

# Connected Lighting System Value - Agenda

## Mega-Trends

- Digitalization
- Adoption Life Cycle

## Implications

- Feasible vs Desirable

## Solutions

- Starting with the end in mind

# 1<sup>st</sup> Mega Trend - Digitalization

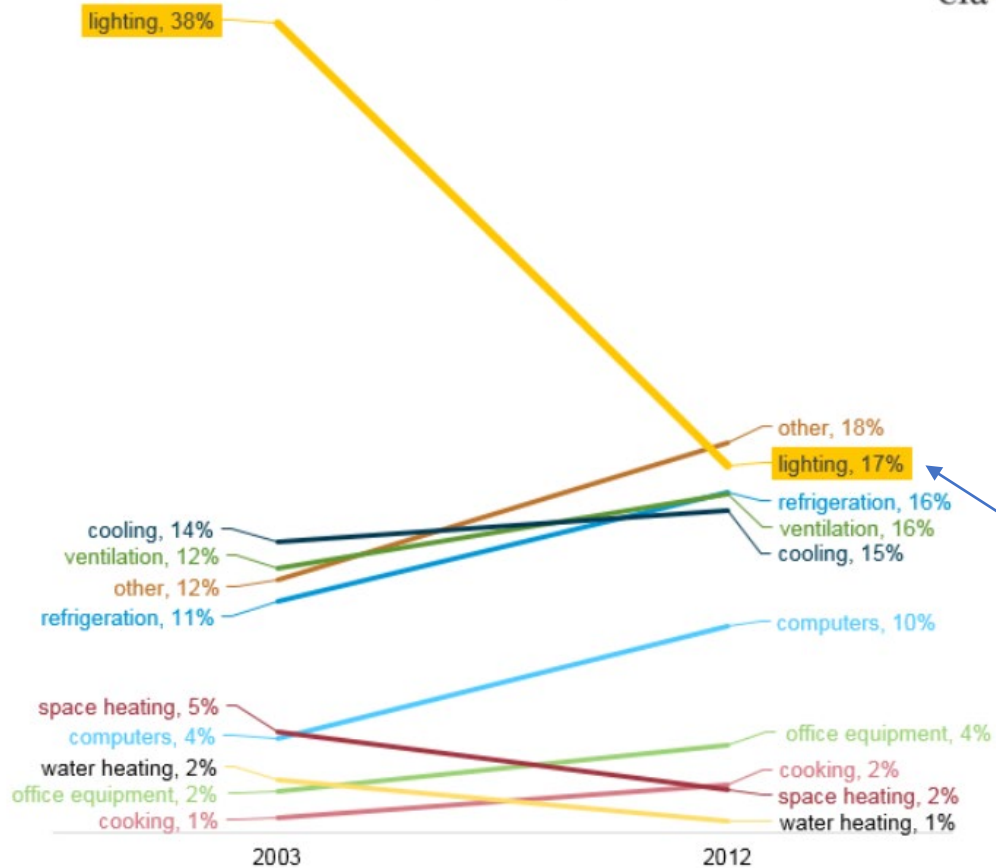
1. Digitalization – when lighting became digitalized (LED)
2. Deception – Slow initial growth – 25, 50, 75 LpW, expensive
3. Disruptive – 100,125,150,175 LpW; inexpensive; CL, IoT
4. Demonetization – more and more cost taken out of products
5. Dematerialization – products reduced in size and/or removed
6. Democratization – more people have access to it (5,000+ OEM's)

*“Today, exponential technology is not just putting linear companies out of business, it’s also putting linear industries out of business.”*

*Reference – “Bold” - authors Diamandis & Kotler*

# Lighting EE Success

Figure 4: In the commercial sector, lighting is no longer the largest end use as a share of total electricity consumption



## Wattage decline – 2x4 Troffer

1980	– 4-40wT12/Magnetic	-	192 watts
1990	– 4-34wT12/ES Magnetic	-	154 watts
1995	– 4-32wT8/SP Electronic	-	112 watts
2000	– 3-28wT8/MP Electronic	-	88 watts
2005	– 2-32wT8/HP Electronic/Rfltr	-	76 watts
2015	– LED fixture/kit	-	50 watts
2019	– LED fixture/kit/TLEDs	-	25-40 watts

As of 2019 – lighting share has further dropped to 9-11%.

Without Connected Lighting

Table D.2 LED Lamp and Luminaire Price Projections Application Submarket (\$/klm)<sup>54</sup>

Application Submarkets		2017	2020	2025	2030	2035
LED Lamps	General Purpose Lamps	12	4	3	3	3
	Downlighting - Large	19	15	14	13	13
	Downlight/Track - Small	35	13	10	9	9
	Track Lighting - Large	20	15	14	13	13
	Linear Fixture - <4ft	13	7	4	4	4
	Linear Fixture - 4ft	9	5	4	4	4
	Linear Fixture - >4ft	11	6	4	4	4
	Low and High Bay	24	19	15	14	14
	Decorative	27	8	6	6	5
	Area and Roadway	18	14	12	11	11
	Parking Lot	18	16	15	14	14
	Garage	16	13	12	11	11
	Building Exterior	22	17	14	13	11
	LED Luminaires	General Purpose Luminaires	59	40	26	20
Downlight/Track - Large		59	40	26	20	16
Downlight/Track - Small		75	50	29	20	16
Linear Fixture - <4ft		36	28 = \$112	24	23	22
Linear Fixture - 4ft		39	27	21	20	19
Linear Fixture - >4ft		52	30	22	20	18
Low and High Bay		26	21	17	16	15
Decorative		254	175	132	114	103
Area and Roadway		44	31	22	17	14
Parking Lot		45	28	17	13	10
Garage		49	30	17	12	10
Building Exterior		52	33	23	19	16

\$/klm =  
Price per  
1000  
lumens

# Demonetization Stage - Cost Reduction

# Demonetization Stage – Luminaires

LED Fixture	Tier Level	Lumens	Watts	Color	Dimming	DLC	Channel	Price
2x2 Vol Troffer	1	3200	26	4000K	Yes	Std	Distribution	\$98.67
2x2 Vol Troffer	2	4700	40	4100K	Yes	Std	Distribution	\$58.50
2x2 Vol Troffer	3	4250	35	4000K	Yes	Premium	Retail	\$49.99
2x2 Vol Troffer	3	4250	35	4000K	Yes	Premium	Dist/Direct	\$25.40
2x2 Flat Panel	1	3200	30	4100K	Yes	Std	Distribution	\$52.50
2x2 Flat Panel	2	3600	36	4000K	Yes	Std	Distribution	\$42.25
2x2 Flat Panel	3	4400	40	4000K	Yes	Std	Dist/Direct	\$22.00
2x4 High Bay	1	21,100	165	4000K	Yes	Premium	Retail	\$169.41
2x4 High Bay	2	18,500	150	4000K	Yes	Premium	Distribution	\$104.99
2x4 High Bay	3	20,000	133	5000K	Yes	No	Distribution	\$124.99
2x4 High Bay	3	22,600	165	5000K	Yes	Premium	Distribution	\$107.00
UFO High Bay	1	26,500	182	5000K	Yes	Premium	Distribution	\$239.00
UFO High Bay	2	19,500	150	5000K	Yes	Premium	Distribution	\$125.71
UFO High Bay	3	25,800	185	5000K	Yes	Std	Dist/Direct	\$87.37



Photo of \$22.00 Flat Panel from previous slide  
*Good enough....*

At Hong Kong “Light Fair”  
Oct 2019:

- New Flat Panel back lit technology
- Shown by 100’s of OEM’s
- Pricing so much lower that the USA reporter “as a service to the industry” would not publish it....

# DLC V5.0 – less focus on energy savings

## DLC Premium Efficacy V4.4 vs. V5.0

General Application	V4.4 Premium	V5.0 Premium	Change vs. V4.4	
Indoor: Troffer	125	125	0	Glare performance requirements apply
Indoor: Linear Ambient	130	130	0	
Indoor: Low-Bay	130	130	0	
Indoor: High-Bay	130	135	+5	
Indoor: Case Lighting	125	110	-15	
Indoor: Interior Directional	90	95	+5	
Outdoor: Low Output	110	120	+10	
Outdoor: Mid Output	115	120	+5	
Outdoor: High Output	120	120	0	
Outdoor: Very High Output	120	120	0	

+ 15 lpW over V5.0 Standard

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# LpW continues to Disrupt

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## Very High Efficiency

- 9.5 watts
- 1800 Lumens
- 190 LPW

## Features

- Double End Bypass
- 50,000 Hours Life
- 5 Year warranty
- Rated for enclosed

## Return on Investment

- 66% Energy Savings vs. 32w Fluorescent
- 30% Energy Savings vs. 13.5w Type B

### 32w T8 Fluorescent

- $(32w \times .88 \text{ BF}) - 9.5w = 18.7 \text{ watts}$
- $18.7watts \times .10 \text{ KWH} \times 50,000 \text{ hrs} = \$93.50$

### 13.5 TLED

- $13.5w - 9.5w = 4watts$
- $4watts \times .10 \text{ KWH} \times 50,000 \text{ hrs} = \$20.00$



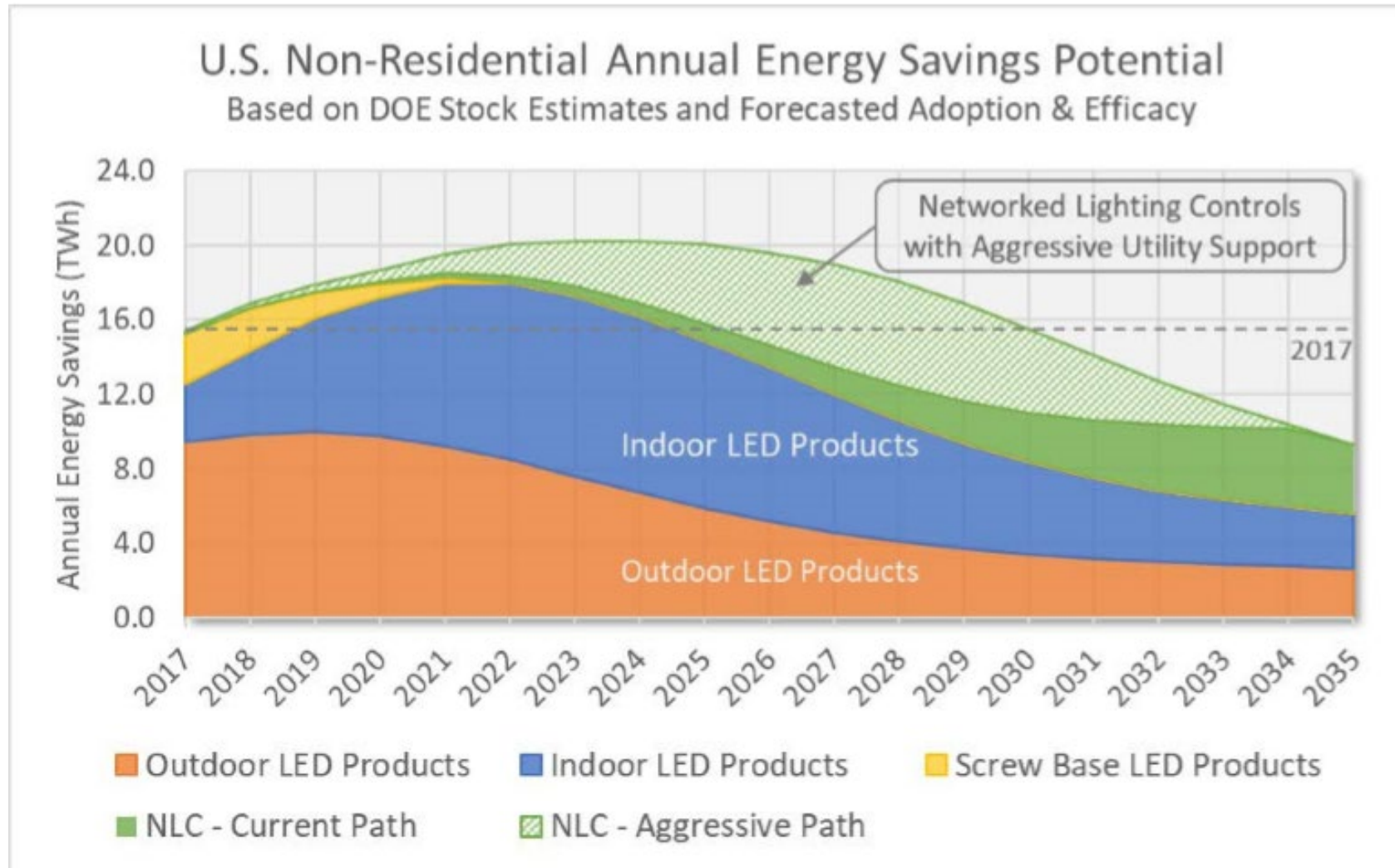
# DLC's Challenges with CL Systems

Table E1. Summary of Energy Savings – All Site Applications and Average

<b>Site</b>	<b>FL to LED Only</b>	<b>Occupancy Control</b>	<b>Daylighting Control</b>	<b>High-End Trim / Task Tuning</b>	<b>Total: LED with All Controls</b>
1 – Brewery	50%	10%	6%	negligible	66%
2 – Office	64%	-2%	5%	included in FL to LED	67%
3 – Med Office	29%	24%	9%	included in FL to LED	62%
4 – Retail (Grocery)	30%	3%	~	33%	66%
5 – Office	43%	-1%	4%	24%	70%
<b>Average</b>	<b>43%</b>	<b>7%</b>	<b>6%</b>	<b>29%</b>	<b>66%</b>

Provided by PNNL – Pacific NW National Labs – MAY 2018

# DLC's Path to Maximum Energy Savings



**Figure 4: Non-residential (C&I) annual energy savings potential from LED & networked lighting controls, assuming aggressive utility support**

# DLC's Challenges with CL Systems

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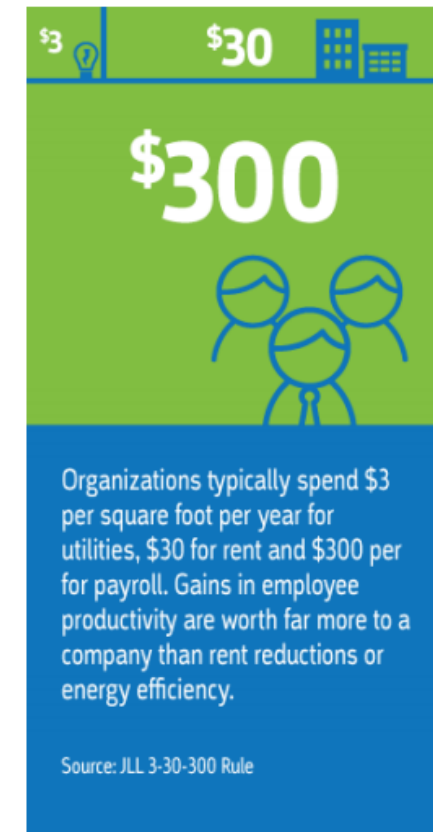
C&I Networked Lighting Controls

September 17, 2019



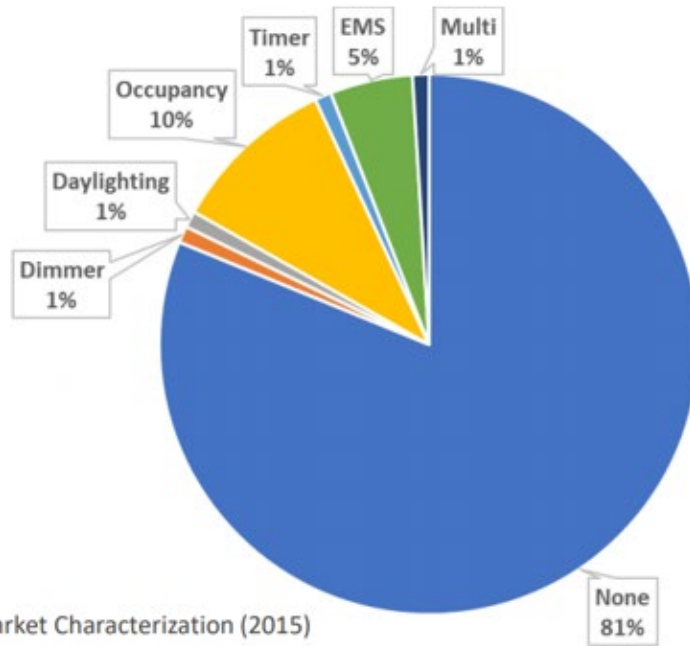
## Why Intelligent Lighting Matters

- Lighting controls as an energy-savings option have decades of low adoption
  - Poor performance
  - Low perceived value (especially once lighting is LED)
  - Complexity
- Energy alone isn't a sufficient driver
  - 3/30/300 Rule
- Intelligent lighting capabilities can unlock energy savings potential
  - Increase value proposition
  - Create "bottom-up" demand at the customer level



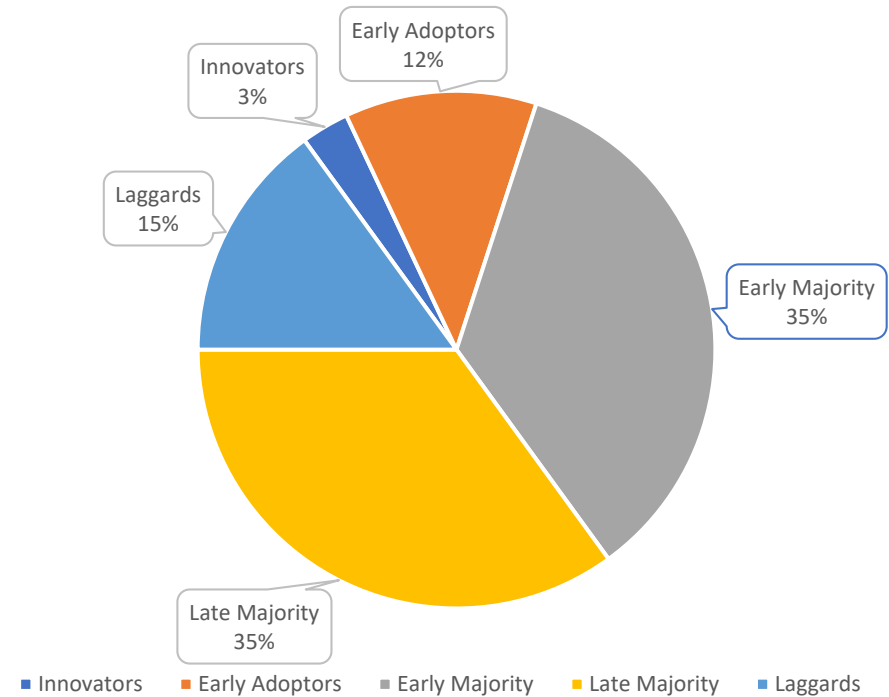
# Adoption Groups and Rates

## Historical C&I Lighting Control Adoption Rates



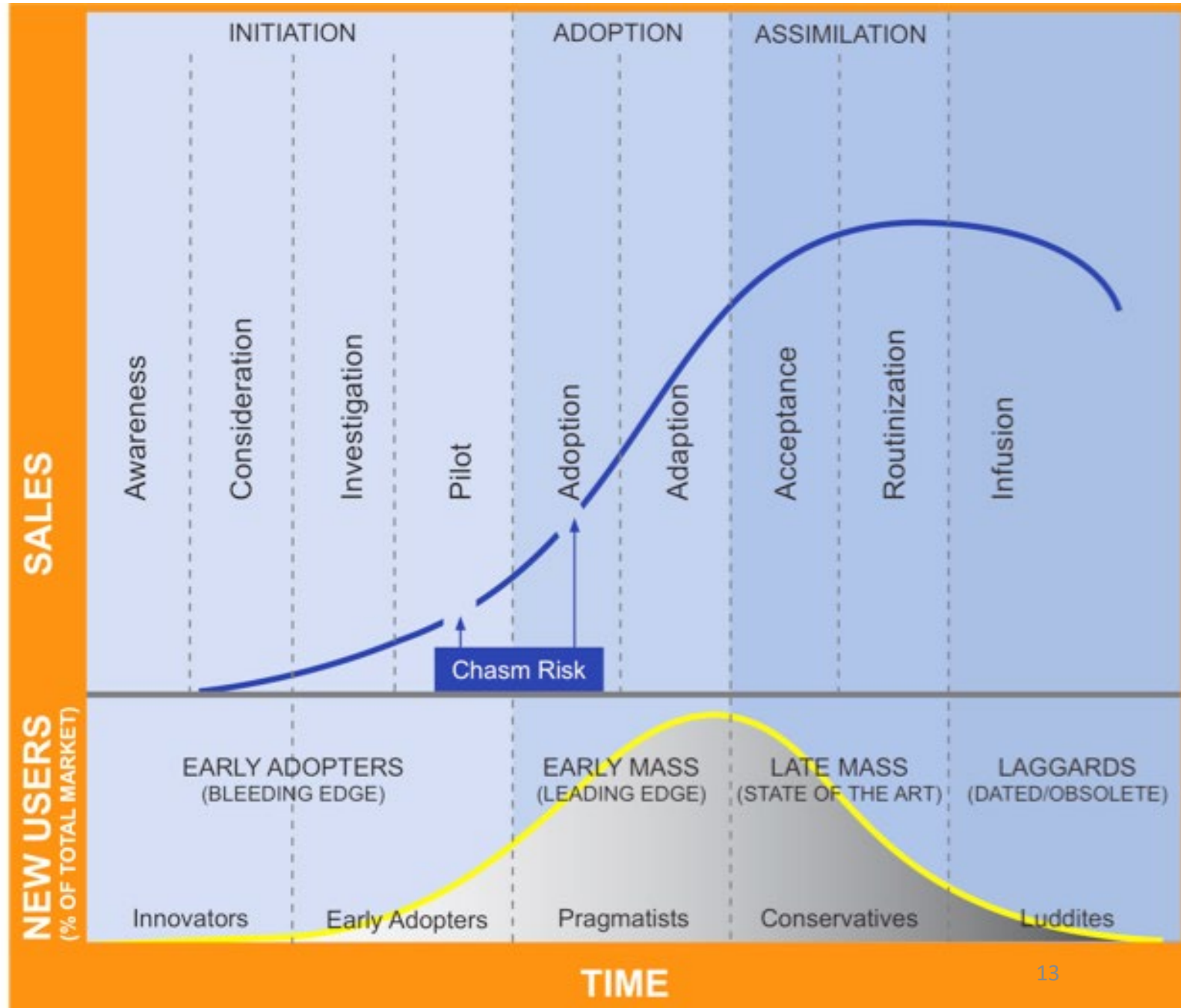
Source: DOE U.S. Lighting Market Characterization (2015)

## Technology Adoption Groups



# 2<sup>nd</sup> Mega Trend

## The Technology Adoption Life Cycle



# Technology Adoption Life Cycle

- 5 distinct Groups of Buyers – *regardless of technology*
  - Innovators - pursue all new technology aggressively
  - Early Adopters - not techno geeks, buy using intuition and vision
  - Early Majority - driven by practicality; peer reviews, value of a competitive advantage; comfortable with technology, *motivated by ROI*
  - Late majority – similar to Early Majority, more uncomfortable with technology; buy only from large, established vendors
  - Laggards – not interested, at all, in any new technology
  - *The order of adoption is always the same*
- Successful adoption requires smooth transition between groups
- Delay in transitions constitute a widening chasm between groups

Geoffrey Moore – Crossing the Chasm -1991

Geoffrey Moore – Zone to Win - 2015

# Signify (Philips) acquires Cooper Lighting



- Signify CEO commented on purchase *“Our strategy calls for us to make the LED conversion first, next we move to connected lighting and third we see light as a language. The North America market is the most progressive for our strategy.”*



# Successful Disruptive Technology Adoption

- iPad
  - Launched 2009
  - 300,000 units sold 1<sup>st</sup> day to Apple enthusiasts (Innovators)
  - Visionary C Suites used as personal digital assistant (Early Adopters)
  - Forcing CIO's to figure out how incorporate them
  - Corporate Sales Executives used for presentations, then their sales team
  - Adoption by teenagers / young adults for social and educational interaction
  - With Facebook came grandparents (Laggards)
  - All by 2014

# Struggling Disruptive Technology

- Electric cars
  - 1980's – Innovators retrofitting ICE cars with electric motors
  - 1999 – Chevrolet introduced the Volt
  - 2013 – Tesla announces 1<sup>st</sup> model
  - 2019 – still <2% of US autos are electric
  - So 98% of car buyers are still saying no
  - Question – when did you / are you / will you buy one?
  - How you answer that question tells a lot about where you are in Life Cycle of Disruptive Technology Adoption

# 2 Types of Technology

- Continuous, sustaining innovations - Lighting up to 2005
  - PG17, T12, T10, T8, T5, T5HO
  - 40w T12, 34w T12, 32wT8, 30wT8, 28wT8, 25wT8
  - 25 LpW to 100 LpW in 70 years
  - Magnetic, ES Magnetic, Electronic
- Discontinuous, disruptive innovations - Lighting 2005 – Current
  - 25 LpW to 200+LpW in 10 years
  - Tunable colors
  - Connectability (BMS, IoT)
  - Data transmission (LiFi)

# Connected Lighting – Largest US project



- Implementation 2016-2019
- 1854 Stores / 2 million LED fixtures / 24M Smartphone users
- VLC (Visual Light Communication) / Bluetooth (Radio wave) / IPS (Indoor Positioning System)
- As of April 2019 Target was only using the Bluetooth system
- Value to customer is store mapping, product location, sale items
- *Completed project is 0.2% of US C&I building stock*

# 2018 Forecast for Linear SSL Adoption Rates

Table 4.24 Linear Fixture Submarket Installed Penetration for the Current SSL Path Scenario

	Technology	2017	2020	2025	2030	2035
<b>Commercial</b>	T12	9%	4%	<1%	<1%	<1%
	T8	72%	60%	27%	9%	5%
	T5	7%	9%	9%	6%	4%
	LED lamp	6%	13%	25%	26%	17%
	LED lamp connected	<1%	<1%	2%	5%	8%
	LED luminaire	6%	14%	33%	44%	46%
	LED luminaire connected	<1%	<1%	3%	9%	20%
<b>Residential</b>	T12	45%	35%	21%	11%	7%
	T8	44%	42%	31%	19%	12%
	T5	4%	4%	4%	3%	3%
	LED lamp	3%	8%	20%	31%	35%
	LED lamp connected	<1%	<1%	<1%	2%	4%
	LED luminaire	5%	11%	22%	31%	34%
	LED luminaire connected	<1%	<1%	<1%	3%	6%
<b>Industrial</b>	T12	13%	5%	<1%	<1%	<1%
	T8	52%	43%	20%	7%	4%
	T5	23%	23%	15%	8%	6%
	LED lamp	5%	14%	26%	25%	15%
	LED lamp connected	<1%	<1%	1%	4%	6%
	LED luminaire	7%	14%	33%	45%	48%
	LED luminaire connected	<1%	<1%	4%	11%	22%

# Adoption Challenges – DLC’s NLC list

- As of 9-2019 – 49 NLC systems – 29 companies
- 38 systems list “Proprietary” as part or all of their “Compliance with Standards”
- 41 systems list “No” under “Cybersecurity standard(s) met”
- LLC – Luminaire Level Lighting Control – not available in 25 systems
- 42 systems list “No” for Luminaires with PoE
- Over 100 specs to be evaluated.

# Adoption Challenges

- Connected Lighting / IoT Lighting does not easily fit into existing channel model of OEM/Rep/Distributor/Contractor / End User
- CL disruptive to both existing lighting buyers (MRO) and IT
- Few lighting OEM's understand disruptive technology process
- *<15% of C&I end users respond to education / features / benefits as main buying decision*



# Implications

- Non CL adoption continues to accelerate at CL's expense
- Mass adoption is user value based, not product feature based
- Tunable lighting remains a niche product due to poor baselines in majority of sites
- Lack of lighting industry standards (security, IoT platforms, health) for CL continues to impede adoption - *UL is to electrical as INFOSEC is to IT*
- LiFi value increases with RF data challenges, 5G capabilities; in test/pilot stages with several major lighting OEM's and wireless carriers

# Solutions

- Measurable - Google has a “MoonShot” group – every innovation *must* be measurable, if not, it is rejected, no matter how promising the technology.
- Auditable – Currently, every light source, in every space, in every existing building can be audited for an energy upgrade. We cannot for non-energy benefits. No audit – no ROI.
- Standards – Industry wide standards for non-energy features and benefits will enable accurate audits. Doable? Not yet.
- Best Plan - Package lighting and HVAC controls – HVAC is auditable.

lighting  
**TRANSITIONS** 

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