U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Lighting Market Trends

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Navigant – A Guidehouse Company

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DOE LED Market Studies

Since 2002, Navigant has conducted many general illumination application and stock analyses for the U.S. Lighting R&D Program.

Lighting Market Characterization (LMC) (2002, 2012, 2017)

Adoption of LEDs in Common Lighting Applications (2008, 2011, 2013, 2015, 2017, 2020)

Energy Savings Forecast of SSL in General Illumination Applications (2003, 2006, 2010, 2012, 2014, 2016, 2019)

And Now…Agricultural Lighting

In 2017, DOE also started to characterize the agricultural lighting market.

Energy Savings Potential of SSL in Agricultural Applications (2017, 2020)

Discussion Overview

The lighting market is continuing to change rapidly due to LED technology, and today we will focus on 3 of our recently and soon-to-be published market reports that highlight the current and expected path of LED market adoption:

- **SSL Forecast Report**
  - Forecasted general illumination market changes between 2017-2035
- **LED Adoption Report**
  - 2018 snapshot of LED adoption and energy savings
- **Agricultural Lighting Report**
  - 2019 market characterization of horticultural and animal agricultural lighting

SSL Forecast (2017 – 2035)

What is the Forecast Report?

Since 2002, the SSL Forecast report has provided a comprehensive overview of the lighting market and analyzes:

The expected path of LED adoption within the U.S. and energy savings offered by LED products out to year 2035 in four sectors: residential buildings, commercial buildings, industrial buildings, and outdoor.

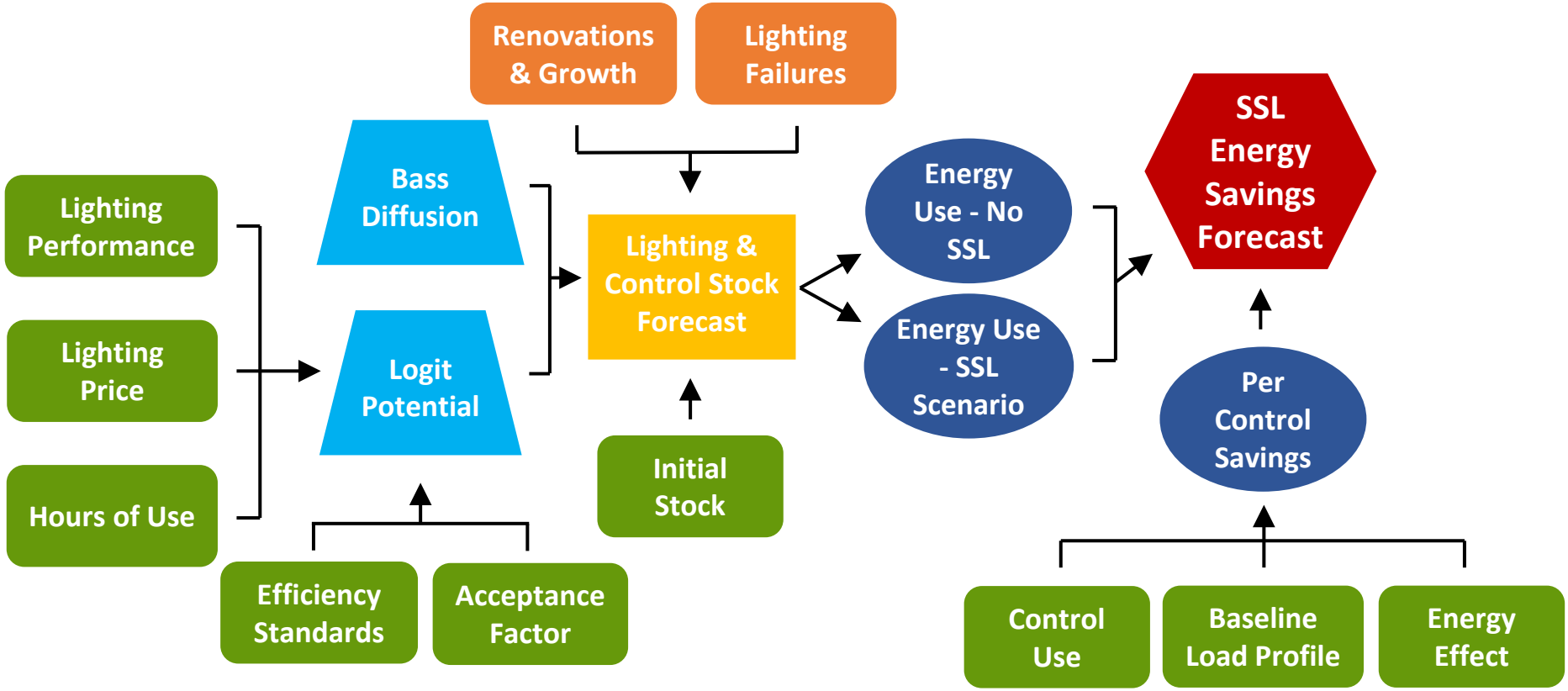
For the 2019 Forecast report, there were over 20 contributors and technical reviewers, spanning several stakeholder groups:

- Federal Agencies
- Federal Research Laboratories
- Utilities
- Commissions/Agencies/Authorities/Alliances
- Manufacturers/Trade Associations
- Industry Expert Consultants

Thank You!

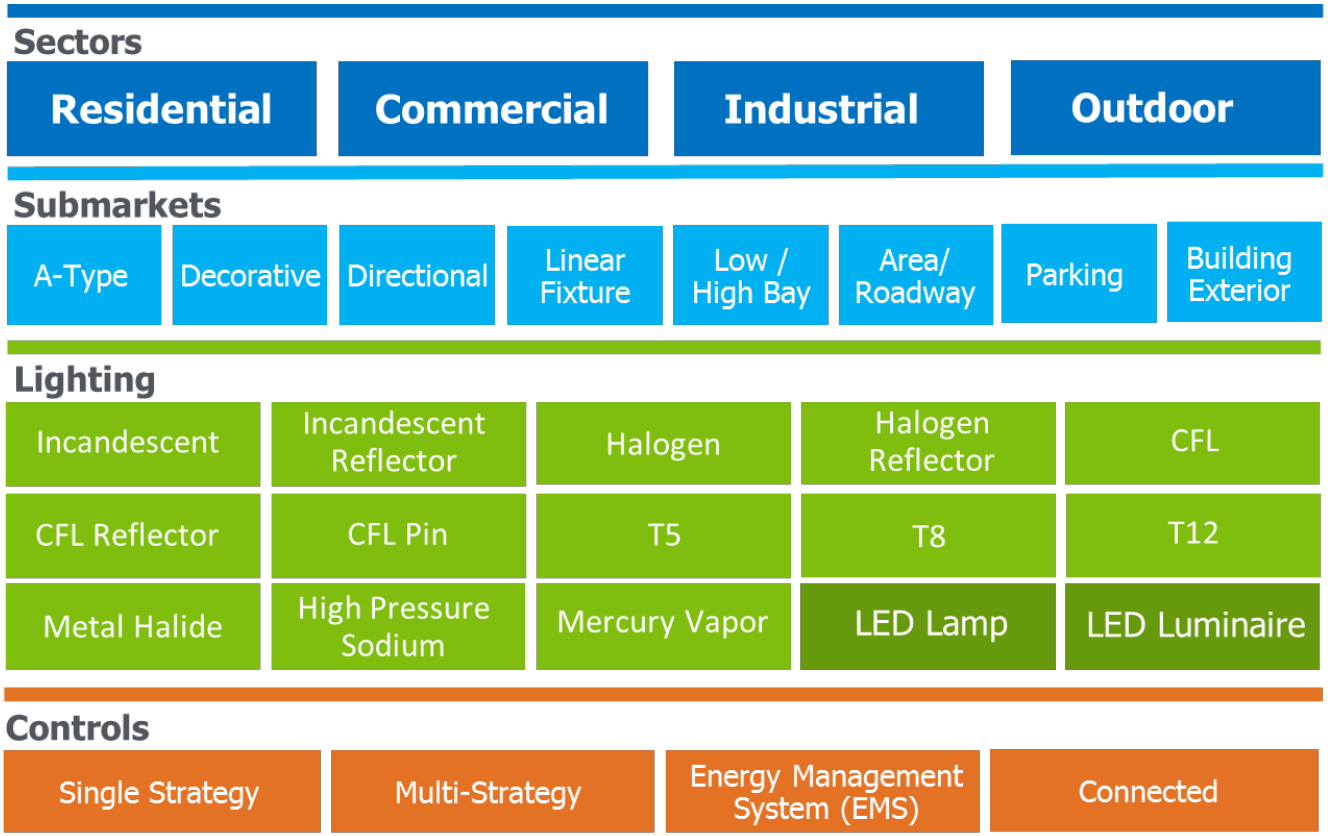
Overview of the SSL Forecast Methodology

The lighting market model is the engine behind the SSL Forecast report, and the major inputs, modules, and analytical flow are shown here:



Lighting Market Model Scope

The lighting market model forecasts adoption across these sectors, submarkets, lighting technologies, and control types.



4 Sectors

8 Submarkets

15 Lighting Technologies

4 Control Types

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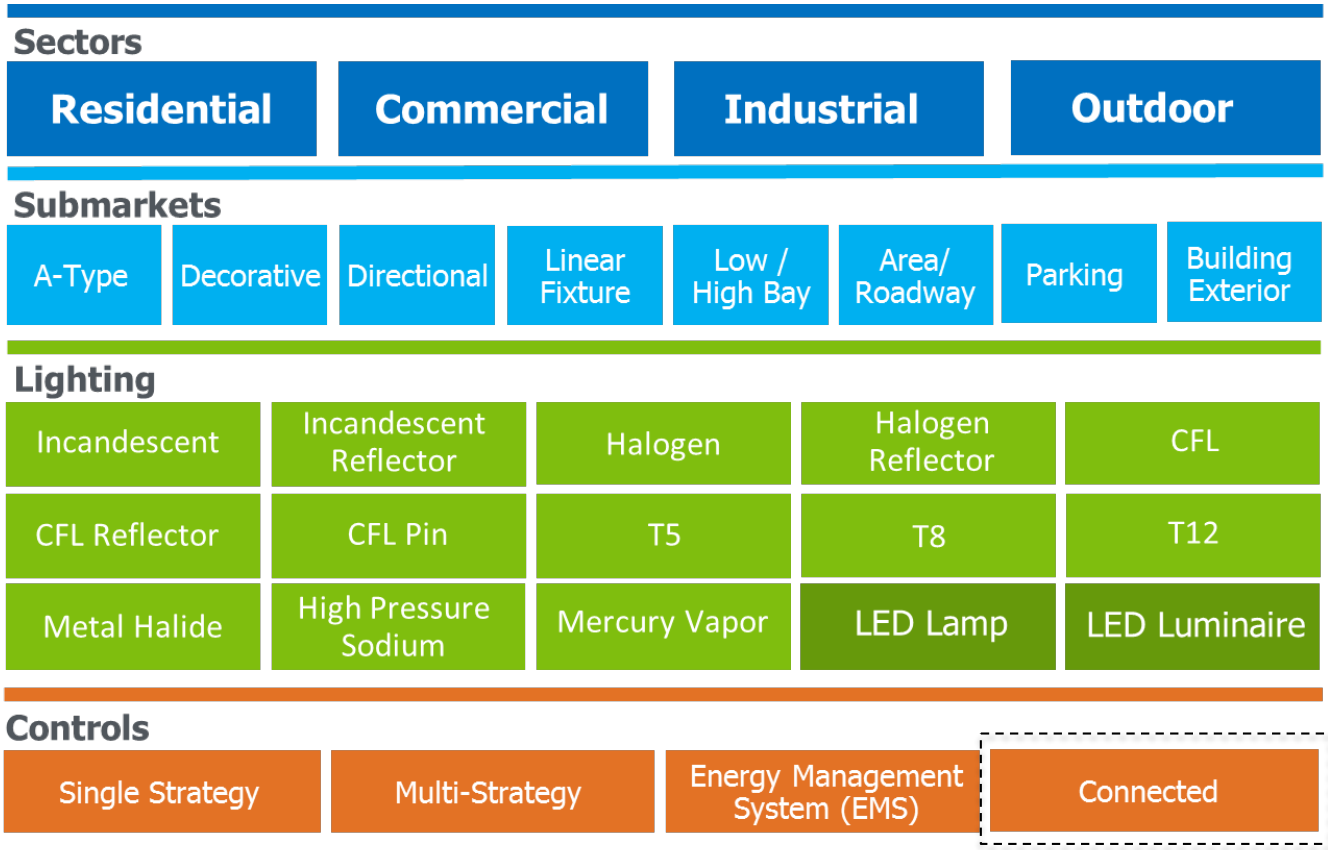


4 Sectors

8 Submarkets

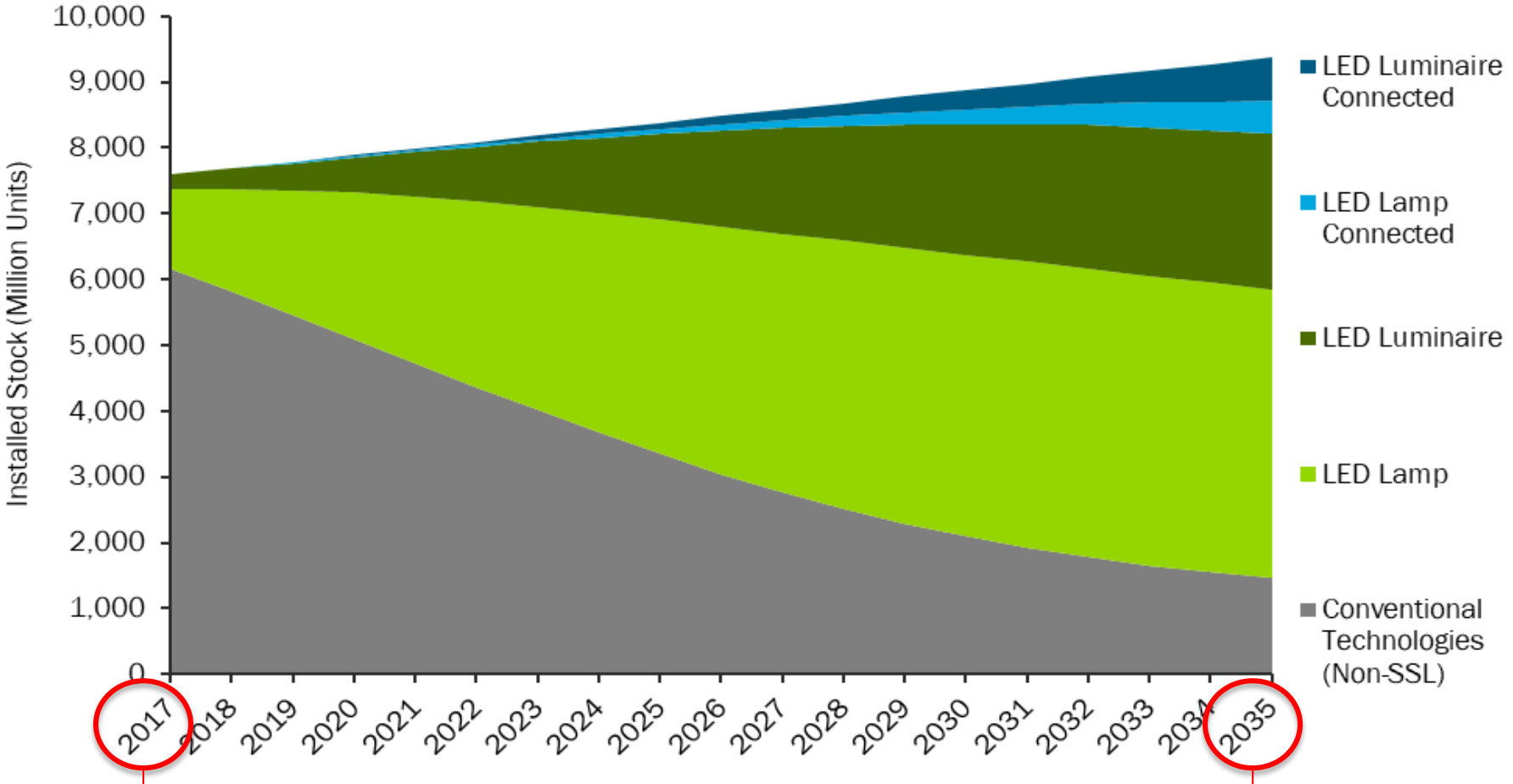
15 Lighting Technologies

4 Control Types

Connected lighting is defined as an LED-based lighting system with integrated sensors and controllers that are networked (either wired or wireless), enabling lighting products within the system to communicate and exchange data with other devices.

Installed Stock Forecast – Current Path

Given continued level of investment and effort, 2035 installed stock for LEDs is expected to rise such that 72% and 12% are non-connected and connected LEDs, respectively.

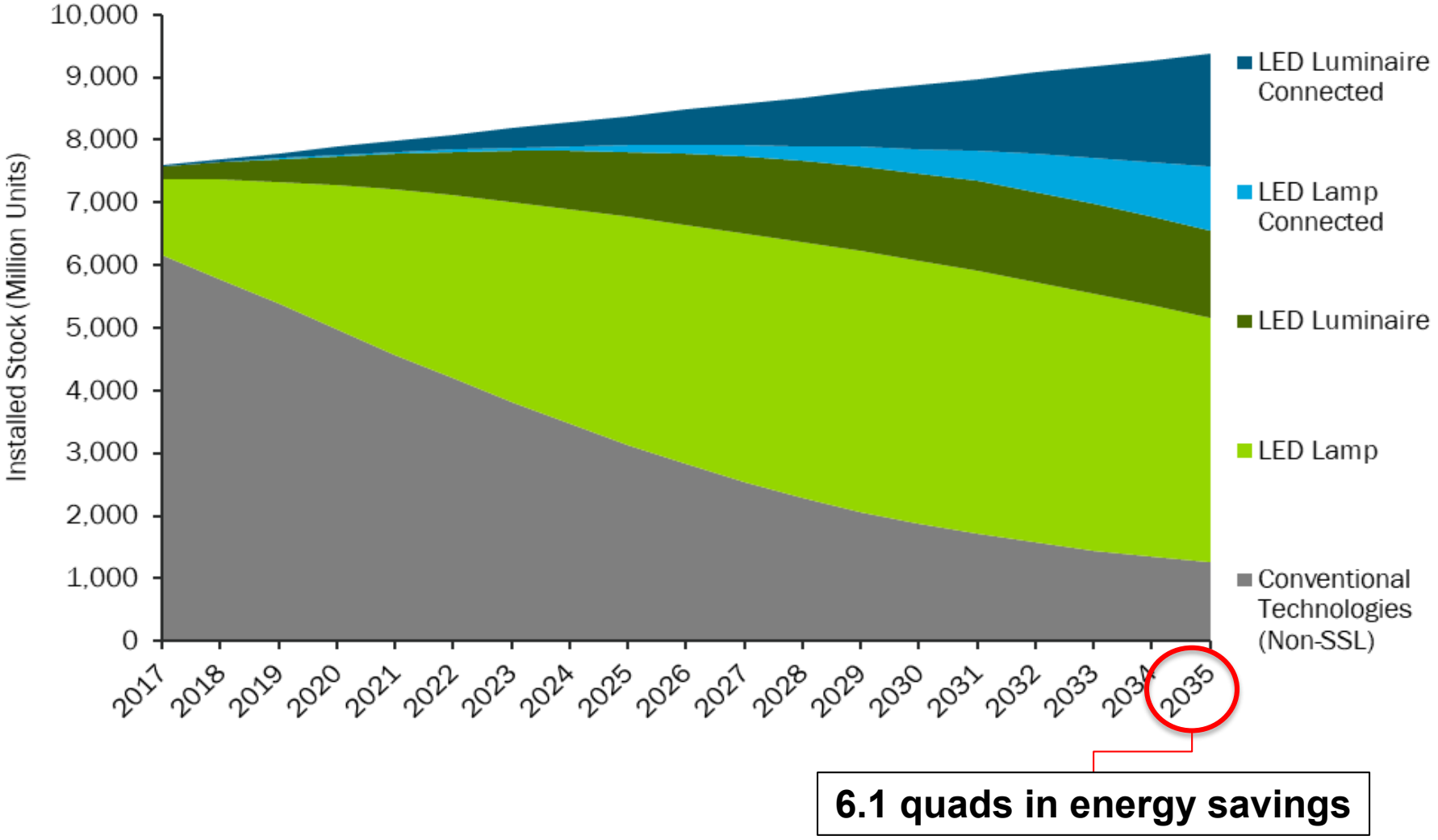


1.1 quads in energy savings

4.8 quads in energy savings

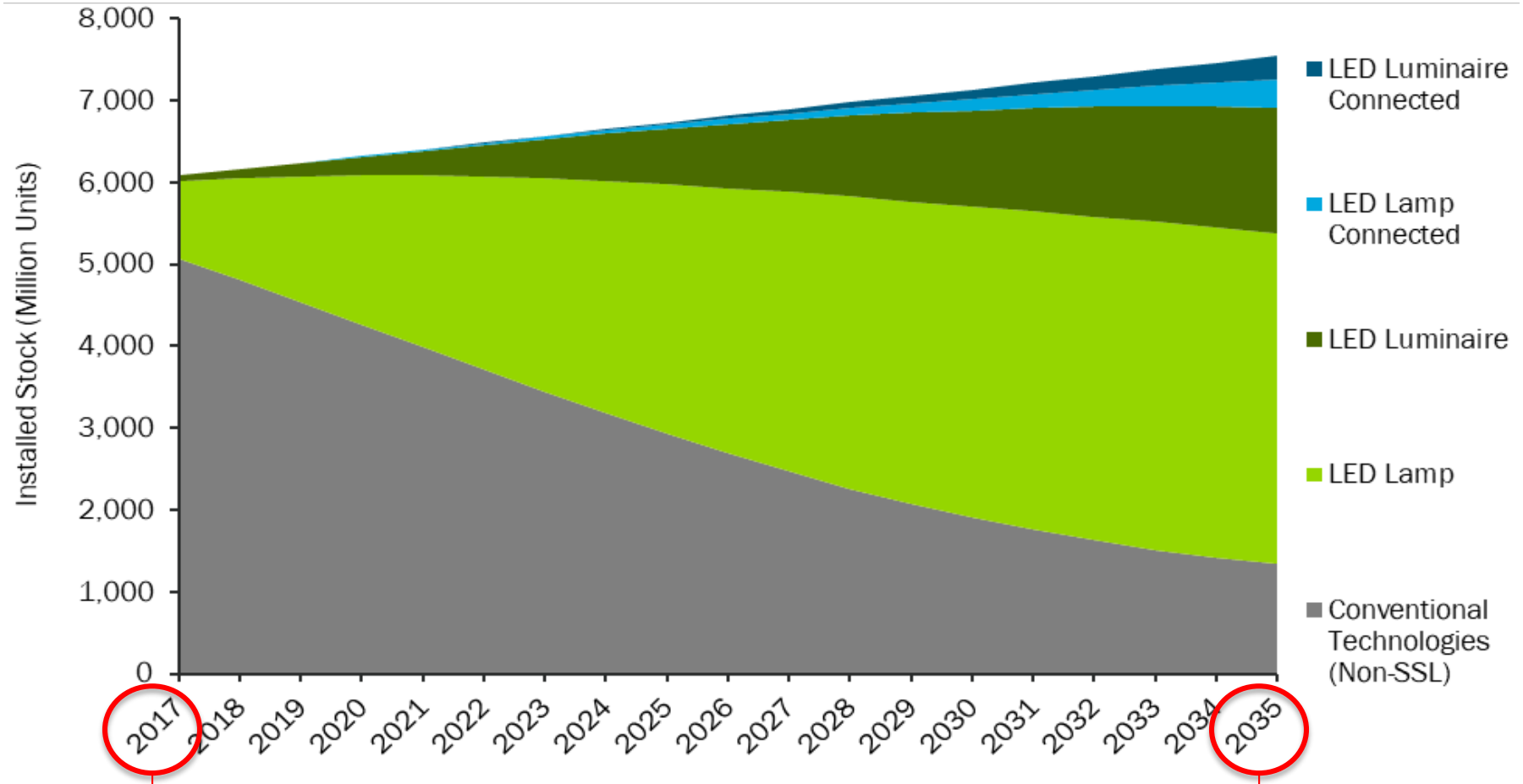
Installed Stock Forecast – Program Goals

Given accelerated adoption of connected lighting, LEDs are expected to rise such that 56% and 30% of installed stock in 2035 are non-connected and connected LEDs, respectively.



Installed Stock Forecast – Residential (Current SSL Path)

The sector with the largest stock, and it is expected that a constant decline in conventional technologies will occur throughout the forecast period, with overall LED penetration reaching 82% by 2035.

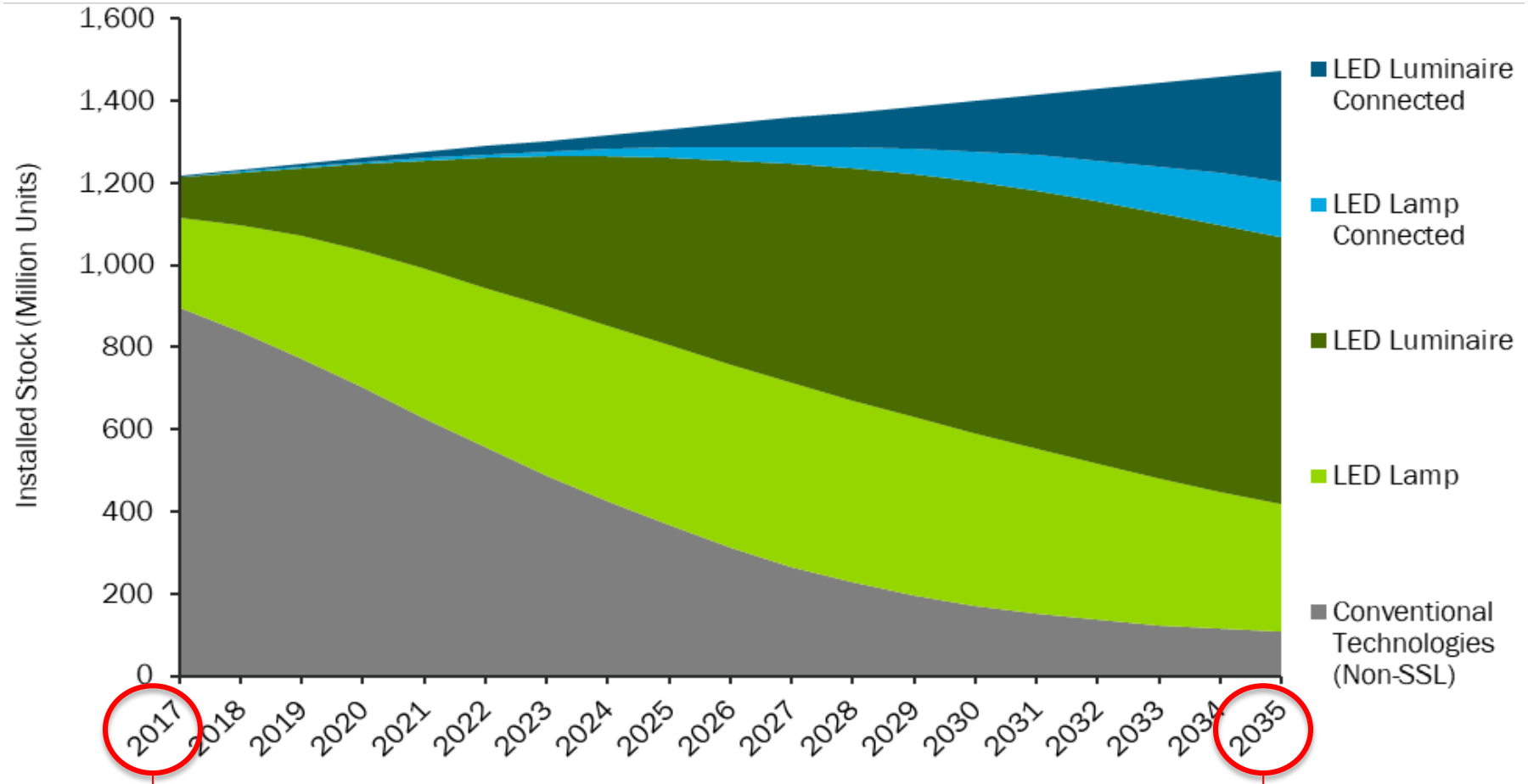


171 tBTU in energy savings

1,270 tBTU in energy savings

Installed Stock Forecast – Commercial (Current SSL Path)

In this sector, the stock of non-connected LED lighting peaks in 2029, at which point connected lighting increases in prevalence through the end of the forecast period to 28% by 2035.

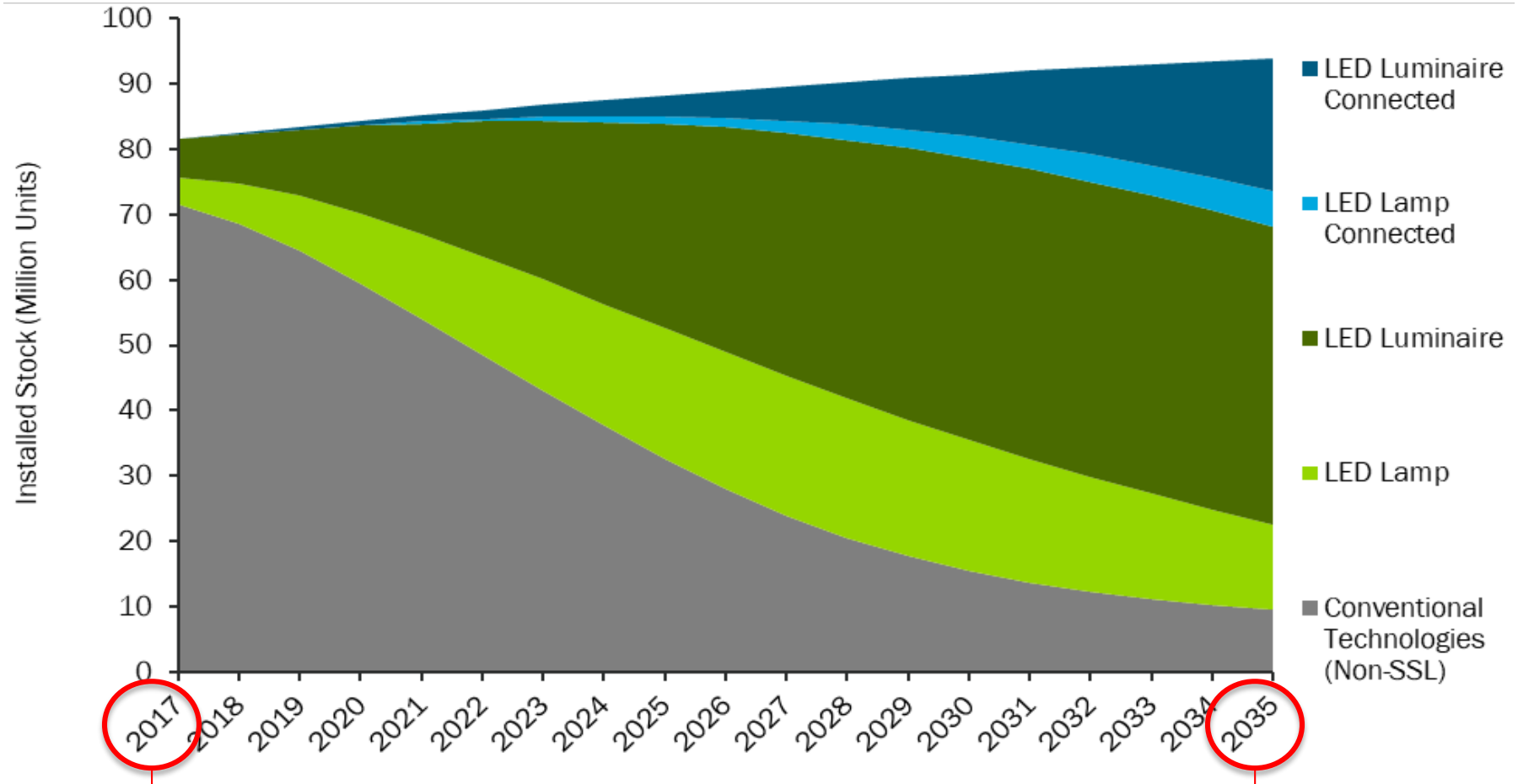


457 tBTU in energy savings

1,900 tBTU in energy savings

Installed Stock Forecast – Industrial (Current SSL Path)

Changes in technology mix are similar to those in the commercial sector, though the industrial sector has a far less significant impact on energy consumption due to the relatively small stock.

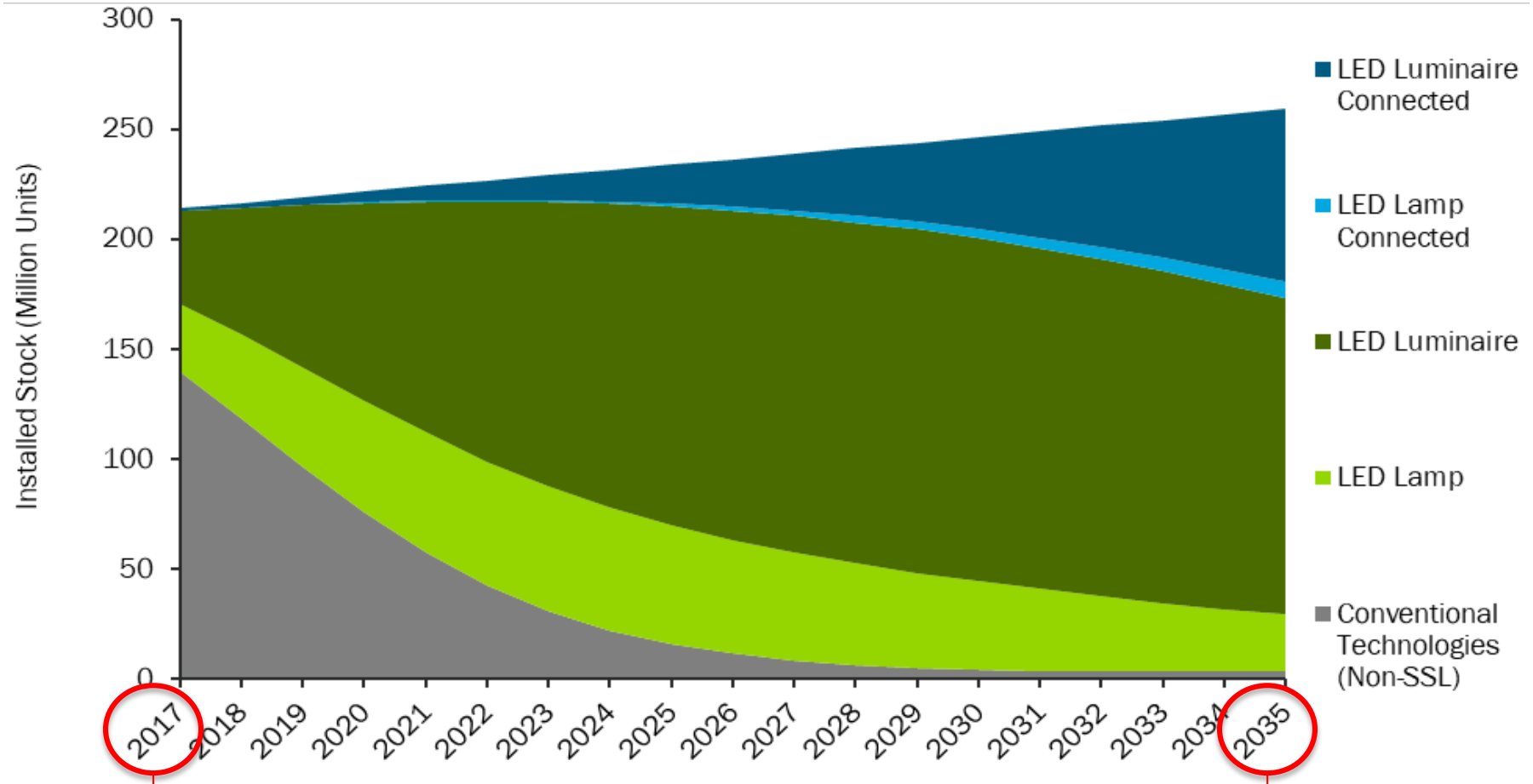


36 tBTU in energy savings

372 tBTU in energy savings

Installed Stock Forecast – Outdoor (Current SSL Path)

The outdoor sector has the highest installed percentage of LED and connected lighting of the four sectors analyzed, and nearly all installations are expected to be LEDs by 2035.

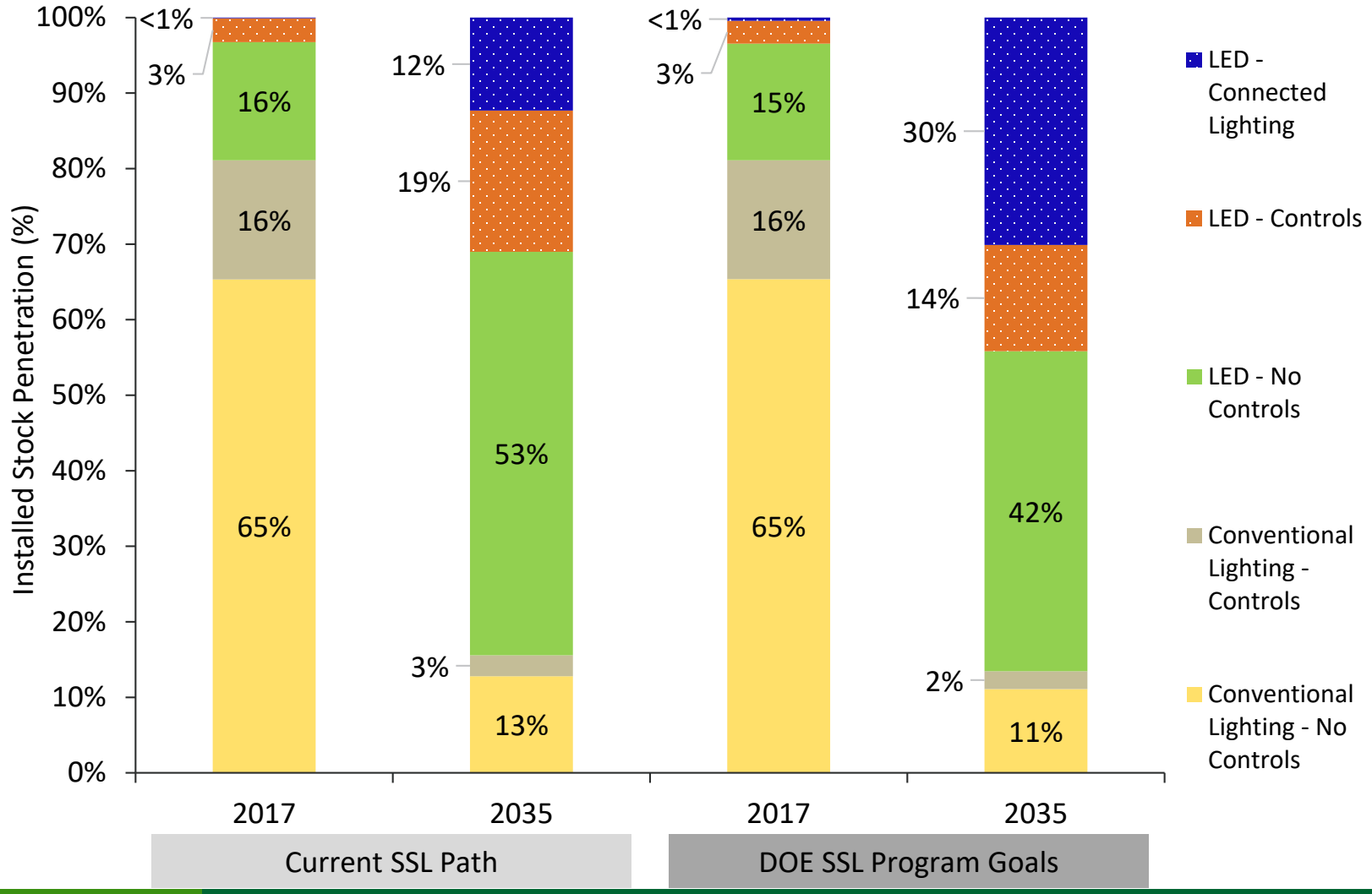


444 tBTU in energy savings

1,270 tBTU in energy savings

Installed Stock Forecast - Controls

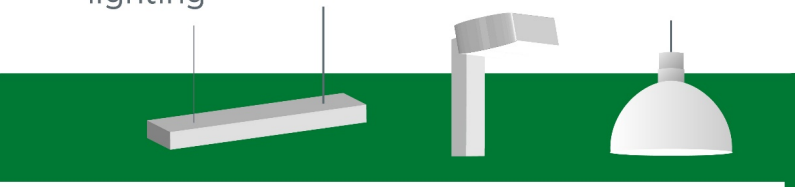
Both connected lighting and traditional control systems are expected to thrive. However, connected lighting represents the majority of the future savings from lighting controls.



Highest Impact Submarkets

Leading the charge: Commercial buildings

Most of the savings will be driven by linear fixtures, outdoor, and low and high bay lighting

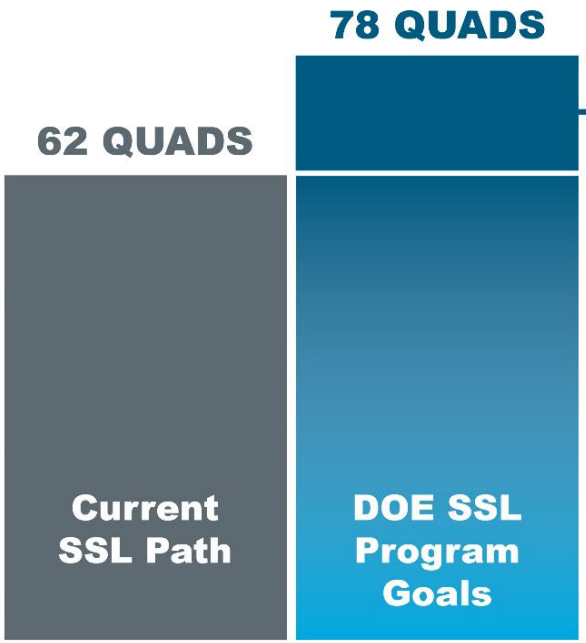


...applications with **high light output** and **long operating hours**

...where **controllability** and **networked capabilities** have the greatest value

	2017 Total Installations	2017 Energy Use	2035 SSL ENERGY USE: Current SSL Path	2035 SSL ENERGY USE: DOE SSL Program Goals
General Purpose	45%	11%	10%	13%
Directional	17%	7%	9%	10%
Decorative	17%	7%	5%	6%
Linear	14%	31%	37%	34%
Low/High Bay	1%	16%	14%	14%
Outdoor	<2%	24%	20%	20%
Other	3%	5%	3%	4%
TOTAL	7.6 Billion	5,970 tBTU	3,350 tBTU	2,040 tBTU

Cumulative Savings: 2017-2035



If DOE targets for efficiency and controls/ connected lighting are met, LEDs will enable an additional cumulative **16 quads** of energy savings through 2035.

The total cumulative energy savings of **78 quads** is equivalent to around **$890 billion** in avoided energy costs.

By 2035, LED lighting is expected to comprise 84% of all lighting installations (following the Current SSL Path), enabling 62 quads of cumulative energy savings between 2017 and 2035. This is equivalent to the annual production of over 1,000 typical U.S. power plants!

2018 LED Adoption

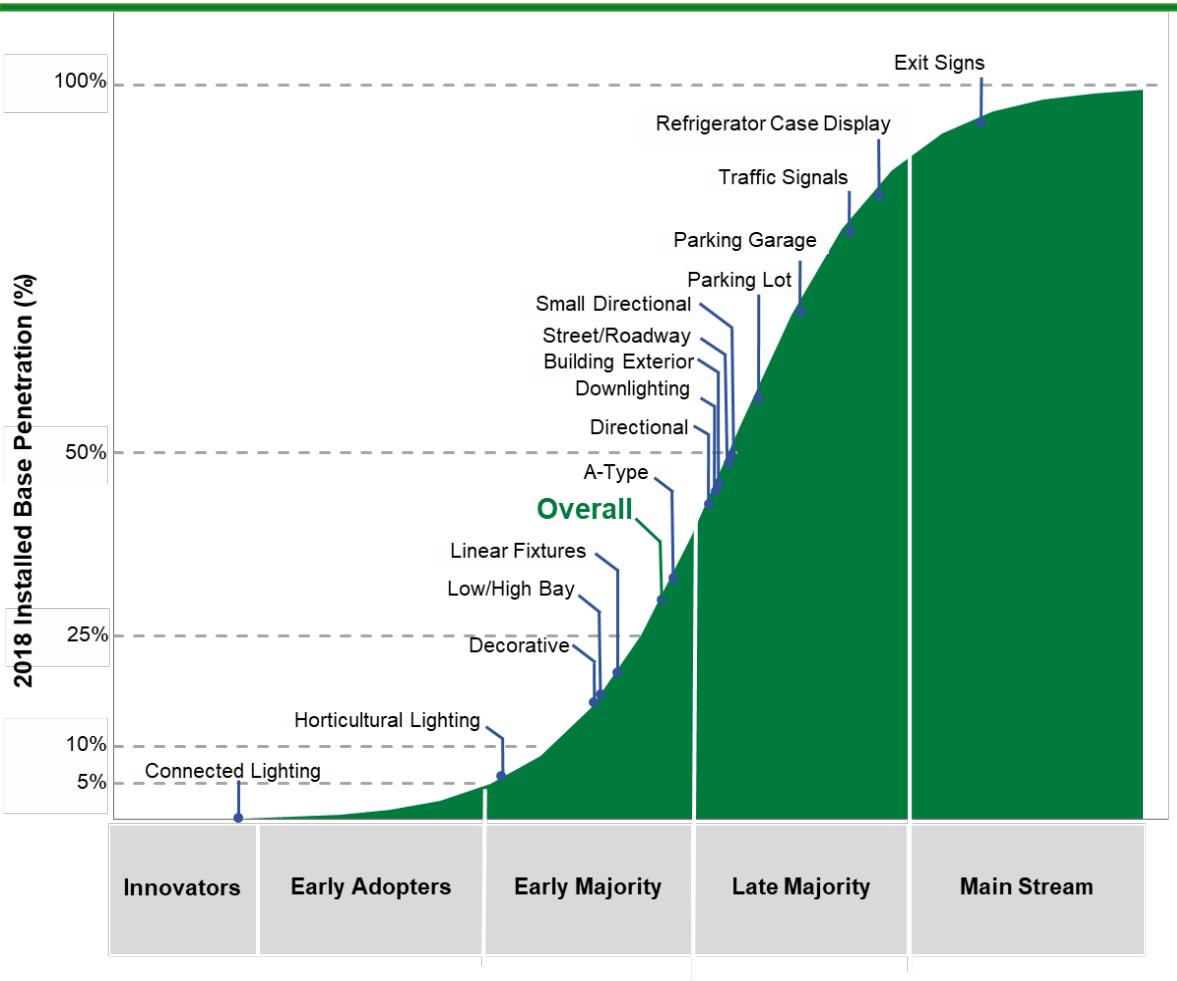
What is the Adoption Report?

The LED Adoption report investigates the 2018 adoption and resulting energy savings of both LED and connected lighting systems in general illumination applications.

The lighting applications analyzed in this study include:

- A-type
- Decorative
- Directional
- Small directional (MR16)
- Downlighting
- Linear fixtures
- Low/high bay
- Parking lot
- Parking garage
- Street/roadway
- Building exterior
- Other

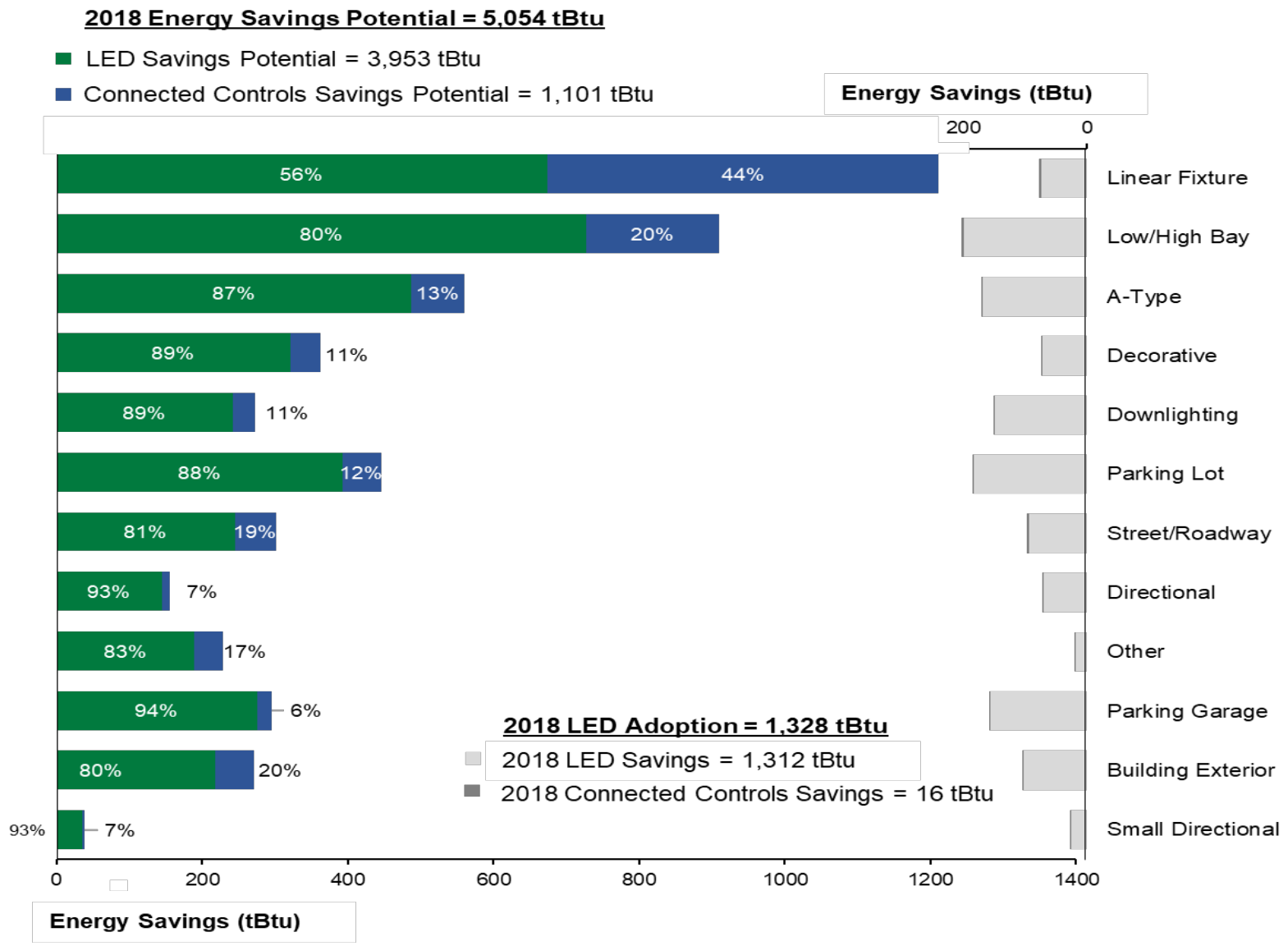
Cumulative LED Adoption through 2018



Application	2018 LED Units Installed (Millions)	2018 LED Installed Penetration (%)
A-Type	1,144	32.9%
Decorative	207.0	16.0%
Directional	228.3	43.0%
Small Directional	43.7	49.7%
Downlighting	308.0	44.8%
Linear Fixture	224.0	20.1%
Low/High Bay	18.0	17.1%
Total Indoor	**2,137**	**29.8%**
Street/Roadway	24.2	48.6%
Parking Garage	19.0	69.1%
Parking Lot	27.1	57.4%
Building Exterior	39.5	45.8%
Total Outdoor	**109.7**	**51.4%**
Other	29.2	14.5%
Connected Controls	**13.5**	**0.2%**
Total All	**2,325**	**30.0%**

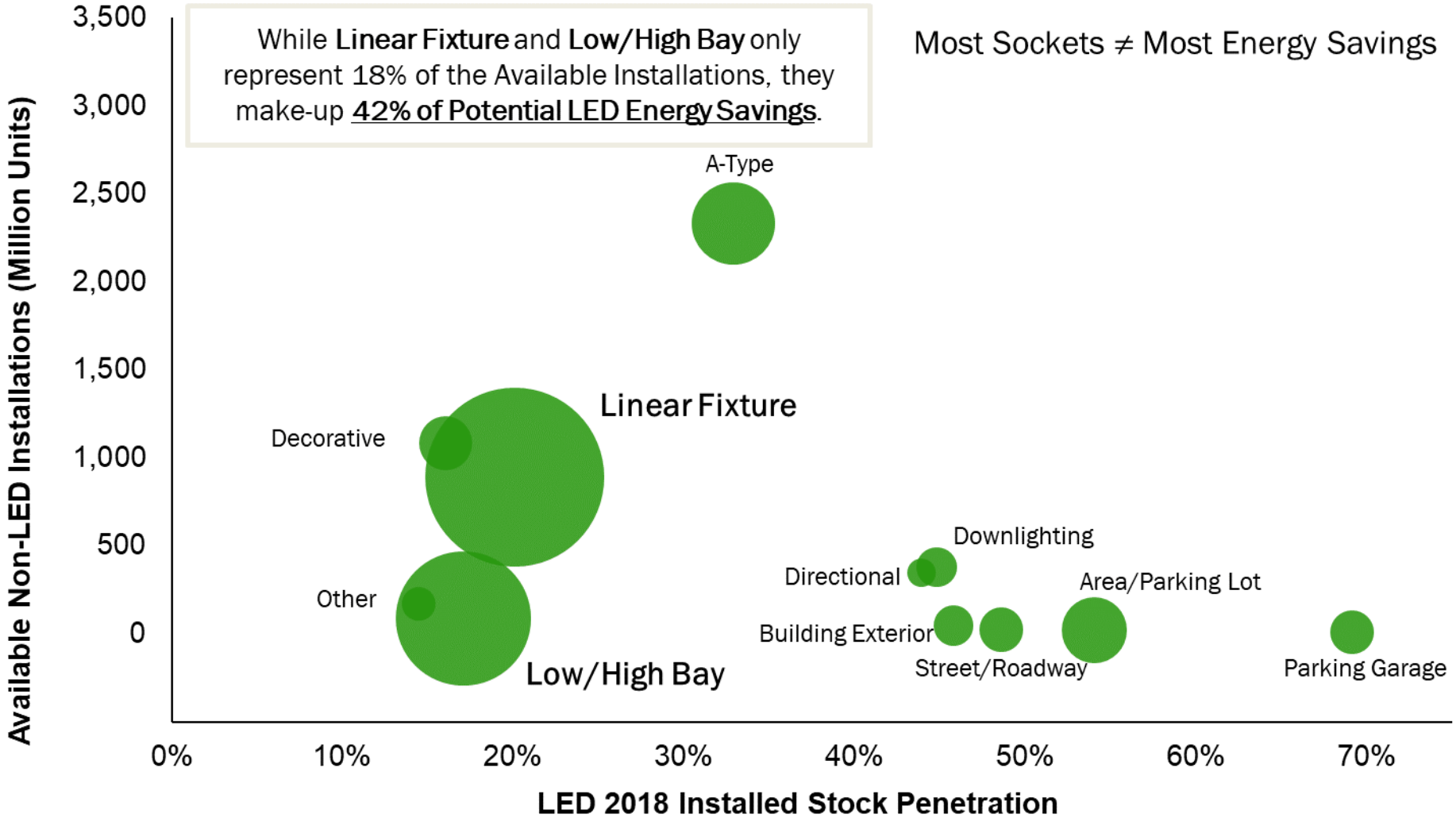
The adoption of LED lighting in general illumination is reaching the majority phases of product adoption, with most of the applications clustered in the "early majority" and "late majority" phases, though there's still room for growth.

LED Adoption Results – Energy Savings Potential



LED Adoption Results – Energy Savings Potential

Due to the unique usage characteristics in each lighting application, the opportunities for LED installations and energy savings vary significantly.



Agricultural Lighting

What is the Agriculture Lighting Report?

This study is an update to the 2017 report characterizing the adoption and resulting energy savings of LED lighting in indoor agricultural applications. The following indoor agriculture sectors were analyzed:

- **Horticulture**
  - Supplemented Greenhouses
  - Sole-Source Indoor Farms (non-stacked)
  - Vertical Farms
- **Animal Agriculture**
  - Poultry - Layers
  - Poultry - Broilers
  - Hogs
  - Dairy

Added to the analysis scope in 2019!

Horticultural Lighting

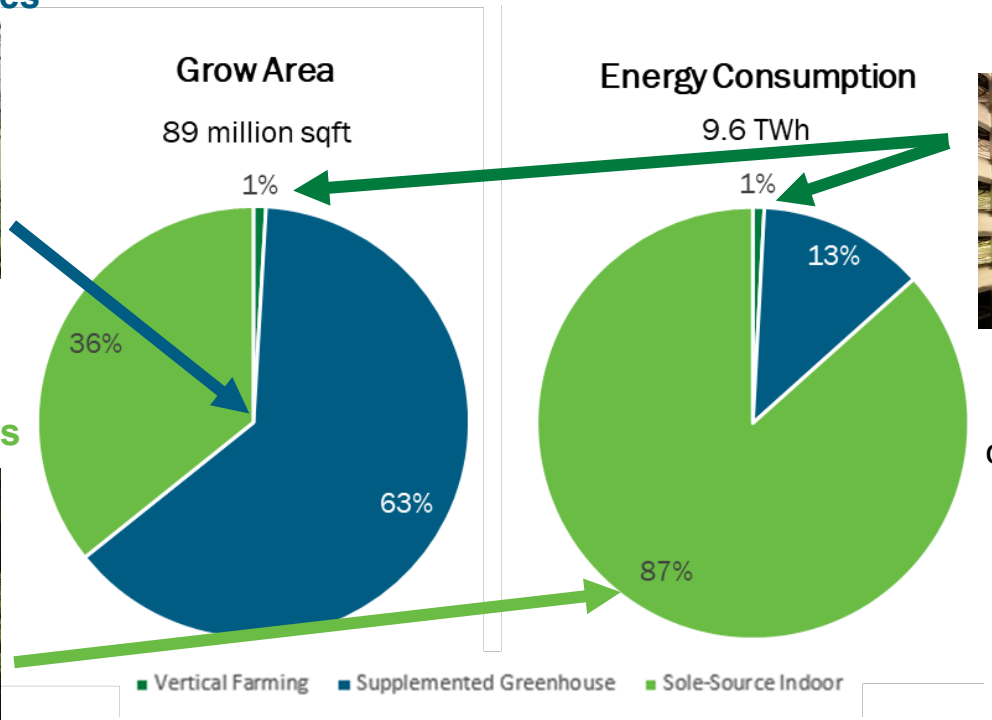
In 2019, an estimated 89 million ft^2 of plant grow area was illuminated by horticultural lighting, which was estimated to consume 9.6 TWh of electricity for lighting annually.

Supplemented Greenhouses

Largest lit-grow area

Sole-Source Indoor Farms

Largest lighting energy consumption



Vertical Farms

Smallest lit-grow area and lighting energy consumption of the three indoor horticulture architectures

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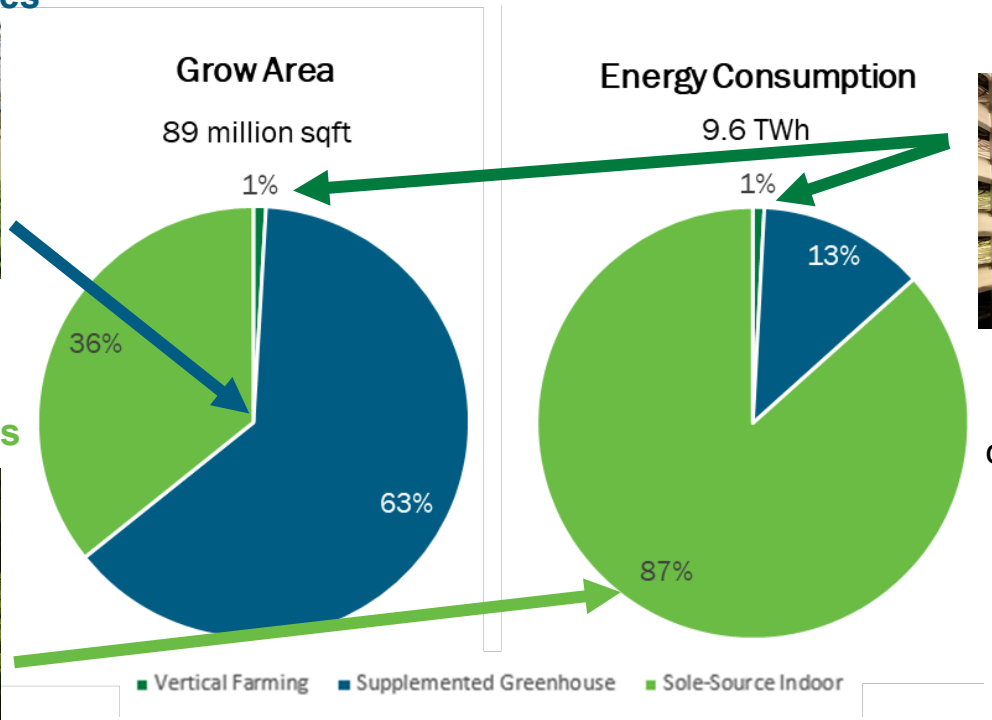


Vertical Farms

Smallest lit-grow area and lighting energy consumption of the three indoor horticulture architectures

6% LED Adoption

Animal Lighting

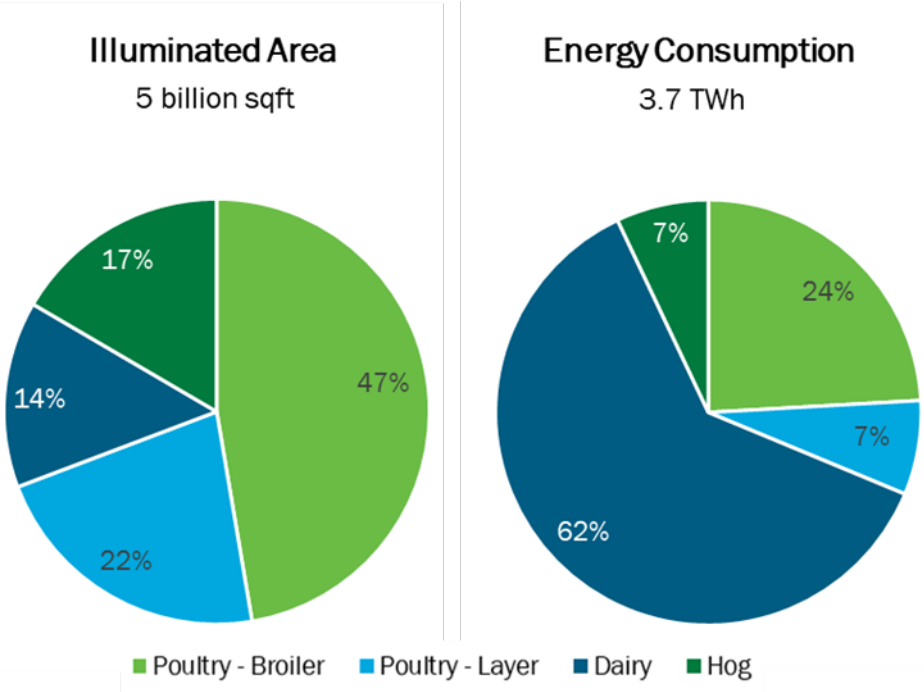
In 2019, an estimated 5 billion ft^2 of area was illuminated by animal lighting for poultry broiler, poultry layer, hog, and dairy production, which was estimated to consume 3.7 TWh annually.

Poultry - Layer

Second smallest lighting energy consumption

Hog

Smallest lighting energy consumption



Poultry - Broiler

Largest illuminated area and animal count

Dairy

Smallest illuminated area
Largest lighting energy consumption

Animal Lighting

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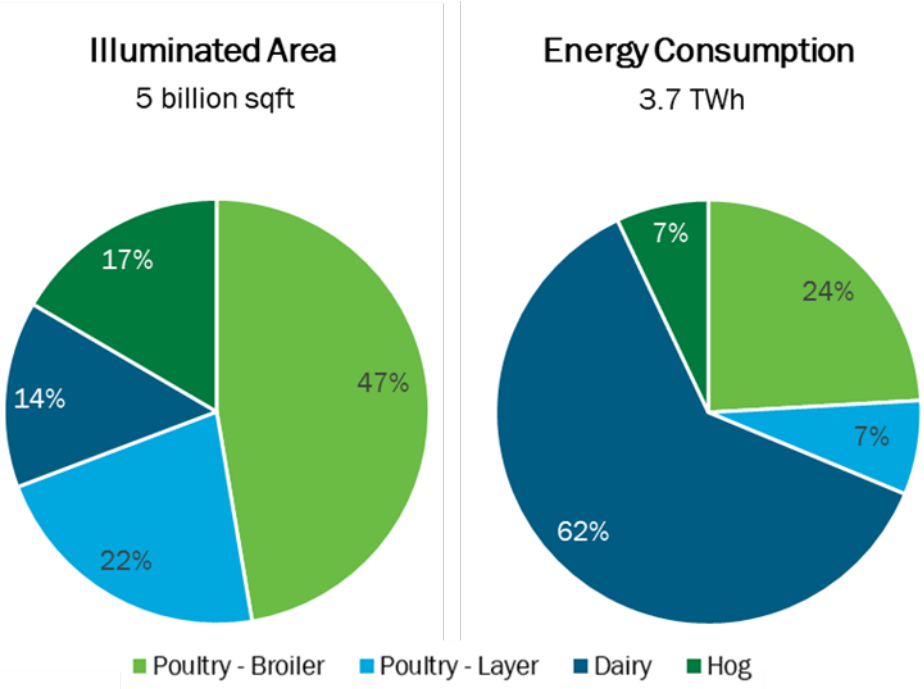
Poultry - Layer

Second smallest lighting energy consumption

Hog

Smallest lighting energy consumption



46% LED Adoption

Poultry - Broiler

Largest illuminated area and animal count

Dairy

Smallest illuminated area
Largest lighting energy consumption

Last Thoughts and Next Steps

- **As LED lighting continues to approach the majority of installations, how will the next generation of lighting savings be unlocked?**
  - Connected lighting and lighting application efficiency
- **How will future generations of advanced lamps and luminaires compete with a future installed base of mostly LEDs?**
  - You can find a glimpse of what this might look like during the **Exploring Effects of Product Valuation on Energy Use** session later this morning!

Links & Contact Information

DOE Lighting R&D Program, Market Studies

http://energy.gov/eere/ssl/market-studies

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