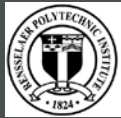


# Oh, the places you'll go, if you have Smart Lighting

Partha Dutta

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Rensselaer

BOSTON  
UNIVERSITY



Where ever you want to go.....



# Define “Smart Lighting”



Smart lighting is a lighting technology designed for energy efficiency. This may include high efficiency fixtures and automated controls that make adjustments based on conditions such as occupancy or daylight availability.

*Wikipedia*



SMART LIGHTING ENGINEERING RESEARCH CENTER

*The right light where and when you need it*

## *Synthesizing Light for the Benefit of Humanity*

Imagine a world where efficient, digital lighting makes us healthier and more productive, produces significant energy savings, and provides wireless, optical access to the internet.

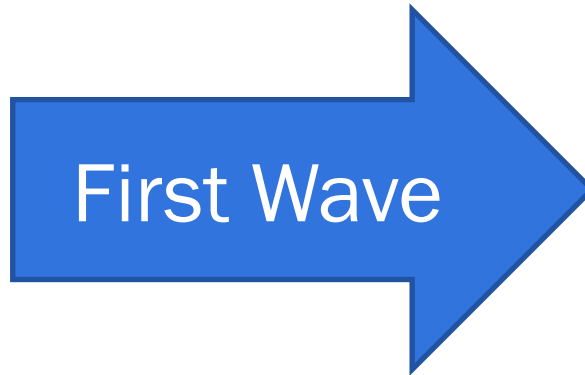
## A more comprehensive definition.....

What most people call smart lighting is "Smart Thinking about Lighting Systems" while what the ERC is looking to do is create **"Smart Lighting Systems that Think"**.

By looking at lighting systems holistically (from the system functionality down to the nanoscale details of light generation and detection), we are looking at how to create efficient lighting systems that: (a) "see" where the light is going and what it is doing, (b) communicate using light to send information and enable lighting information processing, and (c) have novel control systems that "think" about what the light needs to be doing to meet the expectations and requirements of people.

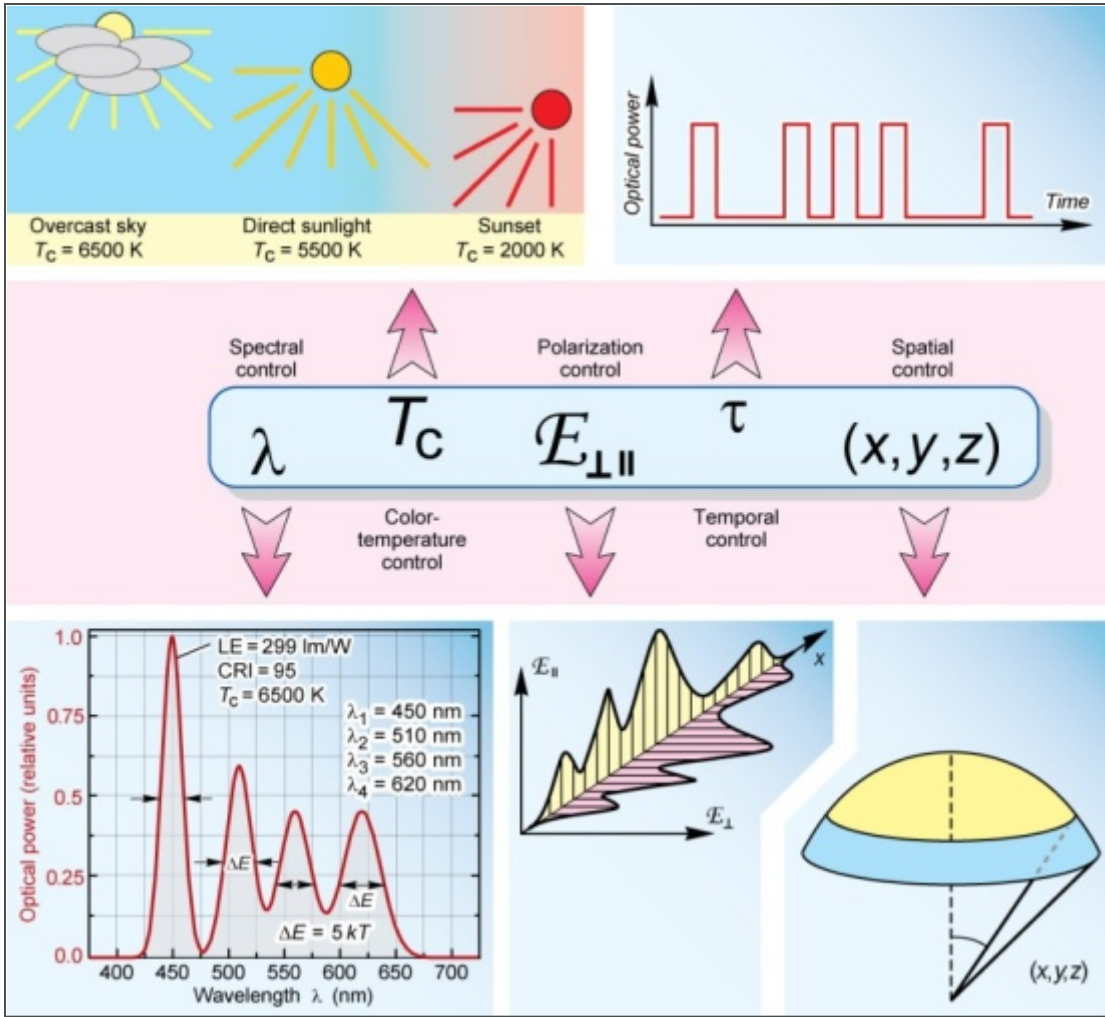
*Robert Karlicek*

# Replacement Paradigm



Impacts Energy, Environment, Economic Growth

# But LEDs can do so much more.....



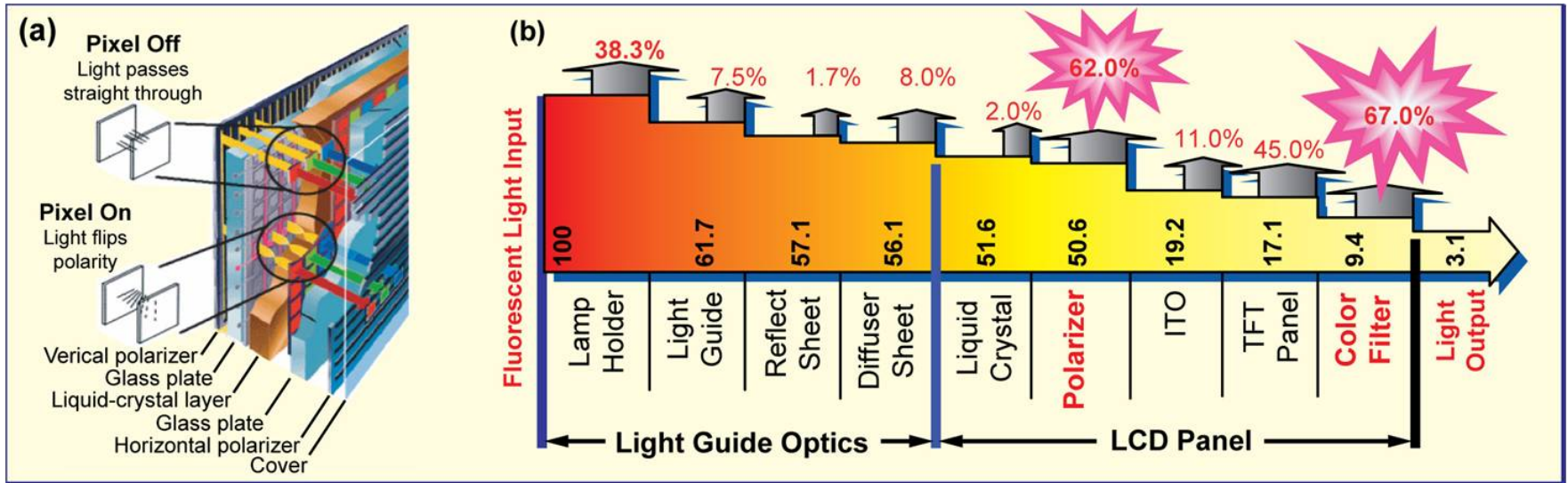
- Color
- Spectrum
- High Speed Switching
- Spatial Control
- Polarization Selectivity

Courtesy: E.F. Schubert

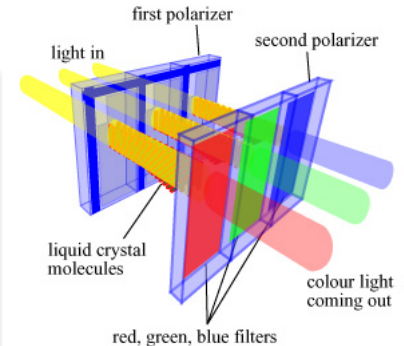
Beyond the replacement paradigm

# Smart Lighting: *Example*

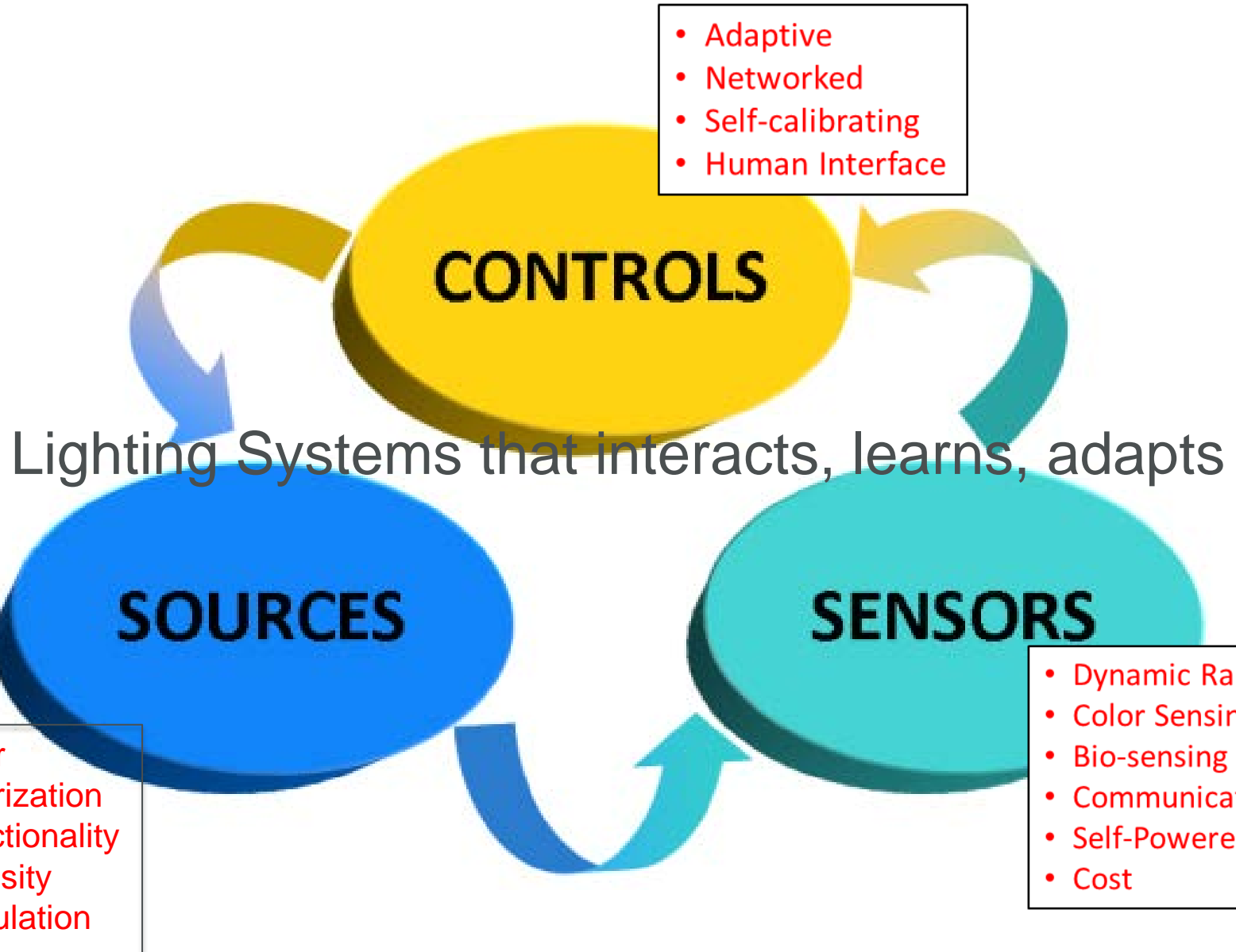
- Polarized LEDs for energy efficient displays!



**LIGHT POLARIZATION** → **ENERGY EFFICIENCY**



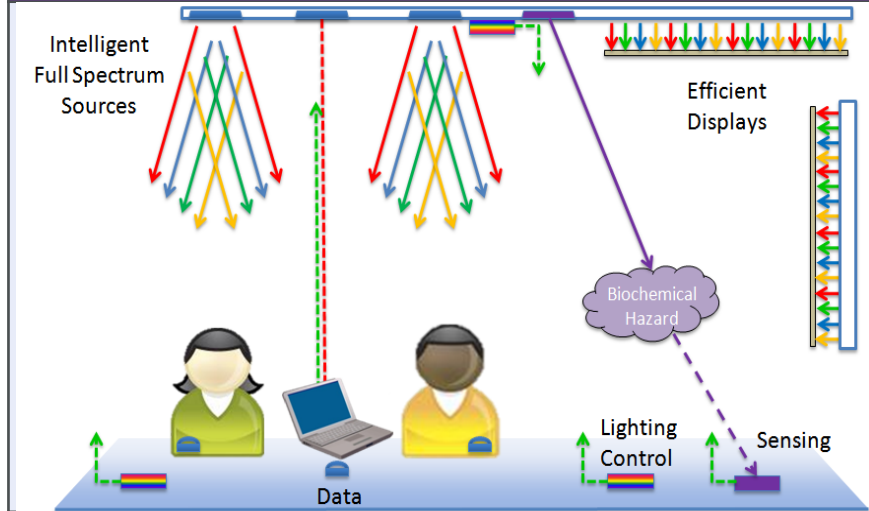
Courtesy: E.F. Schubert



# The Second Wave: Smart Lighting

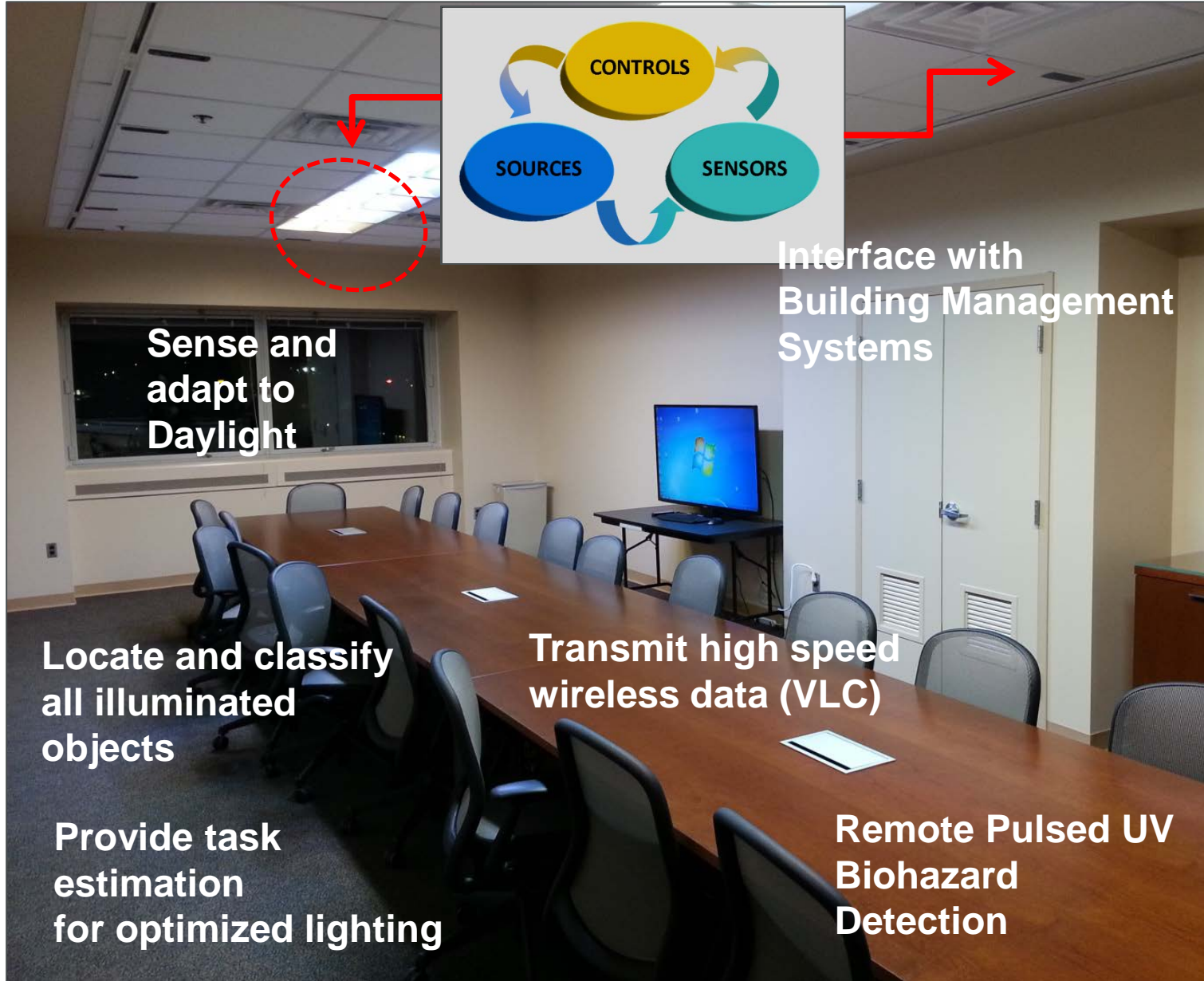
Electric Lighting	Electronic Lighting
Luminaires with Components	Novel Integrated Systems
Bulbs, Sockets, Ballasts (commodity)	Semi-permanent (Durable Goods)
Limited control: on/off/dim	Fully Integrated Sensors, Controls
Different Shades of White	Any Color, any time

## Dual Use Paradigm



Data with Illumination
Illumination-Display Fusion
Biochemical Sensing and Mitigation
Circadian Corrected Lighting
Self Commissioning Lighting Systems

# Smart Lighting – The Systems Perspective



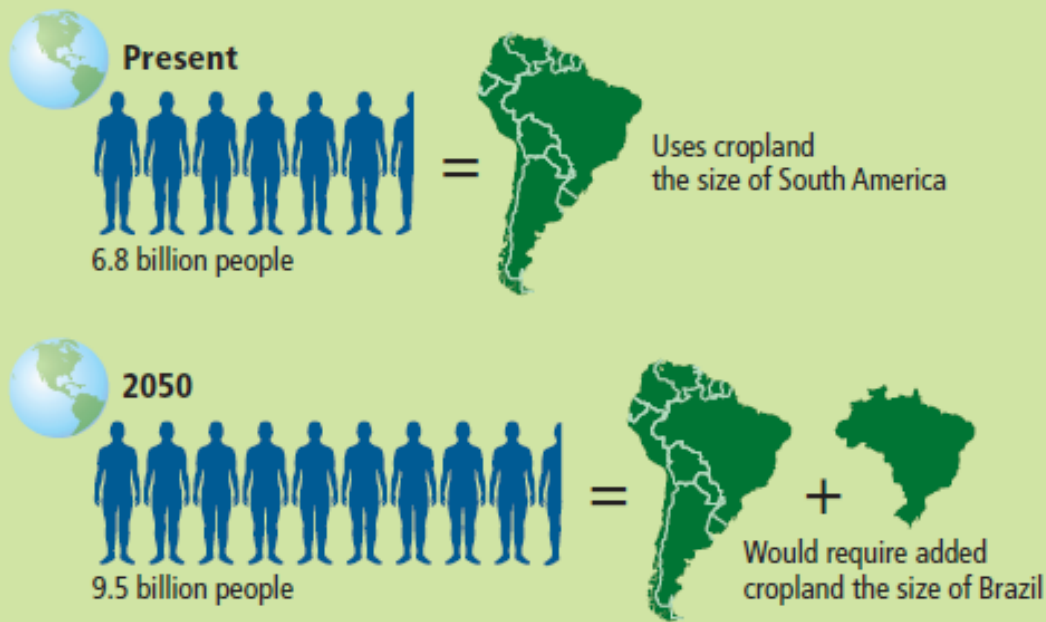
Smart Lighting  
as  
*The Solution*

# Food Security

[PROBLEM]

## Feeding the Future: Not Enough Land

Growing food and raising livestock for 6.8 billion people require land equal in size to South America. By 2050 another Brazil's worth of area will be needed, using traditional farming; that much arable land does not exist.



## The RISE of VERTICAL FARMS

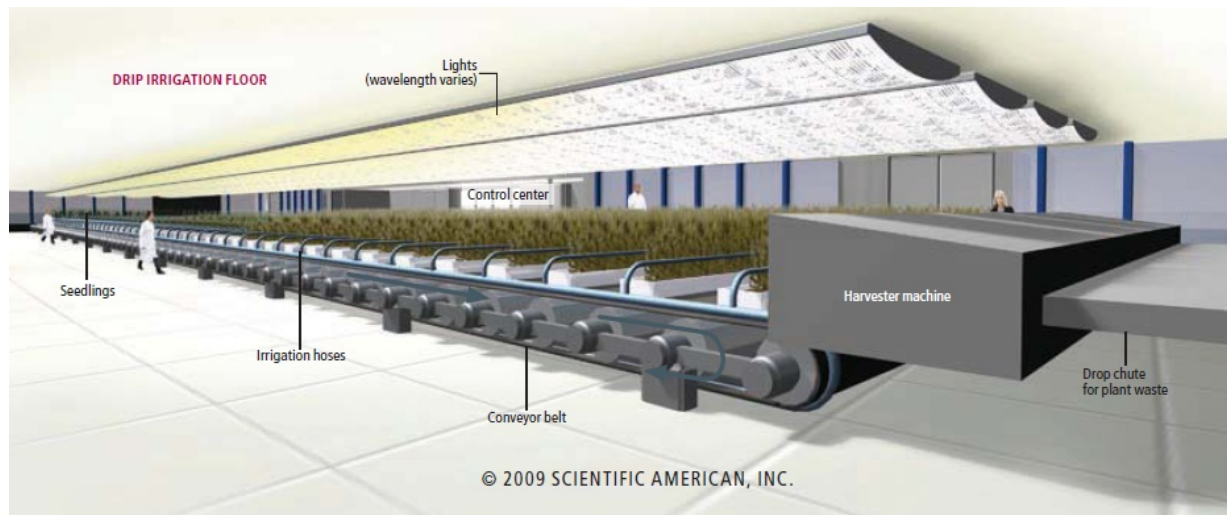
Growing crops in city skyscrapers would use less water and fossil fuel than outdoor farming, eliminate agricultural runoff and provide fresh food

By Dickson Despommier



2009 SCIENTIFIC AMERICAN ARTICLE

# LED Farms



## High-Rise Crops

A 30-story vertical farm would exploit different growing techniques on various floors. Solar cells and incineration of plant waste dropped from each floor would create power. Cleared city wastewater would irrigate plants instead of being dumped into the environment. The sun and artificial illumination would provide light. Incoming seeds would be tested in a lab and germinate in a nursery. And a grocery and restaurant would sell fresh food directly to the public.



*Journal of Experimental Botany*, Vol. 61, No. 5, pp. 1267–1276, 2010  
doi:10.1093/jxb/erq005 Advance Access publication 4 March, 2010

### RESEARCH PAPER

## An artificial solar spectrum substantially alters plant development compared with usual climate room irradiance spectra

Sander W. Hogewoning\*, Peter Douwstra, Govert Trouwborst, Wim van Ieperen and Jeremy Harbinson

Wageningen University, Department of Plant Sciences, Horticultural Supply Chains Group, Wageningen, The Netherlands

# Virtual Windows

Impacts cognitive psycho-physiological health of human beings

## Health & Productivity Gains

Hospitals, Cyber-security spaces,  
Industrial buildings (Boeing).....

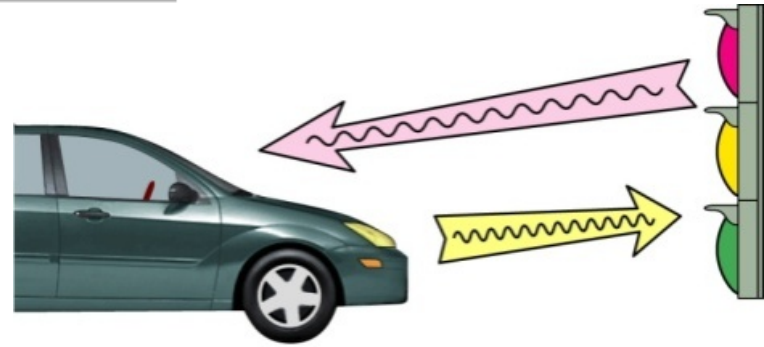
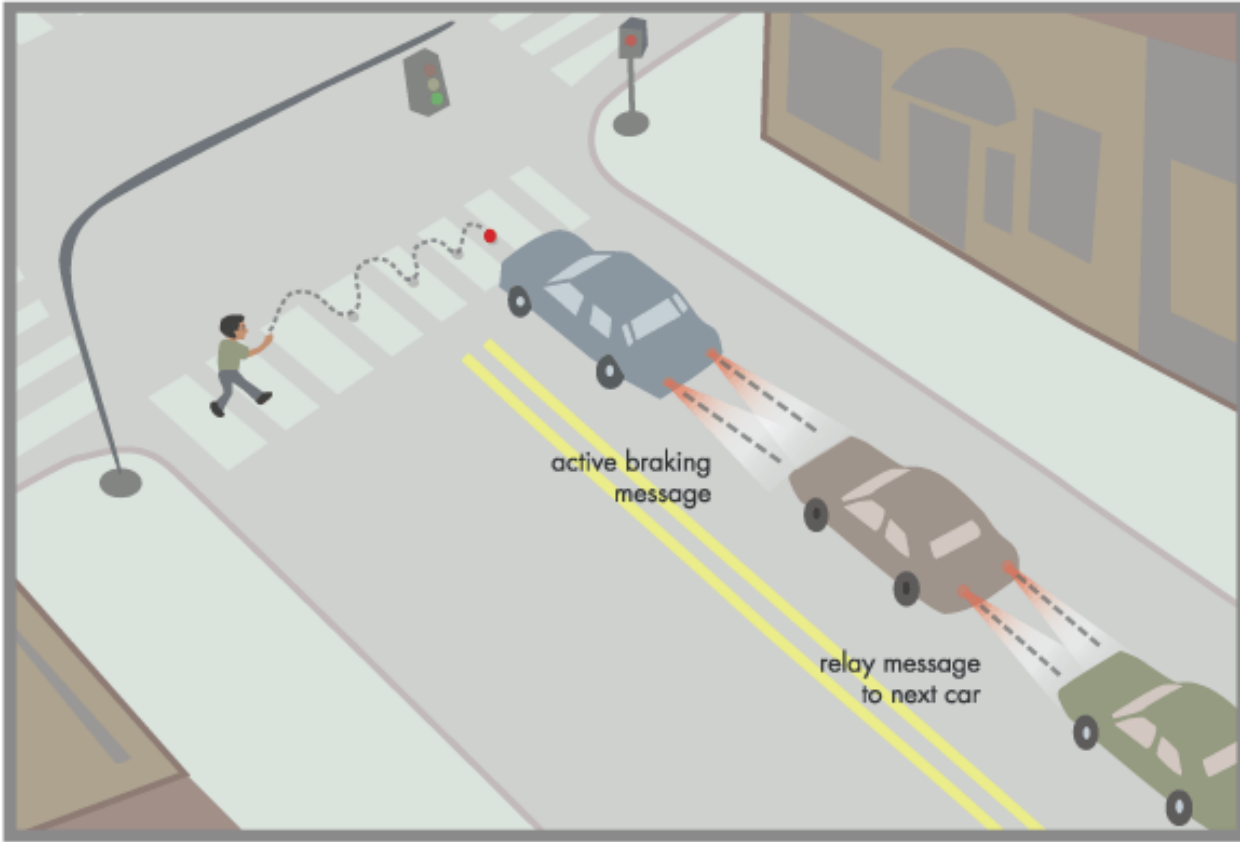
Reducing the risk of Intensive Care  
Units (ICU) associated Delirium

*Preliminary studies on ICU patients  
indicate the preference of artificial  
windows with integrated lighting over  
natural windows*

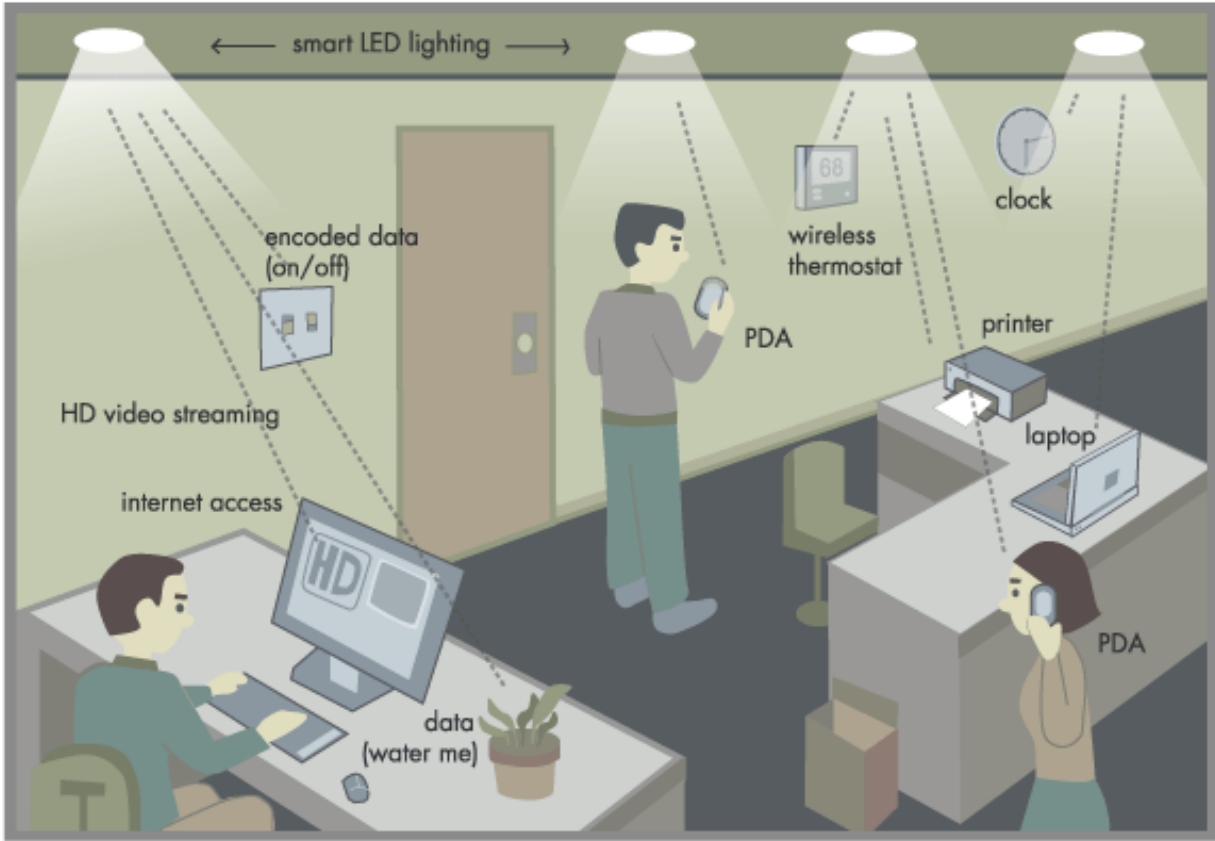


US Patent Application: 20130165741

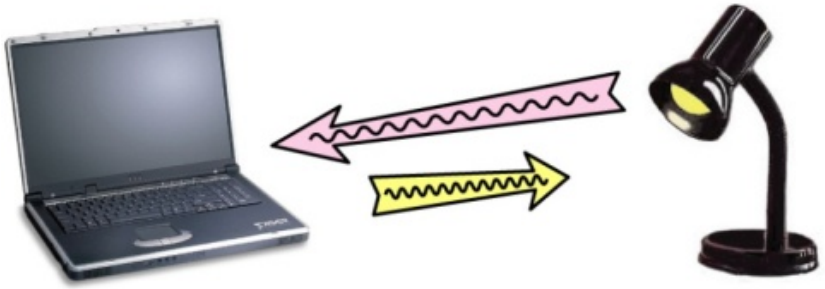
# Safer Transportation



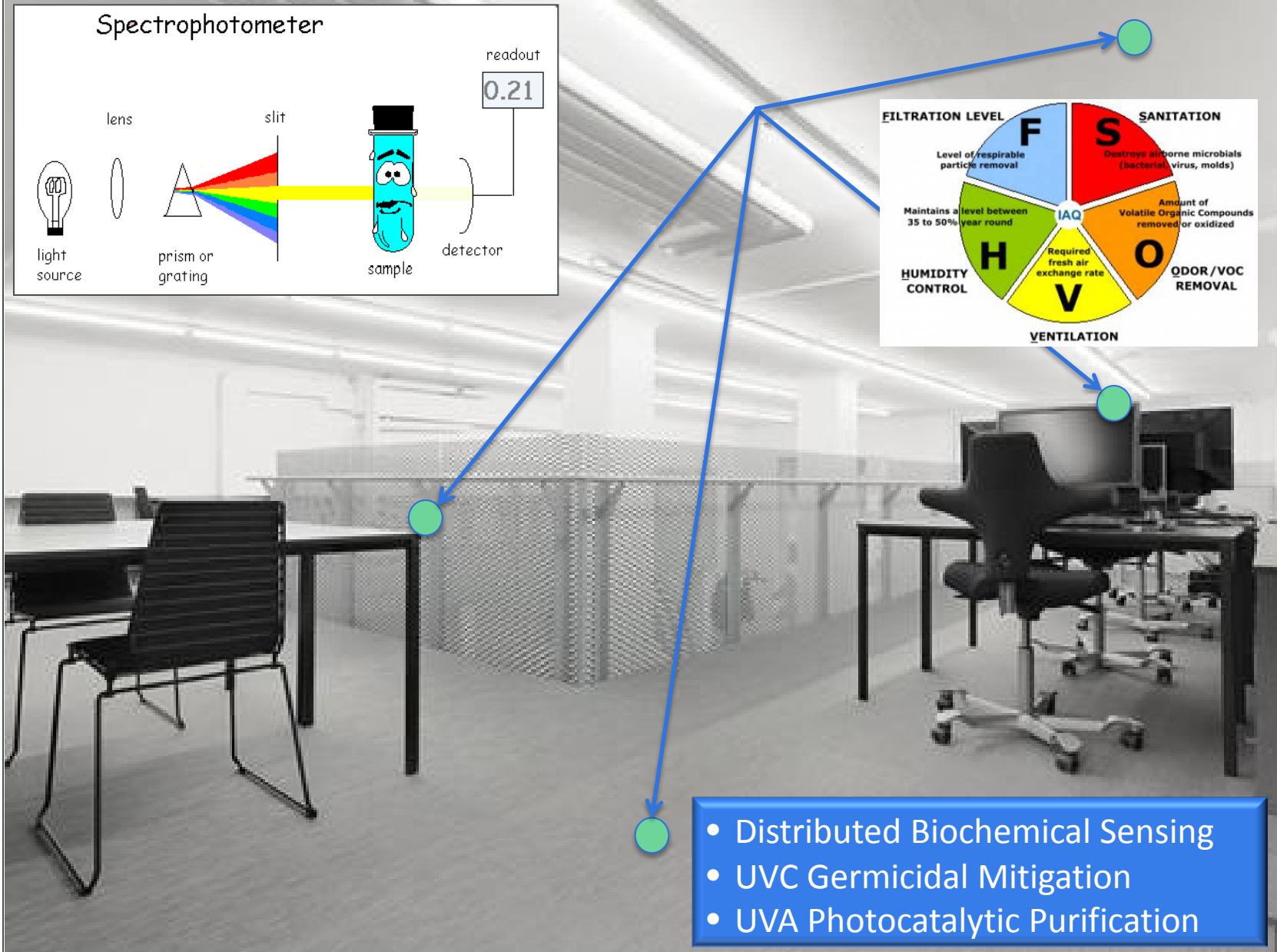
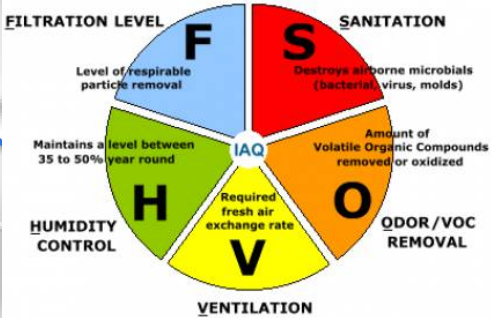
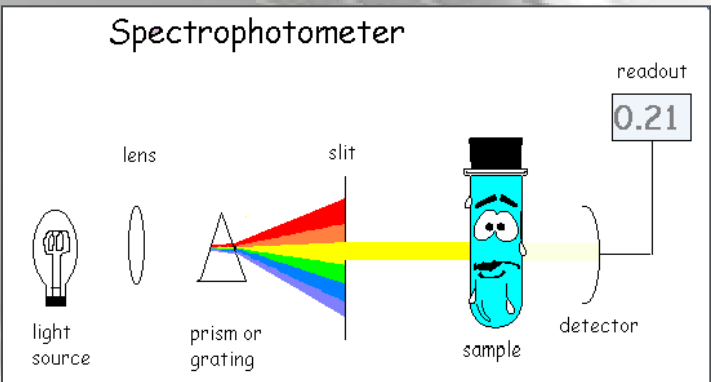
# High Speed Data Access



## VISIBLE LIGHT COMMUNICATION (VLC)



# Biochemical Sensing and Mitigation



- Distributed Biochemical Sensing
- UVC Germicidal Mitigation
- UVA Photocatalytic Purification

# Mood Lighting



# Sky Lighting



# Adaptive Lighting



# Therapeutic Lighting



# Circadian Lighting



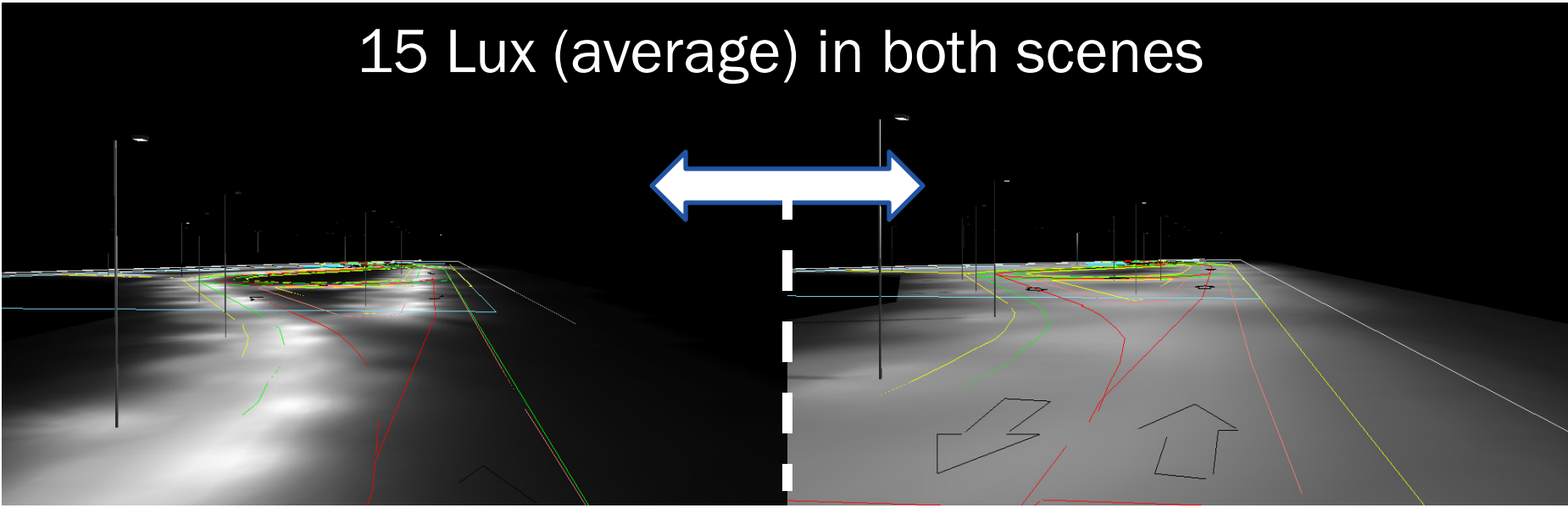
# Personalized Shopping



Indoor GPS

# Safer Lighting with Less Energy

15 Lux (average) in both scenes



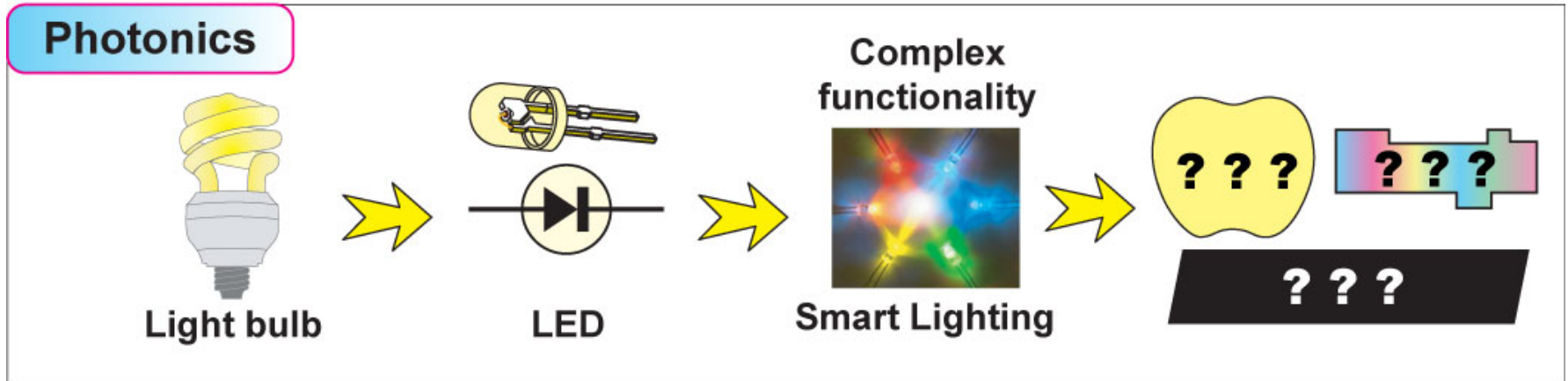
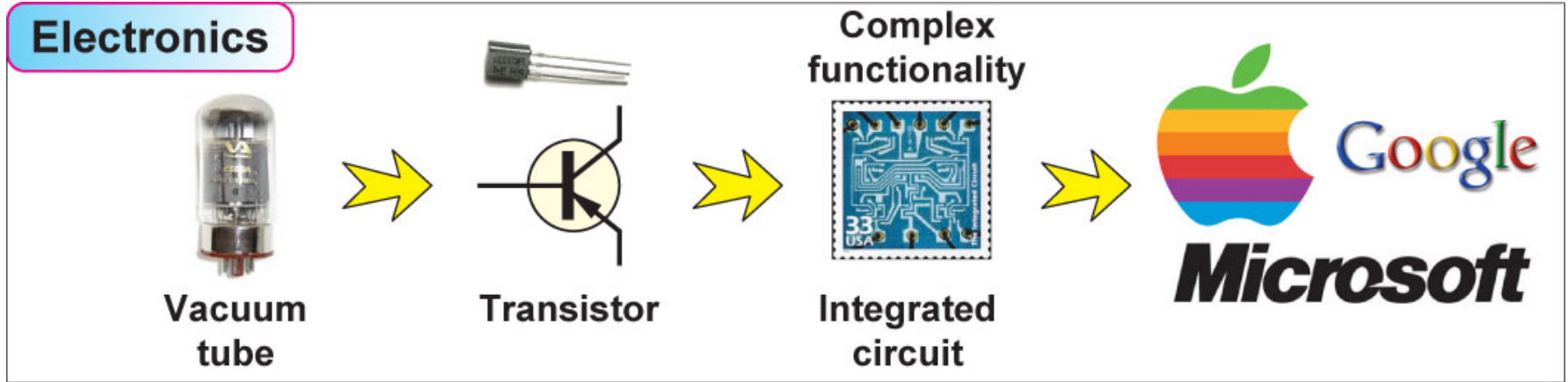
*“The experience of highly motorized countries is that lighting to even a modest standard can reduce accidents by 30%.”*

[REF: CIE 2007-180]






Harvesting Light Transport .....

# Smart Lighting: *The era beyond LED Bulbs...*

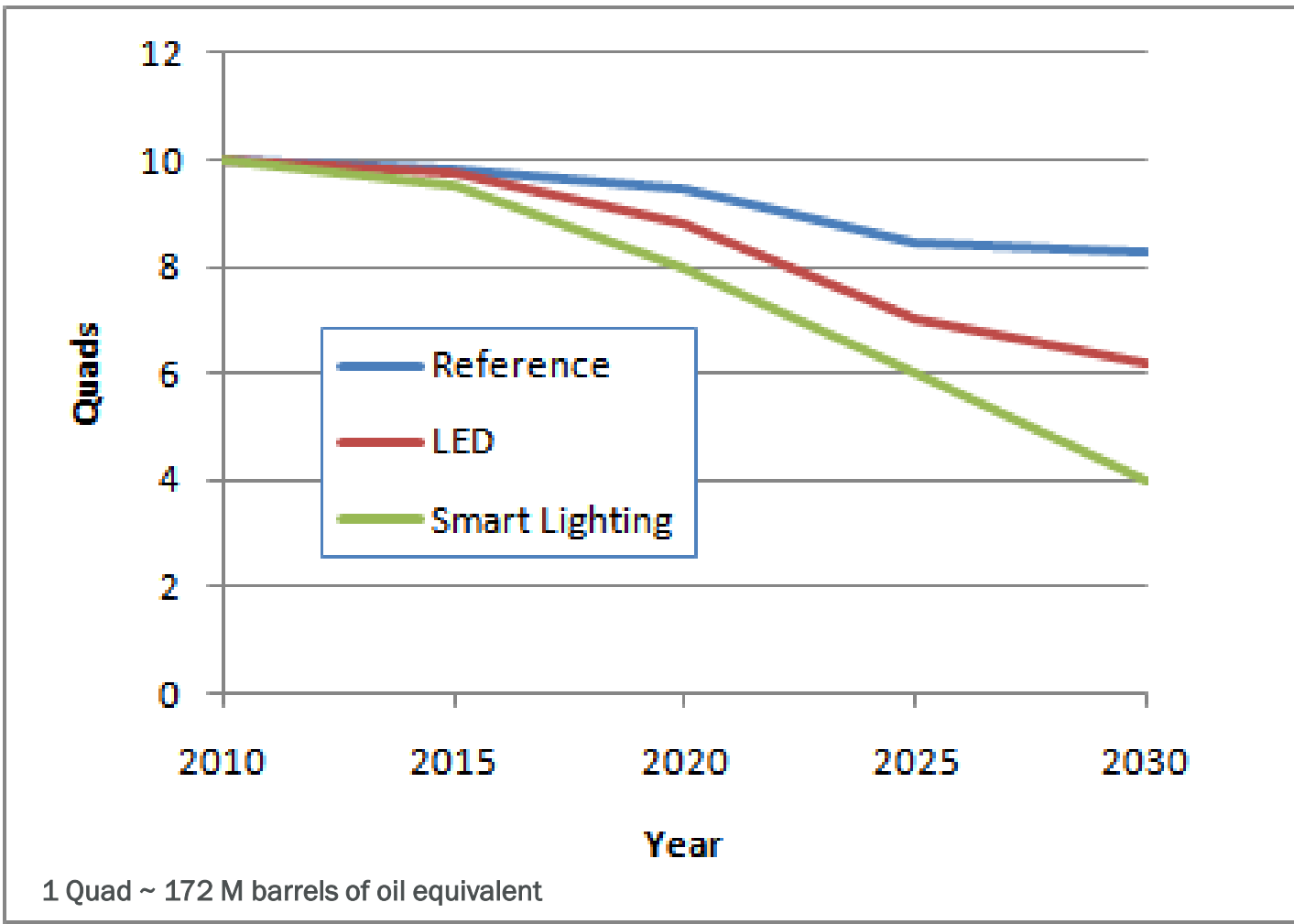


# Smart Lighting ERC: *Projected Societal Benefits*



Center Goals	Societal Benefits
<p><b>Center Goal 1</b> Energy Savings at 2X the current DOE roadmap for Solid-State Lighting</p>	 <p><b>Energy Sustainability</b></p>
<p><b>Center Goal 2</b> Reduce Health Care Costs by 20% with Smart Lighting</p>	 <p><b>Health, Safety and Well-Being</b></p>
<p><b>Center Goal 3</b> Use Smart Lighting to improve workplace productivity by 10%</p>	 <p><b>Productivity</b></p>

# Energy Savings Potential



- RGBY Lighting
- Controls
- Sensors provide key information

Adapted from the DOE SSL Report, February 2010

To learn more about the exciting & emerging  
applications of Smart Lighting

Visit us

@

<http://www.smartlighting.rpi.edu>

***The Right Light, Where & When You Need It***