LIVINGSTON ENERGY INNOVATIONS

Taking it to the streets

Accelerating adoption of LED lighting in public spaces

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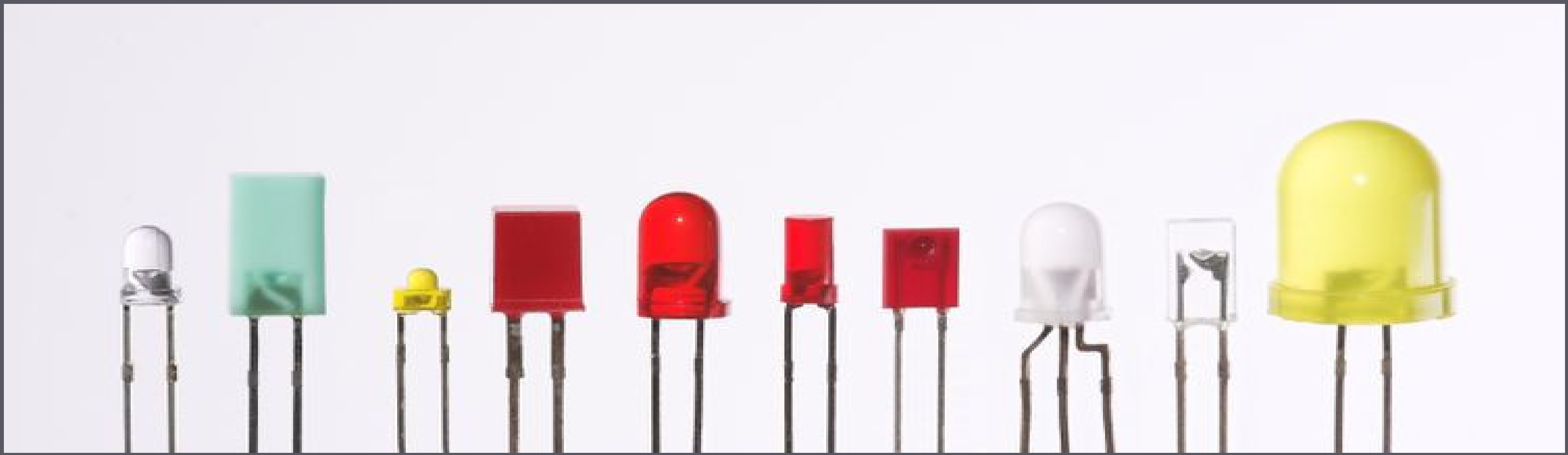
It took a long time for LEDs to get here

Graphic from Haitz *et al* 1999

They started out small

- 1968: Monsanto & HP introduce red indicator lights
- 1989: Cree develops first commercial blue LED
- 1993: Shuji Nakamura develops high-brightness blue LED at Nichia

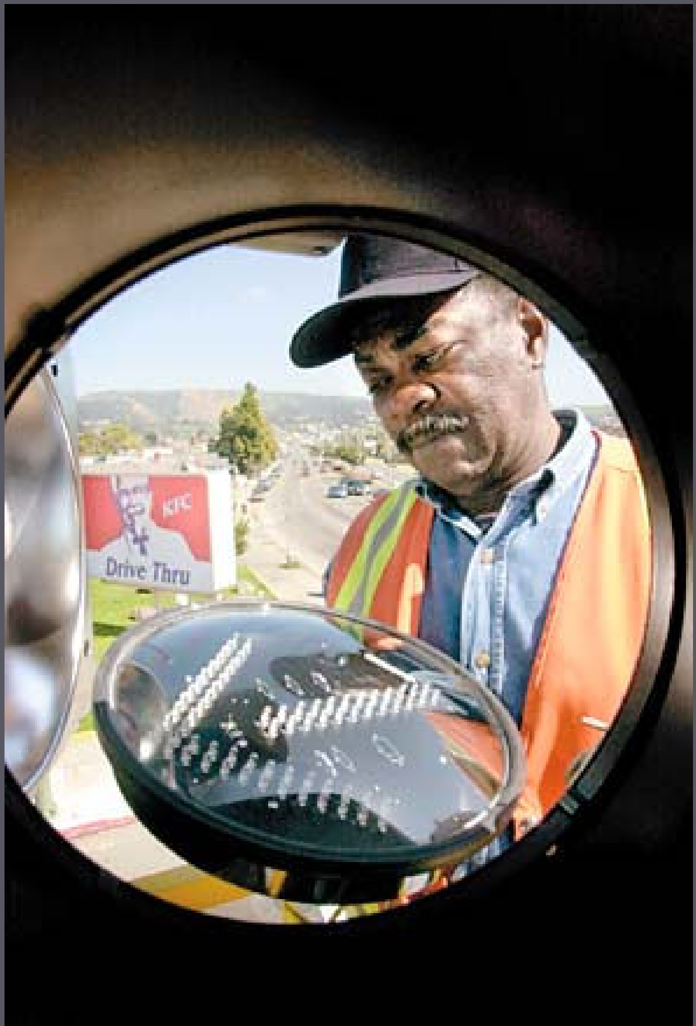


Then something big happened

The first LED energy-efficiency revolution…

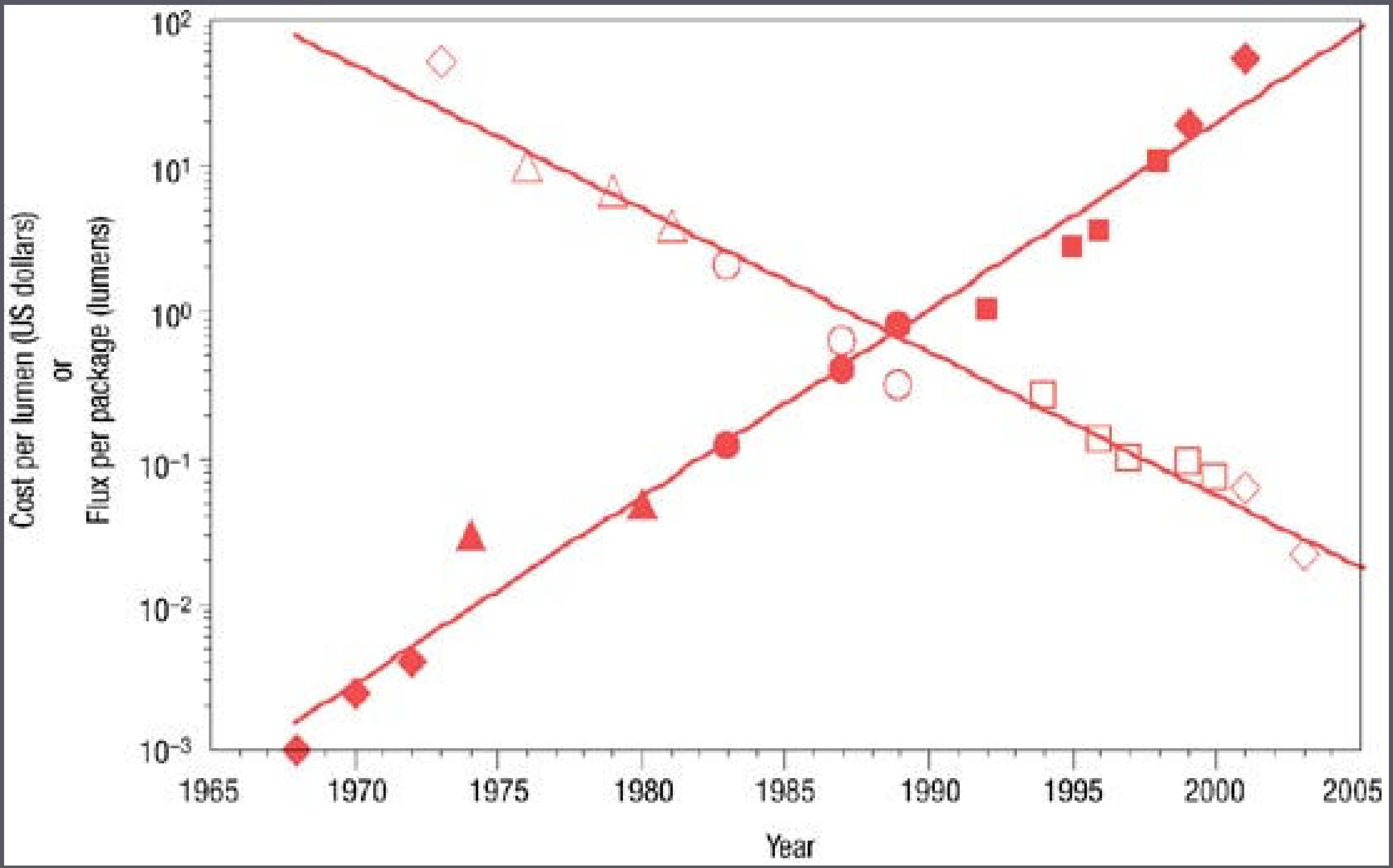
- 1992-93: Introduction of red LED traffic signals

- 2004: 100% of all state-operated traffic signals in California and 65% of all traffic signals in California use LEDs



Chronicle / Mark Costantini

Haitz showed us what's possible (Steele, 2006)



Many factors are driving LED lighting adoption

- Performance – color, efficacy, uniformity, service life
- Lighting designer, local government, and utility support
- DOE standards
- High annual operating hours
- Operations & maintenance (O&M) savings
- Big projects
- Funding: American Recovery & Reinvestment Act

Today the opportunity looks huge

- $500M in 2008 general illumination sales out of $5.1 B total
- Bob Steele / Strategies Unlimited projects 17% general illumination growth in 2009
- Brightness & efficacy continue to improve, laying groundwork for deployment:
  - Streets and walkways
  - Parking garages and lots
  - Indoor directional and downlight solutions
- Potential U.S. electricity cost savings of $280 B by 2025 *(University of California, Santa Barbara)*

But barriers remain to broad adoption

- First cost
- Luminaire designs & reliability
- Evolving standards & specifications
- Efficacy
- Service life

Case Study 1:
Street Lighting Demonstration - Oakland, CA (2009)

- Joint project of PG&E, PNNL / U.S. DOE, City of Oakland, BetaLED
- Site: three Oakland streets
- 14 @ 58-Watt LEDs replacing
  14 @ 121-Watt HPS luminaires
- New LEDs consumed ~52% (63 Watts) less

- Annual energy savings: 257 kWh per luminaire

Case Study 2:
Bi-Level LED Parking Lot Lighting - Sacramento (2009)

- Joint project of PG&E, PNNL / U.S.DOE, BetaLED
- Site: Raley's Supermarket
- Bi-level LED w/motion sensors replacing 320-Watt metal halide fixtures

MH (left); LEDs on low power (right) →

Case Study 3:
Commercial Garage Area Lights - Portland, OR (2008)

- Joint project of PNNL / U.S.DOE, Energy Trust of Oregon, Providence Portland Medical Center, Lighting Science Group
- Site: Providence Portland Medical Center
- LED luminaires replacing HPS - two versions tested on different lot levels

What have we learned?

- Large and consistent performance improvements
  - Reduced power consumption
  - Enhanced lighting uniformity
  - Energy and demand savings >> Δ lumens per watt
- Consistently positive user feedback – but glare is an issue
- Commercial viability depends on first cost, luminaire efficacy & uniformity, service life, O&M costs
- Controls, annual operating hours, new construction applications also drive payback period down
- "Haitz was right"

What's ahead for LED lighting in public spaces?

- Further efficacy & first cost improvements
- Universal standards & specifications
- Enhanced luminaire designs & reliability
- Potential life of ~100k hours
- Network controls for energy, safety, security
- With a keen focus on product quality and performance, we really can take it to the streets and other public spaces.

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