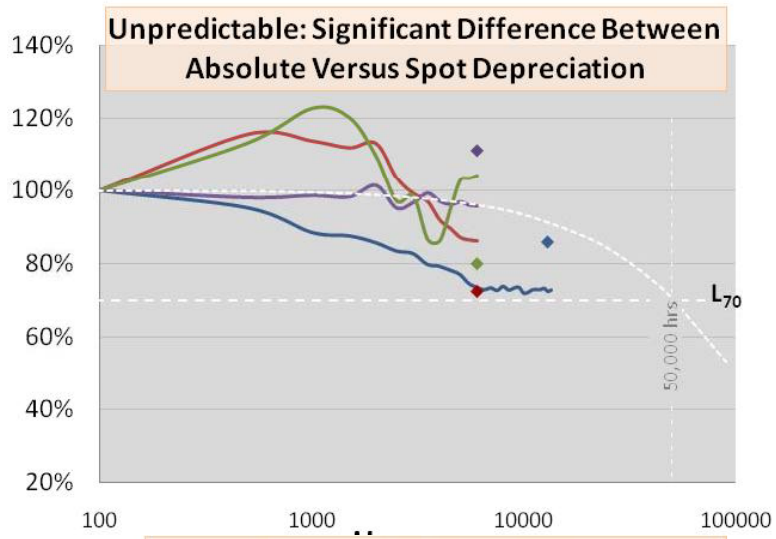
Relative Lumen Depreciation

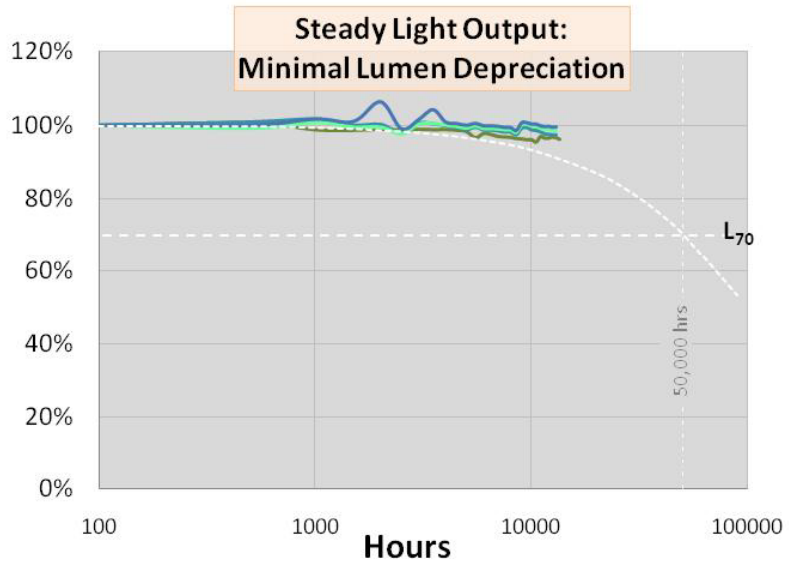


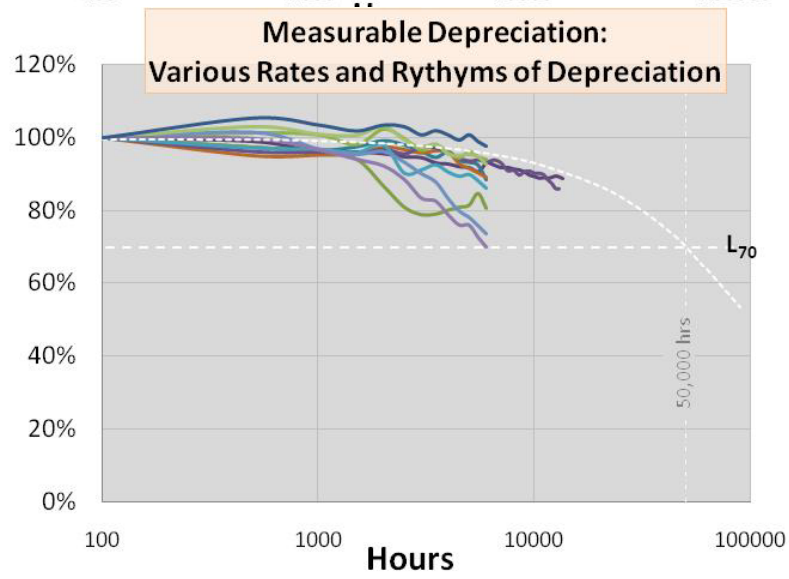
25 Samples, 25 Different Patterns of Behavior

Typical Patterns Observed



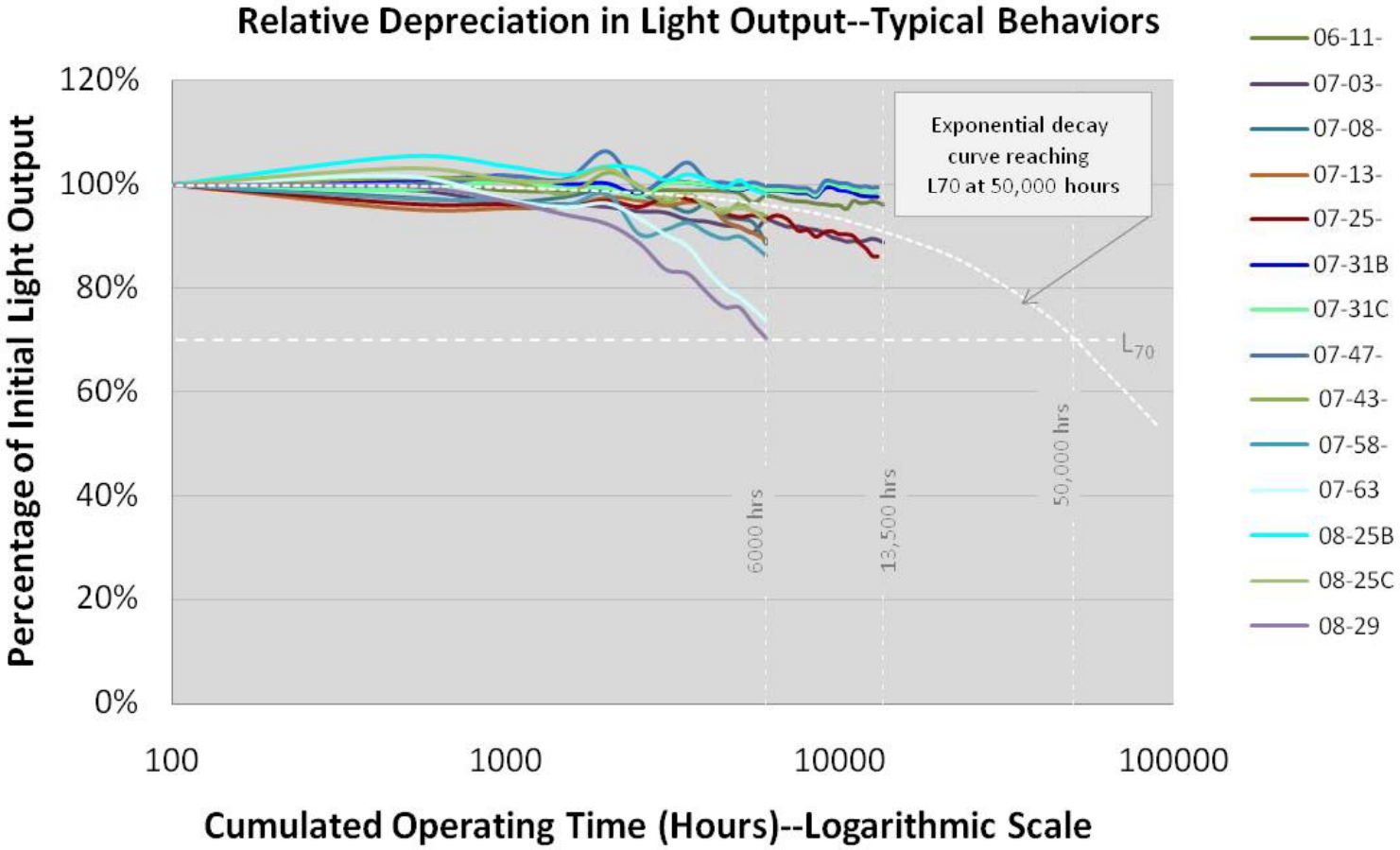






Most Typical Behaviors

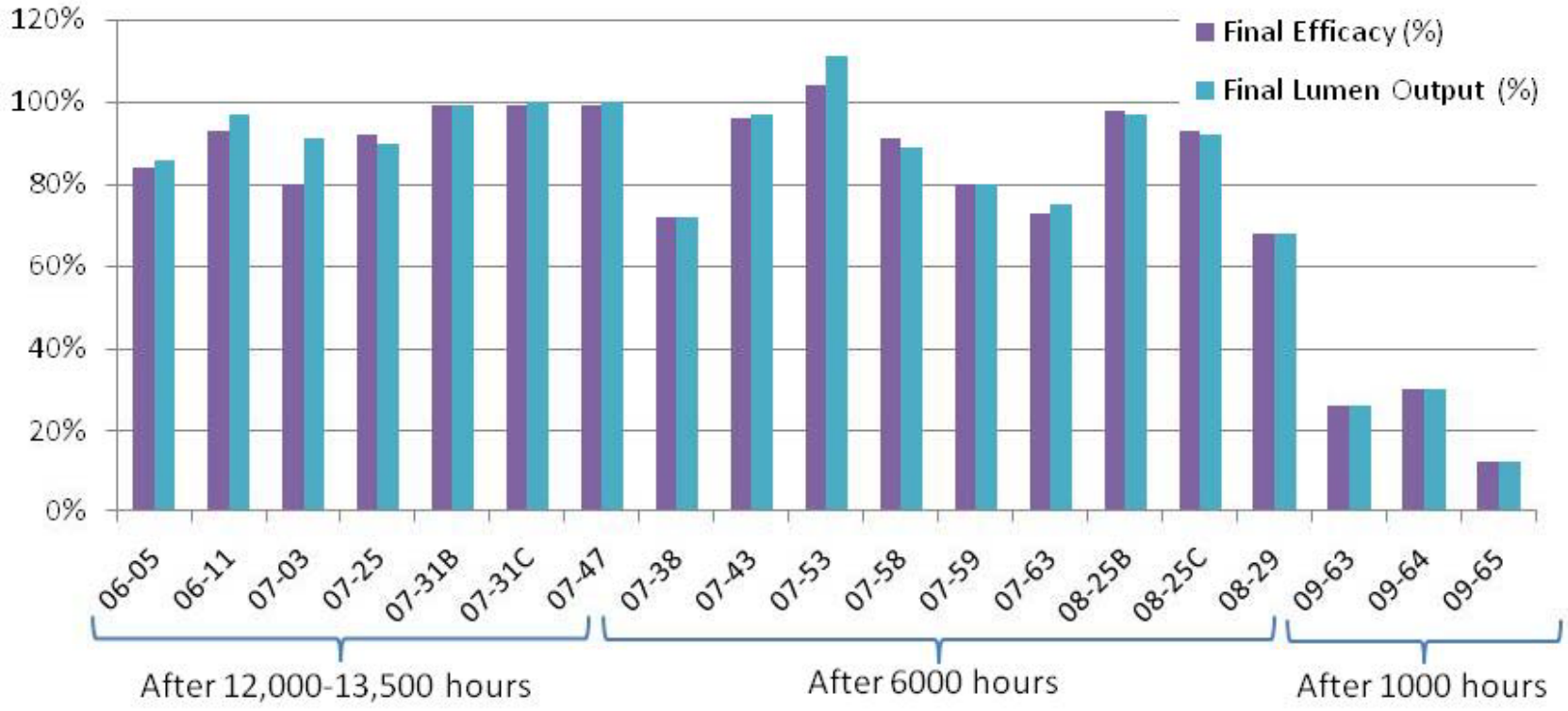
- Spot Measured Illuminance Depreciation After Long-Term Continuous Operation



Efficacy Depreciation

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

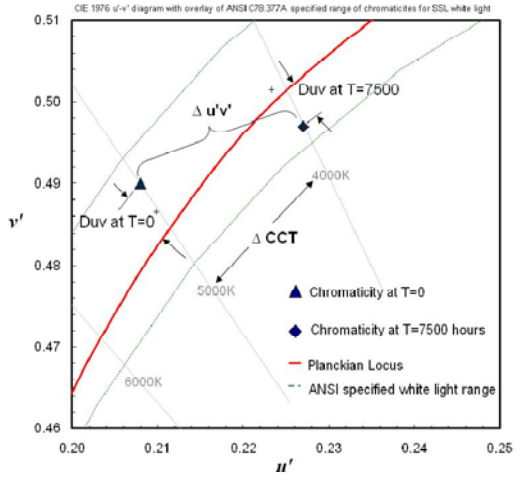
- Power use remains relatively constant
- Efficacy depreciation typically parallels lumen depreciation

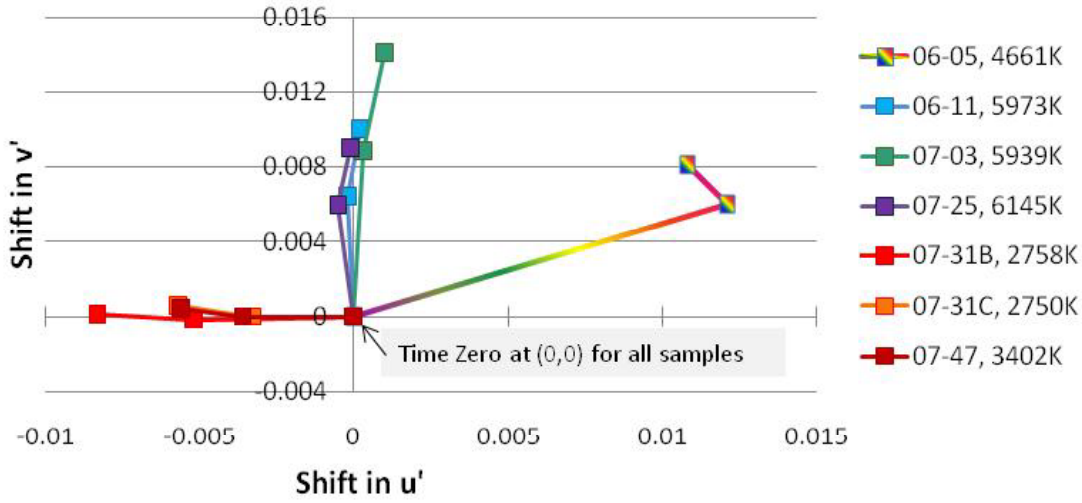


Efficacy Depreciation Compared to Lumen Depreciation

Color Shift

- 75% of samples exhibit significant shift in one or more color characteristic (ΔCCT, Δu′v′, and/or Duv)
- Warmer (lower CCT) tends to exhibit more shifting in u′ rather than v′.
- Cooler (higher CCT) tends to exhibit more shifting in v′ rather than u′.

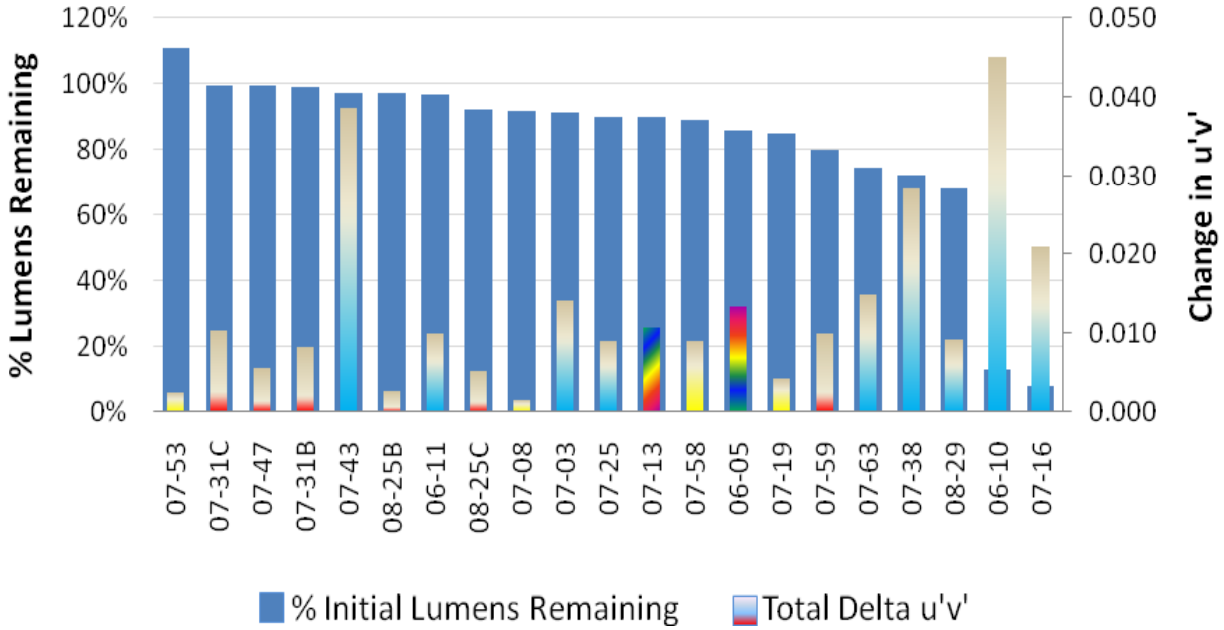




Relative Chromaticity Shift to 12,000 or 13,500 Hours (Sphere Measurements)

Correlations

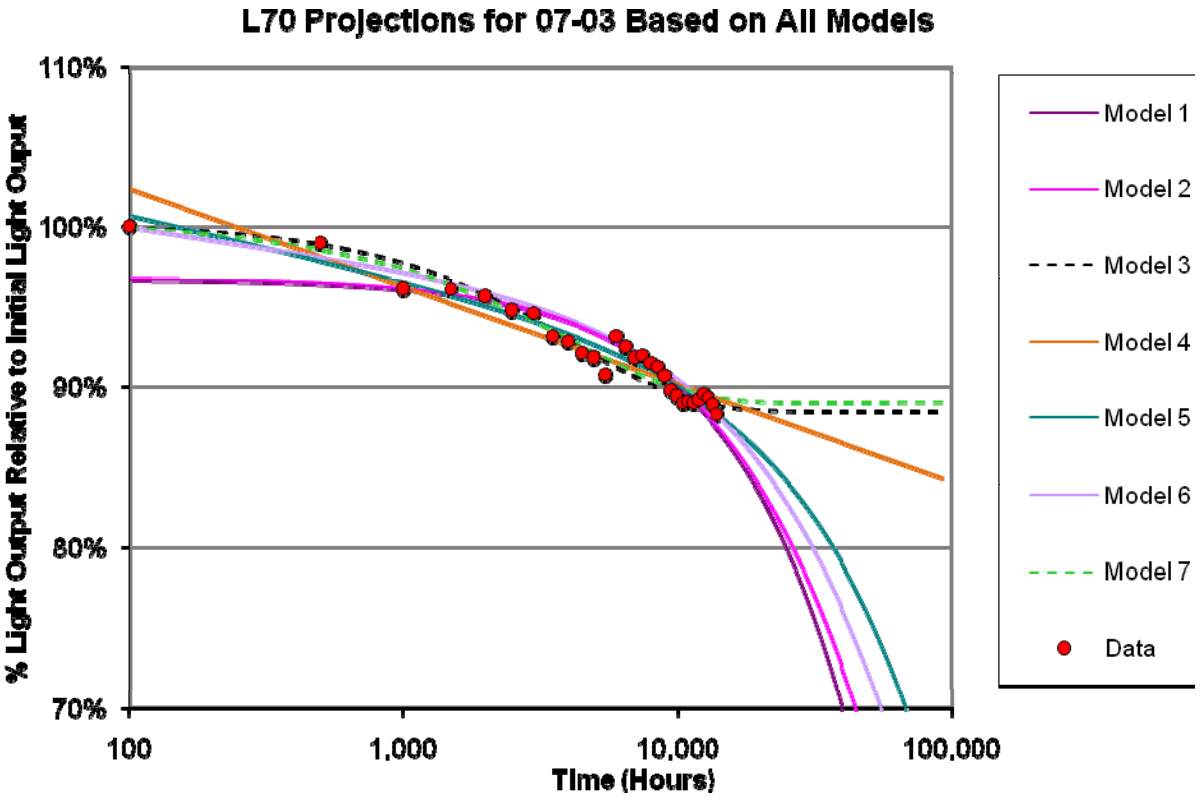
- Little to no correlation of behaviors with initial performance
- Correlations between long-term performance parameters
  - Very strong correlation between lumen depreciation and drop in efficacy
  - No correlation between lumen depreciation and ΔCCT or ΔCRI
  - Slight correlation between lumen depreciation and Δu′v′.



Changes in Light Output and Δu'v' After 6000–13,500 Hours of Operation

Analyses of Projection Methods

- Examining different models, methodologies for applying models, and variations in data sets
- Information shared with TM-21 committee



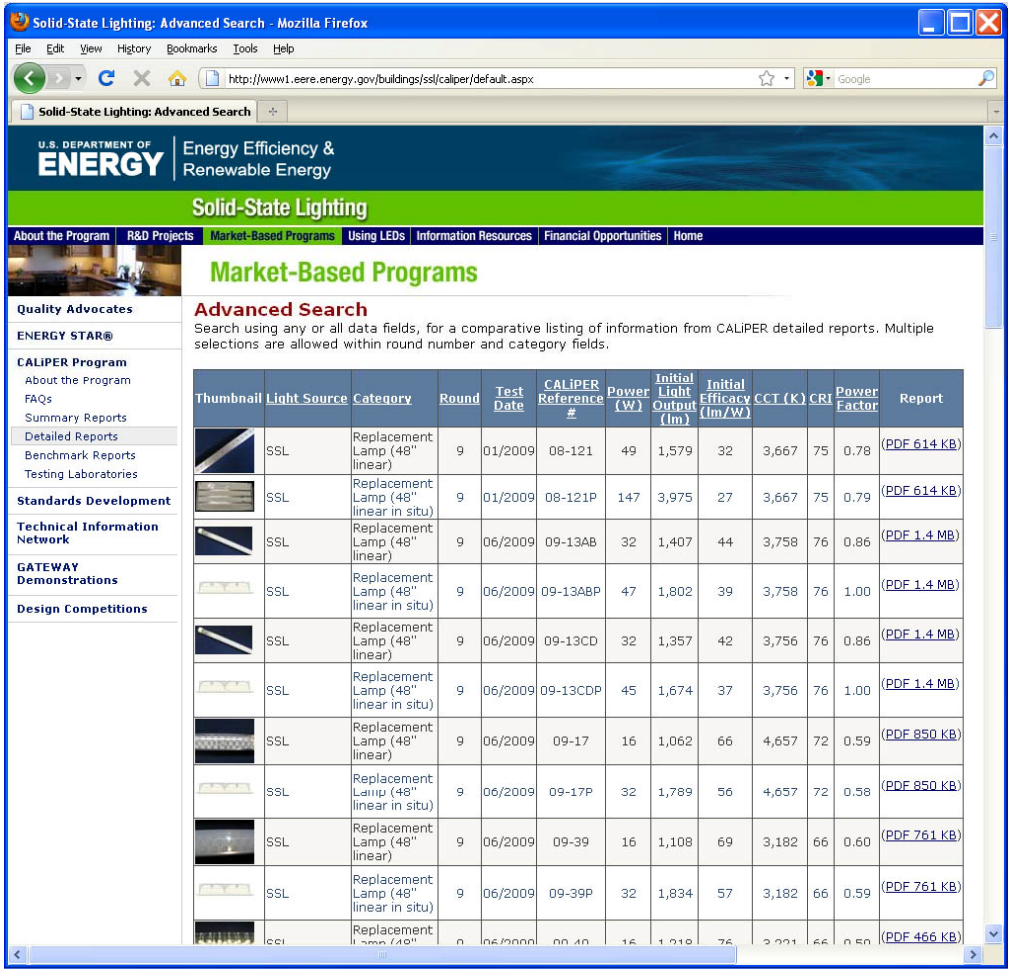
Long-Term Reliability

➔ Expectations and claims are high, reality is highly variable

- Long-term reliability impacted by
  - LED device performance over time (current, voltage, temperature, materials incompatibility…)
    - Lumen depreciation
    - Color shift
    - Distribution shift
  - Driver life (temperature, vibration, inrush, design…)
  - Optics, lens life, dirt accumulation (environment, materials, design…)
  - Materials degradation (system impacts, interfaces…)
    - Thermal compounds
    - Adhesives
    - Electrical junctions

CALiPER Website

- Summary reports
- Detailed reports and listings
- Benchmark Reports
- Roundtable proceedings
- Exploratory studies & reports



www.ssl.energy.gov/caliper.html

No Commercial Use Policy

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- The U.S. Department of Energy (DOE) is a federal agency working in the public interest. Published information from the DOE SSL CALiPER Program, including test reports, technical information, and summaries, is intended solely for the benefit of the public, in order to help buyers, specifiers of new SSL products, testing laboratories, energy experts, energy program managers, regulators, and others make informed choices and decisions about SSL products and related technologies. **Such information may not be used in advertising, to promote a company's product or service, or to characterize a competitor's product or service.** This policy precludes any commercial use of any DOE SSL CALiPER Program published information in any form without DOE's express written permission.

www.ssl.energy.gov