Northwest **Power** and **Conservation** Council

October 3, 2017

MEMORANDUM

TO: **Council Members**

FROM: **Charlie Grist**

SUBJECT: **Briefing on Solid State Lighting**

BACKGROUND:

Presenter: Marc Ledbetter, Pacific Northwest National Laboratory

Summary: This presentation is part of a series of emerging technology briefings. Marc Ledbetter of Pacific Northwest National Laboratory (PNNL) will brief the Council on solid state lighting. For the past decade Mr. Ledbetter has lead a team of PNNL scientists focused on the challenges of adapting solid-state lighting (SSL) to the general illumination market. Mr. Ledbetter will brief the Council on the latest developments, expectations for the future, and his perspectives on the role of the electric utility industry in advancing this efficiency technology.

Relevance: The Council's load forecasting and conservation assessment activities must account for changing technology and market conditions. Over the past decade there has been unprecedented rates of change in lighting technology with ten-fold efficacy improvements in some applications. In the past two or three years, these changes have begun to show up in earnest in lighting markets. Reported utility savings are dominated by residential and commercial lighting initiatives. State building codes and federal appliance standards are reflecting the new technology. Declining electricity use for lighting is evident in utility sales.

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PNNL's work on solid state lighting covers core technology research, product development projects, manufacturing R&D, and technology application. In the course of their business, they partner with researchers, manufacturers, designers and end users. This portfolio of work gives the PNNL team a unique vantage point into historical trends and future expectations.

Workplan: C.1. Prepare for the 8th Plan: Conservation

Background: Congress directed USDOE to carry out a Next Generation Lighting Initiative starting in 2005. In order to effectively fulfill the directives in EPACT 2005 and EISA 2007, USDOE developed a comprehensive national strategy to build collaborative efforts with the lighting industry and research community to guide SSL technology innovation. PNNL is one of the main agents executing the USDOE initiative. The DOE SSL program has been deeply involved in research and development for over a decade—challenging the lighting industry with aggressive reach goals for efficacy and performance, and monitoring emerging products to identify performance issues early on, alerting manufacturers to needed improvements.

U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Solid State Lighting: Update and Opportunities

Marc Ledbetter, Pacific NW National Laboratory

October 10, 2017

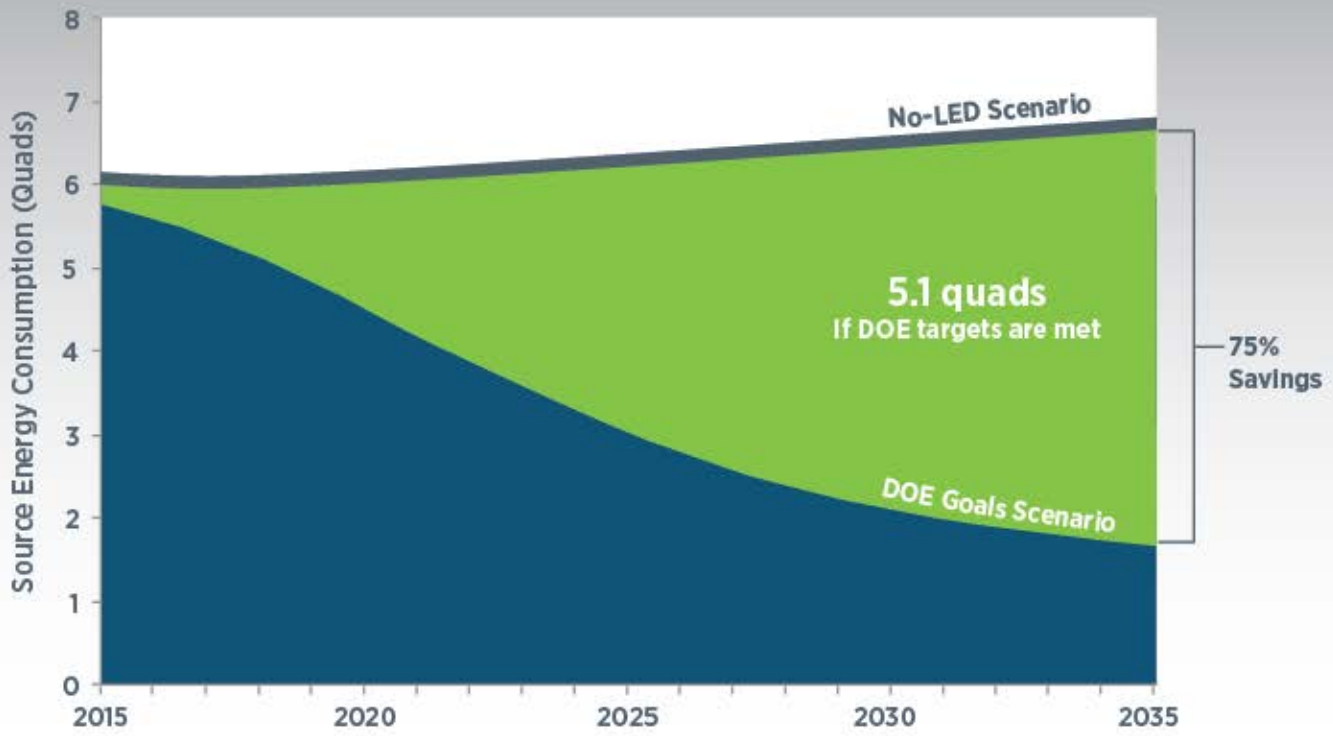
Technical and Market Status of SSL

- Remaining potential energy savings are huge (~75%)
- Product efficacy (lm/W) still rising; much room to increase
- Prices are down sharply; still will go down more
- Competitive in almost every application
- Being widely adopted; market penetration rapidly increasing
- Much research still underway to improve technology
- SSL is not just a replacement for existing lighting; it will add a wide range of important new functionality

SSL Energy Savings Forecast

TURNING **DOWN** LIGHTING ENERGY USE

U.S. energy savings attributable to LED lighting will reach 5.1 quads by 2035. Energy use for lighting in 2035 will be **75% lower** than it would have been if LEDs had not entered the market.



BREAKING DOWN 5.1 QUADS OF **SAVINGS**

CONTROLS
Connected lighting and energy management systems, along with traditional controls, will be essential in realizing the forecast across all sectors. Savings from controls will be enormous for LED luminaires in commercial and outdoor settings.

COMMERCIAL
Long operating hours make commercial lighting installations a prime opportunity for energy savings from improved efficacy and controls.

RESIDENTIAL
The sheer number of sockets nationwide makes residential installations a key target for improved efficacy. Controls will have a small impact.

OUTDOOR
Controls will drive growth and energy savings in roadway and area lighting, and in parking lot, parking garage, and building exterior installations.

INDUSTRIAL
Controls will have less of an impact in the industrial lighting sector than in the commercial sector.

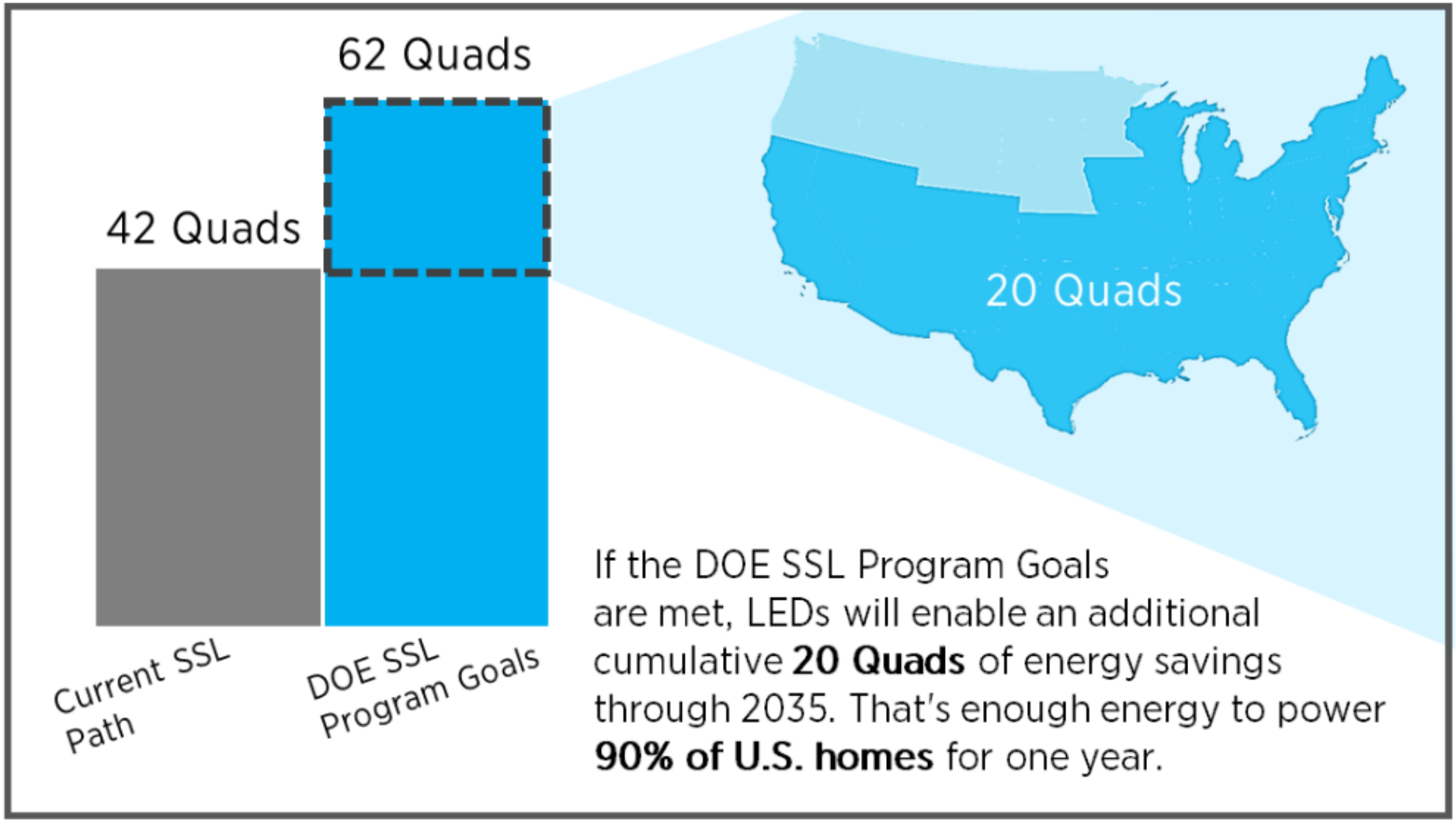
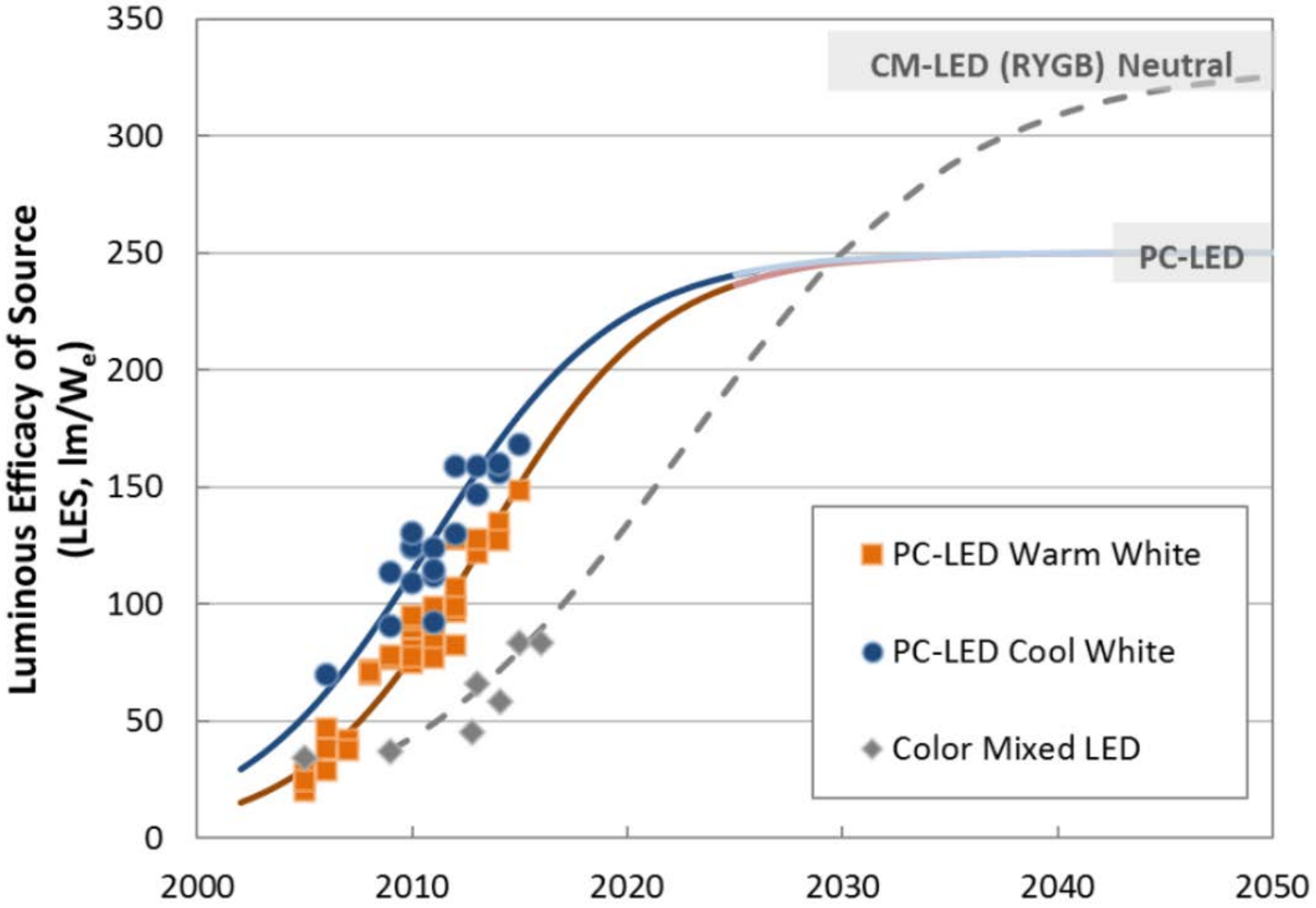


Figure 2.10 U.S. Cumulative Energy Savings Forecast from 2015 to 2035

Source: DOE SSL Program, "Energy Savings Forecast of Solid-State Lighting in General Illumination Applications," September 2016 [1]

Historical and Projected Source Efficacy (DOE)



Global Shipments Growing Rapidly

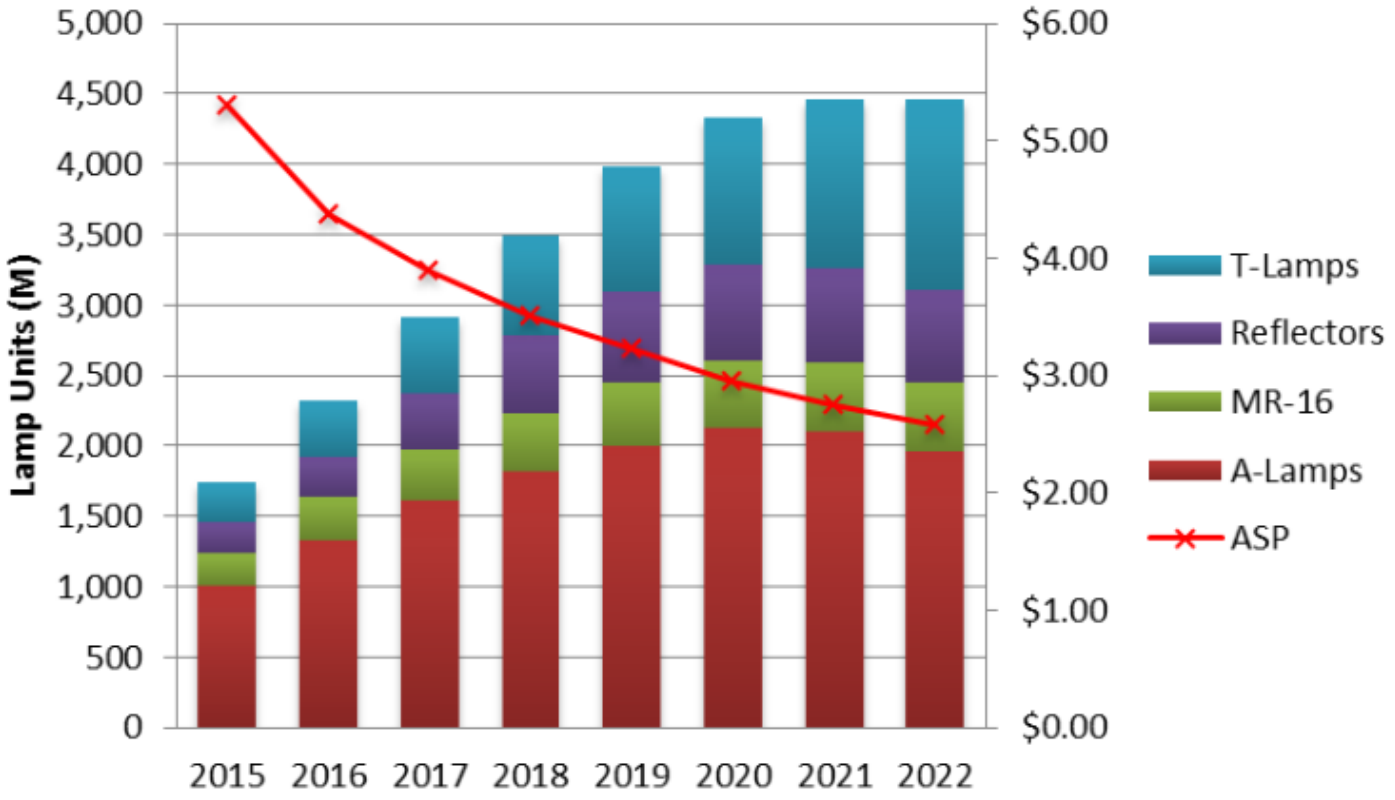
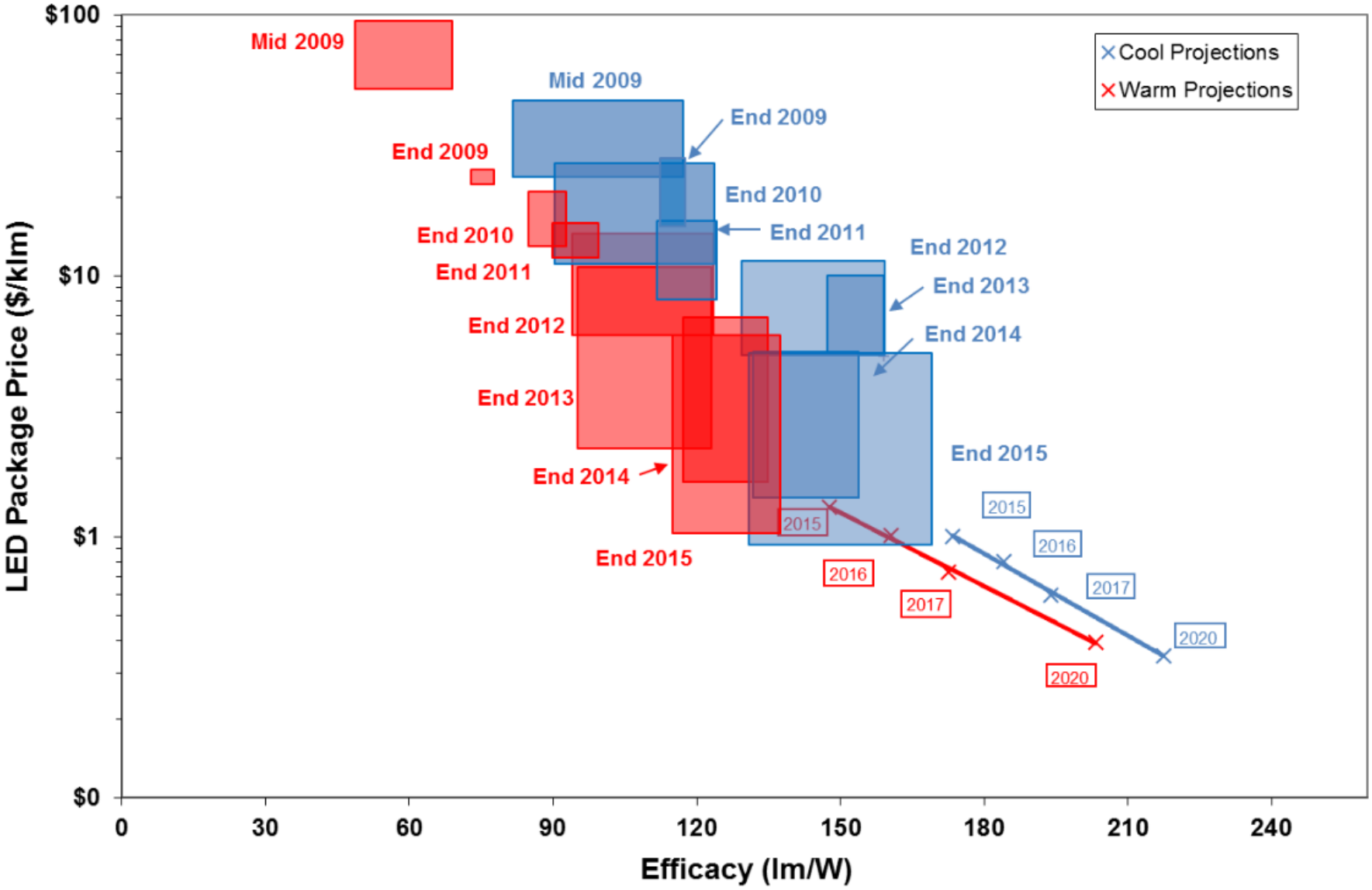
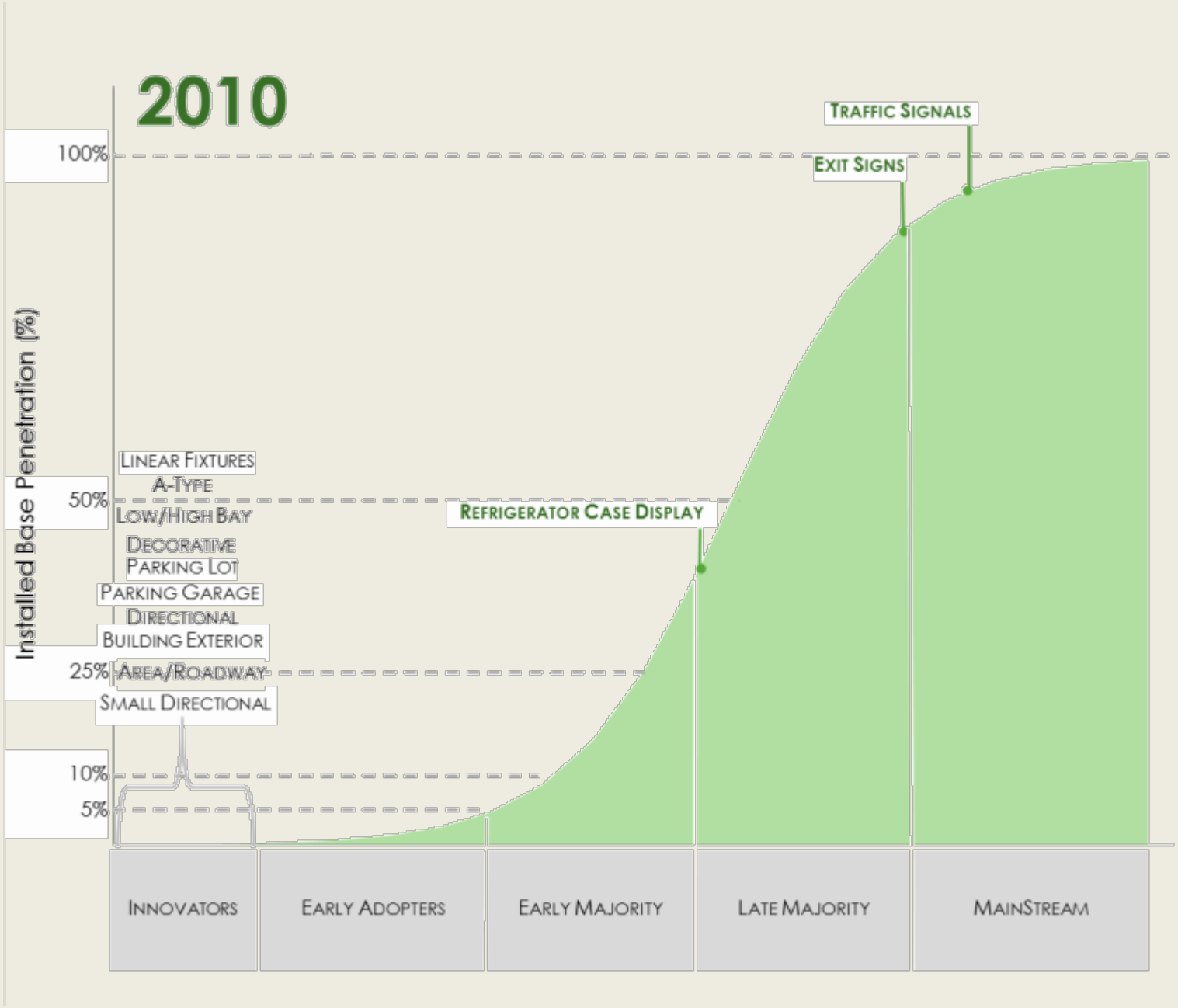


Figure 2.3 Global LED Lamp Shipments by Lamp Type

Source: Philip Smallwood, Strategies Unlimited, Strategies in Light, Anaheim, CA, March 2017 [2]

LED Package Price/Efficacy Status and Projections (1 W/mm^2)

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50%
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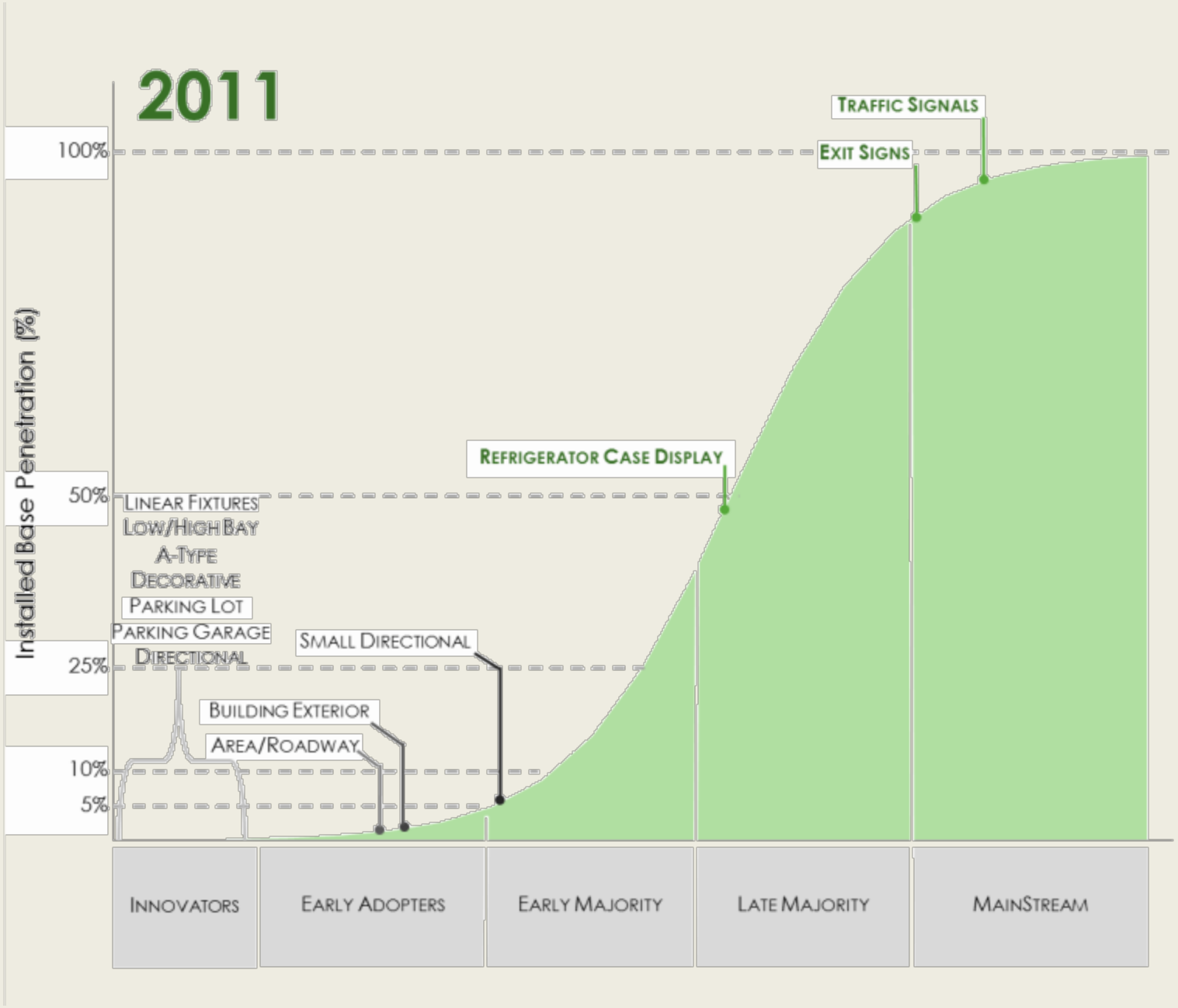
10%
5%
Installed Base Penetration (%)
Traffic Signals
Exit Signs
Refrigerator Case Display
Linear Fixtures
A-Type
Low/High Bay
Decorative
Parking Lot
Parking Garage
Directional
Building Exterior
Area/Roadway
Small Directional
Innovators
Early Adopters
Early Majority
Late Majority
MainStream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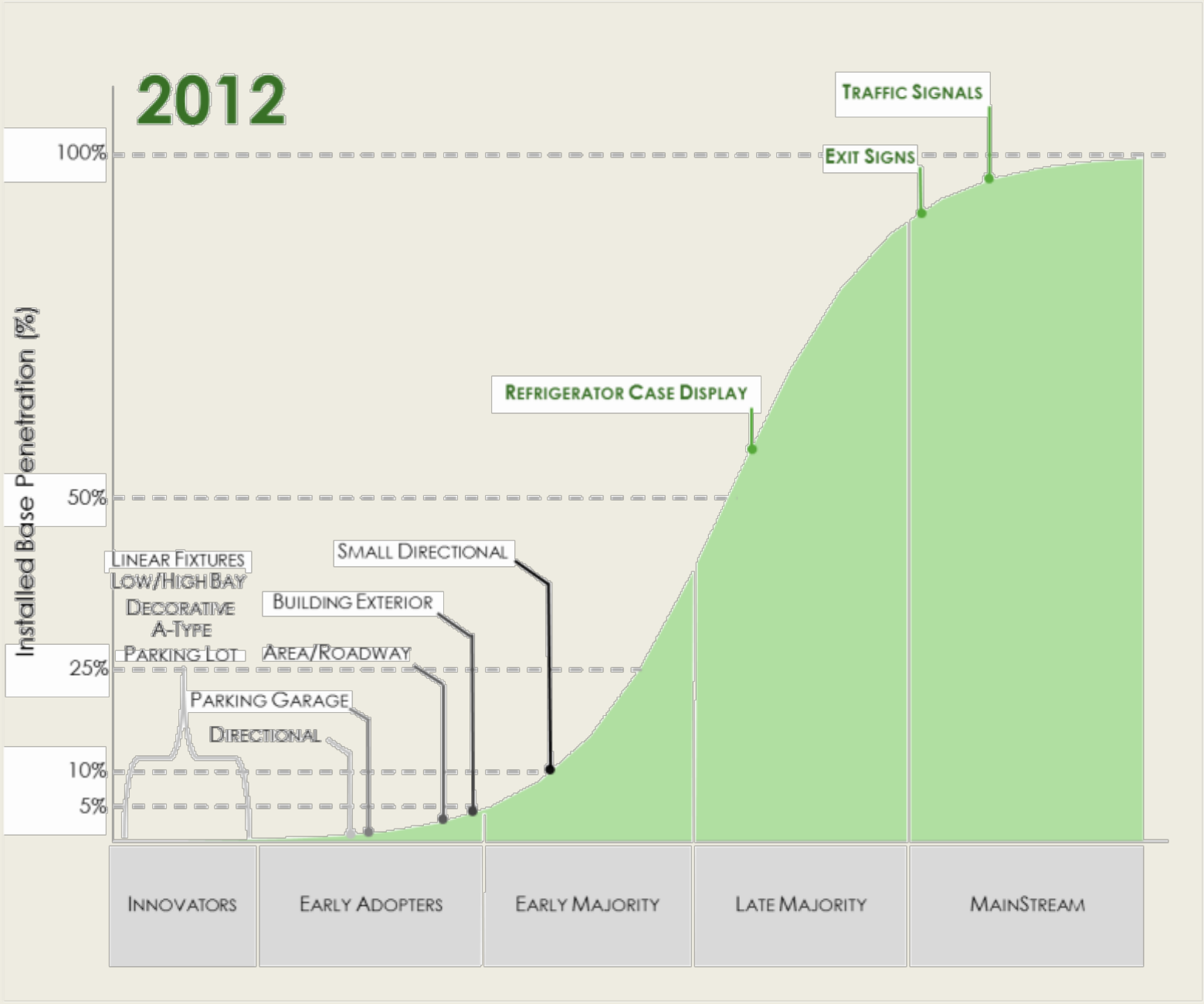
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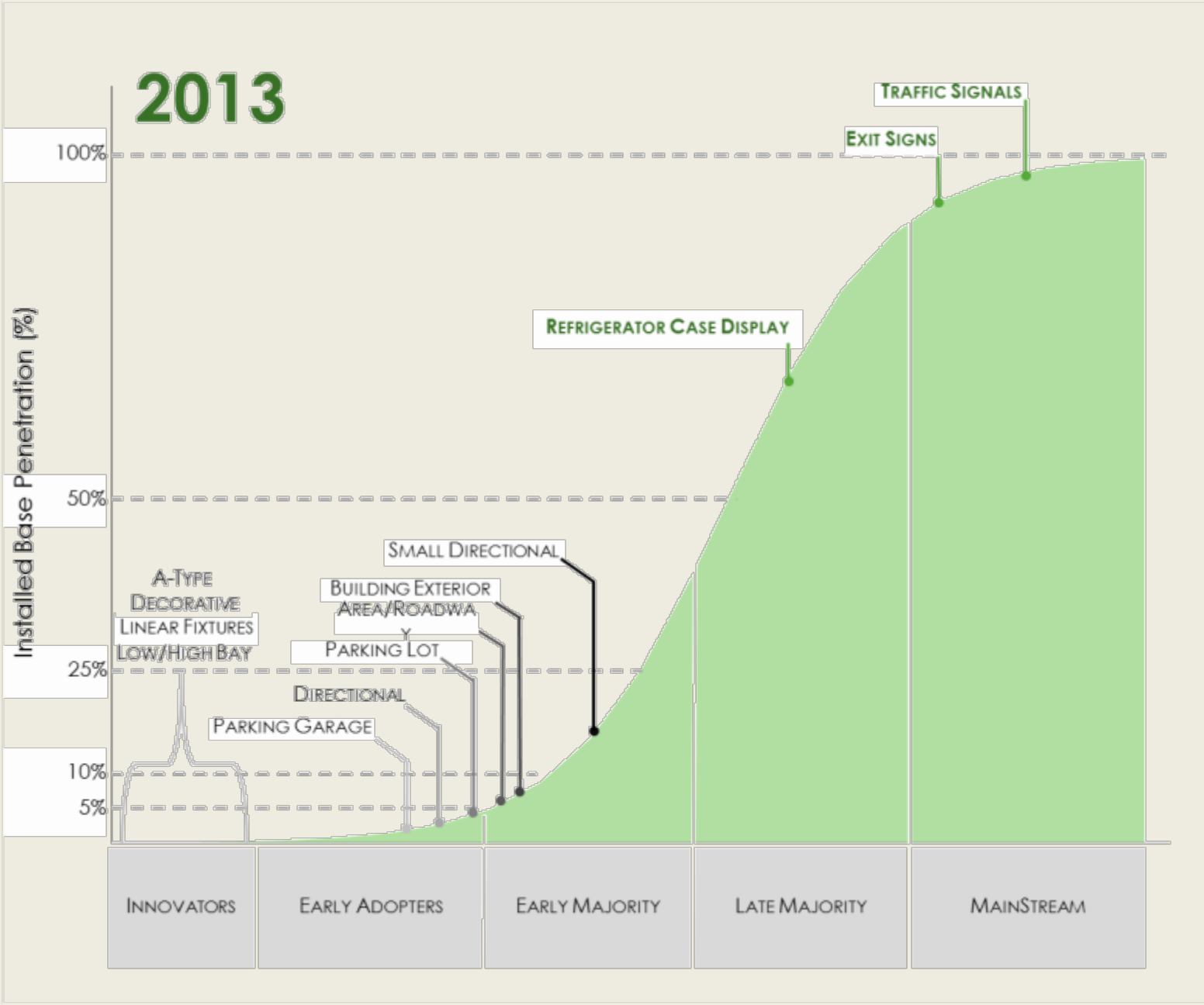
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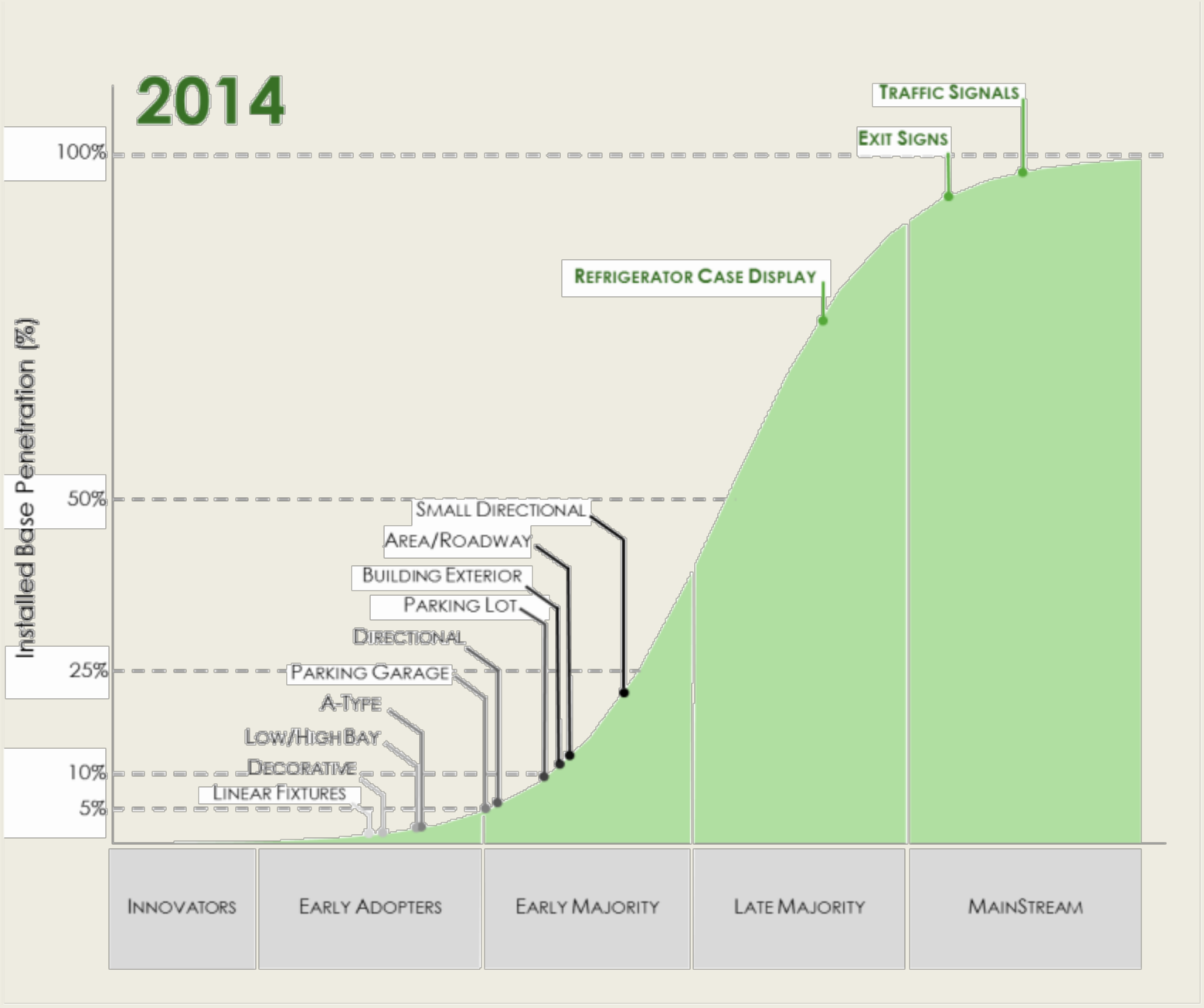
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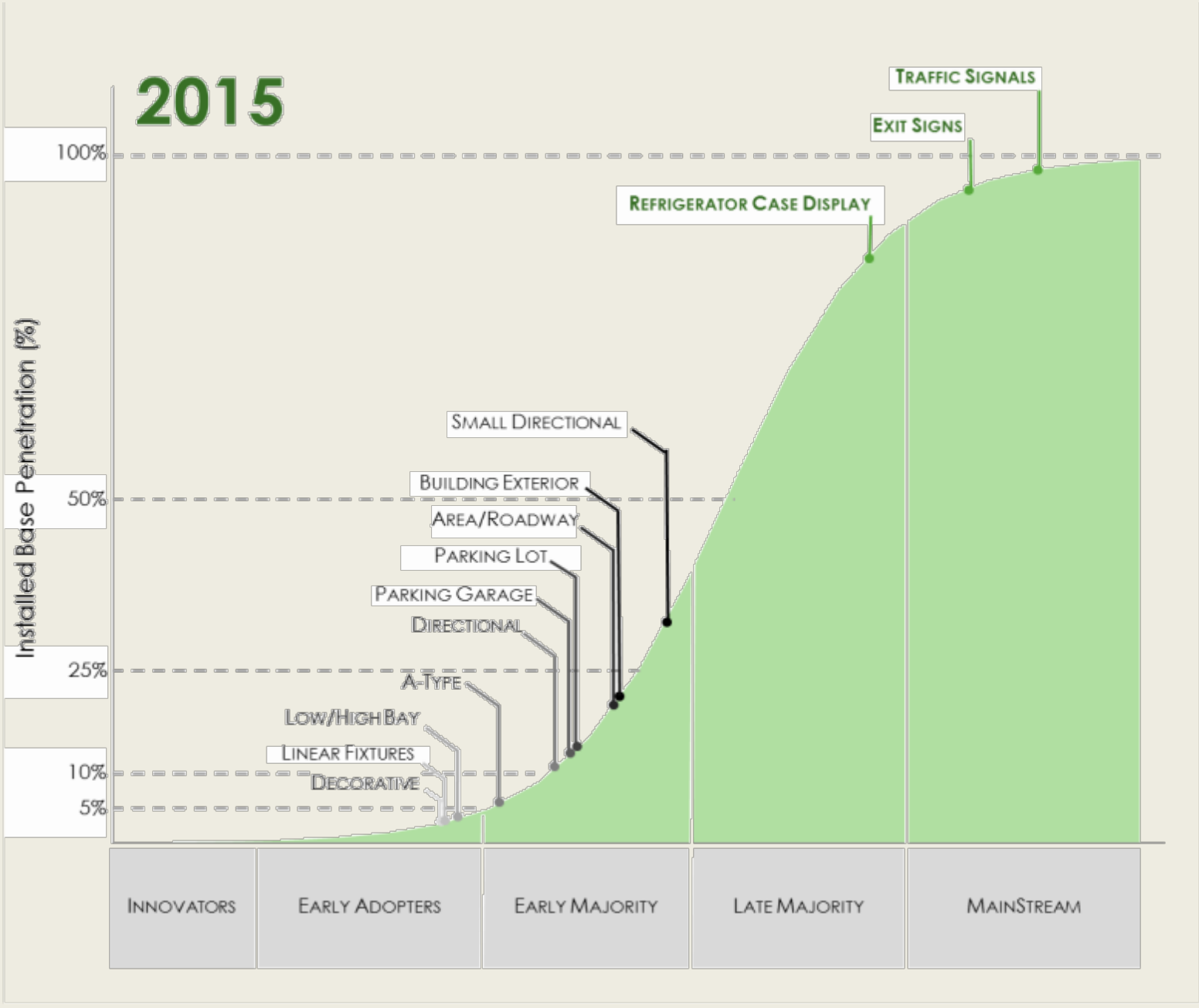
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Still Only About 13% Converted in U.S.

Table 2.3 LED Installations and Energy Savings by Application

Application	2016 LED Installed Penetration (%)	2016 LED Units Installed* (Millions)	2016 Energy Savings (TBtu)
A-Type	13.5%	436	99.1
Decorative	6.7%	58.9	10.3
Directional	15.3%	82.4	37.9
Small Directional	47.6%	21.0	35.6
Downlighting	19.8%	137	92.5
Linear Fixture	6.0%	68.0	62.0
Low/High Bay	9.4%	8.6	46.4
Total Indoor	12.3%	812	384
Street/Roadway	28.3%	12.5	14.9
Parking Garage	32.5%	8.5	14.4
Parking Lot	26.2%	7.1	18.6
Building Exterior	31.2%	18.1	14.0
Total Outdoor	29.7%	46.1	61.9
Other	7.7%	15.6	12.4
Connected Controls	<0.1%	4.0	11.4
Total All**	12.6%	874	469

Source: DOE SSL Program, Adoption of Light Emitting Diodes in Common Lighting Applications, August, 2017 [16]

* Installations are the total cumulative number of LED lamps and luminaires that have been installed as of 2016.

** Values may not add due to rounding.

Wide Range of DOE Research to Improve SSL

- **For example:**
  - Spectral engineering and tunability
    - Circadian effects
    - Color science, human visual performance
    - Horticulture applications
  - Connected Lighting
    - Interoperability
    - Energy reporting
    - Configuration complexity
  - Potential problems
    - Temporal light artifacts (flicker)
    - Glare, visibility
    - Sky glow, light pollution
    - Health concerns

SSL Capable of Whole New Functionality

Figure 2.4 The (a) OSRAM OmniPoint™ Luminaire and (b) User Interface

Source: Jerry Ryu, OSRAM Sylvania, SSL R&D Workshop, Raleigh, NC, February 2016 [14]

Some Thoughts on Utility Industry Role in SSL

- **SSL is going to be widely adopted, with or without help from the utility industry**
  - Its increasing rate of adoption makes this clear
- **It's not a matter of whether customers will adopt SSL; it's a matter of:**
  - How efficient those devices will be
  - How well those devices are applied in the built environment (which also affects energy use)
- **It's important to not think of SSL as a static technology**
  - As with commercial air conditioners, the utility industry isn't trying to get customers to adopt them; they are trying to get customers to buy the most efficient units

Utility Industry Thoughts on SSL (cont.)

- **The utility industry can help realize the high potential energy savings from SSL by:**
  - Focusing its efforts on leading edge energy performance products
  - Help connected lighting technology (outgrowth of SSL) maximize energy savings
    - Work collaboratively with DOE and other utilities to guide industry