World Green Energy Forum 2012

Review of LED Lighting Policies Regulations & Standards

By

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Strategies Unlimited

Gyeongju, Korea,
October 18, 2012

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Media for Strategic Markets Since 1910

Strategies Unlimited™
MARKET INTELLIGENCE | PHOTONICS • LEDS • LIGHTING

Outline

- About Strategies Unlimited
- Why LED Lighting?
- The Need of Market Intervention
- Regulations for LED Lighting
- Outlook

About Strategies Unlimited

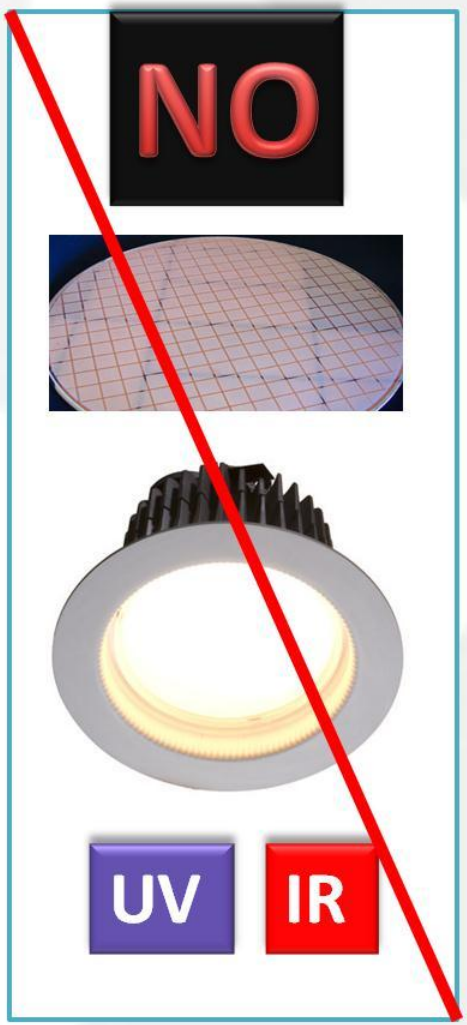
- Market research and consulting firm - founded in 1979
- Long history of market research
  - photovoltaics,
  - compound semiconductor materials and devices,
  - image sensors and lasers
- Have followed the LED market since 1994
- Reports on
  - overall HB LED market (annual),
  - LEDs in lighting (annual),
  - LED luminaire market,
  - LED driver ICs, and
  - LED replacement lamp market
  - LED outdoor lighting market
- Annual LED industry conference, *Strategies in Light*, since 2000
- Acquired by PennWell Corporation in 2001

Why LED Lighting?

Lighting in the middle of a paradigm shift

- LED Technology showing promise
- Energy Consciousness
  - Need to grow with less energy intensity
  - Environmental effects of using energy
  - Reducing energy dependence
- Financial Crisis
  - Stimulus Monies in US and China

LED Packages



Applications-Market Segments

Signs

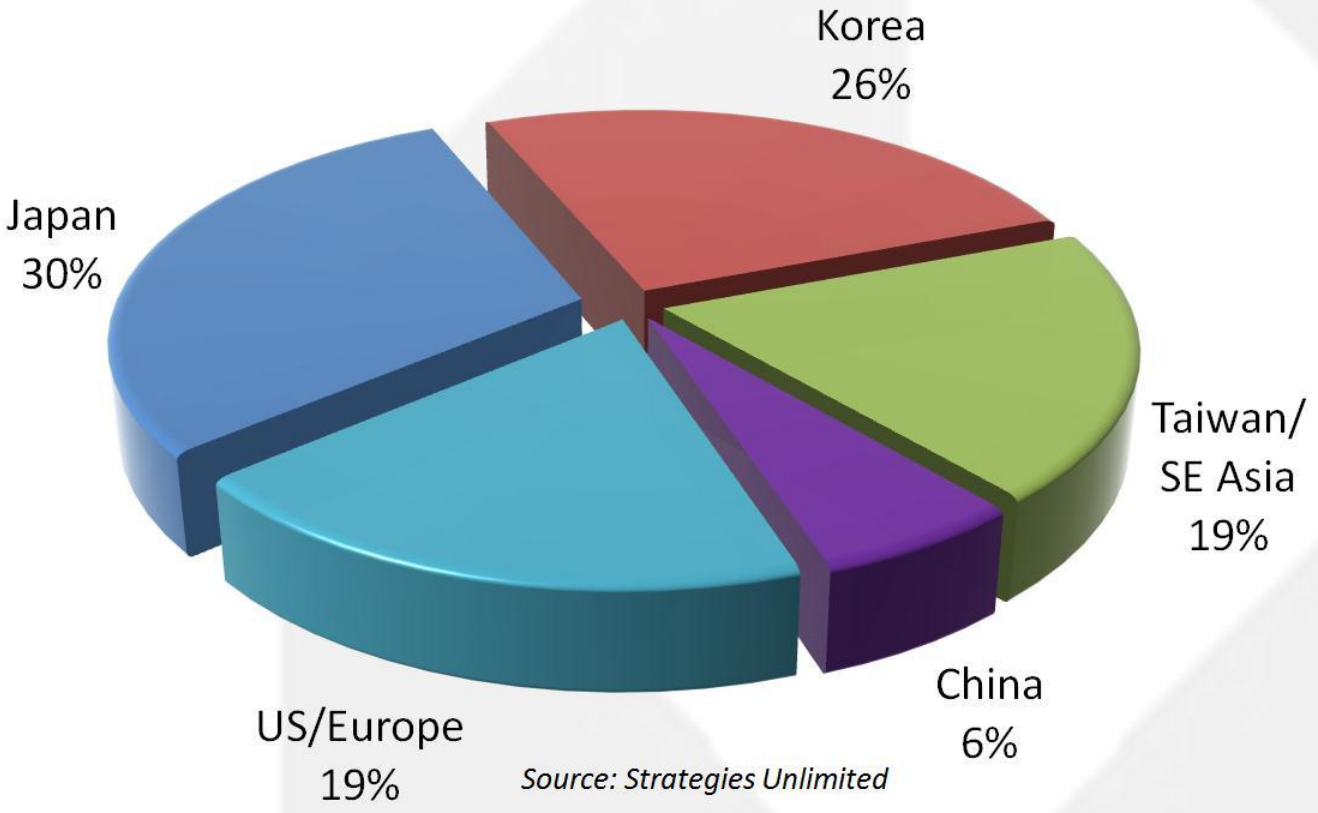
Mobile

TV/Monitor Display

Lighting

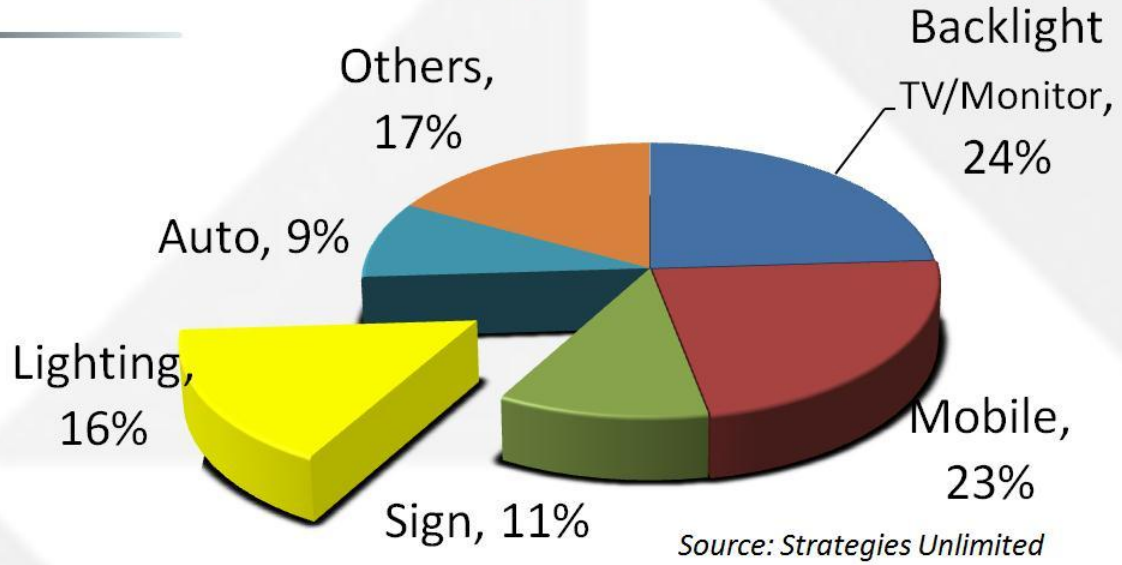
Automotive

LED Packages By Region 2011



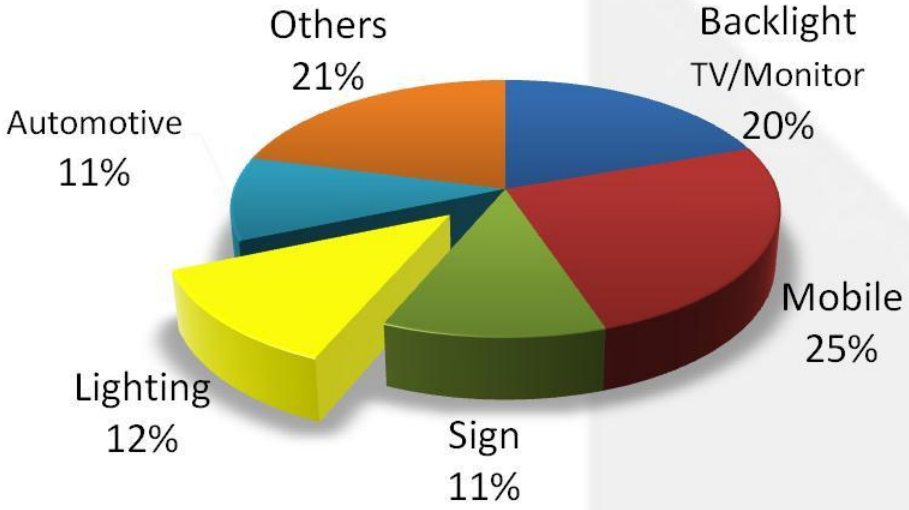
Source: Strategies Unlimited

Market for LED Packages



2010 Market= US$11.34B

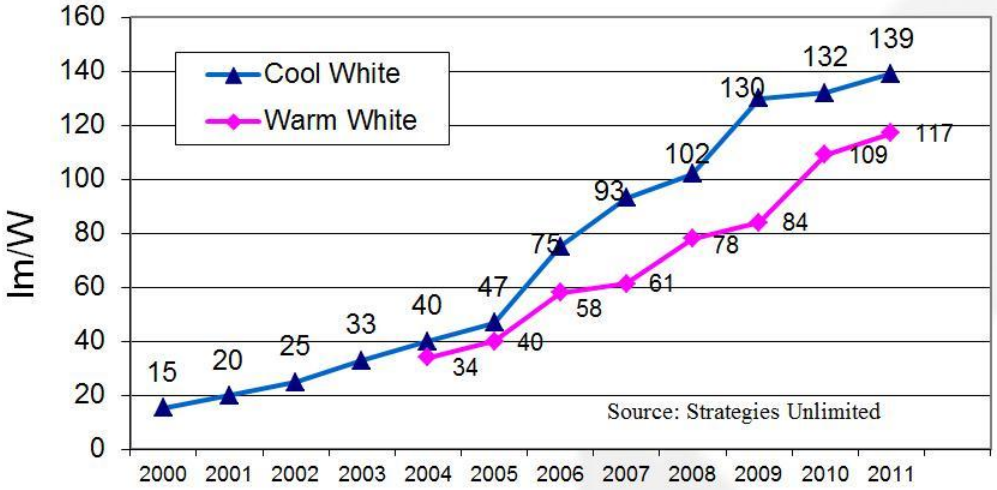
Source: Strategies Unlimited



2011 Market= US$12.52B

LED Performance

Lumens/Watt



Best Commercially available efficacies for 1W chip 2000-2011
2012 values represent multichip packages

$/kilolumen

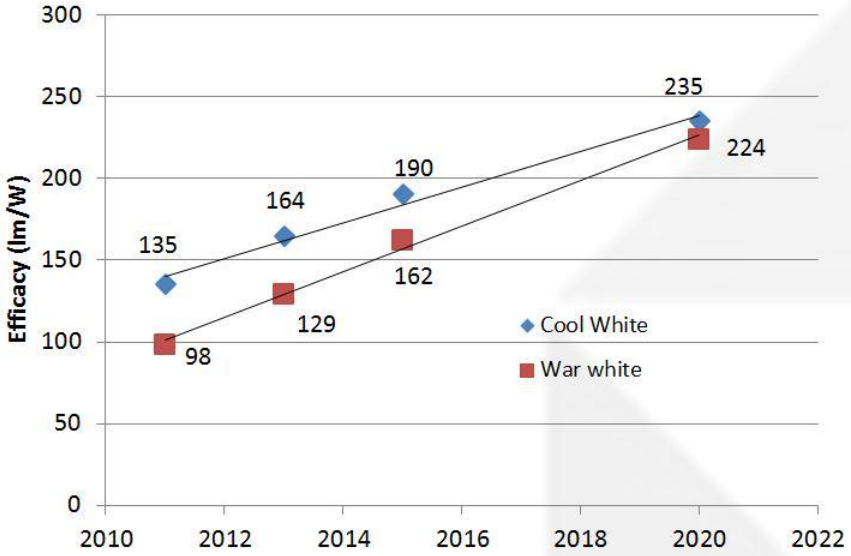
Price $/kilolumen for 1W High-Power LED with CRI: > 75
2011

$/ kilolumen for 2700 K per 1 W package	$ 8.50
$/kilolumen for 3000 K per 1 W package	$ 7.50
$/ kilolumen for 3000 K - 4000K per 1 W package	$ 5.00
$/ kilolumen for 4000 K and up per 1W package	$ 4.50

Source: Strategies Unlimited

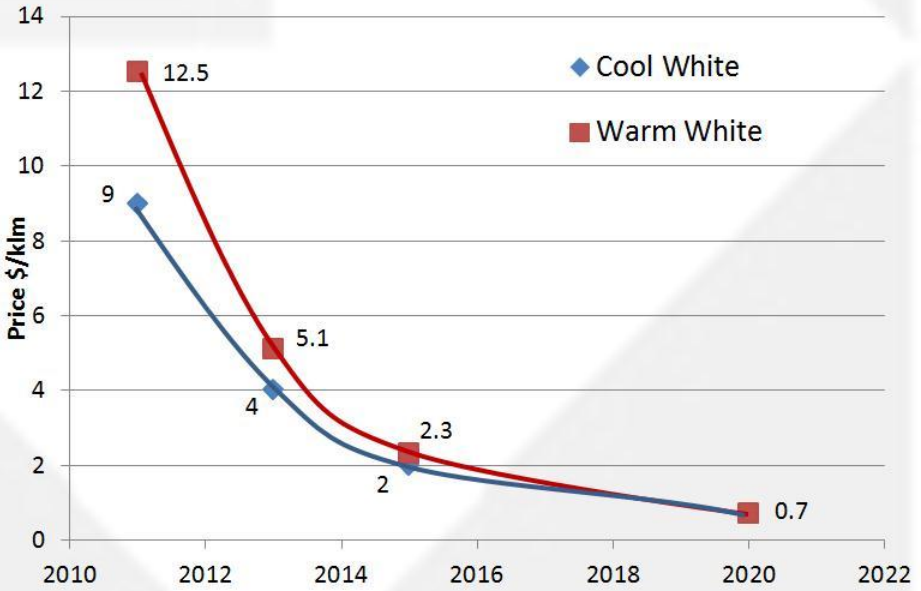
US DOE Projections

LED Package Performance



Price CAGR 2011-2015

Cool White -31%
Warm White -35%



LED Lighting

Lighting Industry

Lamps—Light source

Technologies include Incandescent, Halogen, Compact fluorescence(CFL), Linear Fluorescent Tubes(LFT), High Intensity Discharge(HID) includes, Mercury Vapor(MV), Low Pressure Sodium (LPS), High Pressure Sodium(HPS), Metal Halide and Ceramic Metal Halide, Induction, and LED

Fixtures-

Does not include the light source

Ballasts

Power Management

Luminaires

Light Source + Fixture

–New nomenclature for SSL

–Convergence of light sources, ballasts and fixtures

Controls

Lighting system controls including Dimmers, Color dials, Mood Lighting, Wall plug controls, facility wide lighting controls, wi-fi, radio and internet controls

LED Lighting Market Segmentation

- LED Lighting Market
  - Replacement Lamps
  - Luminaires

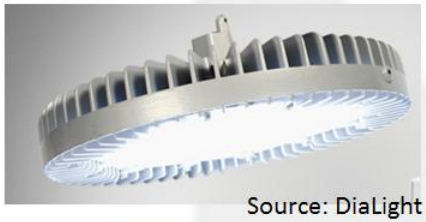
Source: Switch

Source: LSG

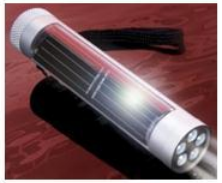
Source: Philips Lighting

Source: DIY Trade

Source: Beta Lighting



Source: DiaLight



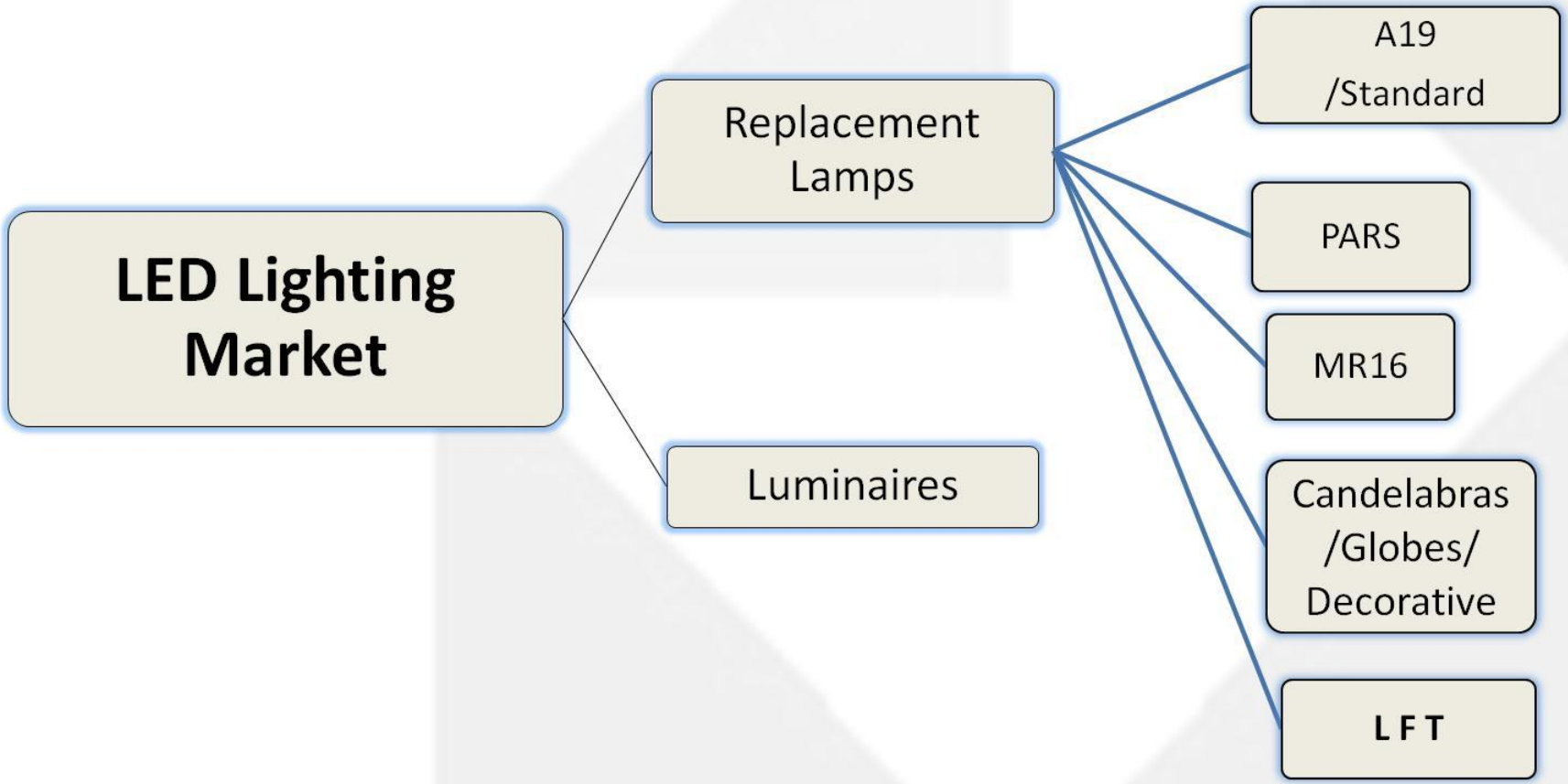
Source: Techfresh.net

Source: Unic-Light

Source: Planetware

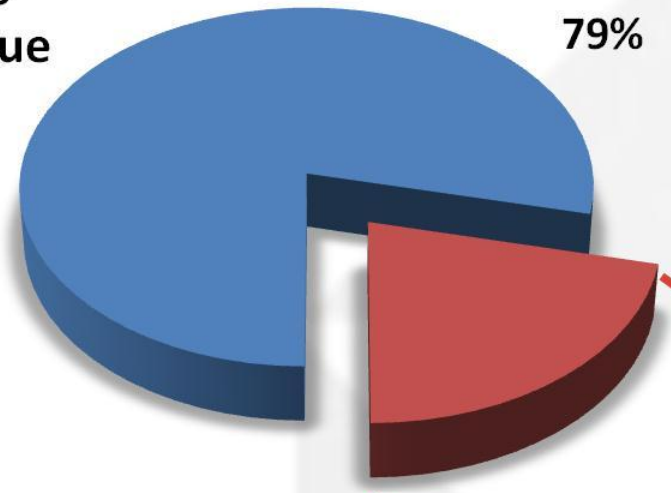
Source: Zumtobel

LED Replacement Lamp s--Segmentation



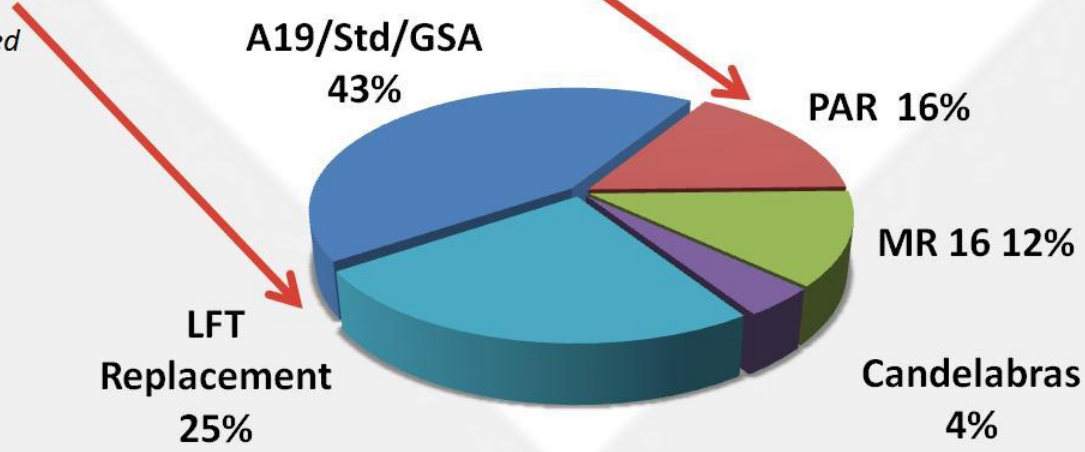
LED Replacement Lamps 2011

LED Lighting
2011 Revenue
$9.8 billion

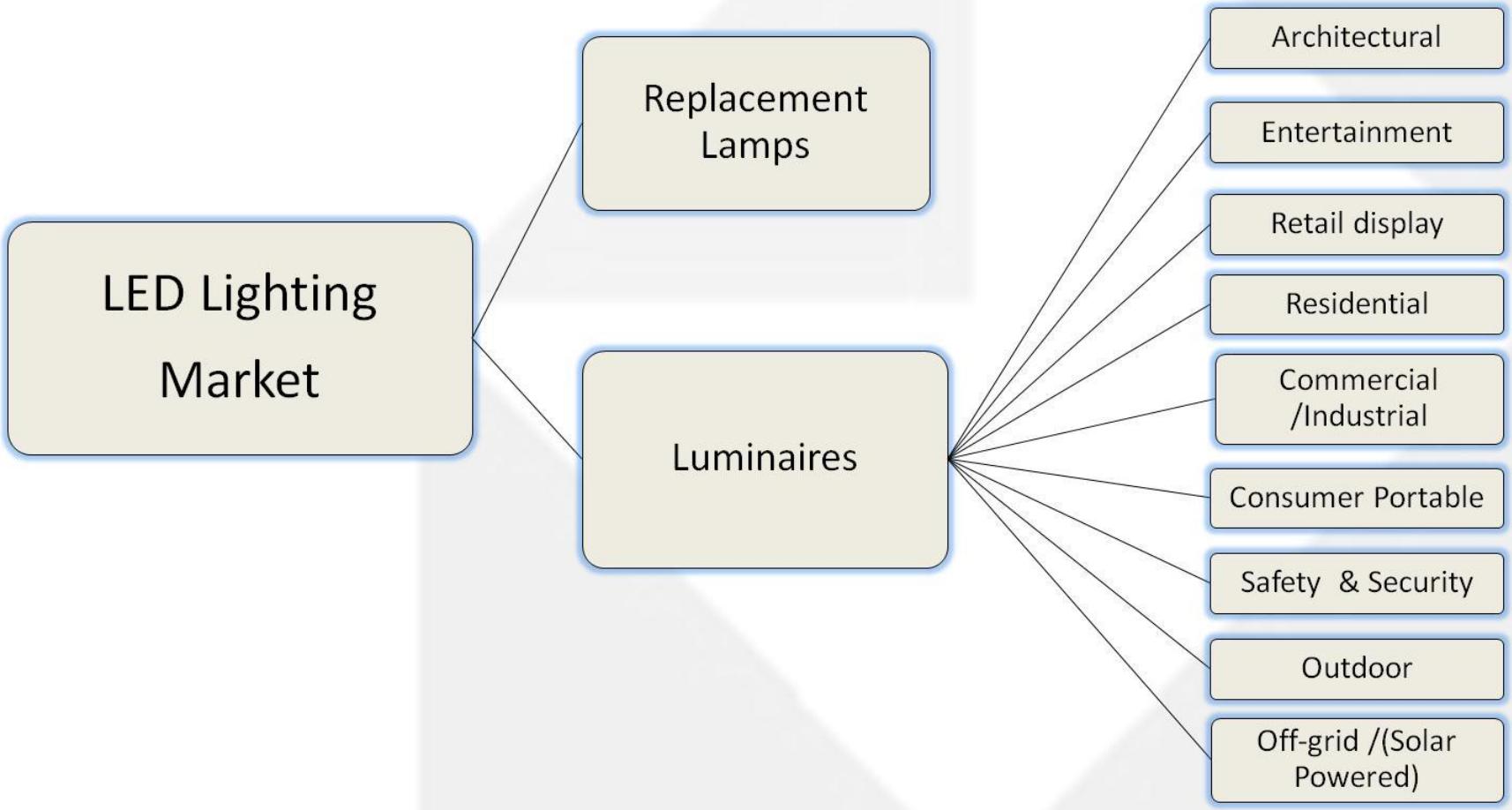


Replacement Lamps
21% -- $2.1 Billion

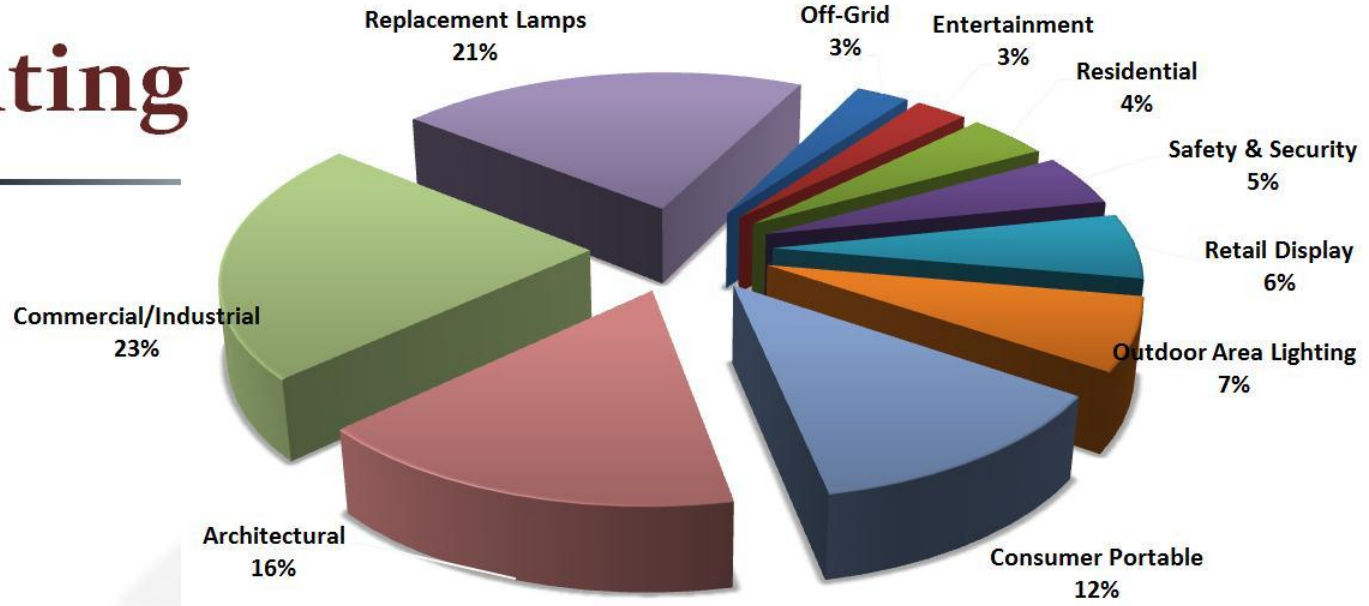
Source: Strategies Unlimited



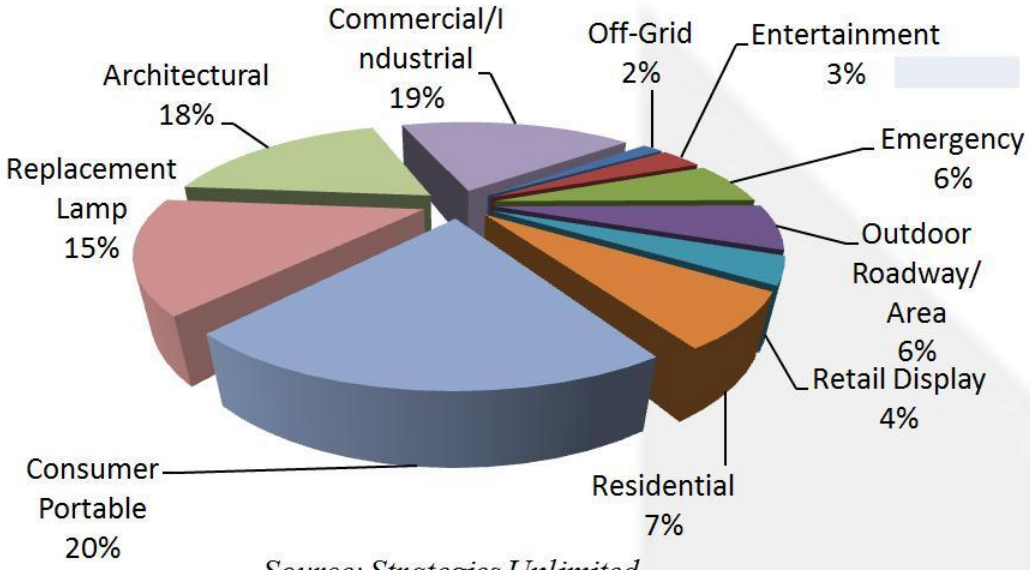
LED Luminaires--Segmentation



LED Lighting



2010 Rev : $5.5 B



Source: Strategies Unlimited

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2011 Rev: $9.9B

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Reasons for Market Intervention

- Safety
- Quality Assurance
- Environmental Sustainability
  - Reducing the carbon footprint
  - Reducing energy use per unit of GDP growth
    - As per capita income increases, demand for lighting increases
  - Release energy for other uses
    - Increased urbanization
    - Growing middle class
  - Concerns about dark sky

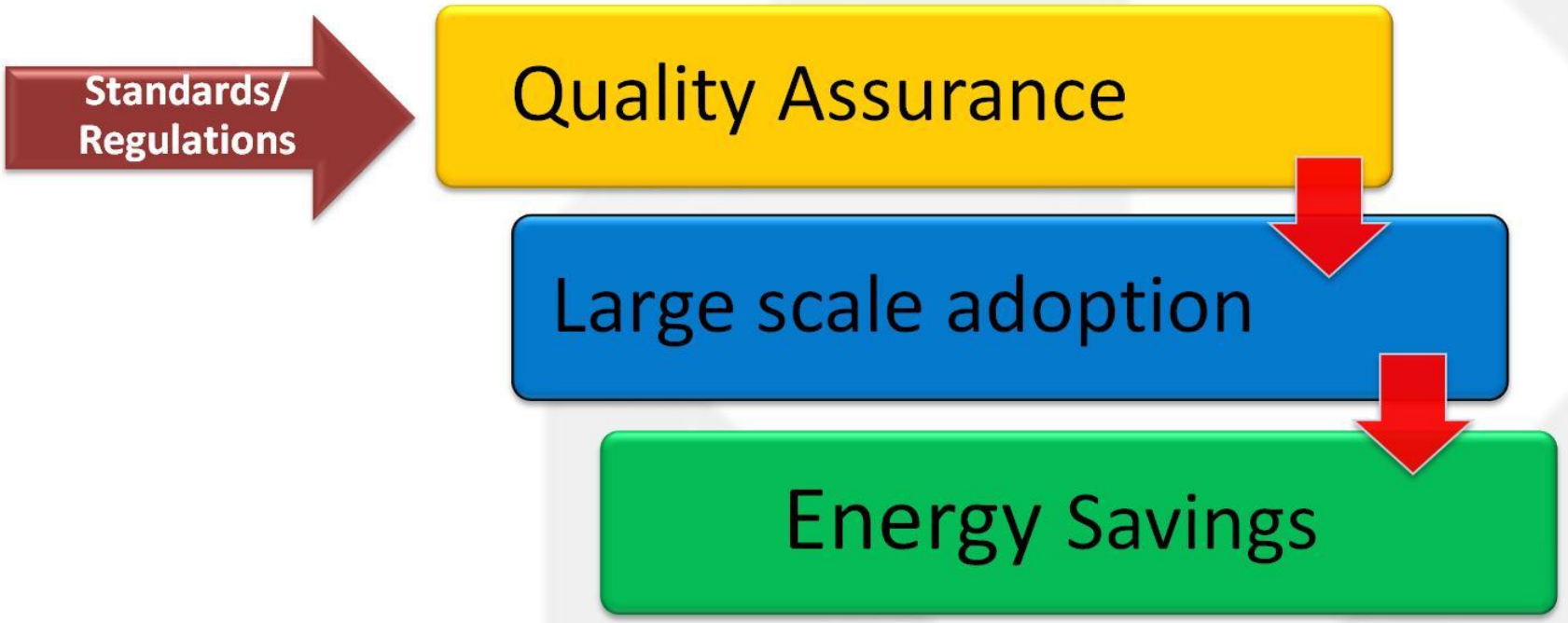
Lighting low hanging fruit for reducing energy use

Safety

- Electrical Safety
  - UL, CSA, CE, ETL , S(Europe), ASTA Diamond (Europe), BEAB Approved, CCC(China), NOM (Mexico)
- Biological safety~ effects on human health

  CIE has taken the lead, many standards being considered, work in progress
  - Glare
  - Flicker
  - Circadian rhythm

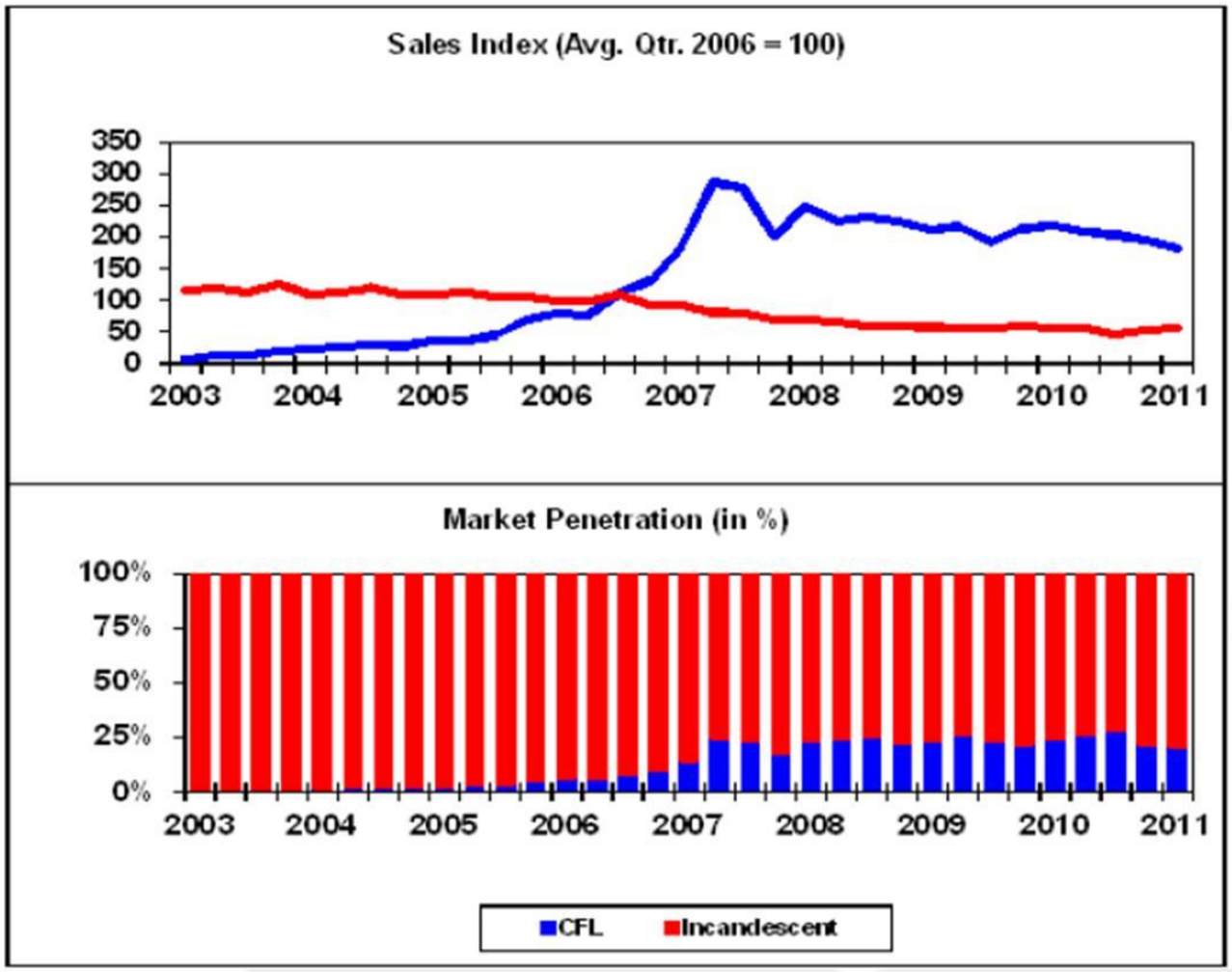
Role of Government Policies



Quality Assurance

- To make effective choices that lead to energy efficiency
  - Lessons from the CFL experience
    - Initial price
    - Size of lamps
    - Poor performance
      - » low light output
      - » exaggerated lifetimes
      - » overstated equivalency claims
      - » inconsistent performance that compared unfavorably with incandescent light sources
      - » negative characteristics, such as humming, flicker and poor color quality
    - No consumer education
- To ensure environmental sustainability
  - Lifecycle cost assessment
  - Opportunity cost

The CFL experience



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What is different about LEDs

- Option of color temperature
  - Warm white, cool white
- Variable CRI
- Luminaire/replacement lamp design
  - Efficacy
  - Life
  - Color/Lumen Maintenance
  - Color temperature
  - CRI
  - Light distribution, beam angle
  - Glare
  - Flicker
  - Power factor

Measuring Performance

US DOE finalized standards

- Chromaticity --LM79
  - Lumen output for light sources/luminaires
  - Color Temperature
  - CRI
- Lumen maintenance for LED packages at 6000 hours

  —LM80
- Extrapolating Life—TM 21
  - Based on junction temperature

What next?

Issues not yet addressed in measuring Performance

Durability

- CRI/or other color quality indices
- Color Maintenance
- Lumen distribution/color uniformity
- Lumen Maintenance
- Electrical
  - Voltage, wattage and drive current
  - Dimming
  - Flicker

Assuring Ease of Adoption

Standards

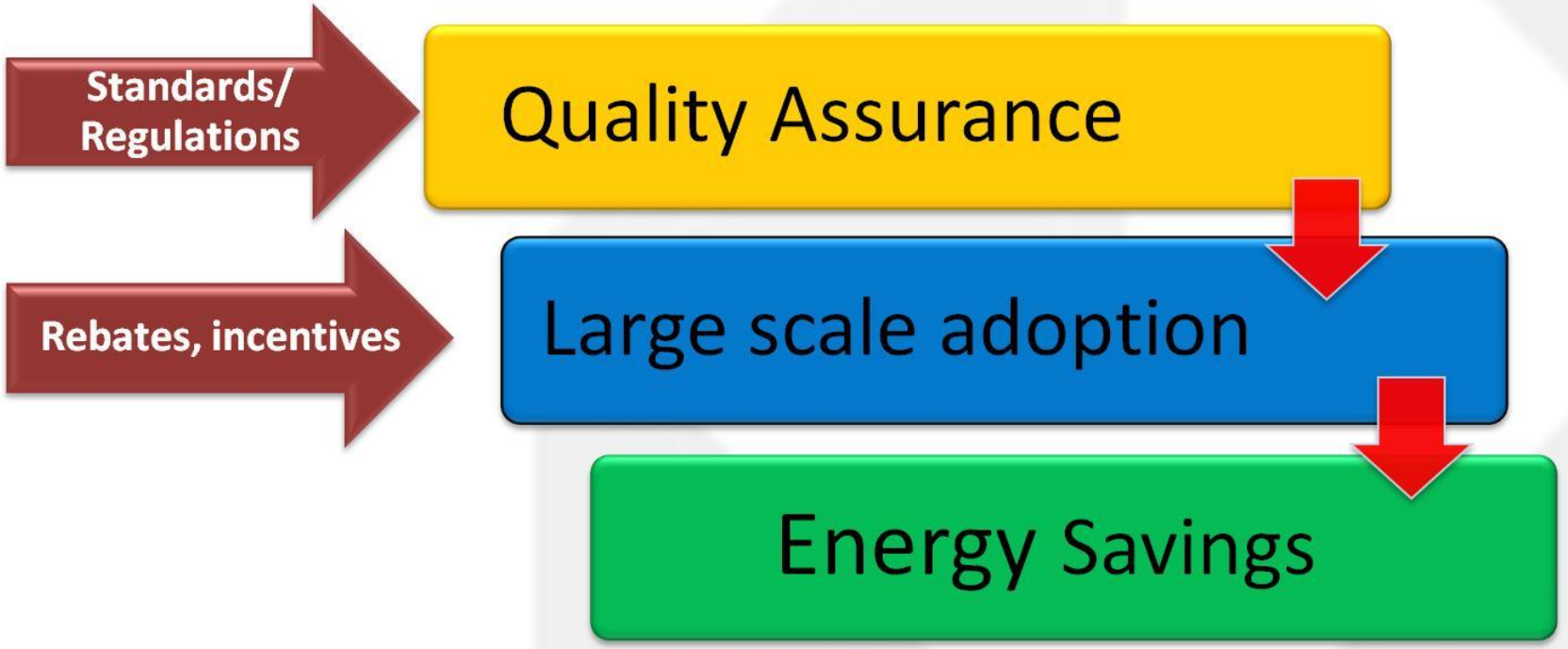
- Zhaga--Physical properties of the interfaces
  - To promote multiple sourcing
  - Seven books published
- IEA-4E Annex--across the globe harmonizing standards—a Tiered approach
- China working on their own standard

Premature standards can sub-optimize the potential of LED technology

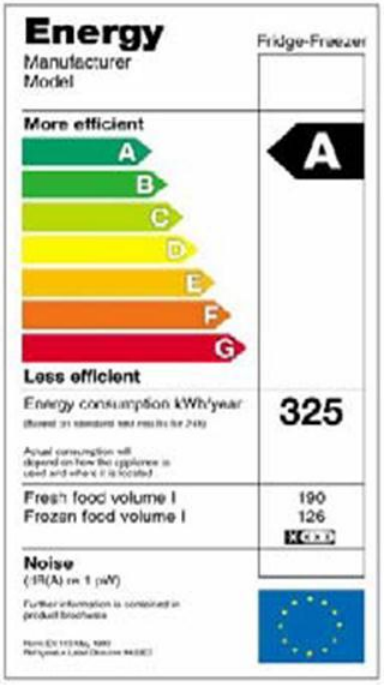
Subsidies for LED Industry

- Supply
  - China direct and indirect subsidies for production– a national priority
  - Indirect many countries offer investment incentives through tax relief
- Demand
  - Fiscal stimulus in US, China,
  - 21 city program in China
  - Latest 2B RMB subsidies for LED lighting products
  - Eco-point program in Japan
  - Public Education
  - Rebates for energy efficient products --widely used for CFL products
- Technology R&D
  - ITRI in Taiwan
  - DOE program in US
  - University grants in Europe

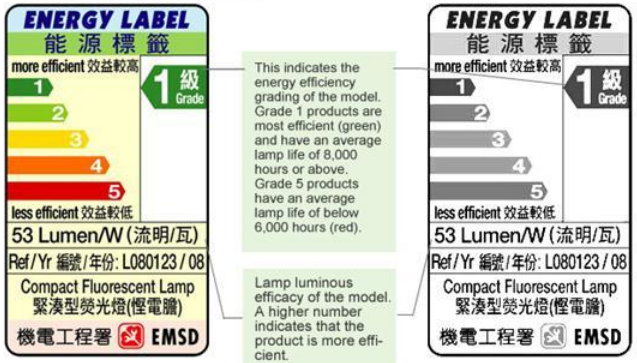
Role of Government Policies



Labels to implement compliance

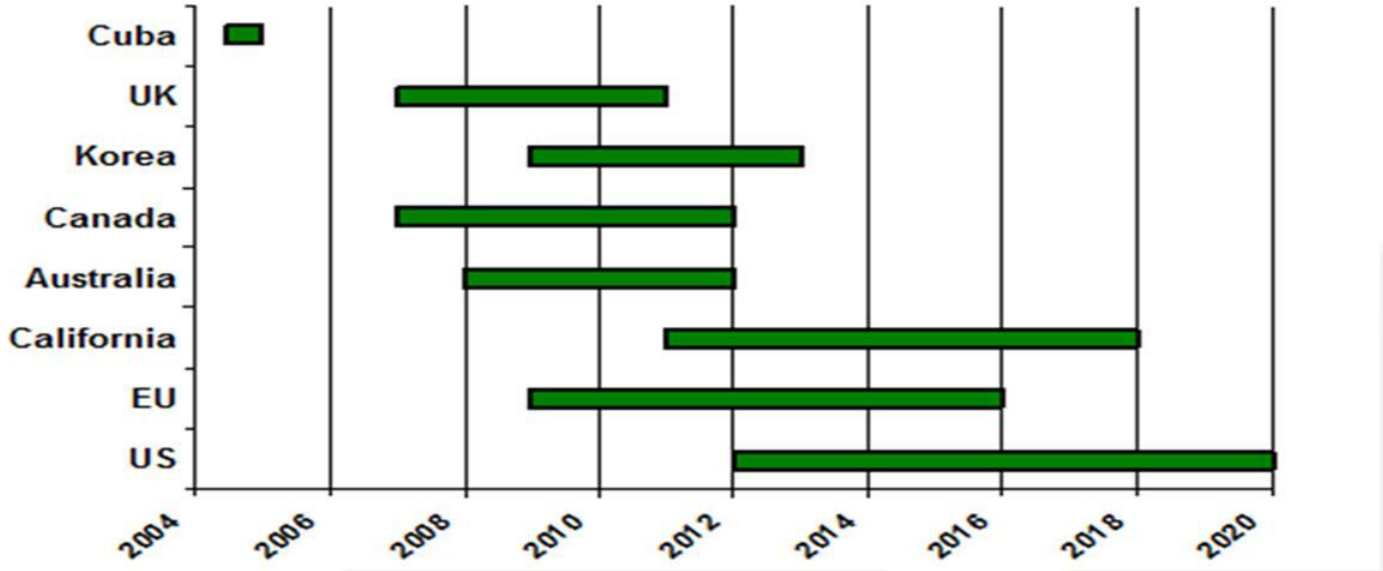


Standard Label



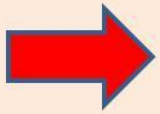
Energy Efficiency--Through Standards

- Phasing out of incandescence/mercury vapor lamps
- Changing magnetic ballasts with electronic
- High efficiency standards for ballasts for fluorescence as well as metal halide light source



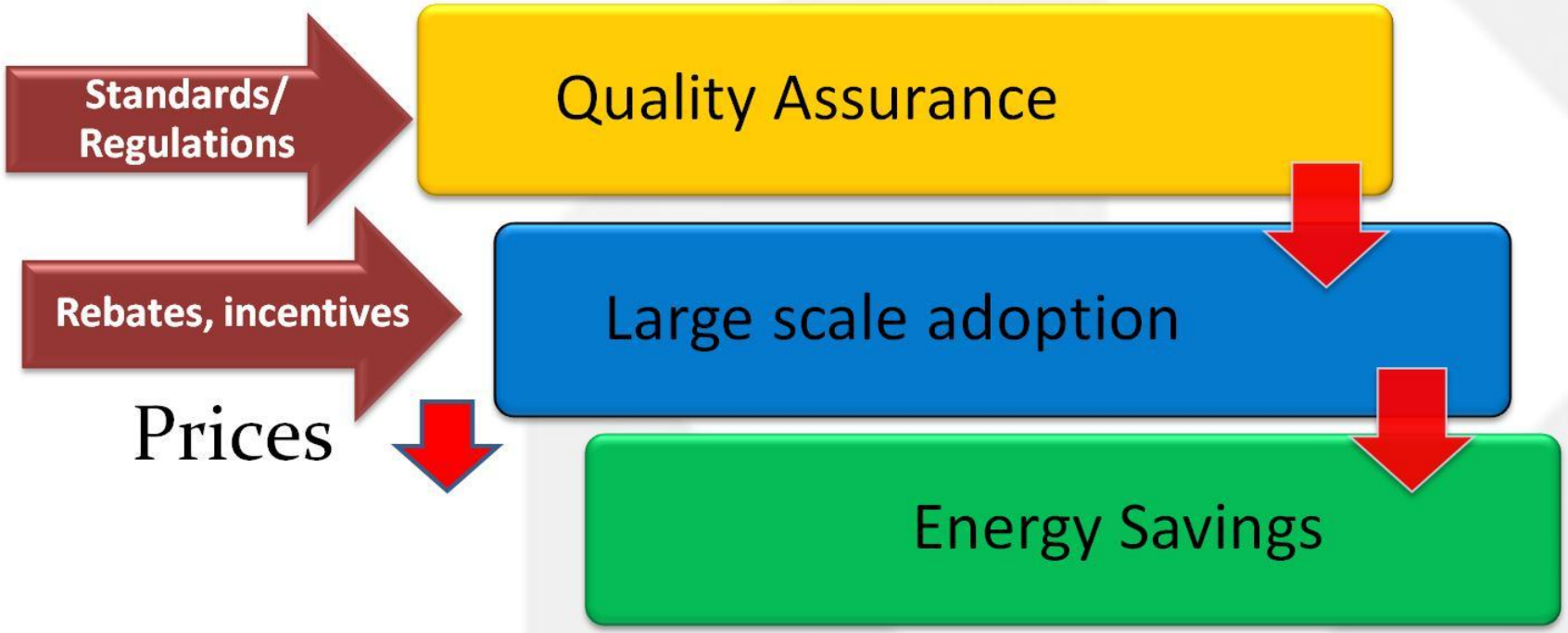
Implementation

- Setting Standards
- Standardizing measurement Protocols
- Setting up testing facilities
- Surveillance
  - Implications of non-compliance



Education –manufacturers, distributors, retailers , lighting designers, engineers, specifiers and end-users

Role of Government Policies



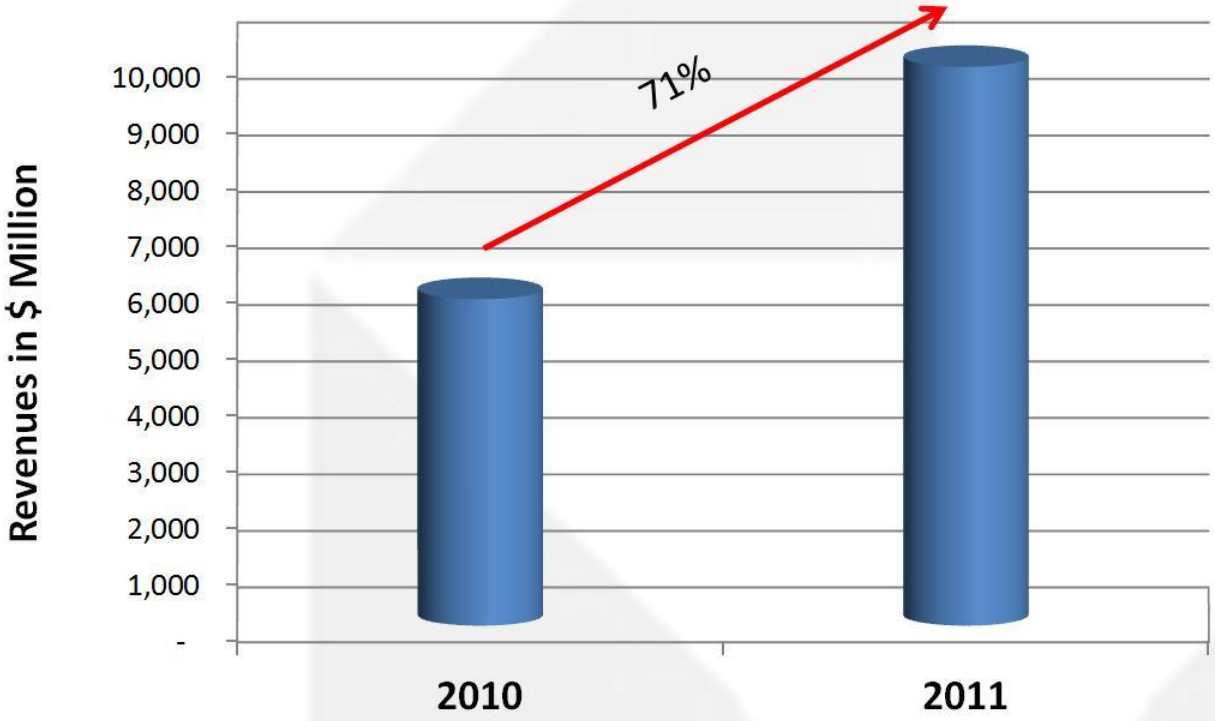
LED Supply 2010-2012

- Slower than expected penetration in TV and Display market led to overcapacity in manufacturing and packaging LEDs in Taiwan and Korea
- Subsidies in China increased manufacturing capacity

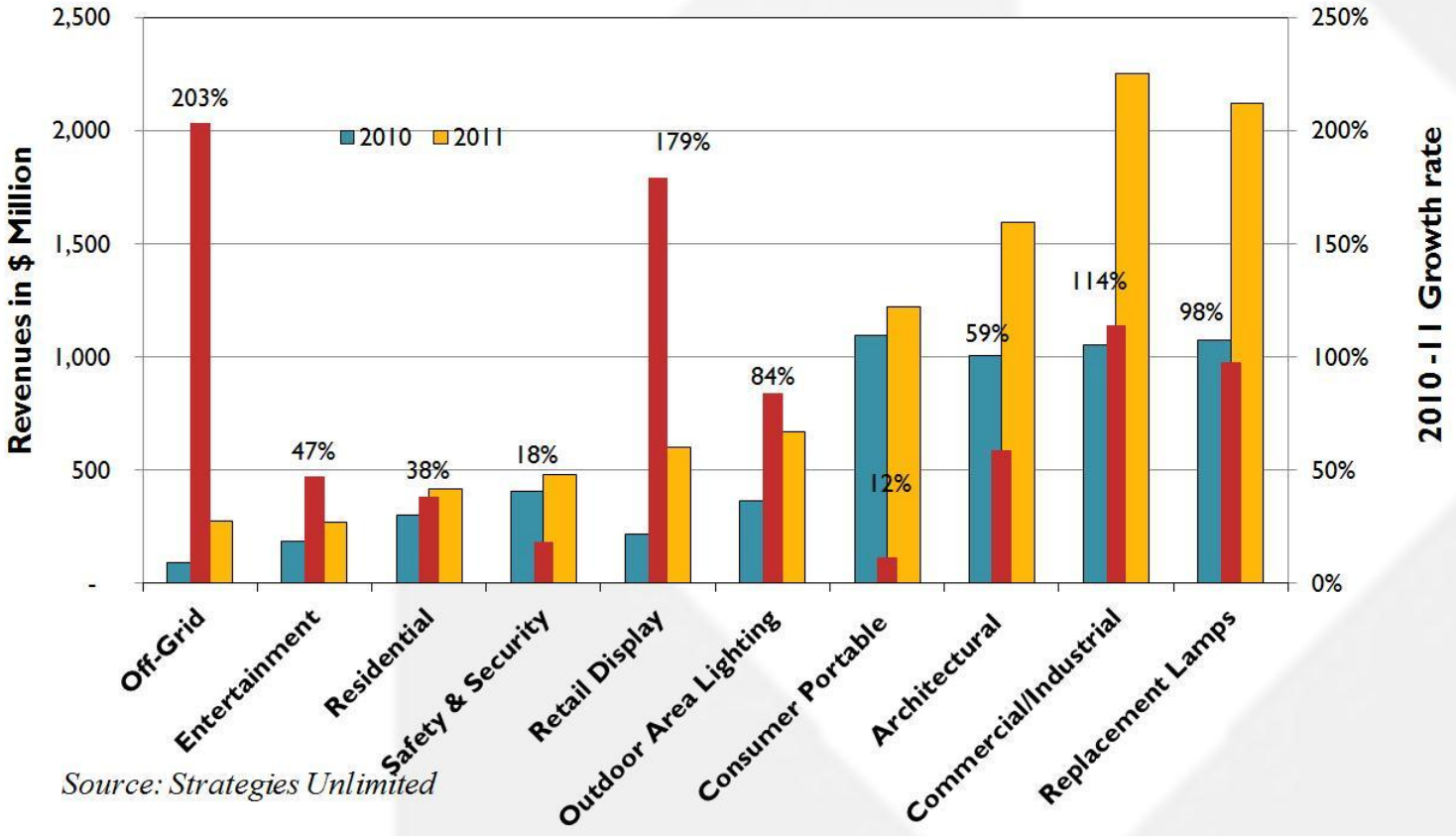
Industry Trends 2011

- LED Count dropping fast
- Prices dropping even faster
  - 35% to 45% reduction in prices of LED chips in 2011
  - 30-35% decline in prices of LED packages
  - Price of low end products declined faster than the high end
- Major growth in the use Low & Mid power LED for ambient lighting applications
- Koreans and Taiwanese have excess capacity to package mid-power and low power LEDs
- Increasing use of Multichip Arrays/COB for lighting applications
- All major suppliers offer multi-chip/COB/ arrays
- Prices of mid-power and low power dropped the fastest

LED Lighting Revenue



Segment Analysis



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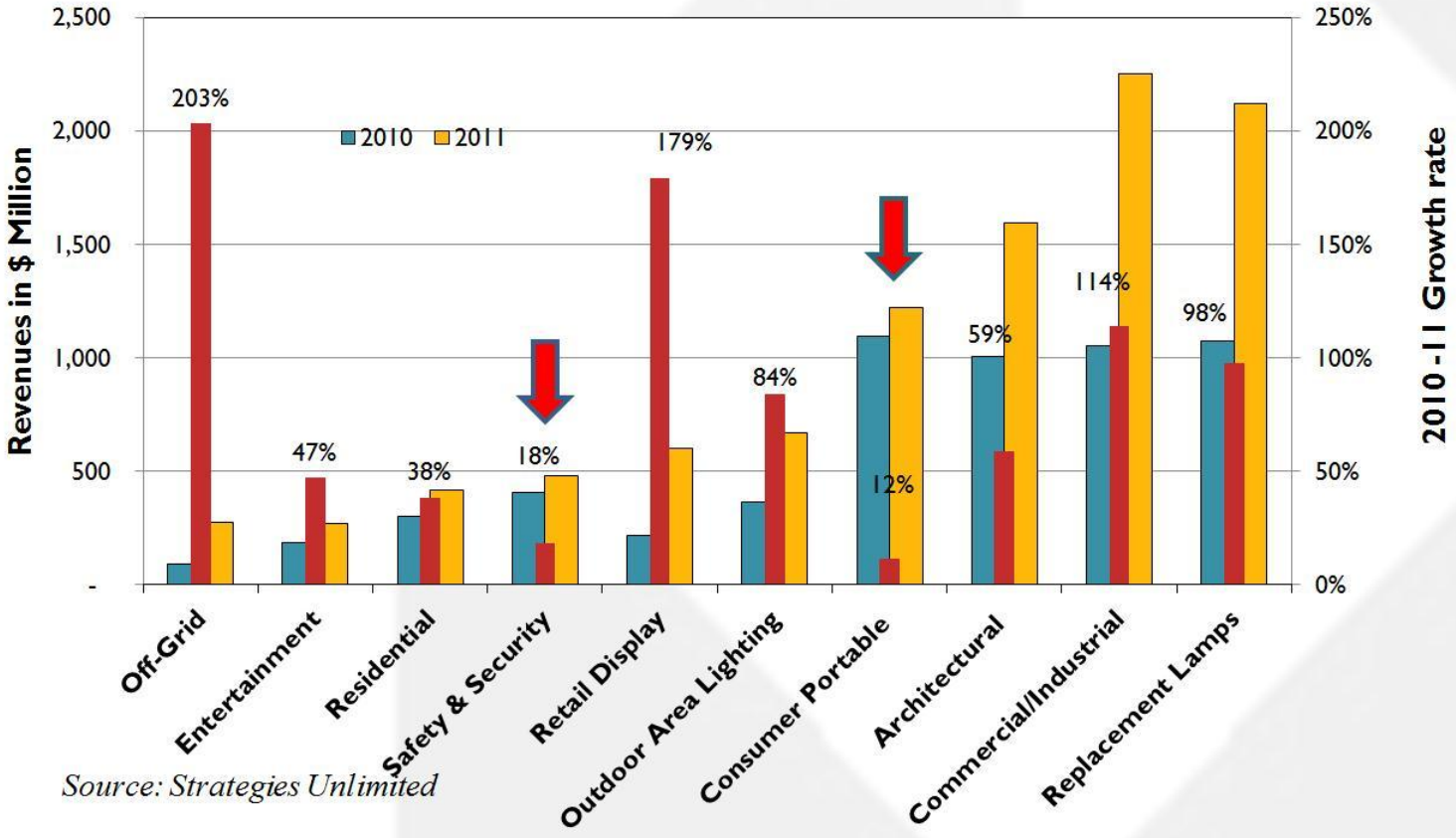

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Looking Forward

Lighting is in transition in many arenas

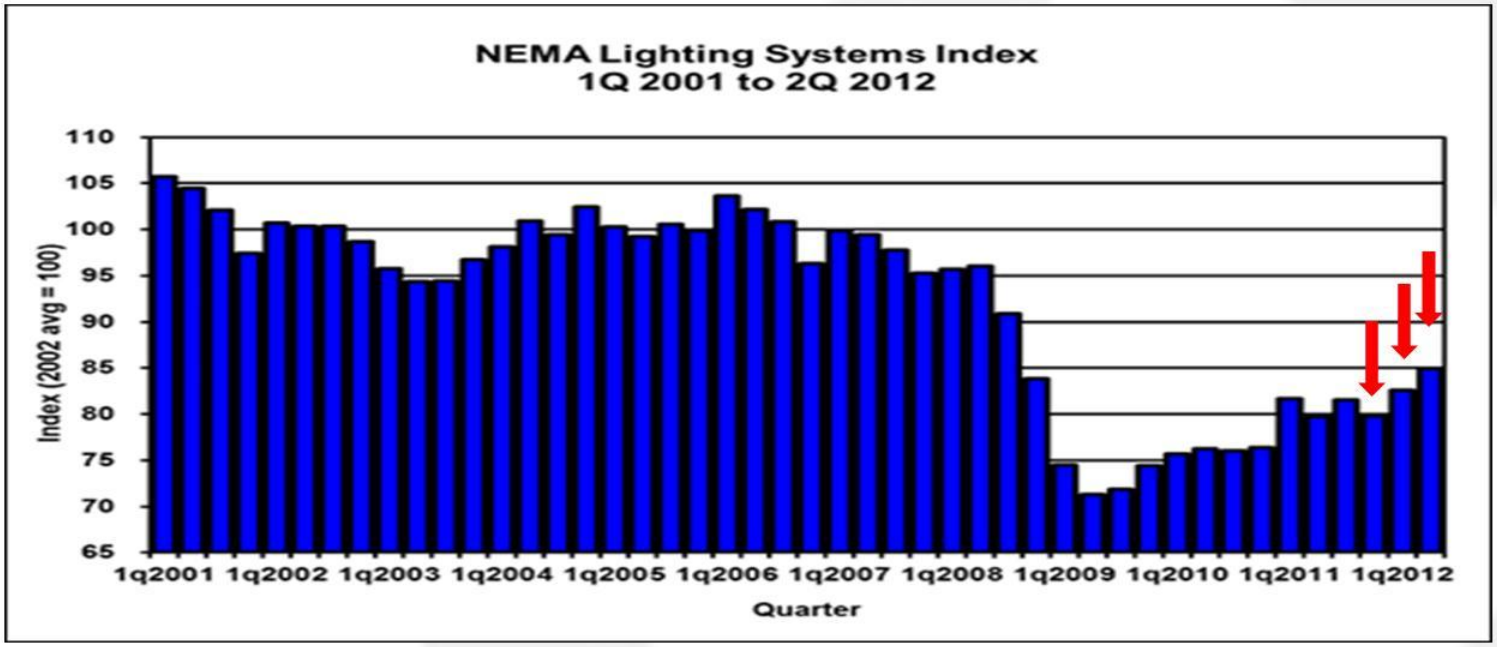
- New technologies are becoming competitive to the established
  - LEDs
  - OLEDs
- Rethinking energy use on lighting
  - Carbon emissions
  - Over dependence on nuclear energy
  - Reducing dependence on oil imports
- Availability of resources
  - Rare earths

    Prices of fluorescent phosphors are increasing and supply is limited, 2011 saw lamp price increase-10-25%

Many Challenges Ahead

- Increase in demand for incandescent for "industrial use"
- Reports of spike in halogen demand in US
- Competition from CFLs in the consumer markets
- Increasing use Ceramic Metal Halides for retail lighting
- Eurozone financial uncertainties
- Predicted slow down in Asian economies

U.S. Economy—in the US



- Building permits rose nearly 7 percent to 812,000 from June to July
- electrical intensive commercial construction fared somewhat better posting a second consecutive quarter of near 10 percent annualized growth
- By latter half of 2013, with the homebuilding is expected to rebound and the electrical intensive commercial construction segments expected to pick up

Regulatory Outlook

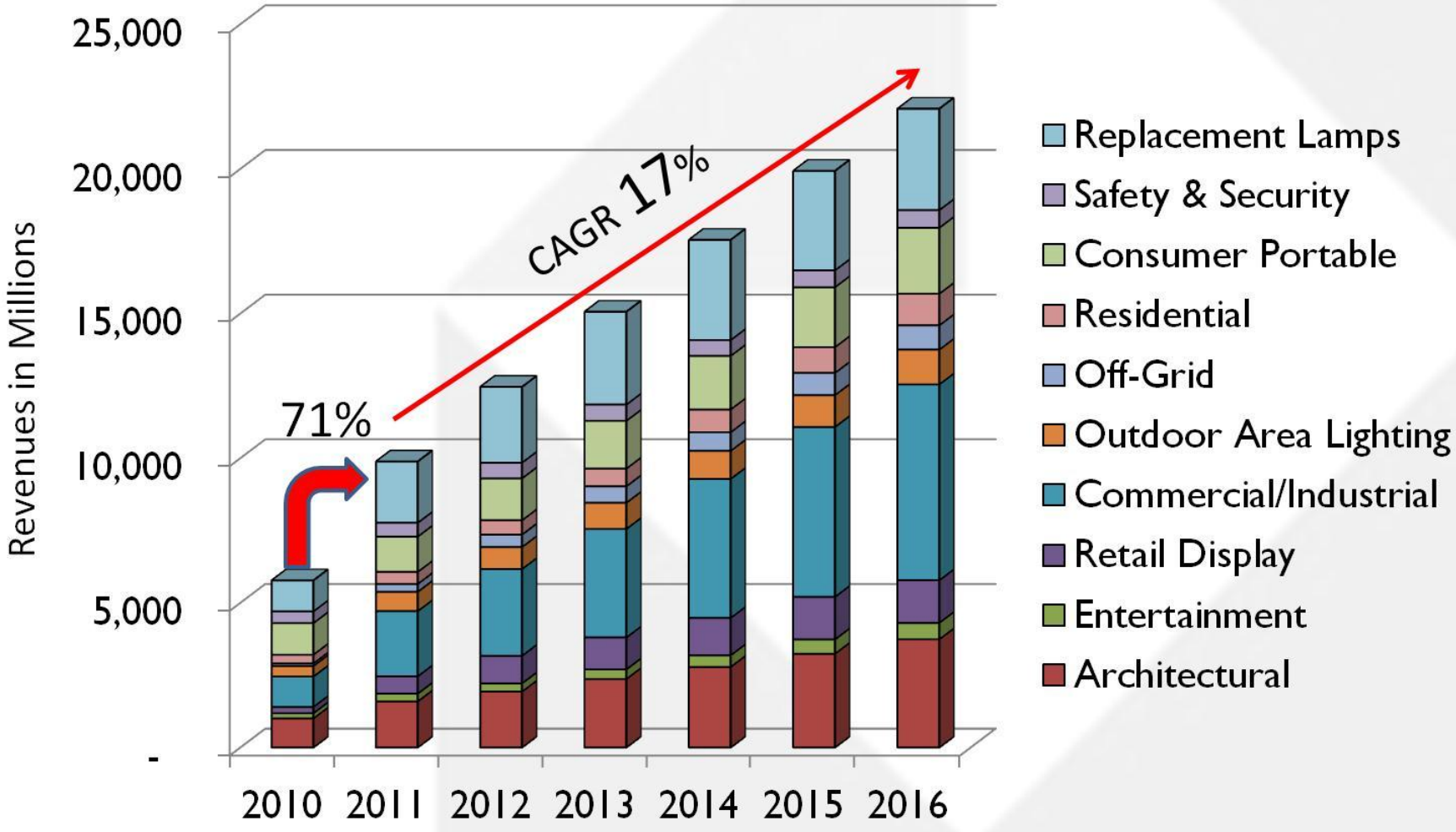
- Standards setting is moving rapidly,
  - consistency between regions-IEA-4E-Harmonization of Standards—a Global effort
- Standardization of product interfaces —drivers, dimmers, controls –Zhaga
- Many countries now recognize the importance of standards including China, and India
  - S DOE Efforts to set standards and CALiPER testing has far reaching global influence
- Europe:
  - CELMA-Optical Safety, Color Quality and other standards
  - ErP Directive (Ecodesign Requirements for Energy-related Product, Directive 2009/125/EC) –will be reviewed in 2014
  - 20-20-20 target for EU
  - Carbon Reduction Commitments (CRC) in UK

Regulatory Outlook—Controls!

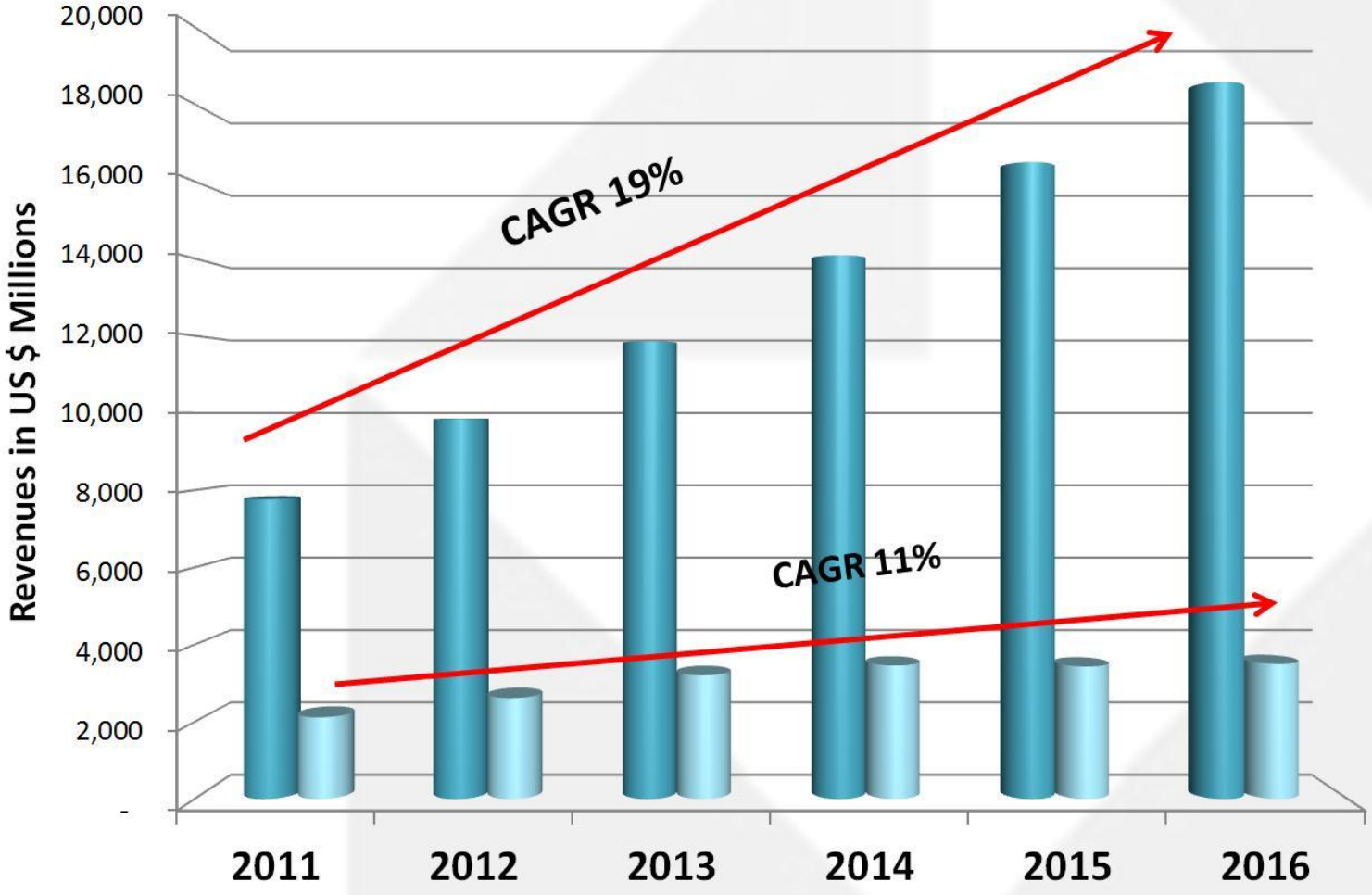
Standards encouraging controls

- ASHRAE Releases 90.1-2010
- Formation of TALQ-Consortium for standardization of a management software interface for Outdoor Lighting Networks
- ESOLi
  - Intelligent energy saving outdoor lighting funded by Intelligent Energy Europe Program

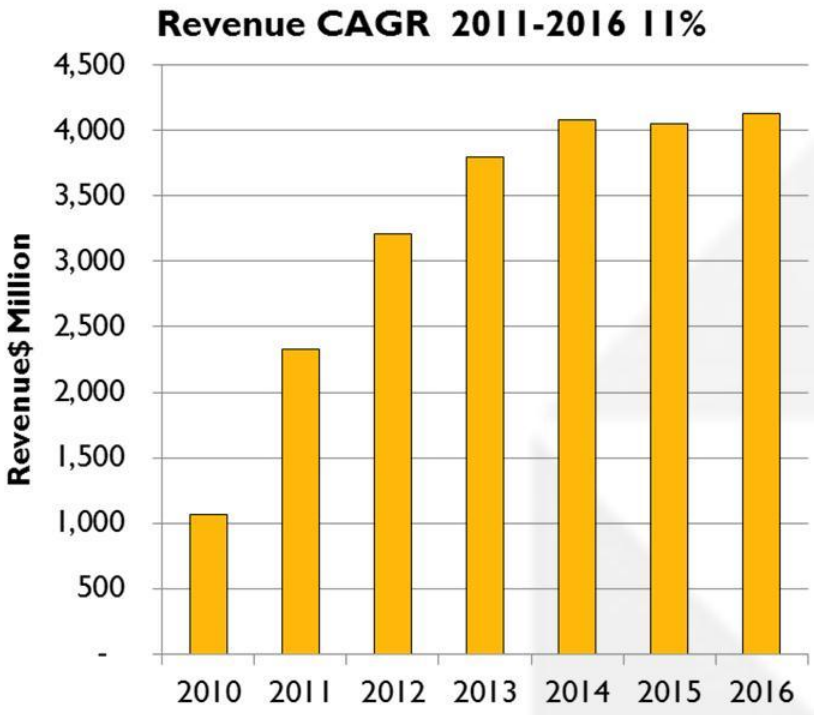
LED Lighting Market Forecast 2011-2016



Luminaires & Replacement Lamps



Replacement Lamp



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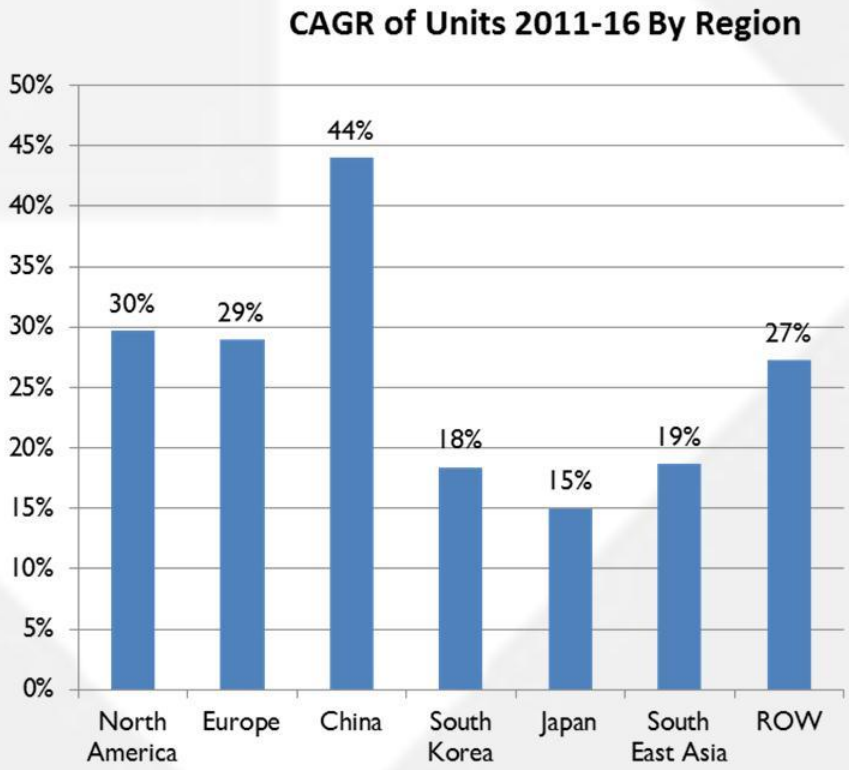

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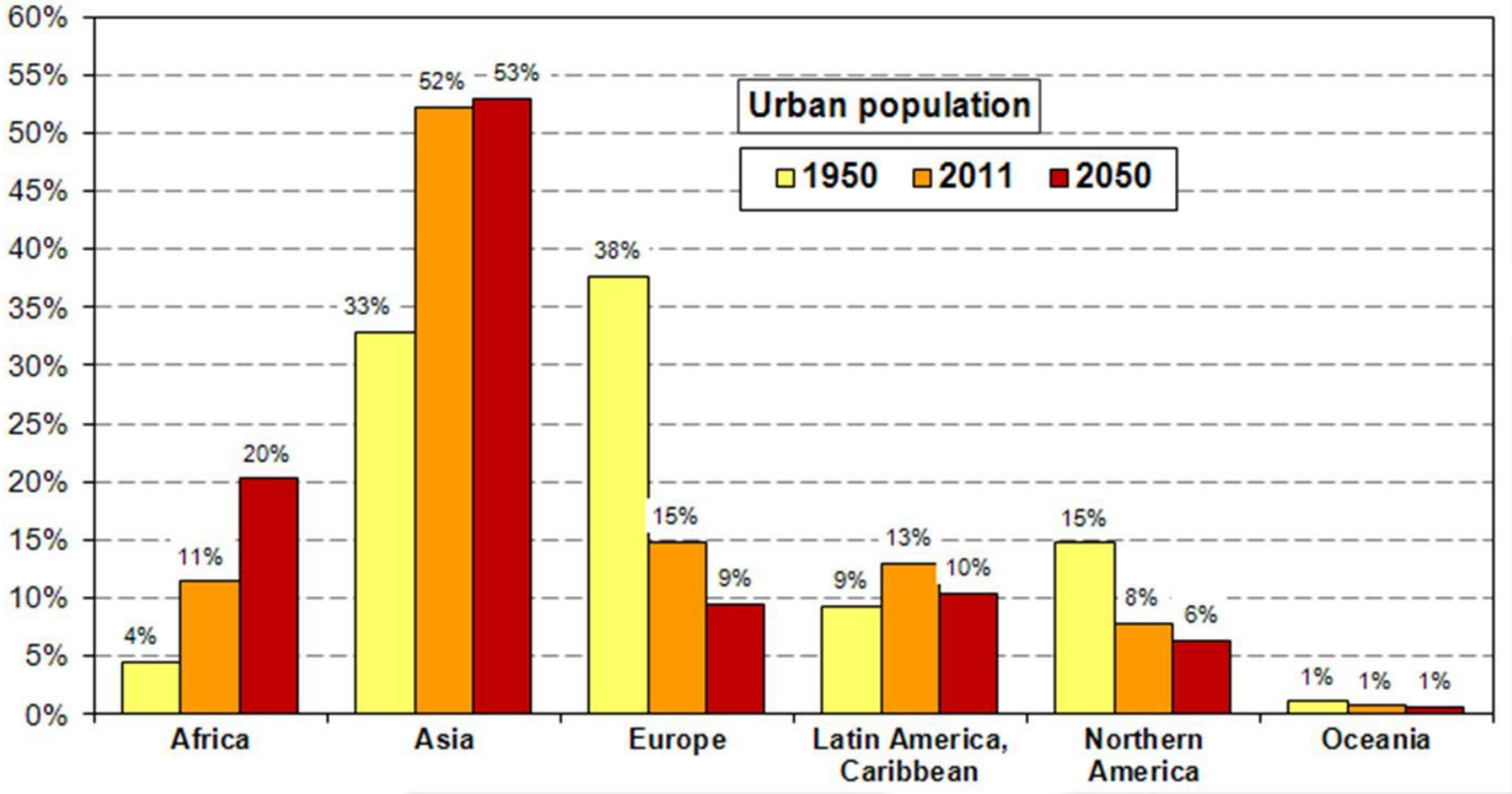
Urbanization

Distribution of the world urban population by major area



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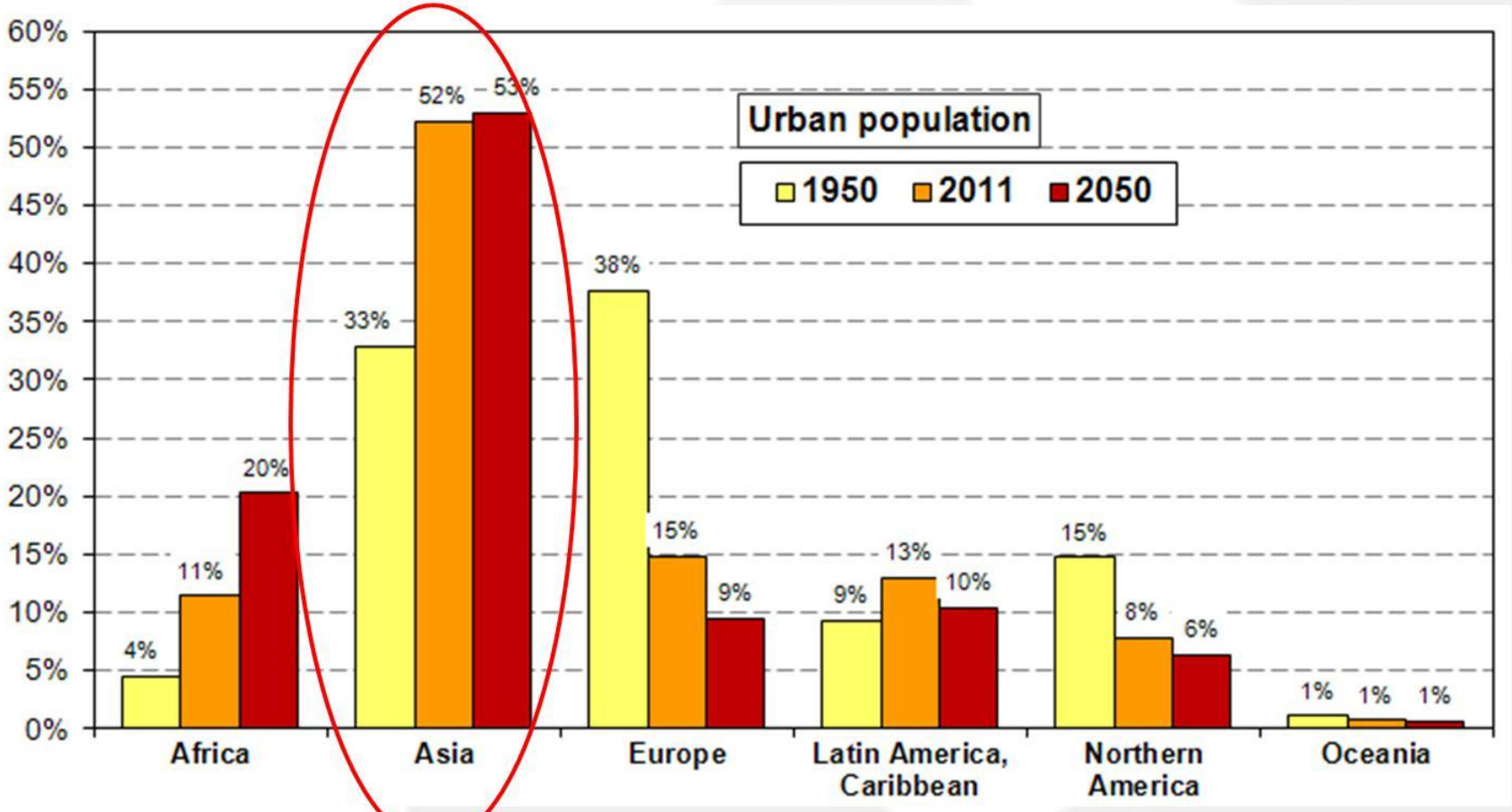

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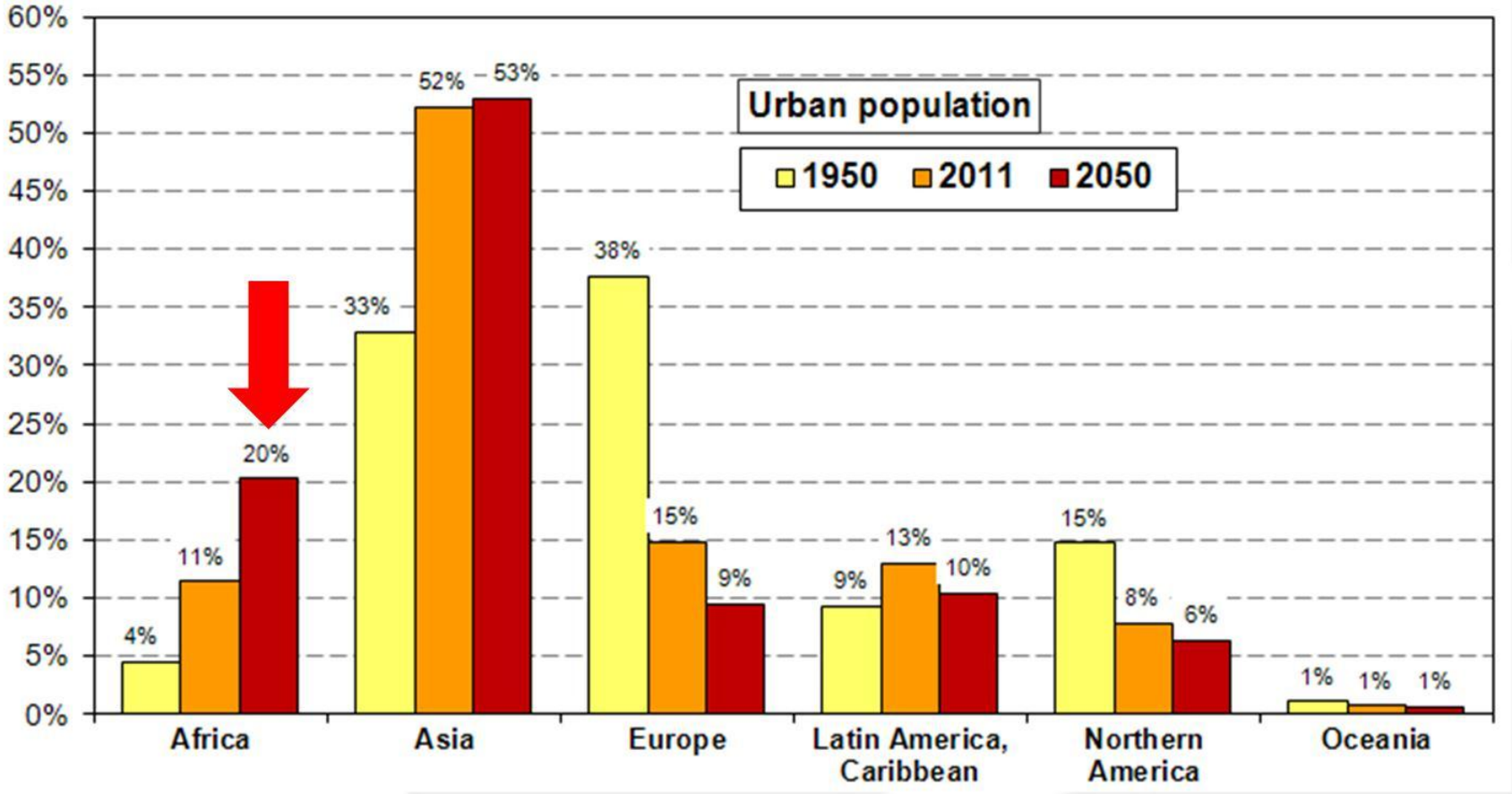

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Role of Modules

Reduce cost of luminaire designs

=> Increase volumes

=> Reduce differentiation

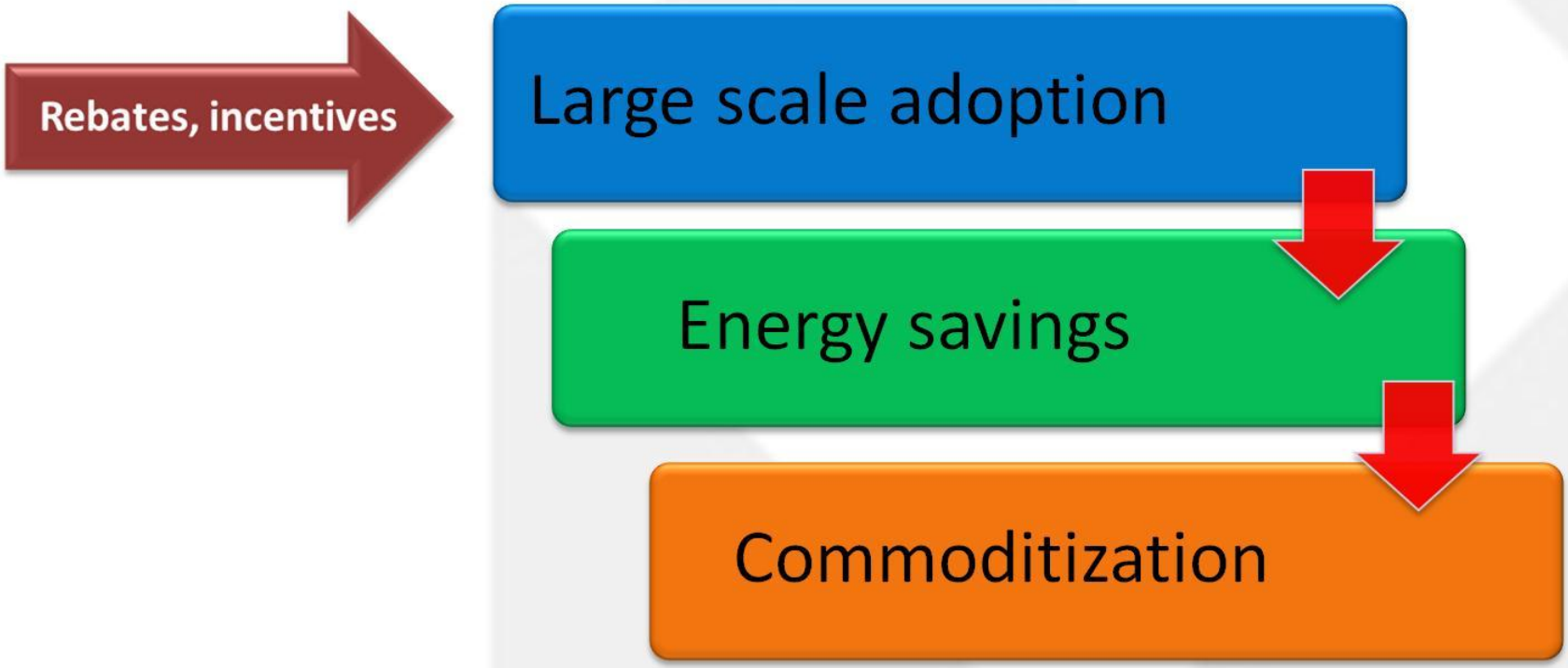
=> Commoditization

Also enable integrating controls

=>Energy Savings

Commoditization

Government policies push for commoditization



Bigger picture

- ✓ Commoditization of LED Lighting products
- ✓ Industry consolidation to increase scale
- ✓ Increasing use of controls for better energy efficiencies

Thank you

Questions?

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