QUANTIFYING POTENTIAL ENERGY SAVINGS OF NEXT GENERATION LED LIGHTING TECHNOLOGIES

VALERIE NUBBE AND CLAY ELLIOTT

JANUARY 30, 2020

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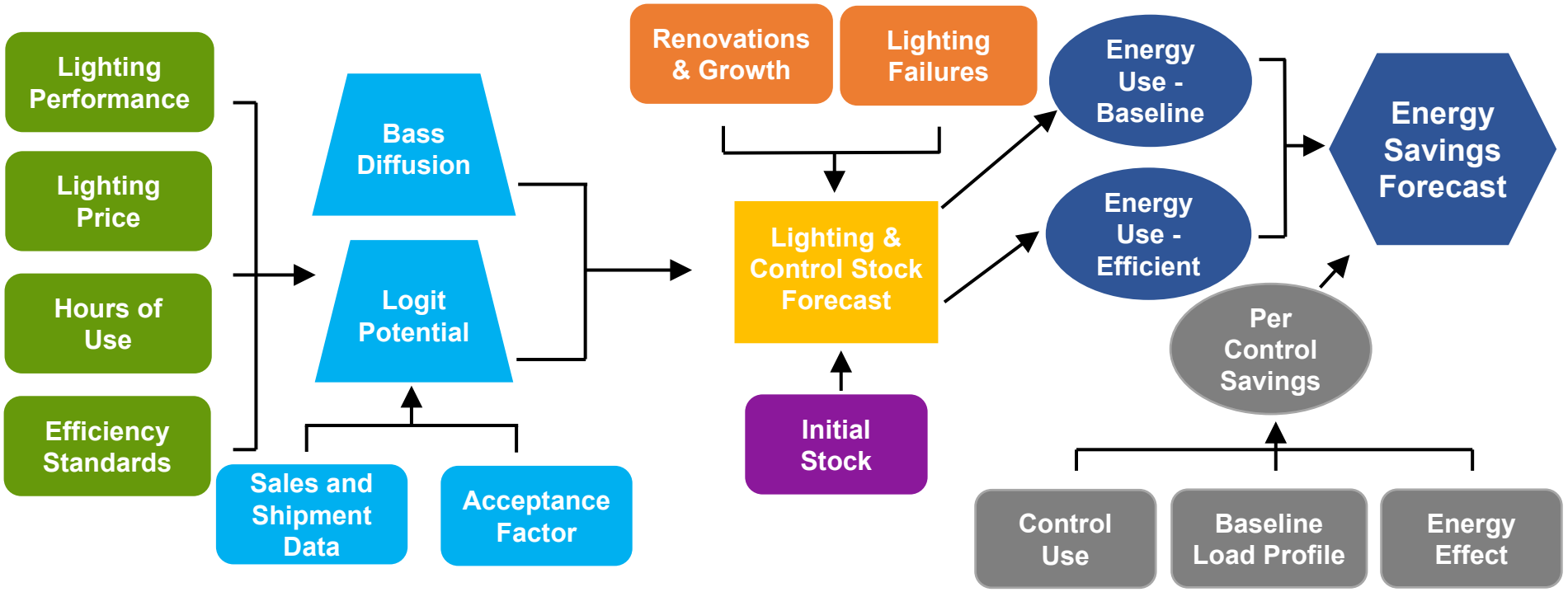
MODEL APPROACH



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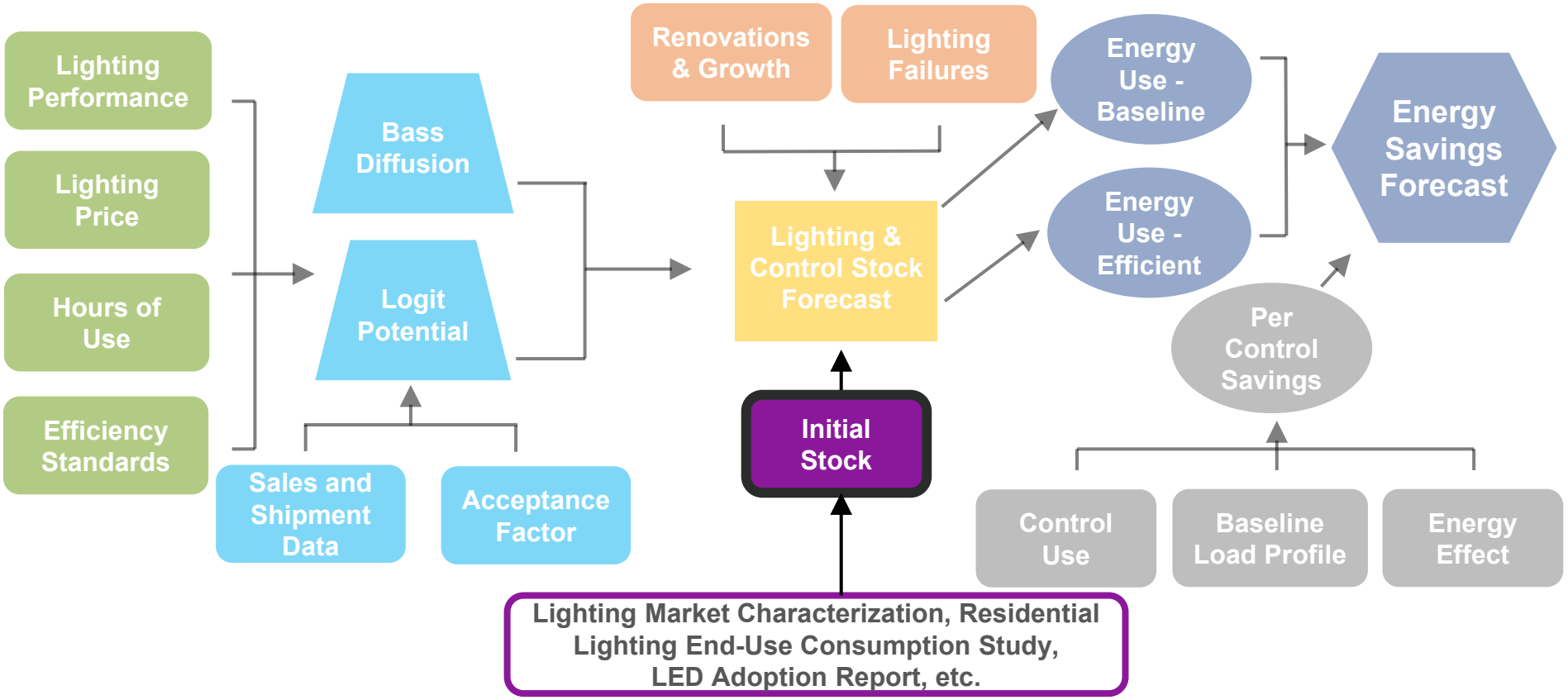
MODEL APPROACH

1. Calculate national lighting inventory and service



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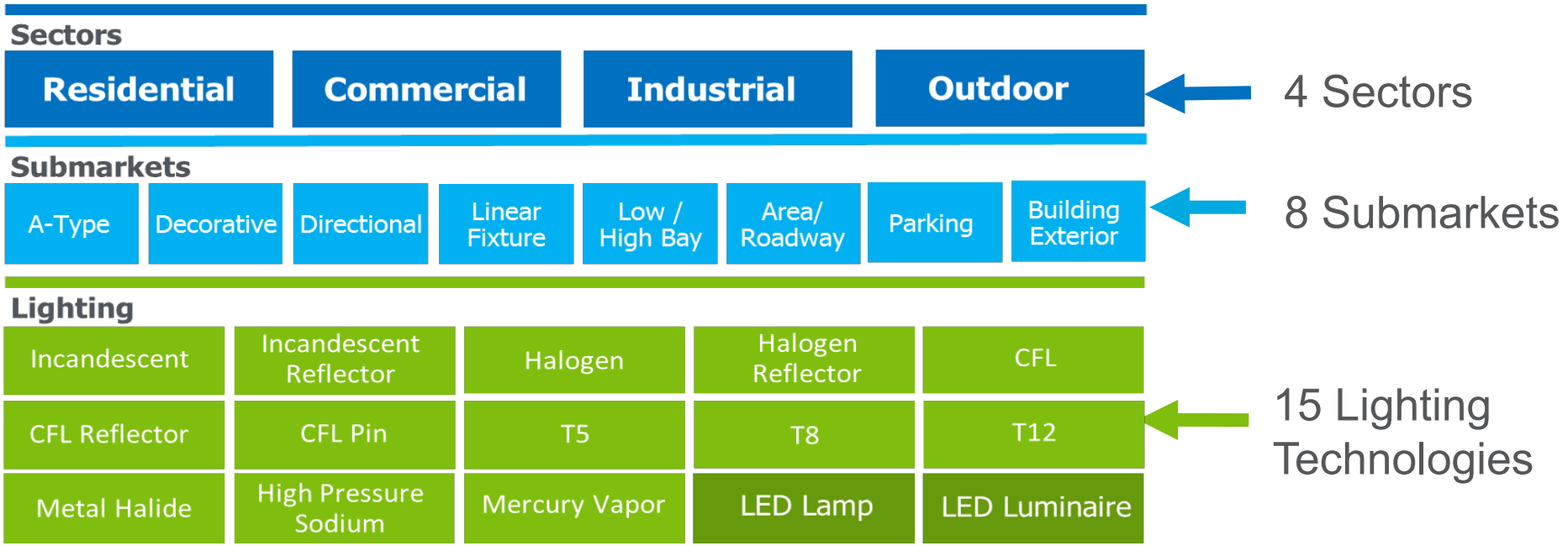
LIGHTING COMPETITION AREAS

2. Develop arenas for competition



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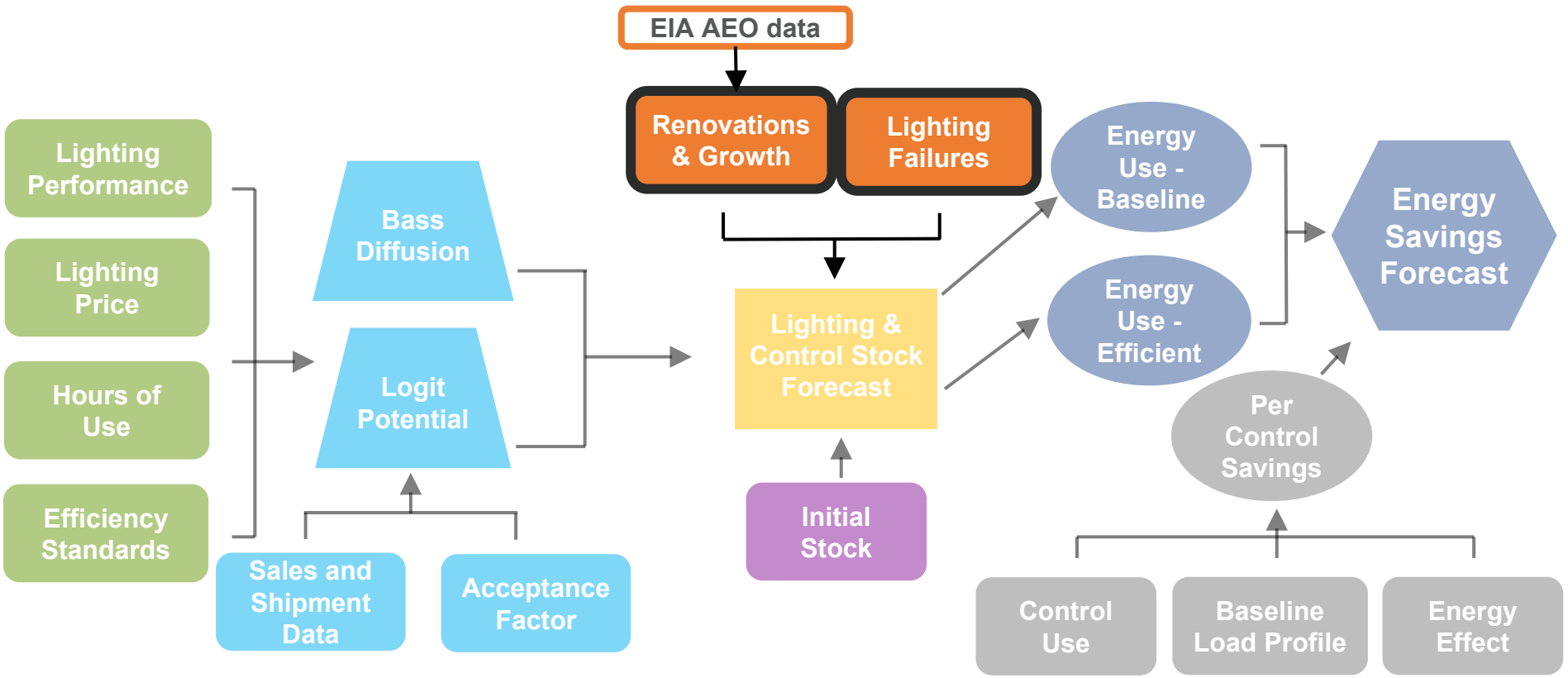
MODEL APPROACH

3. Project annual lighting demand forecast and calculate available market



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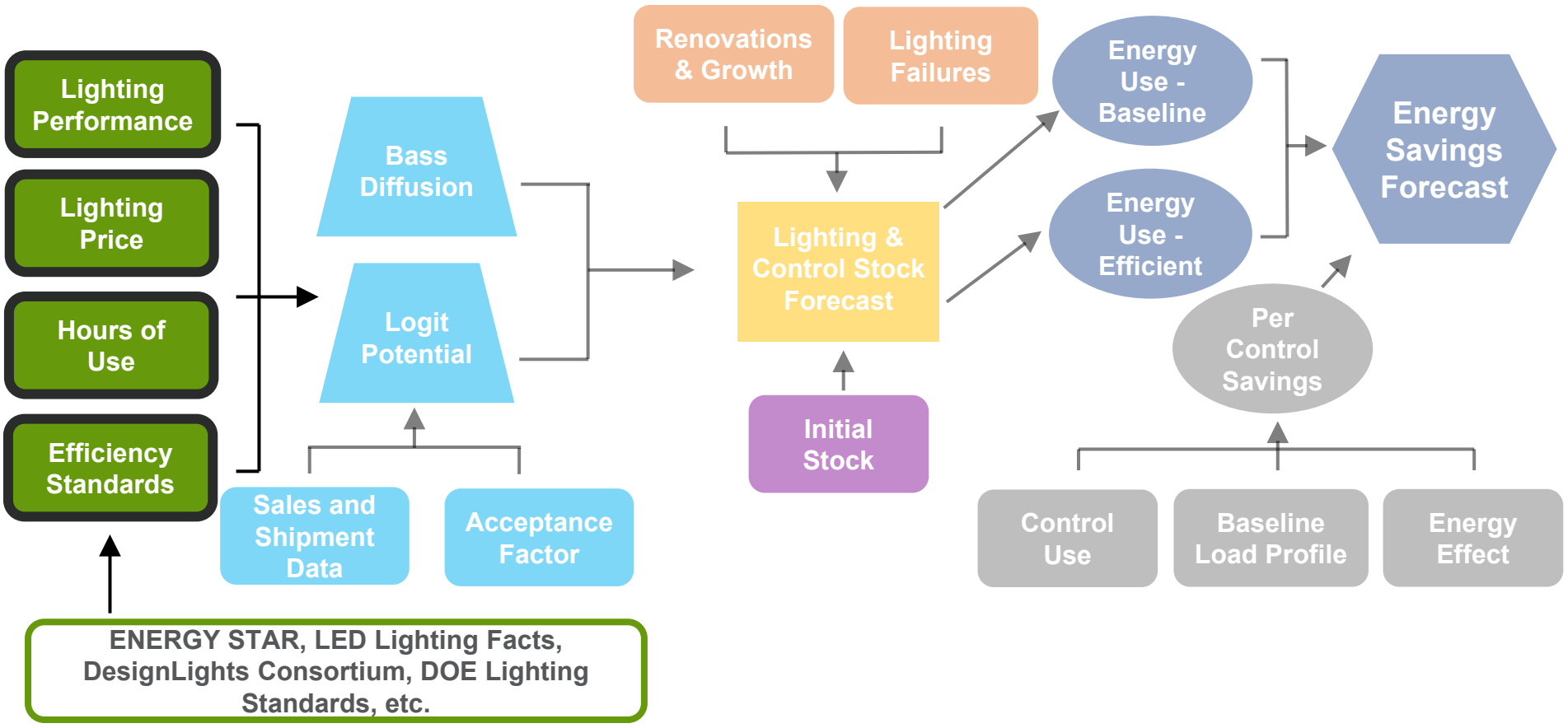
MODEL APPROACH

4. Project conventional and LED technology improvement



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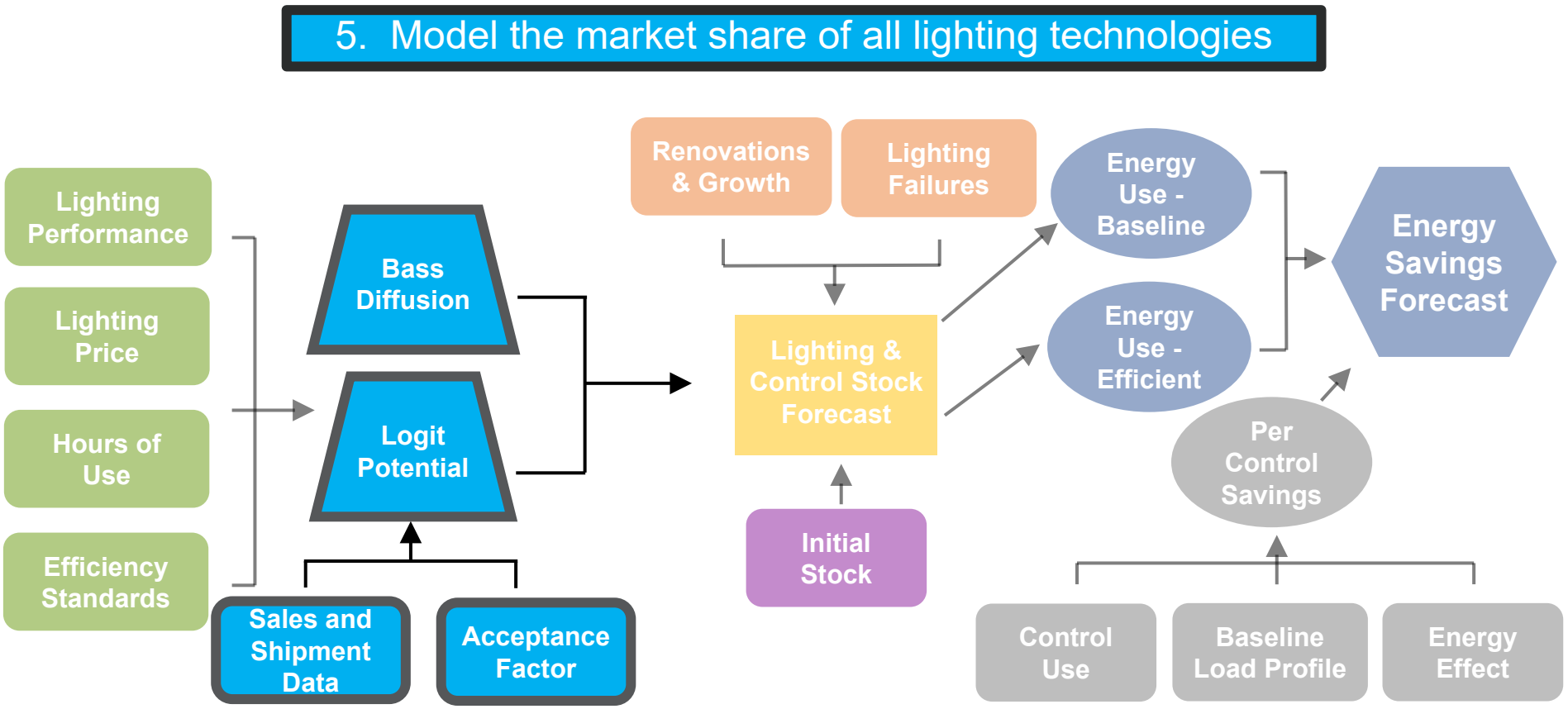
MODEL APPROACH



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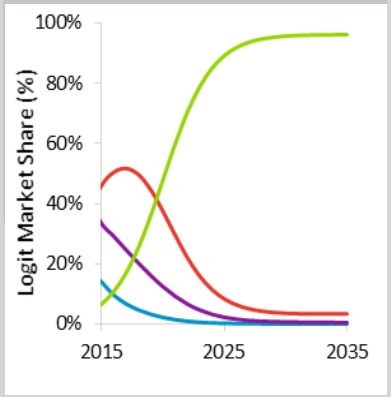
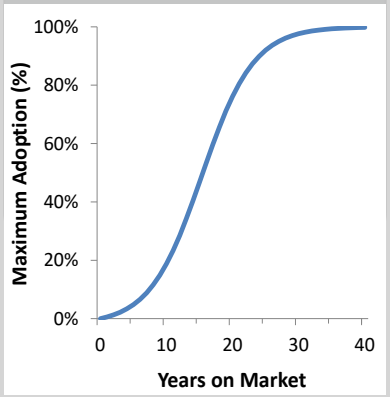
MARKET SHARE METHODOLOGY

1. The lighting market model uses a **conditional logit model** to award available market to multiple competing lighting technologies.
2. To simulate this lag effect on newer technologies, the lighting market model applies a **Bass technology diffusion model** to the logit model market share predictions.
3. Calibrate the modeled data to actual recent data.

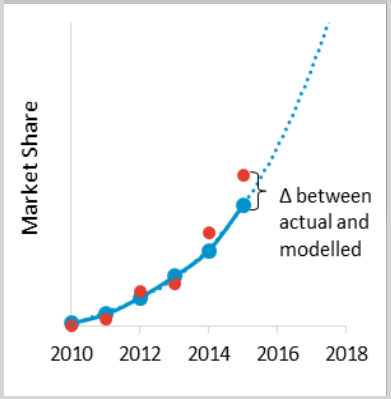
Step 1. Develop initial market share through an econometric logit model that considers first and annual O&M costs of a technology.



Step 2. Limit market shares using Bass diffusion that predicts maximum adoption potential due to market barriers of a technology.



Step 3. Calibrate LED market share projections by minimizing delta between actual and modelled market share.



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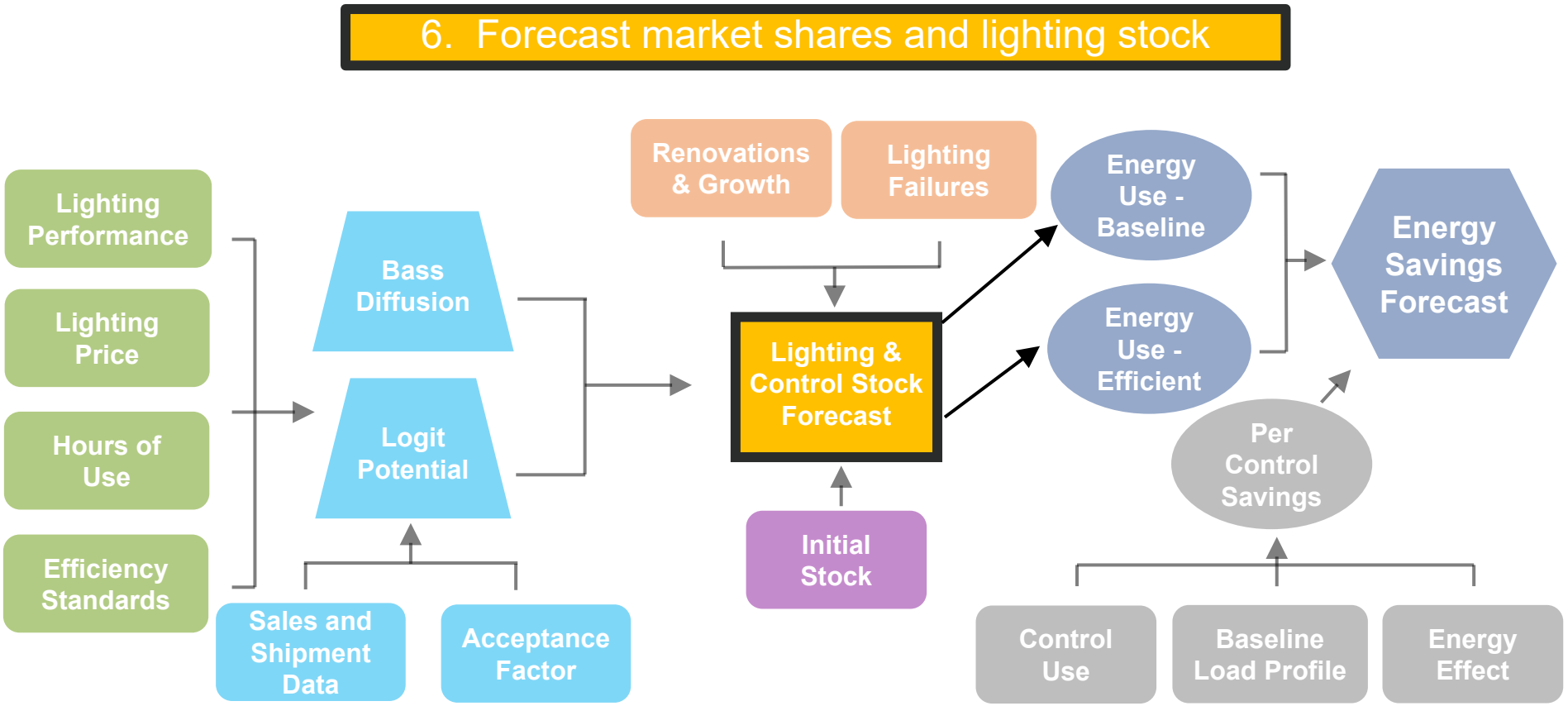
MODEL APPROACH



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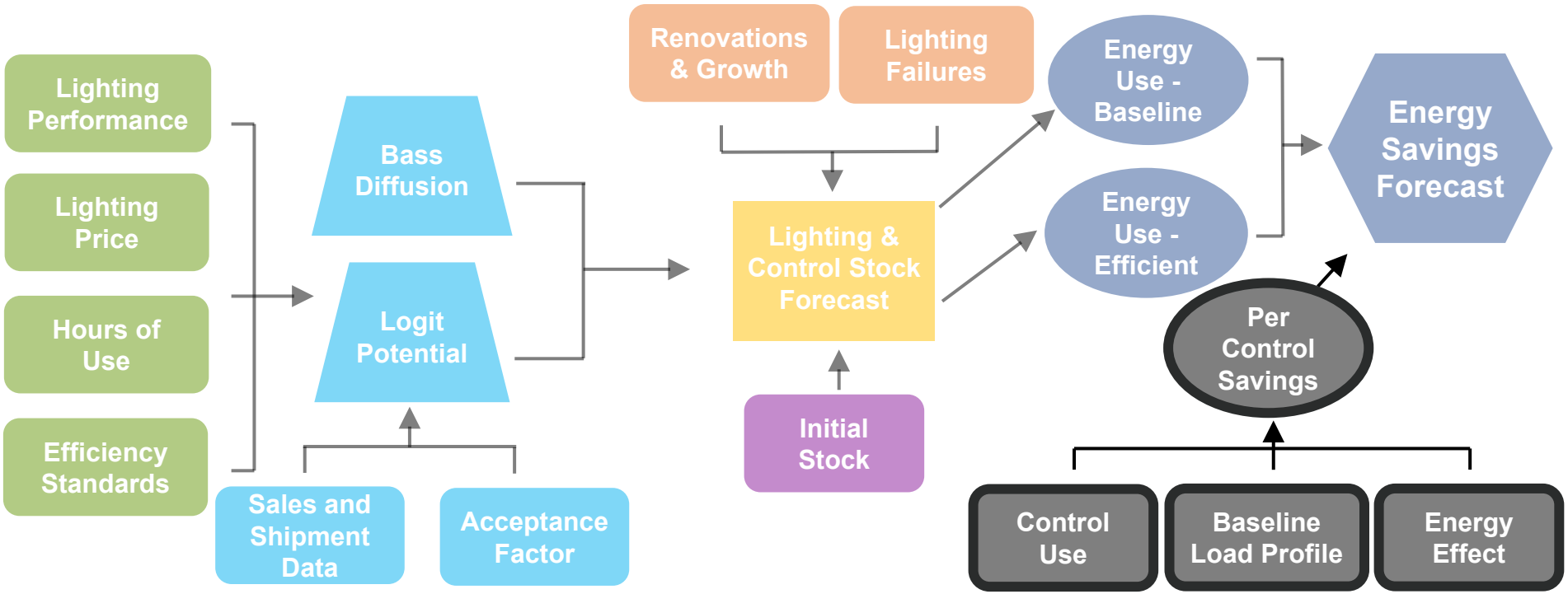
MODEL APPROACH

7. Model market share and energy savings of lighting controls.



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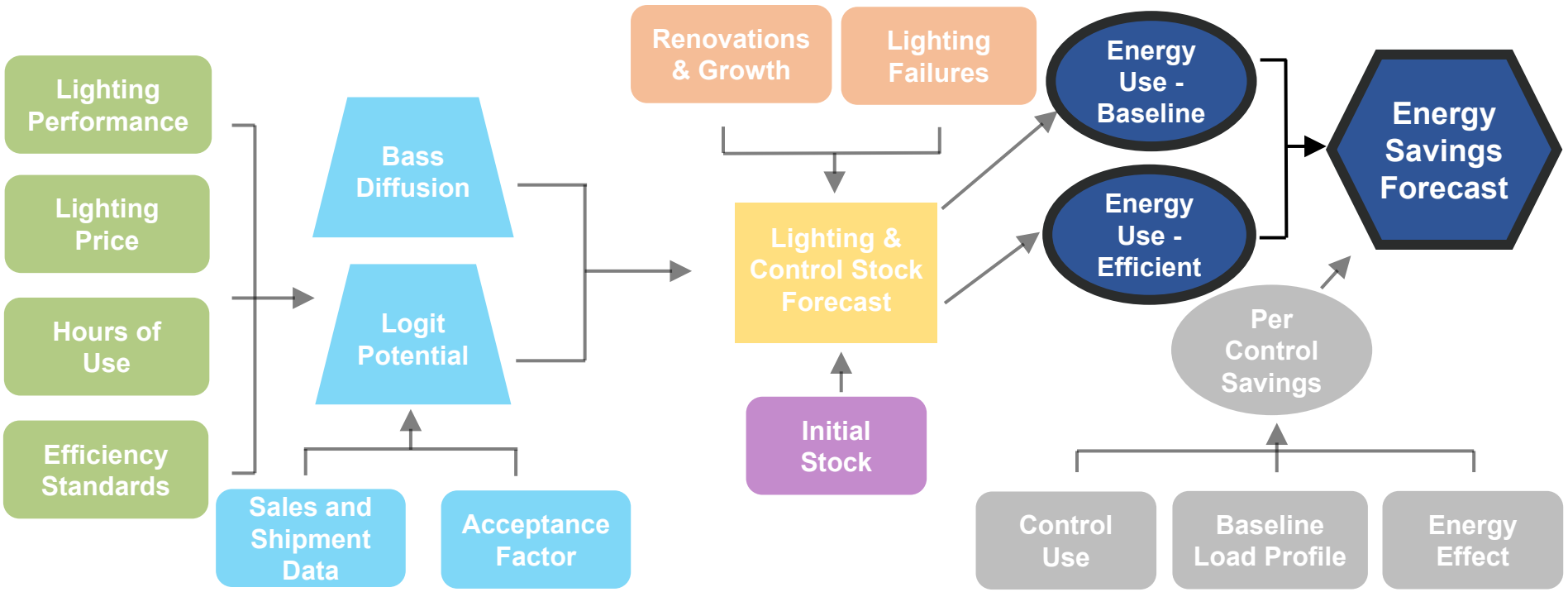
MODEL APPROACH

8. Calculate overall lighting market energy savings



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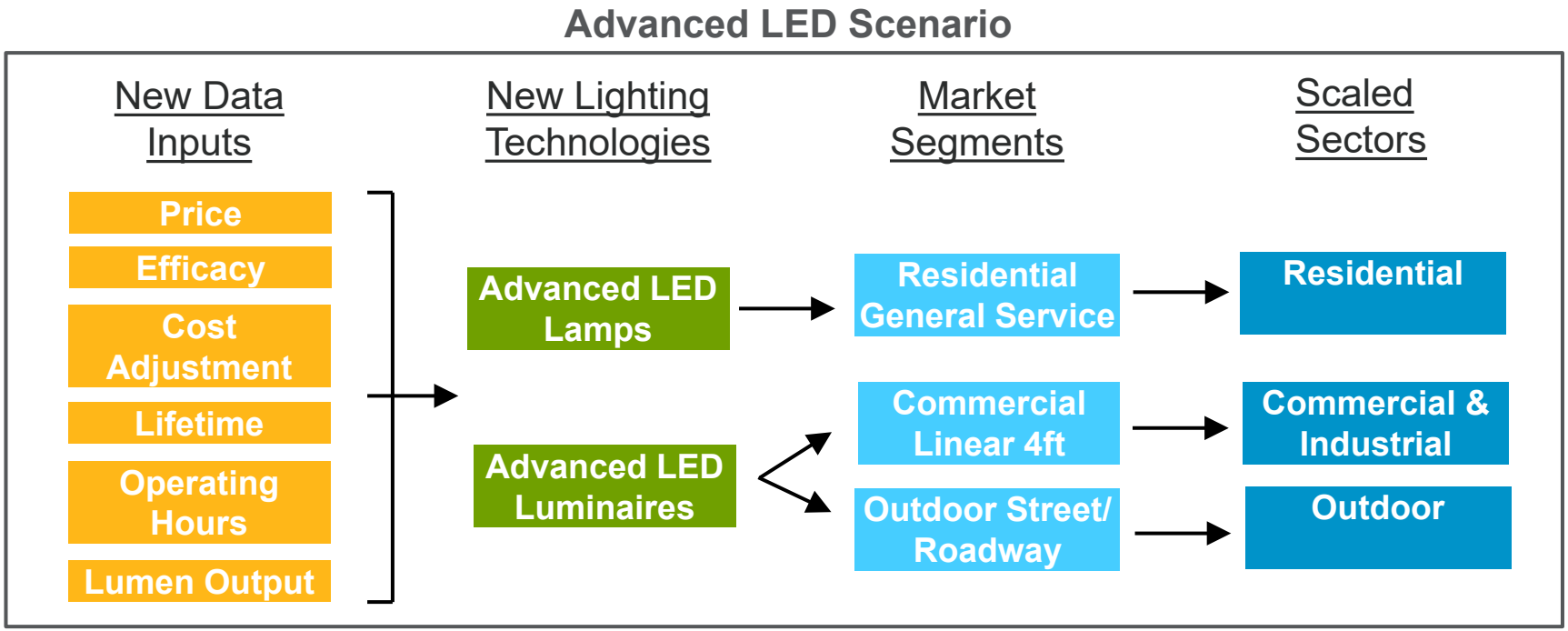
MODEL UPDATES

- A new scenario was created in the model with advanced LED technologies entering the market in 2022.
- New data inputs were used to define advanced LED lighting technologies in 3 representative market segments
- Results from these segments were scaled to all other segments in the sector



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MODEL INPUTS AND ADJUSTMENTS

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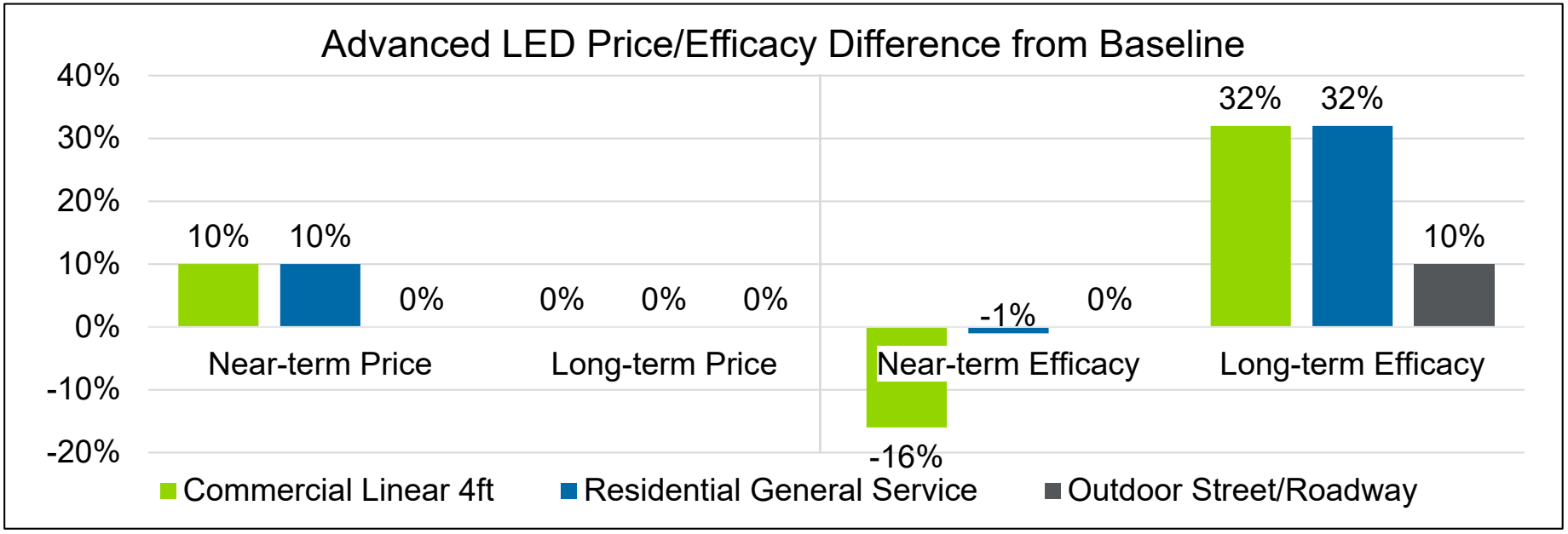
ADVANCED LEDS

- PNNL is conducting advanced LED lighting research focused on glare reduction, flicker reduction, non-visual effects (lighting intensity and color temperature adjustment), color rendering, and dark sky and environmental impacts.

Research Features	Submarket	Long Term Result (2030-2035)
Glare Reduction	Commercial	Updated glare metrics combined with new findings on optical materials and optical control eliminate visual discomfort.
Flicker Reduction	Commercial	Updated flicker metrics and application guidelines combined with new developments in driver, dimming, and control technologies eliminate noticeable flicker.
	Residential	
Non-Visual Effects	Commercial	Wide range of adjustment possible for both light levels and various light colors. Addresses the desire to have bluer light during portions of the day, with higher light levels, and redder light at night, with lower light levels.
	Residential	
Color Rendering	Commercial	The light makes colors look vibrant and pleasing. Whites are crisp and clean. The light is an untinted neutral white.
	Residential	
Dark Sky/ Environmental Effects	Outdoor	Advanced understanding of interactions between light, wildlife, and dark skies lead to better metrics and user guidance, allowing light that minimizes impact on dark skies and wildlife, while allowing improved human visibility.

PNNL MODEL INPUTS

- PNNL provided estimates of the price and efficacy effects in the near term and the long term that are expected from their research conducted on each lighting feature
- Values for each feature were combined to obtain a single price and efficacy value for advanced LEDs in each submarket
- The labor costs, operating hours, and lifetime projections are assumed to be the same as the non-advanced LEDs. Lumen output was the same except decreased for outdoor.
- Market entry year is assumed to be 2022.



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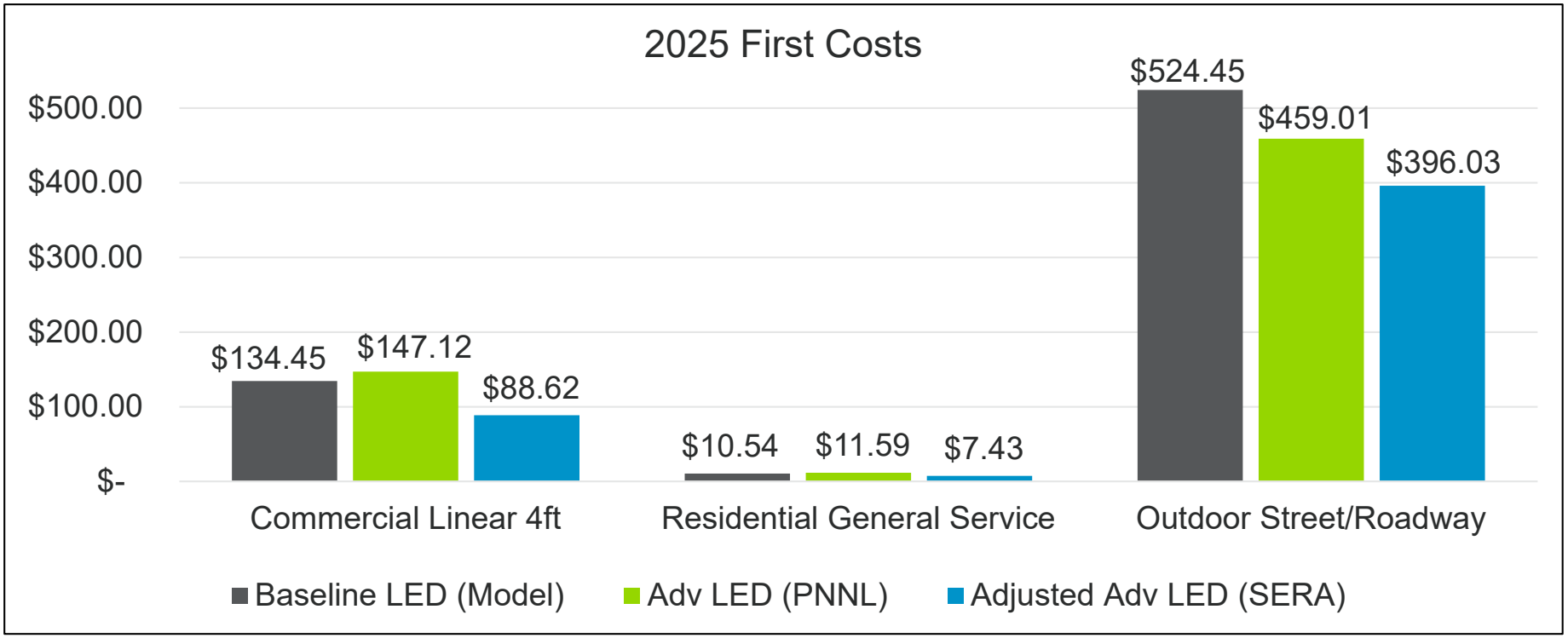
SERA MODEL INPUTS

- Additional adjustments were needed to account for the added value of the advanced technology features relative to the baseline.
- The values estimated from SERA's analysis were used to adjust the first cost of advanced LED technologies to simulate increased favorability in the market.



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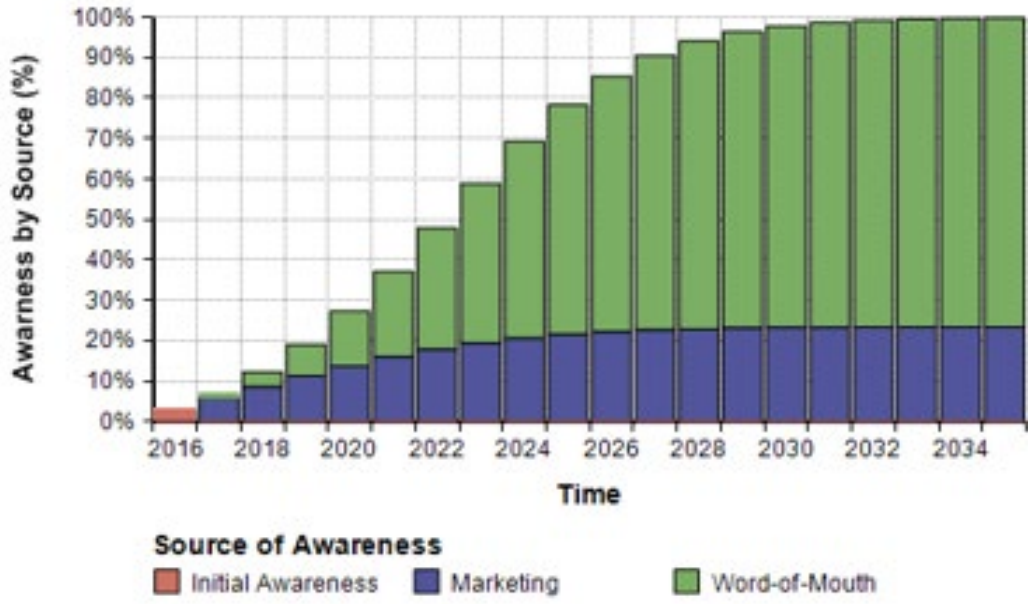
DIFFUSION AND CALIBRATION

- There are three primary coefficient factors that affect bass diffusion curve:
  1. **Word of mouth factor**:
  2. **Marketing factor**:
  3. **Initial acceptance factors**
- *Assumed default 'moderate' coefficients for Advanced LEDs*



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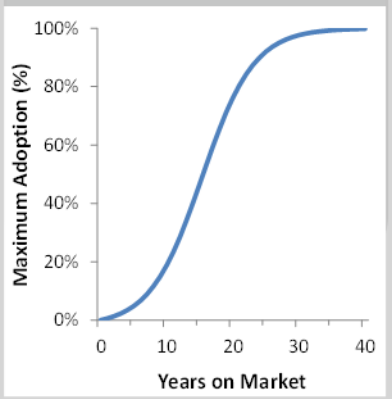

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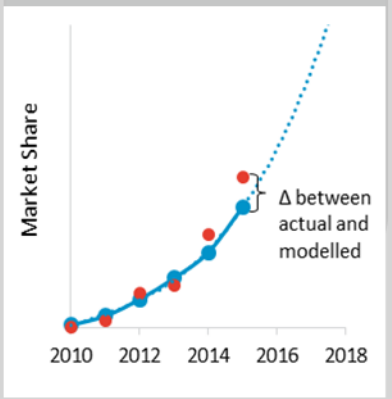

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SCALING AND RESULTS

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ENERGY SAVINGS METHODOLOGY

Energy savings for the *Advanced LED Path Scenario* were estimated relative to a *Current SSL Path Scenario.*

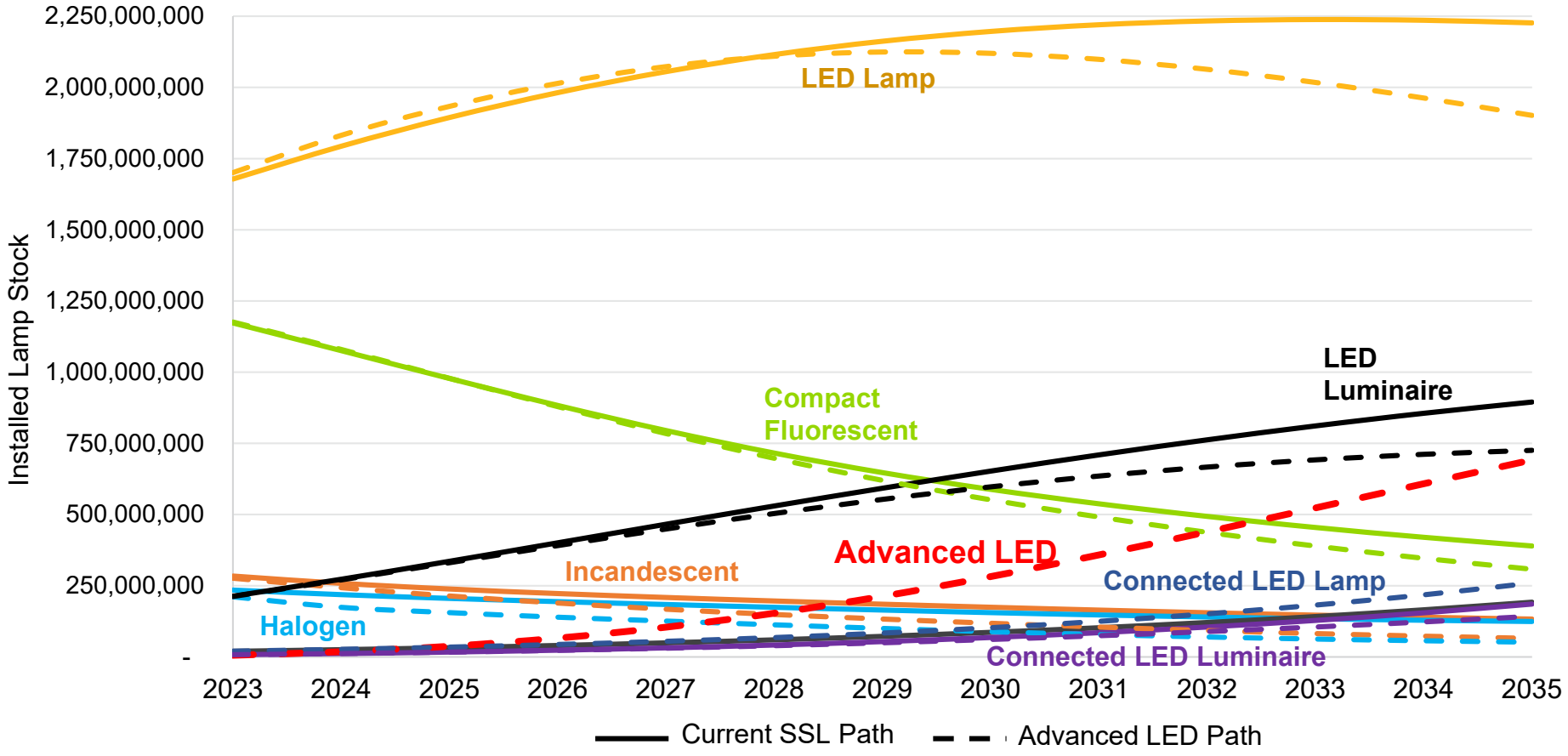
These are defined as:

- **Current SSL Path:** the expected future path for LED lamps and luminaires given continuation of current levels of SSL investment AND NO investment in the advanced LED technologies that are the focus of this study.

- **Advanced LED Path:** the expected future path for LED lamps and luminaires given continuation of current levels of SSL investment AND additional investment in advanced LED lighting features (glare reduction, flicker reduction, flicker reduction, non-visual effects, color rendering, dark sky/environmental effect) which result in commercialized technologies in 2022.

RESIDENTIAL GENERAL SERVICE

- In 2035, advanced LED technologies are projected to represent the **third most** installed lighting technology in the residential general service submarket, representing **17%** of the market.



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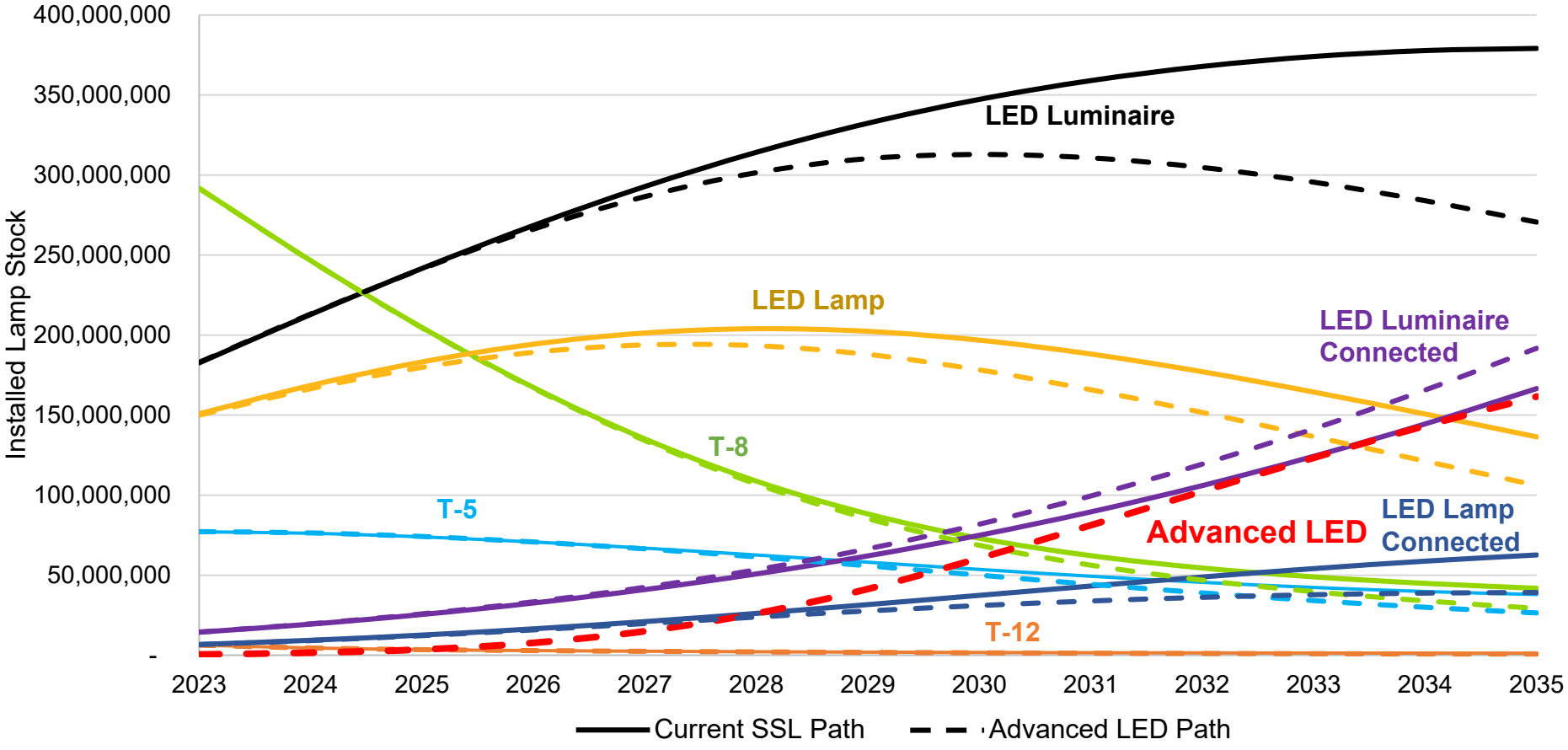
COMMERCIAL LINEAR 4FT

- In 2035, advanced LED technologies are projected to represent the **third most** installed lighting technology in the commercial linear 4ft submarket, representing **20%** of the market.



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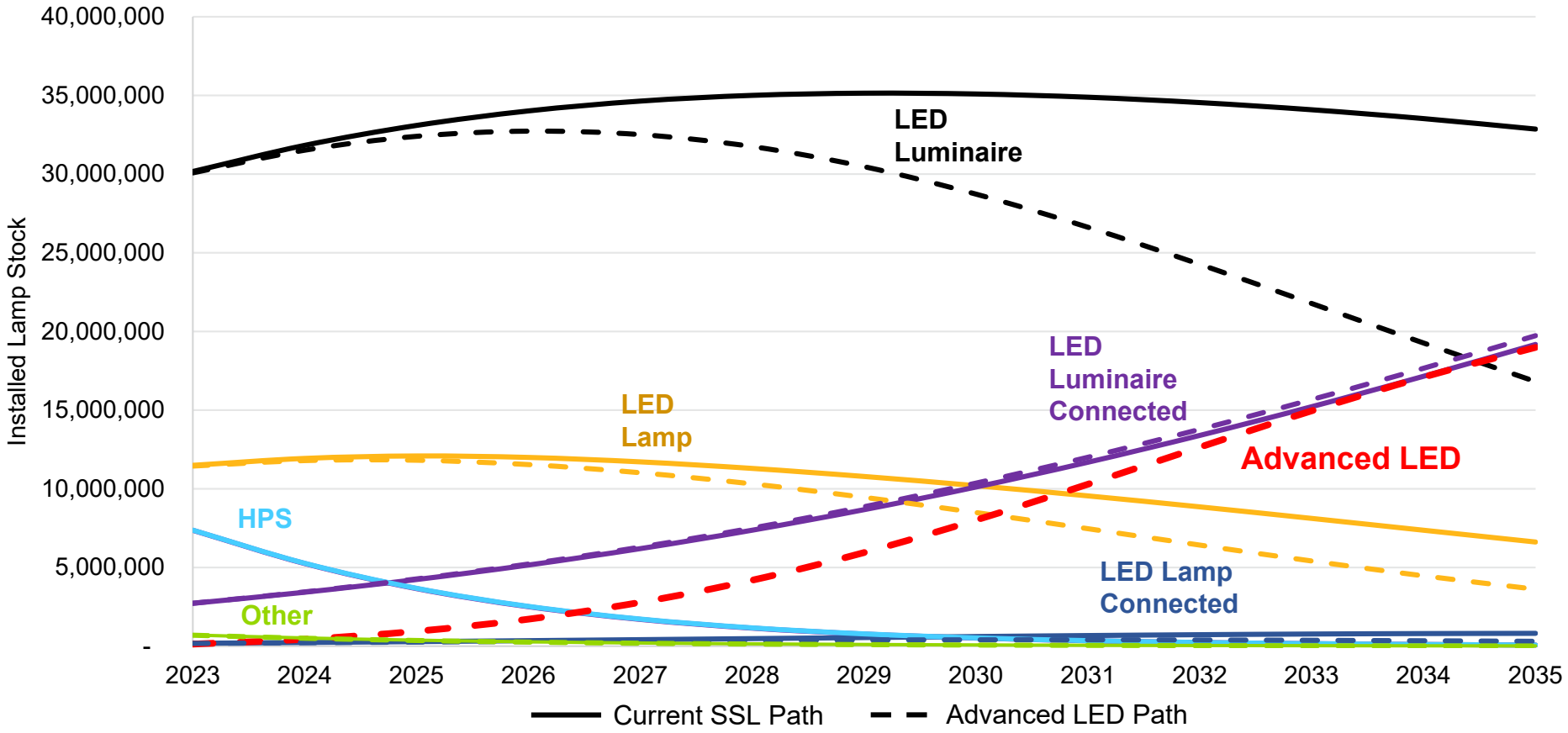
OUTDOOR STREET/ROADWAY

- In 2035, advanced LED technologies are projected to represent the **second most** installed lighting technology in the outdoor street/roadway submarket, representing **32%** of the market.



Note: Other represents a combination of incandescent, mercury vapor, metal halide, low pressure sodium, and other technologies.

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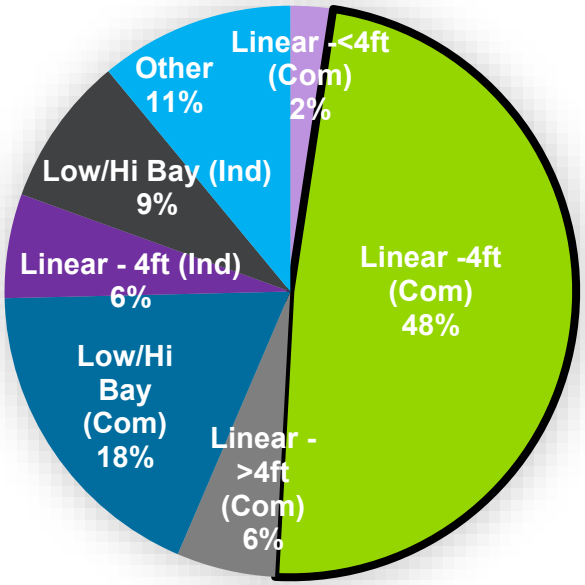
SCALING METHODOLOGY

- Advanced LED technologies were modeled for three market segments:

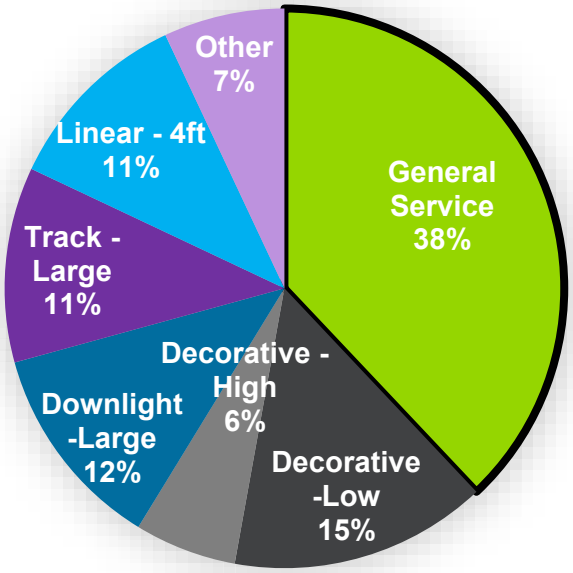
1) Commercial linear 4ft 2) Residential general service 3) Outdoor street/roadway

- The energy savings were scaled to the other submarkets within the sectors using the **ratio of energy use** for each submarket to the total energy use in the sector
- This was used to reduce number of model runs due to time/budget constraints

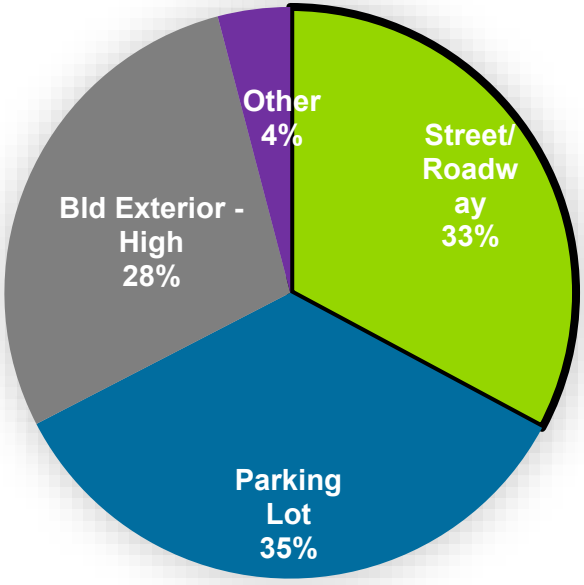
Commercial/Industrial



Residential



Outdoor



Note: Some smaller market segments are combined into the 'other' category in these graphics for simplification purposes.

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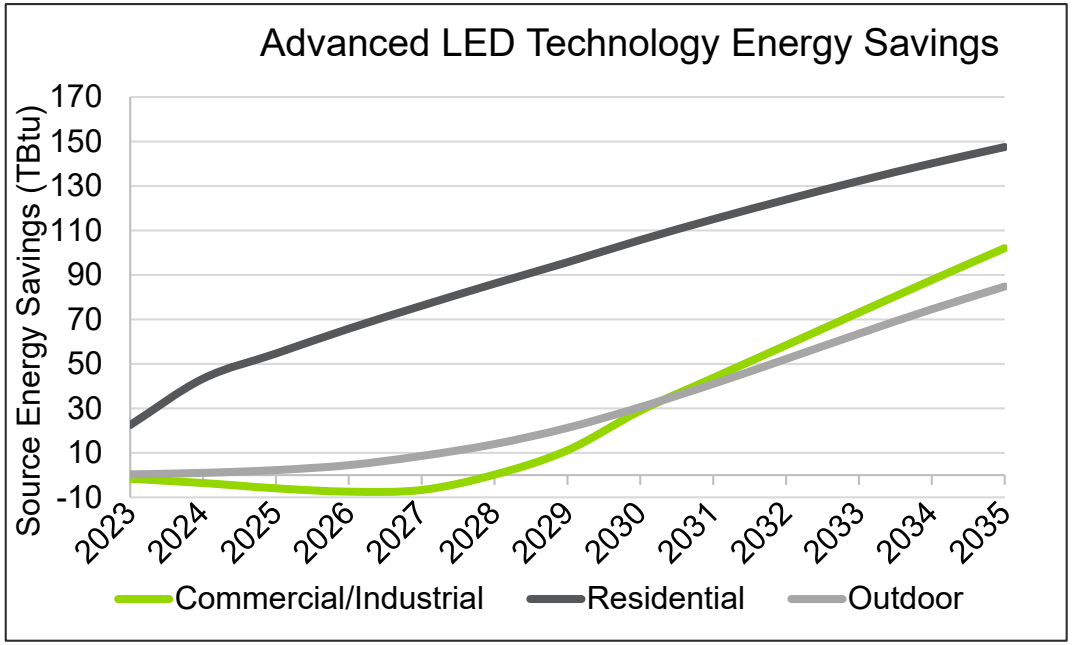
ENERGY SAVINGS RESULTS

- Results showed the greatest cumulative energy savings in the residential sector, then outdoor, and finally the commercial/industrial sector.
- In 2035, source energy savings were **334 TBtu** representing **10%** of lighting energy use.
- Cumulative energy savings (2023-2035) were estimated to be **1,987 TBtu**

Sector	Advanced LED Technology Source Energy Savings	
	2035	
Commercial/ Industrial	102 TBtu	6%
Residential	148 TBtu	18%
Outdoor	85 TBtu	12%
Total	334 TBtu	10%



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CONTACTS

VALERIE NUBBE
Senior Consultant
Valerie.Nubbe@Navigant.com

CLAY ELLIOTT
Managing Consultant
Clay.Elliott@Navigant.com

JULIE PENNING
Managing Consulting
Julie.Penning@Navigant.com

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