Future of Lighting
The Future of Lighting

Photo: Oddballs.co.uk
The Future of Lighting

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Dark Quark at QuarkStar
The Future of Lighting

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The Future of Lighting

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The Future of Lighting
Honest Metrics for Energy Efficient Lighting

Eric Bretschneider, Ph.D.
QuarkStar
The History of Lighting Sources and Fixtures

Gas
Incandescent
HID
LED

A Brighter Idea™
Evolution of A19 Lamps (and Airplanes)

Early models...  ... Modern examples
Key Points for Efficient Lighting

• Uniformity
• No light wasted on Trespass or Glare
Importance of Uniformity
Bar charts show % of maximum across 5 samples

<table>
<thead>
<tr>
<th>Source:</th>
<th>T5-A</th>
<th>T5-B</th>
<th>LED-A</th>
<th>LED-B</th>
<th>Quark Star</th>
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<td></td>
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<td>5:1</td>
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Real World Results

“The [QuarkStar luminaire] is a completely new type of ... luminaire that efficiently provides asymmetric glare free illumination from a very compact recessed housing ... providing excellent uniformity on vertical surfaces.”

- DOE Next Generation Luminaires comments
Real World Results

Uniformity doesn’t just matter on walls …

* Patterns on wall and ceiling were for laboratory calibration and registration and are not in commercial products.
The Consequences of Inefficient Lighting
The Importance of Control

Control of lighting is important – in all directions

Street lights should light the street ...

... the region around the sidewalk ...

... NOT the houses behind them
Drops of Sunlight
Equivalent Glare in Nature
How Do We Measure Glare

Type C goniophotometer: Intertek, Cortland, NY

Imaging photometer 1,370 x 1,020 pixels
How Do We Measure Glare
What We Gain From Optical Control

LEDs are among the most compact light sources we have ever created ... why aren’t we taking **full** advantage?

* All distributions are laboratory measured from real world prototypes
How to Save Light (and Lighting)

Future metrics to increase energy savings should:

• Consider Uniformity, especially for minimum illumination levels
• Reward fixtures that deliver light to the target & minimize light trespass
• Measure Glare the way we experience it

*Haitz’s Law will only continue to drive the glare problem – we have to find a solution for managing the extra photons NOW*
The Future of Lighting

Karyn Gayle (Twitter: @karyngayle)
Vice-President, Healthcare, Acuity Brands
“Making Buildings Smart” is a common refrain…
Smart-Building Technology Stacks can be daunting…

- Building Management Systems (BMS)
- Indoor Positioning (IP)
- Hurdles
  - Complexity
  - Coordination
  - Capability
  - Scale
Lighting has entered the networked age…

- Optimize Function
- Enhance Occupant Experience & Comfort
- Drive Energy Management & Sustainability
- Ensure Code Compliance
- Lighting and HVAC are the 2 largest consumers of electricity in buildings
As we distribute intelligence through our lighting systems, do we have a responsibility to do more than “simply” deliver light?
How hard are lighting systems willing to work?
Can smarter lighting make us healthier?
Lighting Impacts Our Visual & Biological Systems

+ Rods and cones are photoreceptors for our visual system
+ The 3rd photoreceptor, the intrinsically photoreceptive retinal ganglion cell (IPRGC), impacts our circadian systems (peak sensitivity at 460-480nm, seeks blue light during the day)
“Everyone wants it, but nobody is getting any...”

- Anonymous
The Importance of Sleep
Sleep…the perfect storm.
Some Less-Obvious Implications of Sleep…

+ People who get sufficient sleep have increased gray matter in their brains, which is connected to psychological health. (Harvard Medical School Study)

+ Brain clears out waste proteins between cells, and this waste product is linked to Alzheimer’s disease, (Dr. Maiken Nedergaard, University of Rochester, 2013)

+ People who are chronically sleep-deprived are 7 times more likely to feel helpless and 5x more likely to feel alone (Great British Sleep Survey)

Sleep deprivation is the “epidemic of the 21st century”

- **Obesity**
  - Higher BMI with insufficient sleep
  - Disruption of appetite hormone secretion (leptin & ghrelin)

- **Diabetes**
  - Slower processing of glucose

- **Hypertension**
  - Elevated blood pressure
  - Link to heart disease & stroke

- **Mood Disorders**
  - Sadness, irritability, negative outlook, reduced sociability

- **Immunity**
  - Increased susceptibility to infection

- **Self-Medication**
  - Potential for increased alcohol consumption, dependence on sleep aids

- **Life Expectancy**
  - Sleeping 5 hours or less increases mortality risk by 15%

Source: Division of Sleep Medicine at Harvard Medical School
Regulating Circadian Rhythms

+ Early morning exposure to higher light levels, especially in the short wavelength region of the visible spectrum (460-480 nm)
+ Warmer, long-wavelength light in late afternoon and evening
+ Dark at night to allow for melatonin production
People Are Getting Older, Living Longer…

- US: The “oldest” baby boomers turned 65 in 2011

- Life expectancy:
  - US is 78 years (76 for males, 81 for females)
  - Canadians & Spaniards can expect 81 years
  - 80 years in the UK
  - 76 years in Mexico
Can we make life easier for our aging population?

- Less light is transmitted to the retina – from 100% at age 25, to roughly 25% at age 75

- Pupils become smaller, less able to adapt

- Lenses darken over time

- Increased prevalence of eye diseases (aging and related to other chronic conditions)
Aging reduces transmission of short wavelength light to the retina

Known age effects in eyes:
- Haze in dioptric apparatus
- Yellowing of lenses
- Reduced performance of iris

→ Reduced biological stimulus
→ Rhythm problems
Can smarter lighting make us more aware of the world around us?
Borrow from other industries IoT breakthroughs...
Real-time location tracking services (RLTS) for wayfinding, asset tracking, patient safety?
The Energy of Things

A Quantified Path Forward

August 3rd, 2016

PRESENTED TO
DLC Stakeholders

PRESENTED BY
Kelly Sanders, Senior Technology Director
Energy Solutions
Technology Trends

Values...

IoT  Fog  NEB’s  A.R.  Big Data  A.I. / M.L.
VLC Cloud M2M Q.C.  Mist Storage  DER’s  Noise
The *Energy of Things*: energy portion of the IoT

**Idea!** EoT is valuable, quantifiable, and simple to explain.
Energy Example: M.L. at work at Google

A rough graph showing how using machine learning (ML) helped reduce power consumption in Google's data centers.

(Image credit: DeepMind)
Maturity Lifecycle of a Smart Device

Increasing Business Value

Idea! Utility programs should follow the curve to unlock greater value!
What Value?

Products
- Energy monitoring
- Occupancy trends
- Main. Efficiencies
- Micro-zone Controllability

Systems
- Dynamic Pay for Performance
- Automated M&V Facility
- Optimization
- NEB’s
- D.R. Grid Visibility
- Edge Device Analytics

Processes
- Cognitive Services
- LaaS / EEaaS
- Energy Services Bundle
- Productivity
- Health & Wellness

Services

Traditional Utility Programs

2016 DLC Stakeholders Meeting
A Quantified Path Forward

**EoT**
- Maturity Validation
- Performance Data
- Open Standards
- Influence ET
- …Help Define EoT

**Value**
- BE the Trusted Advisor
- Real-time Data Programs
- Grid Services
- Support Best Practices
- Services Model Focus
- Quantify Business Value
Performance Data Program (PDP)

• A program to quantify the business value of EoT performance data to utilities and their customers.

- **PDP Design**
  - Consortium Guidance
  - Technology Validation
  - Process Optimization
  - Services Creation

  - **Technology Validation**
    Consolidate/define/pilot activities and best practices to validate product/system maturity and focus investments.

  - **Process Optimization**
    Baseline and gap analysis of utility processes needed to support EoT integration and quantify value.

  - **Services Creation**
    Evaluate/design/test emerging service offerings that leverage performance data, for utilities and their customers.

2016 DLC Stakeholders Meeting

Idea! PDP consortium forming now!
Why EoT Now?

- IoT is confusing, Energy is not!
- Performance data unlocks new services
- Utility/Industry partnerships can reduce the noise and accelerate adoption.

...our contribution to IoT is to define and deliver on the Energy of Things.
CONTACT

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The Future of Lighting as the Enabler for IoT

Joe Costello, CEO, Enlighted

Let’s Dream Together, Work Together
Thank You

Enlighted. Changes Everything.