# 2022-2027 Nonresidential Lighting Interim Market Model Expert Panel Activity Summary

June 2025

This summary documents the activities, process, and participants of the expert panel for BPA's 2022-2027 Nonresidential Lighting Interim Market Model and related market research. Panel activities described in this summary took place between May 2023 and July 2024.

## Nonresidential Lighting Market Research and Purpose of Expert Panel

Efficient lighting technologies continue to drive significant energy savings in the Northwest. One of the regional markets that BPA studies is nonresidential lighting, which encompasses commercial, industrial, and outdoor (street and roadway) lighting. BPA built and maintains a quantitative market model to understand the energy consumption of this equipment and track the impact nonresidential lighting has on Northwest energy consumption over time. BPA has reported Momentum Savings from nonresidential lighting since 2009.

In 2024, BPA developed a forecast of Momentum Savings from nonresidential lighting during BPA's Energy Efficiency Action Plan period of 2022 to 2027. BPA refers to this current model iteration as the 2022–2027 Nonresidential Lighting Interim Market Model and intends to update it in 2028 to finalize results for 2022–2027. Because of uncertainty around forecast results, BPA has not published materials related to the 2022–2027 Interim Market Model. For more information on BPA's nonresidential lighting market research, please contact Joan Wang, the BPA project lead, at jjwang@bpa.gov or visit https://www.bpa.gov/energy-and-services/efficiency/market-research-and-momentum-savings/lighting-market-research.

BPA contracted with DNV to facilitate a panel of independent experts and regional stakeholders to review and provide feedback throughout the development of the 2022–2027 Nonresidential Lighting Interim Market Model and related market research. The goal of the expert panel process is to provide BPA with independent expert review and advice on their market research, methodologies, market model, and results. Additionally, the expert panel process ensures continuous engagement in BPA's market research from its stakeholders representing the Northwest Power and Conservation Council (Council), the Northwest Energy Efficiency Alliance (NEEA), the Regional Technical Forum (RTF), and internal BPA staff.

## Overview of Panel Engagement Activities

This section summarizes panel activities that took place between May 2023 and July 2024 throughout the development of the 2022-2027 Nonresidential Lighting Interim Market Model and related market research. A more detailed catalog of specific panelists engaged in each activity and meeting minutes for each working session are

accessible at the end of this document. A copy of the comment tracker with panelist feedback and BPA's responses is available upon request.

**Expert Panel Model Kickoff and Data Source Recommendations Working Session on May 17, 2023:** BPA engaged with the full expert panel to kick off the nonresidential lighting market model development process. BPA presented its model development plan, ensuring panelists have clarity on the interim model update (versus the final model update). The panelists provided additional data sources for building stock, installed stock, and tech specs that BPA uses to support the model update. The panel's feedback helped inform BPA's model development plan.

**2022 Sales Data Collection Desk Review from June 28 to July 12, 2023:** BPA requested panelists to review three documents: 1) a memo detailing the data collection, representativeness assessment, and extrapolation processes used to create the nonresidential lighting dataset; 2) a workbook documenting all sales data, both collected and extrapolated, from 2013 through 2022 from the nonresidential lighting sales data collection study; and 3) a workbook providing additional context about the nonresidential lighting sales data analysis study. BPA asked the panelists to respond to questions regarding the data gaps memo and the market results summary. Panelists gave feedback on distributor outreach/maintaining participation, alternative sales channels, extrapolation percentages, and alternative/additional data sources. The feedback led to BPA's exploration of alternative extrapolation methodologies in 2024.

**Building Stock Desk Review from July 21 to Aug. 4, 2023:** BPA had panelists review commercial, industrial, and outdoor (street and roadway) sector building stock estimates. BPA provided a workbook detailing the data sources and calculations used to derive building stock estimates for each modeled sector. Panelist feedback included insights on trends in commercial and industrial office building stock as well as alternative/additional data sources.

**Sales Mix Allocation Methodology Working Session on Aug. 25, 2023:** BPA presented its proposed sales mix allocation methodology to panelists. The methodology described how to allocate sales data to stock data within the stock turnover model. BPA asked the panelists to provide feedback on the methodology, installed stock, sales mix forecast, and allocation data sources. Panelist feedback included market scaling factors, accounting for market events (e.g., COVID, changing codes, etc.), and representativeness of collected sales data.

**Technical Specifications Desk Review from Oct. 27 to Nov. 10, 2023:** BPA requested panelists to review nonresidential lighting technical specification (tech spec) estimates. Specifically, BPA asked for feedback on recommendations for improving the analysis or source data for the tech spec estimates and for improving the analysis or source data for the COVID-adjustments made to hours of use (HOU) estimates. Panelists responded to a series of questions regarding wattage, lifetime, HOU, and HVAC interaction factor. Panelists provided feedback about potential alternative data sources for product wattages, including DesignLights Consortium (DLC), ENERGY STAR, and audit software providers. Panelists raised questions about making an HOU adjustment to

the industrial sector and/or the commercial warehouse building type and asked whether the HOU estimates include the impact to operation due to controls. Based on this feedback, BPA made updates to the tech spec estimates.

**Technical Specification Updates Desk Review from Jan. 26 to Feb. 9, 2024:** BPA engaged the same panelists from the previous tech spec desk review to review the updated nonresidential lighting tech spec estimates. Based on panelist feedback from the tech specs desk review in November 2023, BPA made updates to the wattage forecast to use DOE forecast, revised the limits on wattage change over time based on market actor interviews, and updated the assumption for impact of hybrid work on HOU for certain building types. Panelists pointed out that forecasted wattages may be too low in the model period, suggested making an HOU adjustment to the industrial sector and/or commercial building type, and to review the impact of controls. BPA will explore and consider these for the final market model.

**Sales Mix Allocation Draft Results Working Session on Feb. 23, 2024:** BPA presented its nonresidential lighting model sales mix allocation and forecast to panelists. BPA asked panelists for feedback on the draft estimates of technology mix by application by year. BPA incorporated panelist feedback on the sales mixes and refined the sales mix through model quality control processes.

**Controls Analysis Memo Desk Review from April 1-16, 2024:** BPA asked the panel to review a controls analysis memo. BPA made the decision to exclude controls from the interim market model due to data availability constraints. The controls analysis memo documents these constraints and BPA's resulting decision. BPA asked for panelist recommendations on overcoming barriers to including controls in the nonresidential lighting market model in the future, improving the analysis to characterize controls saturation from available Commercial Building Stock Assessment (CBSA) data, and improving the analysis to quantify uncertainty related to controls saturations developed from available CBSA data. The panelists identified several barriers to modeling the presence of controls that deepen BPA's understanding of this market. They also provided helpful insights into how BPA may overcome these barriers in the future by focusing on specific segments of the controls market.

**2023 Sales Data Gaps Desk Review from June 28 to Jul. 12, 2024:** BPA requested the panel to review three documents: 1) a sales data gaps memo detailing the data collection, representativeness assessment, and extrapolation processes used to create the nonresidential lighting dataset; 2) market results spreadsheet documenting all sales data, both collected and extrapolated, from 2013 through 2023 from the nonresidential lighting sales data collection study; and 3) workbook providing context about the nonresidential lighting sales data analysis study. The panelists provided responses to six questions about the data gaps memo and market results summary. BPA will consider implementing some of the panelist feedback in future annual data collection efforts.

**Interim Market Model Draft Results Working Session on July 30, 2024:** BPA engaged with the full expert panel to review the draft results of the 2022-2027 Nonresidential Lighting Interim Market Model and supporting model documents. Key themes emerging from panelist feedback included distributor outreach and improving

participation (e.g., alternative sales channels and re-recruiting large distributors), the extrapolation methodology, and alternative/additional data sources. Feedback on the draft results was very valuable as BPA finalized this iteration of the model.

## Expert Panel Process

For each panel engagement, DNV first met with BPA to understand the research of modeling needs and identified the appropriate panelists. Then DNV scheduled the working session meeting or review, distributed materials, and facilitated the discussion and feedback response. Panelists were responsible for showing up to the working session, completing their desk review on time, and contributing critical feedback in a professional and respectful manner.

BPA and its research contractor documented all panelist feedback in a comment tracker and provided responses to the feedback received including any follow-through actions taken. For transparency, panelists received a copy of the comment tracker and meeting notes in a thank you email that DNV sent after activity completion.

## Expert Panelists

The panel included both experts and stakeholders with a diverse range of nonresidential lighting knowledge and capacities. DNV recruited the independent expert panelists while BPA recruited regional stakeholders as appropriate for this market. BPA requested DNV to recruit independent experts that provide expertise on all elements of the market research.

- **Market/Industry Expert:** A market/industry expert helps BPA ground its research and analysis in reality and ensures BPA is not missing any important aspects of the regional market when trying to model annual full-market stock and sales. A market/industry expert has a strong understanding of the following across different nonresidential lighting technologies:
    - Regional market trends and how technology adoption is changing over time
    - How specific technologies are changing over time (e.g., efficacy)
    - Sales and market turnover, including relative (%) market share and total sales
    - Supply chain trends and actors
- **Technology Expert:** The technology expert has a strong understanding of how nonresidential lighting technologies — including commercial, industrial, and indoor agriculture — work, and preferably know how to model energy consumption for these technologies using engineering models. Technology experts are up to date on technology trends and issues, emerging technologies, and current and any potential future federal or state codes and standards impacting the nonresidential lighting market. A technology expert understands how different technical specifications and installation conditions affect the equipment's performance and energy consumption, which technologies are appropriate for which applications and can

explain tradeoffs in efficiency, cost, and performance across numerous technology categories. BPA prefers technology experts that have a strong understanding of:

  - Technology applications within specific building types and within new and existing construction
  - Technologies for indoor agricultural and industrial applications
  - Full-space lighting redesigns and general trends in lighting design choices
  - Codes and standards impacting the lighting market

- **Market Analysis Expert:** A market analysis expert is someone with experience using a mix of datasets such as sales data, regional building stock assessment data, utility program data and census data, and analyzing them for the broader regional market/population. A market analysis expert is well versed in assessing the representativeness and uncertainties of a sample dataset to determine whether and how to use it to make inferences on the population. A market analysis expert has knowledge of inputs, methods and outputs of stock turnover models and is preferably familiar with the Council's power plans and baseline methodologies.
- **Sampling/Statistical Expert:** A sampling/statistical subject matter expert (SME) has a strong understanding of sampling methods and techniques. They can review and provide feedback to BPA on sampling plans for primary data collection in a way that ensures the data is robust and representative of the population. Sampling/statistical experts help inform BPA on the appropriate use of primary and secondary data sources, including appropriate uses of weights.
- **Regional Stakeholder:** Regional stakeholders are those from the Council, NEEA, RTF, or BPA that participated on behalf of their organization.

Table 1 shows the independent experts and regional stakeholders in the nonresidential lighting expert panel.

### Table 1. Nonresidential Lighting Expert Panelists

| Panelist Name | Expert Classification | Affiliation during Panel |
|---|---|---|
| **Peter Brown** | Market/Industry Expert | Electrical Transitions, LLC |
| **Gina Hicks** | Market/Industry Expert | SBW Consulting |
| **Lauren (Morlino) Eagan** | Market/Industry Expert | Evergreen Energy |
| **Wes Whited** | Market/Industry Expert | DNV Energy |
| **Chris Meeks** | Technology Expert | University of Washington |
| **Geoffrey Cooper** | Market Model Expert | DNV Energy |
| **Eric Mullendore** | Regional Stakeholder | BPA |
| **Kevin Smit** | Regional Stakeholder | Council |
| **Chris Wolgamott** | Regional Stakeholder | NEEA |
| **Paul Sklar** | Regional Stakeholder | RTF |

## Catalog of Panel Activities

The panel kicked off in May 2023 and ended in July 2024, completing a total of 10 engagement activities. Table 2 shows the full list of panel engagements, topics covered, and panelists involved. Appendix A provides the detailed meeting minutes to the working sessions. A copy of the comment tracker with panelist feedback and BPA's responses is available upon request.

### Table 2. Nonresidential Lighting Expert Panel Completed Activities

| # | Review Type | Panel Engagement Period | Topics Reviewed | Independent Experts | Regional Stakeholders |
|---|---|---|---|---|---|
| **1** | Working Session | May 17, 2023 | Modeling background, 2023-2024 model update priorities, market actor interviews, and modeling timeline. | Christopher Meek, Lauren Eagan, Geoffrey Cooper, Gina Hicks | Chris Wolgamott, Paul Sklar, Kevin Smit, Eric Mullendore |
| **2** | Desk Review | June 28-July 12, 2023 | Sales data gaps memo and data collection market results. | Christopher Meek, Lauren Eagan, Geoffrey Cooper, Wes Whited | Chris Wolgamott, Kevin Smit |
| **3** | Desk Review | July 21 – Aug. 4, 2023 | Commercial, industrial, and outdoor (street and roadway) sector building stock estimates. | Christopher Meek, Lauren Eagan, Wes Whited | Chris Wolgamott, Kevin Smit |
| **4** | Working Session | Aug. 25, 2023 | Sales mix allocation background and context, data sources, and methodology. | Christopher Meek, Lauren Eagan, Geoffrey Cooper, Wes Whited, Gina Hicks | Paul Sklar, Kevin Smit |
| **5** | Desk Review | Oct. 27 – Nov. 10, 2023 | Nonresidential lighting technical specification estimates including wattage, lumens, and efficacy; lifetime; daily hours of use, HVAC interaction factor, lamps per fixture; and ballasts per fixture. | Lauren Eagan, Geoffrey Cooper, Wes Whited, Peter Brown | Chris Wolgamott |
| **6** | Desk Review | Jan. 26 – Feb. 9, 2024 | Updated nonresidential lighting technical specification estimates, specifically for wattage and hours of use. | Christopher Meek, Lauren Eagan, Wes Whited, Peter Brown | Chris Wolgamott |
| **7** | Working Session | Feb. 23, 2024 | Sales mix forecasting and allocation, methodology refresher, and draft results for five key applications. | Peter Brown, Wes Whited, Geoffrey Cooper, Lauren Eagan, Christopher Meek | Chris Wolgamott, Paul Sklar |
| **8** | Desk Review | April 1-16, 2024 | Data availability constraints and controls analysis. | Geoffrey Cooper, Lauren Eagan, Wes Whited, Peter Brown | None |

| # | Review Type | Panel Engagement Period | Topics Reviewed | Independent Experts | Regional Stakeholders |
|---|---|---|---|---|---|
| **9** | Desk Review | June 28 - July 12, 2024 | Sales data gaps memo and market results. | Christopher Meek, Geoffrey Cooper, Lauren Eagan, Wes Whited, Peter Brown | Paul Sklar |
| **10** | Working Session | July 30, 2024 | Model methodology refresher; interim model results for momentum savings forecast, energy consumption forecast, forecasted market trends, and program savings forecast; sources of uncertainty, future research, and model planning. | Christopher Meek, Geoffrey Cooper, Lauren Eagan, Wes Whited, Peter Brown | Chris Wolgamott, Paul Sklar |

## Appendix A: Working Session Meeting Notes

The following contains the meeting minutes to all working sessions.

# Working Session: Expert Panel Kickoff and Data Source Recommendations – May 17, 2023

ACTION ITEM – This highlights an action item for a panelist.

ACTION ITEM – This highlights an action item for BPA and/or Cadeo.

## Attendees

**BPA:** Juan Carlos Blacker, Eric Mullendore

**DNV:** Tyler Mahone, Lorre Rosen, Bridget Ransford

**Cadeo:** Kate Bushman, Kate Donaldson

**Panelists:** Christopher Meek (University of Washington), Chris Wolgamott (NEEA), Paul Sklar (RTF Forum), Kevin Smit (NW Council), Lauren Morlino (Evergreen Efficiency), Geoffrey Cooper (DNV), Wesley Whited (DNV), Gina Hicks (SBW Consulting)

## Introductions

**Tyler** led the panel through brief introductions and then walked through the agenda topics.

## Working Session Agenda

- Panel Objectives and How-To
- Modeling Background
- 2023-2024 Model Update Priorities
- Modeling Plan
- Market Actor Interviews
- Modeling Timeline
    - Tentative Expert Panel Engagement Summary

**Tyler** noted that the main purpose of the meeting today is to kick off the non-res lighting market model process. Kate Donaldson will go through the model's background, and we will discuss model updates and priorities for 2023-2024. Today's panel is more informative, but there will be a couple of opportunities to provide feedback. After the call, we will send an Excel spreadsheet where written feedback can be provided.

## Panel Objectives and How-To

**Tyler** reminded everyone that these expert panels support and improve the market models. We are looking for the following from the expert panelists:

- Technical expertise and experience
- Creativity and open-mindedness
- Consistent/ongoing feedback

The purpose of the expert panel session is:

- To share BPA's non-residential lighting model development plan.
    - Ensure panelists have clarity on this interim model update (versus the final model update).
    - Share out when we are engaging with the Expert Panelists and on what topics.
- To ask Expert Panelists for data sources to aid in model input development.

Provide data sources via the provided workbook by June 2nd

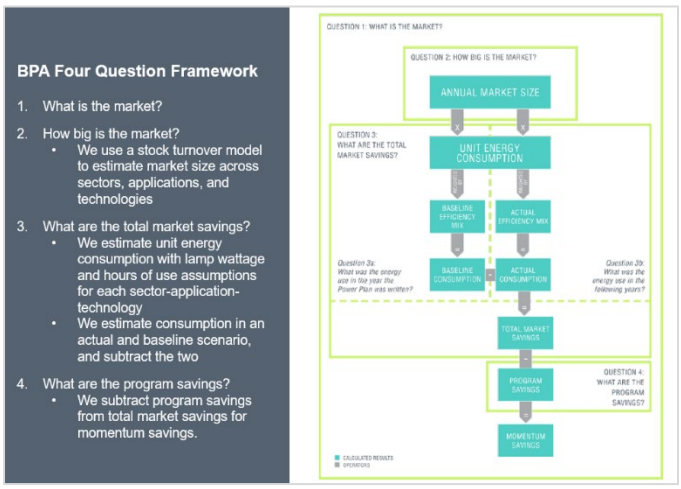
**The lightbulb icon indicates when we are looking for feedback or discussion from the panel about a particular topic.**

## Modeling Background

**Juan Carlos** provided modeling background to remind the panelists about the project.

BPA's market models:

- Quantify momentum savings as a regional power resource.
    - Momentum savings are electrical energy savings that are above baseline and outside of incentive programs coming from the utilities or NEEA.
    - We use momentum savings to forecast energy consumption and to inform our regional power plans.
- Utilize the best information from available sales data or market studies to accurately characterize market trends, what is happening, and what is selling in the market.

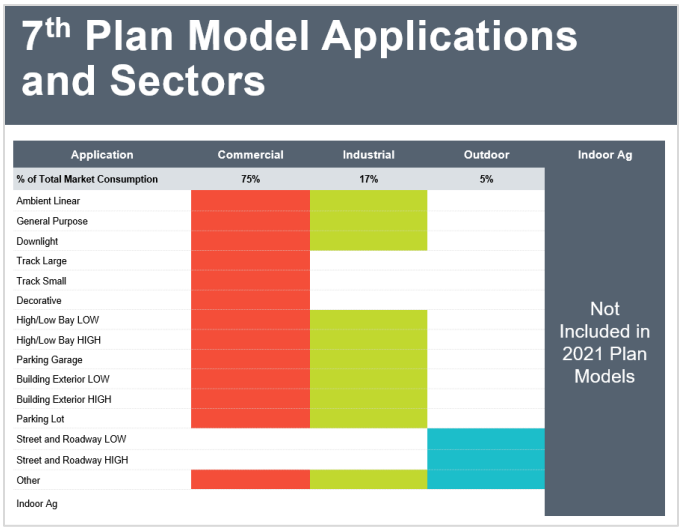



Next, **Juan Carlos** reviewed BPA's four-question framework. We use the framework to not only quantify momentum savings, but also to understand the market better, and help inform our programs and our energy efficiency department. With an understanding of the efficient lighting market, we can better plan, not only for power research, but for program development and design. Below is an outline of the four-question framework to help guide our understanding of the market.

**Kate Donaldson** reviewed the non-residential lighting market model structure. BPA's non-residential lighting market model currently includes four sectors: Commercial, Industrial, Agricultural, and outdoor lighting. Each sector is segmented into applications, which are specific uses of lighting technologies in specific spaces that share some common characteristics, e.g., ambient linear or high-/low-bay are two applications in the model. Within each application, the model specifies a mix of lighting technologies. So, within ambient linear, to continue that example, there would be a mix of linear fluorescent, Tubular LED (TLEDs), and Light-emitting diode (LED) fixtures that would make up that application.

**Juan Carlos** jumped in and asked if everyone on the panel is clear with the overarching reach of this model. There were no concerns.

**Tyler** reminded the panel that they can use the "raise hand" function in Teams at any time to ask a question.




**Kate D.** For the previous BPA model, which covered the 7th Plan period, the table below maps which applications are included in which sectors and it also shows the relative size of each sector in terms of the percent of total market consumption. Commercial is by far the largest sector in terms of market consumption and therefore is the biggest ticket item in our model.

**Kate D.** discussed that for the 2021 Plan models, BPA will not be including indoor agriculture in the model. Indoor agriculture was previously included because of high regional interest in that market, and it was a quickly changing market.

**Indoor agriculture is not included in 2021 plan period models because:**

Including indoor agriculture in non-res lighting model is inconsistent with 2021 Plan. The 2021 Plan load forecast includes electricity consumption for recreational cannabis producers as part of irrigation/agricultural load forecast. In other words, it is not actually a lighting end use. The total aMW for 2022 equals 72 aMW but includes non-lighting end-uses.

BPA program savings do not offer programs around recreational cannabis or cannabis grow. BPA's program savings do not include indoor ag. and for the model, we have the most visibility onto BPA program savings. So, the lack of that BPA-specific program savings data from indoor agriculture makes it challenges to accurately characterize program savings in this sector in the region.

**Lauren** asked about other agriculture buildings, such as cow farms with high-bay fixtures? **Kate D.** asked Kate Bushman to confirm that the only agricultural end use in the previous non-res lighting model was indoor ag. So, with the removal of indoor agriculture, we are pulling out agricultural form the model altogether. Because, based on available data it is hard to pull out what is lighting and what are other end uses in agricultural. With indoor agriculture specifically, grow lights operate on a different set of rules, assumptions, and operating principles than regular lighting end uses. So, like all of the operation is tailored around plant growth with indoor ag. So, it makes it really challenging to develop a set of assumptions that applies evenly across the model. So, we have to tailor that sector. Kate B. has more insight into the lack of other agricultural end uses from the last model update since she managed that one.

**Kate B.** said that Kate D. is right, we will no longer have an Agricultural sector within the model. The only place agricultural buildings might be represented in the model would be within the Industrial sector. There is some gray area between what gets categorized as industrial or agricultural. We are not building this model on a building-by-building basis. Kate B. suspects that within our estimated floor area for industrial, there would be some agricultural buildings included there. That is where we would have some touch on the Agricultural sector.

**Eric** said that we should be careful about the netting out program savings because we do have some indoor agriculture reported to BPA. For a non-cannabis example, there is an oyster farm that uses a large number of LEDs. We also see lettuce and tomato farms in the region, so we do have some of that in our program-reported savings. We also have self-funded savings. BPA will not reimburse utilities, but utilities that want to support those types of facilities are able to report the savings to the BPA. They just

cannot seek reimbursement from BPA for those savings. When we are netting out program savings, we want to scrape those things that could be considered indoor ag.

**Kate D.** commented that Eric made a great point and said that we will go through program savings with a fine-toothed comb for anything that can be considered indoor ag.

**Kate D.** continued with a discussion on model objectives. The overarching goal of BPA's market model is to quantify both electric energy consumption and momentum savings for BPA for the 2021-2027 time period with 2021 as the baseline year and 2022-2027 as the action plan years.

We do this in two models: Interim and final:

- Interim model update (2023-2024): Incorporates available data from 2021-2022
- Final model update (Expected 2026-2027): Add available data to model through 2027

The Interim model update is what we are kicking off today. It will provide energy consumption and momentum savings estimates for 2021, the baseline year, and 2022, as well as forecasts for future years through 2027 using collected and available data.

Based on limited data availability and timing constraints and the fact that more data will become available as we move through the action plan period, we will not be able to comprehensively update the entire model in this Interim model. But we will develop this model looking forward to the forthcoming model update, meaning that we will do what we can to anticipate future model update needs or upcoming data sources and build what we can in this model to limit having to restructure things in the future model.

**Kate D.** asked if there were any questions.

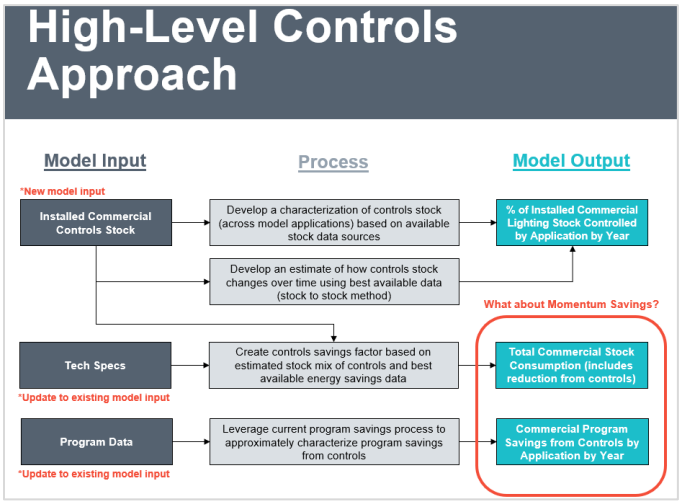
**Kate B.** said that the big data source that we will not have for the interim model, but we will have for the final model is the CBSA. For those involved in the last model period, we spent a lot of time integrating the CBSA into our model update, we will not have that for this interim model, but we will for the final model.

## 2023-2024 Model Update Priorities

**Kate D.** continued and reviewed the key priorities for the 2023-2024 model updates.

We have a couple of key priorities. First, we will be transitioning the model out of Analytica and into Python, which is a more user friendly code platform. Not only does it make the model easier to interact with, but it also gives us the opportunity to evaluate our model calculations and determine if or where improvements, changes, streamlining, or alterations can or should be made. We can take stock of the full model, make sure it is functioning the way we want it to, and make tweaks where we think we can make improvements. This is already partially done. We have transitioned part of the model to Python already. We will continue to do that behind the scenes. You will not necessarily hear a lot of updates on that. By the end of this model update, the model will be functional in Python. The main priority you will insight into is updating each of the model inputs to do a couple of things. First, to reflect 2021 Action Plan period. This is going to impact things like building stock estimates and when we develop scenarios for model inputs. It is also an opportunity to true-up the model, taking it out of the 7$^{th}$ Plan period and moving it into the 2021 Action Plan period with that Plan's data. Second, making sure that we are updating any model inputs to reflect new market data (where there is any). Not all model inputs will have new model data (CBSA), but we will leverage what new data is available. In other words, no data still means there will be updates, just not with new data. Finally, we will be updating some select model updates to include controls. So, as you know, we recently completed work determining the feasibility of including controls in the non-res lighting market model. Through that work, we have confirmed that it is feasible at a certain level of granularity, and we have developed an approach that accounts for best available data and related data constraints. Since most of you were there at the controls data

availability share-out in the winter, you should be familiar with that information. But we will walk through our approach over the next couple of slides. We will also provide forecasted momentum savings for the full 2021 Plan period to BPA either late this year or early in 2024.




**Kate D.** discussed the high-level controls approach illustrated in the next slide. In our controls data availability presentation, we walked through the limitations of available data, particularly in accurately characterizing the control stock size and mix based on limitations of the CBSA and a lack of a good, robust control-specific stock data source.

We hope the forthcoming CBSA will include more controls data. In the meantime, we developed this approach that is going to leverage best available data but also limits uncertainty as a result of the limitations of available data.

As a first step, we will develop a new model input called Installed Commercial Controls Stock. We will use best available data to develop that like the 2019 CBSA and the Department of Energy (DOE) forecasting reports to develop a very high-level, rolled-up characterization of control stock size and to develop an assumption of how control stock size is changing over time. The outcome of that is going to be a percentage of installed commercial lighting stock controlled by application and by year. That is not going to account for stock mix in the model output. In other words, it is not going to be a granular characterization of the presence of each different control strategy type. But it is going to show how much lighting in a given application is controlled.

**Eric** asked if by controlled, she means automated controls…any non-manual control? **Kate D.** said yes; controlled by more than just and on/off switch.

**Kate D.** continued. In the tech specs, we are going to create a controls savings factor based on some estimate of stock mix of controls based on available data. Once we develop the installed commercial control stock estimate, we will determine the best approach for developing that controls savings factor. There is a spectrum of how robust we can be in developing that controls savings factor since data is so widely available for saving potential of different systems. But after we do the installed stock step, we will determine which approach is right for this. The outcome of that will be our estimate of total commercial lighting stock energy consumption will include a reduction from consumption of controls.

**Eric** noted that there is an intense interaction between annual hours of use and controls. He asked how we plan to avoid double discounting the consumption as a result. The hours of use already include the impact of controls further derating that based on anticipated controls.

**Kate D.** said she can speak to the control side of that question, and Kate B. can address how previous models have taken out or accounted for that controls hours-of-use assumption in the previous lighting-only models. But for the controls savings factor, most of the controls savings factor that we have seen in our study of available data are all based on an hours-of-use reduction. So, the way that this would work is we would apply some sort of savings factor on top of hours of use to account for controls. Kate B. can speak to if or how the model has previously accounted for controls and hours-of-use estimates?

**Kate B.** said that hours-of-use is one of the model inputs we want to look closely at in this update. Our existing data is medium quality for hours of use and quite outdated. For example, the existing data does not reflect any changes in building usage since the pandemic. Eric raises an important point, we need to understand when we developed the updated hours of use input, and what assumptions are being made about controls. We have not looked at the data sources available. We do not know yet whether

we will be able to develop a pre-control hours of use, and then separately estimate the impact of controls on hours of use or if we will embed the controls impact into the hours of use estimate. But this is a great point and something that we need to watch out for.

**Kate D.** continued. We are going to update our current program savings characterization methodology to account for controls. In the previous model, we calculated program savings from controls and removed it from total program savings to arrive at program savings from lighting. This time we will investigate the methodology to see if any refinements are needed to dial in that controls characterization. We will be characterizing program savings from controls and for lighting by application by year. Any thoughts on the controls approach?

**Chris Wolgamott** asked about the controls fraction savings number that BPA will produce. Will that be a mixture of different control strategies? Including the occupancy, daylighting, high-end trim?

**Kate D.** said that there is light-touch option and a not-so-light-touch option. A light-touch option is taking the controls strategy types that are in the CBSA at the mix that they are in the CBSA and trying to develop aggregate number of controls saved on average (say, 30%) and using that as our controls savings fraction. The more robust version would be something like the RTF; in their protocol they use a standard table with savings fractions by control strategy type and building type. We could do some layering from what is in the CBSA for stock size and mix. Because the RTF method is by building type, we can lay those sources on top of each other and try to develop a more robust way of getting at the controls reduction percentage. It is a matter of how much the installed stock is controlled and how critical it is and what the margin of error is compared to the light-touch option. There will be a trade-off discussion. Yes, that controls savings fraction will account for a mix of controls strategies like the ones that are reported in the CBSA. High-end trim is an interesting one, since that is a function of luminaire-level lighting controls or other network-lighting controls. It is like making some assumptions about how many of those systems are operating using that and what that % reduction is. When the next CBSA comes out, we can see if they have refined their ability to identify those more advanced lighting control strategies and we can develop some assumptions from there. But for now, we will see how far we can get with the current data available.

**Kate B.** added that we do not want to be too optimistic about the next CBSA information because we know how challenging it is to identify how a controls system is implemented and how it is functioning from a site audit. The strategy is to get the information we can out of the available data without over interpreting that data.

**Momentum savings from controls:**

- We will ensure there are no Momentum Savings reported for controls in the interim model update (i.e., ensure baseline scenario = market scenario and 100% of savings are program savings).
- We will reassess the feasibility of controls Momentum Savings in the next model update, but we do not expect circumstances to change much.

**Kate D.** continued discussing controls. We determined in our review that there are limited opportunities for calculating momentum savings from controls. One opportunity is new construction projects that are exceeding code, which we know to be rare and hard to quantify. We know that Luminaire Level Lighting Control (LLLC) projects are the main opportunity to exceed code, but that NEEA LLLC program savings will claim all LLLC regional savings starting in the 2022 data year. Most of the savings above code are going to be claimed by programs. Another opportunity is retrofit projects: installing non-code-required controls, which we also know to be rare. It is possible that there are small pockets of savings happening above code and outside of NEEA LLLC savings, but there is no empirical way right now for us to quantify those savings with currently available data. We are going to set up the model to ensure that there are no momentum savings from controls in the Interim Model update. Functionally, this means

that we are going to ensure that the controls presence in the baseline scenario is equal to the controls presence in the market scenario. If you think back to the flowchart of the model that Juan Carlos showed earlier, if you subtract that out, it will come out to zero and that all regional savings from controls are program savings. To Kate B.'s point, we hope that data availability is going to improve between the Interim and Final model updates, but controls are really tricky. The stock size and mix for controls is a famously hard thing to empirically quantify. We are just going to see what we get, and we will reassess to determine if we can pursue momentum savings from controls in a future model update, but that is to be determined.

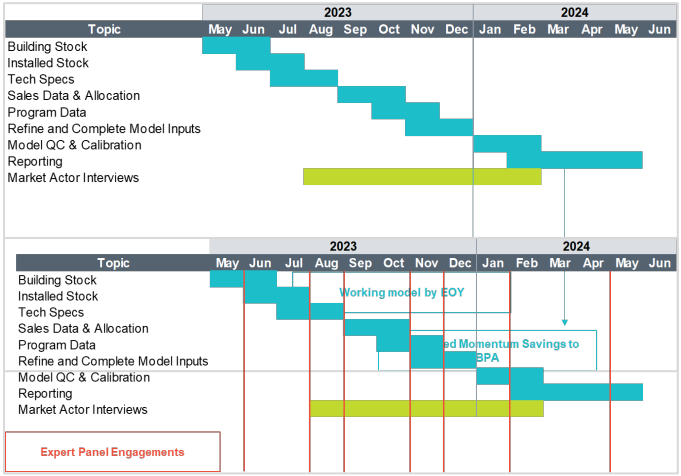
Comments from the meeting chat window included:

**Lauren:** Actual high end trim usage may be important. Customers often dim the lights once installed, even if the controls are basic, customers will keep lights dimmed to a certain amount. It is also possible high-end trim could be a way building operators are reducing lighting load during lower occupancy levels or peak load times. We do not need to discuss this today, just thought I would note high end trim may be undercounted in typical program savings.

**Eric:** I agree Lauren. Unless they install NLC we do not account for any high end trim.

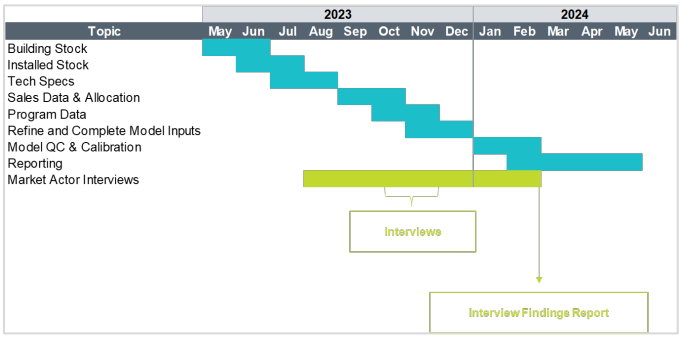
## Modeling Plan

**Kate D.** began to walk through the Modeling Plan slides. It is really important to note that the model is in flux. As we work through the model inputs, refine what BPA's goals are, find out new things from the data, and determine what forecasting needs are, our planned activities may shift. So, this reflects the best that we know at this moment in time, but this is an evolving topic. The table below provides a high-level overview of our modeling plan. We are tracking to two main timeline goals, even though these goals and the timing are also in flux. We are working to have a functional model by the end of 2023 so that we can provide BPA with a momentum savings forecast in early 2024. BPA is currently refining its timeline for that forecast, so these dates may shift. In general, having that functional model by the end of the year is what we are shooting for.

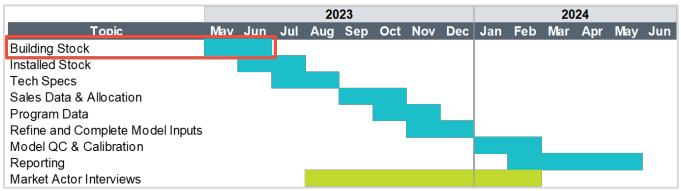



As with the previous model, we are planning to engage with the expert panel regularly throughout the model build. In the next few slides, we will discuss these engagements. We plan to engage with the panel on each model topic around the time that we complete it.

**Kate D.** continued. Looking at interviews, our plan is to develop the interview topics and targets based on early modeling work. We will work on the model in July, then we will start developing our plan in August and September, then we will hold interviews in October and November and develop an interview findings report by early 2024. We might be reaching out to you all additionally to support that interview process on an as-needed basis.




The first model topic we will focus on is building stock. It is first because all the data sources are currently available. The 2021 Power Plan is the primary data source for commercial building stock. Because the 2021 Power Plan is such an important resource for all the upcoming installed stock, particularly, but for the other inputs as well, we are going to review the plan early in modeling to make sure there is no unexpected surprises.




Finally, building stock is a key component of the stock turnover model, which is at the heart of the non-res lighting model.

## *Building Stock*

| Data Sources | Activities |
|---|---|
| • 2019 CBSA<br>• 2021 Power Plan (new, previously 7th Power Plan) | • Bring estimates up to date with 2021 Power Plan, including updating demolition rates<br>  • Transitioning from the 7th Power Plan to the 2021 Power Plan will result in a change in building stock estimates,<br>  • We will explore the magnitude of the change and account for any implications |

**Kate D.** continued. We will be updating building stock estimates for commercial building stock, industrial building stock, and outdoor stock, which represents street and roadway lighting. Since we are working on building stock first and this is the first engagement that we have planned with the expert panel, we will go over our activities for this topic in more detail and then go through the other upcoming topics a little quicker since those are all off in the future.

### Commercial Building Stock

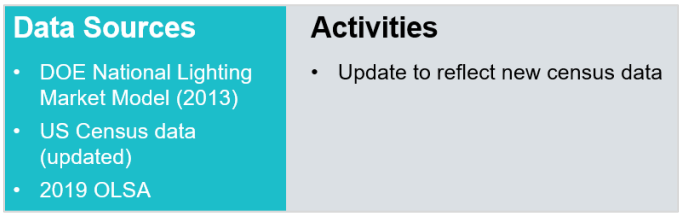
**Kate D.** continued. For commercial building stock, our main activity is to bring building stock estimates up to date with the 2021 Power Plan. This includes updating existing building stock estimates and generating new construction and demolition rates. We know from the last model when they reviewed the 2021 PP, the estimates of building stock between the 7$^{th}$ plan and the 2021 plan were different. One of the things we will do is investigate the magnitude of change between those two sets of estimates and determine and account for any downstream implications of adjusting building stock. As a reminder, the Commercial sector is three quarters of our model's energy consumption, so most of our time is going to be spent on the commercial building stock and then we will focus on industrial next, and then outdoor.

### Industrial Building Stock

| Data Sources | Activities |
|---|---|
| • US Census data (updated)<br>• MECS data (updated)<br>• 2021 Power Plan (new, previously 7th Power Plan) | • Bring estimates up to date with 2021 Power Plan, including updating demolition rates<br>• Update to reflect new data sources |

**Kate D.** continued. For industrial building stock, we will also bring estimates up to do date with the 2021 Power Plan and will update input calculations to reflect new data sources. The two data sources we use for industrial: US Census data and Manufacturing Energy Consumption Survey (MECS) data have both been updated, so we will account for those updated data sources as we update the industrial building stock input.

## Outdoor (Street and Roadway) Stock




**Kate D.** continued. We will update our input calculations to account for new Census data. In the previous model we used the 2013 Department of Energy (DOE) National Lighting Market Model as the basis of our outdoor stock estimates along with Census data. We also used Outdoor Lighting Stock Assessment (OLSA), which is a regional stock source, as a comparison. In this model update, we will assess if that still make sense, if we want to adjust our approach to use OLSA as the primary stock source or something else. Other than US Census data, there is not another outdoor stock source. We will need to determine if the DOE (national) or OLSA (regional) is the better starting place.

**Tyler** reminded the panel that we will be asking them to help BPA identify additional data sources, not just for building stock, but for other inputs as well.

**Eric** wondered if, in regard to commercial building stock, whether "currently occupied" is a factor in that or if it gets rolled into hours of use. Depending on the timeframe, and other things in flux, particularly in office sector, which could have a big impact on the model.

**Kate B.** said that for building occupancy, we will roll it into our hours of use assumptions. We need to revisit and develop new inputs for hours of use. We hope that the forecast for building occupancy statistics will change over time, so we will include it as an element in our hours of use input. But we are open to opinions on different approaches to that.

**Tyler** asked if the new CBSA would be happening concurrently with this. **Kate B. and Juan Carlos** confirmed that it is not yet in the field but would be soon. BPA is on the steering committee for the new CBSA.

## Planned Expert Panel Engagement

- Topic: Building Stock Input Review
- Request: Review updated building stock inputs (input development workbook) and provide feedback
- Type of engagement: Desk Review
- Timing: July/August 2023

**Kate D.** mentioned that she went through that section in more detail because at the end of BPA's work on building stock, we will be requesting that expert panelists review our stock input development workbook, provide feedback on our approach, and insights on if our estimated trends for building stock over time look accurate or expected. That will be a desk review occurring in July or August. For the non-res lighting data collection and analysis contract, the panelists will be reviewing the sales data in June or early July. So, we will wait until you are done with that before sending you the building stock estimates. You will have a chance to review our work and provide feedback on what we calculated.

**Chris W.** asked about roadway and exterior lighting. Are the controls savings only for commercial and industrial?

**Kate D.** replied only for commercial.

**Chris W.** asked if that includes exterior lighting.

**Kate D.** thinks that BPA is planning to do commercial interior and exterior as covered by the CBSA, but no outdoor street or roadway and no industrial.

**Chris W.** asked if that exterior means parking lot or not?

**Kate D.** could not remember. She said it does include parking lot, but parking garage as well.

**Kate B.** confirmed that it does include parking lot and garage where they are affiliated with a commercial building.

**Chris W.** On the control fraction you are going to produce, are you going to have an overarching one that is everything or are you going to have use-specific fractions. It feels like if you try to dump what a commercial building controls fraction is to a parking structure or garage, it is completely different. I think there will be some wrong numbers if that is what you are doing.

**Kate D.** said that we have not developed that methodology yet because we want to see how the installed stock characterization goes in the beginning. But, at a minimum, we would have a different number if we did the "one number" approach, then we would do something different for interiors and exteriors since those uses are so different in hours of use, lifetimes, and various technical specifications for indoor vs. outdoor. We would be chasing those down separately. Any additional granularity we could add, we could break it out more from there. At a minimum, we would definitely have a separate interior and exterior. Great point!

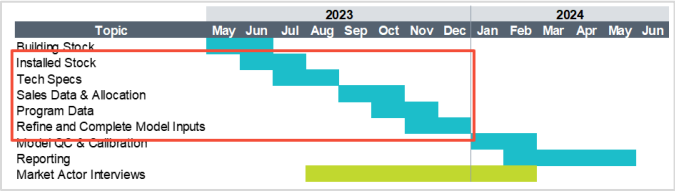
**Expert panel request: Can you think of any other data sources we should leverage to characterize building stock?**

**Kate D.** noted that the data previously mentioned are the only sources we have identified or have previously used to calculate the building stock. If the panel knows of any other data sources that we should leverage to characterize building stock for commercial, industrial, or outdoor, please let us know now by submitting data sources in the provided workbook by the end of May.

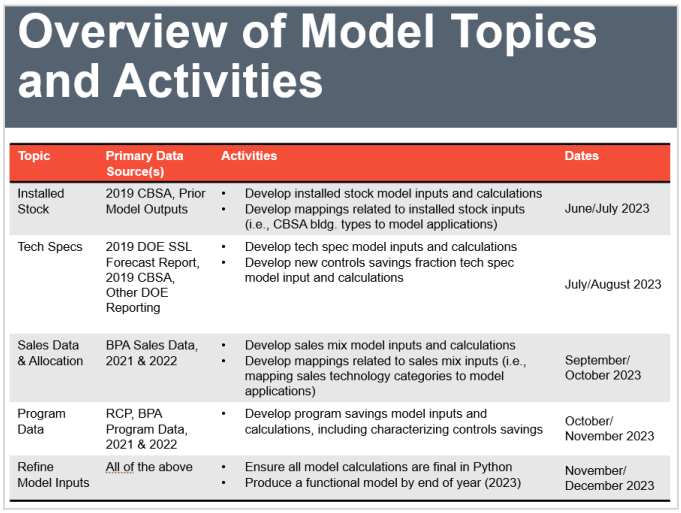
**Chris W.** mentioned that the DOE is coming out this year with a new lighting market characterization study. The last one they did was in 2019, but the data was from 2017. The new study will not be 100% building specific, but it will at least give us a good idea of what lighting there is.

**Kate B.** asked if anyone else had intel about when the DOE study is expected? **Chris W.** confirmed that the DOE said the report is "coming" and is in final edits now.

**Kate D.** said that if it comes out too late this year and too late to include in the interim model, that we will catch it next time and include it in the future model update.




Next, **Kate D.** quickly displayed the next topics to be discussed as shown below. She reiterated This is just a primer of what is next to come.




**Kate D.** reviewed the inputs in the left-hand column of the slide below: Installed Stock, Tech Specs, Sales Data and Allocation, Program, Data, and Refine Model Inputs. For Installed Stock and Tech Specs, we do not know of any new data sources. These two will come after building stock since we have all of the data sources for that. For Sales Data and Allocation, BPA sales data for 2022 will be finalized around end of July, early August. BPA's work on that will come after we have that finalized sales data, in September/October. For Program Data, typically the Regional Conservation Progress (RCP) report takes time to get out. We expect 2022 data to be available around the fall. That is our rational for working on them in this order.

## *Installed Stock*

**Kate D.** continued. Starting from the top of the table above, there is no new data for any installed input. For commercial, our main data source is the CBSA. For industrial, there has not been a new report since IFSA in 2014. For outdoor, the regional stock data source there is the OLSA done in 2019. We are planning to develop the installed stock model inputs and calculations using a combination of the 2021 Power Plan for baseline scenarios and the previous model outputs for 2021 and 2022 that account for all available data to forecast the installed stock estimates for the action plan period. The last year that we updated stock data and the model was calibrated, and everything was regionally approved by the expert panel and the BPA was 2019. We are going to start the model for the 2021-2027 plan period in 2019, and we will grab that year from the previous model to make sure all the estimates still look right and then we will use best available data to project from that start date through the 2021-2027 period using the Power Plan. We are also going to be developing that installed commercial controlled stock input at that time.

**Eric** said he got confused about the explanation for moving from 2019 to 2021. Are we trying to account for momentum savings during that timeframe?

**Kate D.** replied, no, the purpose of starting in 2019 is that 2019 is the last year of actual empirical data. Whereas 2021 would be a forecasted number. Instead of starting the model from a forecast and then moving it forward (starting in 2021), we are going to start at the last actual data (2019). But then 2019 and 2020 will be non-functional in the model.

**Eric** asked if we will be shifting the building stock assumptions from the previous Power Plan (in 2019) to the 2021 Power Plan assumptions?

**Kate D.** said yes, building stock will be shifting. 2021 will be based on actual Power Plan data. But for installed stock, there is no 2020-2022 data source, we are going to start with 2019 and cast that forward.

## *Tech Specs*

**Kate D.** noted that most of the panel is familiar with this from the last model, but tech specs are things like wattage, efficacy, lamp light times, hours of use, and several others that HVAC interaction factors. This is where commercial lighting controls savings factor will come in as well. We do know that there is some new DOE reporting, separate from what Chris W. was talking about earlier, that could include some tech spec updates. But otherwise, we are not aware of any other data sources that would update

our tech specs, specifically hours of use. Currently in the model, hours of use were developed using the 2019 CBSA. But, as Kate B mentioned earlier, that does not include 2020-2022, which saw impacts to hours of use based on COVID impacts and influences. And we know that accurately characterizing hours of use is really important because when we ran our sensitivity analysis on the model results last year, we found that our model results are sensitive to adjusted hours-of-use estimates. So, we are looking to hone in on the hours-of-use estimate, particularly as we add the controls influence. As Eric pointed out, we want to make sure that characterization is as accurate as possible. That work will occur in July and August.

**Eric** asked if in the model, the tech spec does not evolve over time, like the installed stock does.

**Kate B.** said that they can. We have tech specs indexed over time, in many cases they do not change over time, but we have the ability to vary them over time if that is appropriate.

**Eric** noted that there is a lot of discussion around first gen LEDs vs. what is on the market. Has the shift been significant enough to try to account for that improvement in the technology?

**Kate B.** said that is an interesting question and we can look at that in our tech specs update.

**Chris W.** noted that because BPA is going to use this for a controls fraction, it does not cover all of it. You might look at that NEEA, NLC, LLLC study, which would give you the upper end of controls savings fractions. They also break it down, which is another good thing. It shows the high-end trim and daylighting, so you get a better feel for how the whole system operates. Those numbers are pretty close to what is coming out of that report. We should not totally count on DOE for controls savings data.

**Kate D.** commented that this column of primary data sources mostly reflects what the prior data sources were and what forthcoming data sources will be. But for controls, we can definitely refine that list to include the DesignLights Consortium (DLC) study because that is a great one.

**Expert panel request:**

- Can you think of any other data sources we should leverage to characterize installed stock?
- Current data sources are 2019 CBSA, 2014 IFSA, 2019 OLSA
- Can you think of any data sources we should look at for HOU estimates?
- Current data source is the 2019 CBSA, which does not include COVID-impacted years.

**Kate D.** stated that we do not currently know of any new data sources for installed stock or hours-of-use estimates. If you know of any data sources we can leverage for these two inputs, that would be great. Does anyone on the panel have thoughts about COVID-impacted hours-of-use estimates and where we could find them?

**Lauren** commented that commercial real estate would have some numbers because those folks are affected by rental rates of office space and things like that. **Lauren** will look into that and forward anything she can find.

**Chris M.** added a caution on the COVID impacts. Despite the super low occupancy. Most offices were run in some cases even more aggressively in terms of ventilation rates and settings. So, occupancy sensing might be picking up a lot of savings, but it is hard to imagine that it would be correlative with the actual usage rates that are published.

**Chris W.** added that we should not assume that the controls in existing buildings actually turned the lights off when nobody was there, a lot of them were on timers, regardless of if there was one person or 40 people in the space. Just be careful assuming that just because people were home that the lights were off at the office.

**Kate D.** said that is why we are hoping for really solid empirical data source on hours of use so that we can actually see what the trends were and see if they were as much of an impact as people would expect there to be. If not, we are hoping that some of our interviews can inform what was actually happening in buildings during that time period so that we can make sure that any of our estimates, the trend for those years, looks as accurate as possible.

**Kate D.** discussed sales data and allocation and program data.

## *Sales Data and Allocation*

**Kate D.** discussed that sales data will become available around early August. The panelists are lined up to review associated sales data to support the sales data collection process. So, the panelists will be reviewing that input a little earlier in the summer. We will be developing our sales mix model and calculations. One thing to point out is that there is an open methodology question about the sales data. In the past, the way that we have allocated sales data to stock data over time as part of our stock turnover model has been based on a more economic approach based on consumer behavior and various economic data sources. Those assumptions and the way that allocation methodology works has not been updated in a long time. Part of our transitioning the model to Python is investigating if that process still makes sense or if we want to adjust that methodology based on what we know. If you were around for the last model update, we adjusted sales data based on the calibration of the model results to the CBSA. We want to reflect what we know about how the sales data has operated in the model in the last couple of years and develop a way to allocate those sales to the stock in a way that makes the most sense.

The panel does not need to worry about any of that right now. As a sneak preview, we are going to have a presentation with you about the methodology that we choose and the rational for choosing it later in the year. So, we will talk about that in more detail later.

### Program Data

**Kate D.** said that for program data, we do not expect there to be many changes to the way we have characterized that in the past, with the exception of characterizing controls savings and keeping those savings in instead of pulling them out.

## *Refine Model Inputs*

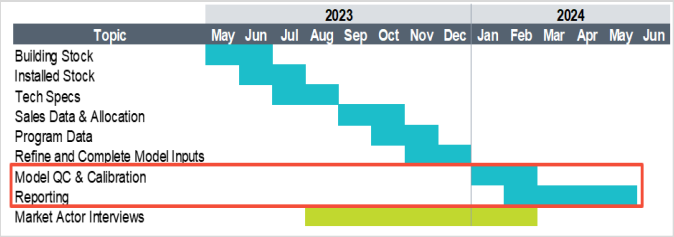
**Kate D.** said that if you think of our modeling plan as a waterfall, each time we finish a topic there will be little bits that do not get 100% resolved right away. There might be something that comes out of engagement with the panelists that alters the way that we are working on something. For example, for hours of use, there is going to be a pre-interview set of estimates and a post-interview decision about whether or not we adjust those estimates. So, this refining model inputs makes sure that all these pieces of the model (building stock, installed stock, tech specs, sales data, program data) making sure that the calculations that make them interact with each other are functioning and producing that functional model. But also making sure that we are catching the waterfalling tasks from the previous model topics.

**Kate D.** asked if there were any questions, concerns, or thoughts about these topics and activities before moving on to the Model QC and Calibration and Model Reporting topics.

## *Model QC and Calibration and Model Reporting*

### Overview of Model Topics and Activities

| Topic | Activities | Dates |
|---|---|---|
| Model QC and Calibration | • QC of all model inputs and outputs<br>• Determine what model calibration is needed and conduct model calibration | January/ February 2024 |
| Draft Reporting | • Produce a summary of draft model results<br>• Review of draft results (internally and with BPA)<br>• Report draft model results to BPA for Momentum Savings Forecast (March 2024) | February/ March 2024 |
| Final Reporting | • Produce final model results<br>• Deliver final updated model methodology memo<br>• Share with Expert Panel for external review | April/May 2024 |




**Kate D.** said she would not send much time on these topics since they are so far away, but there are a couple of key points to make. One, we will do a comprehensive QC of all the model inputs and outputs. Gina from SBW will follow along with BPA as we develop input and will review everything as we put it together. That is also a big part of the role that the panelists will play throughout – walking through each of the chunks of inputs making sure things look right, that the assumptions we make are valid, or that the trends we apply to stock mix over time, for example, look accurate based on your knowledge. But then we will do a final, comprehensive quality check of the model at the end. In the previous model, we calibrated the model to the 2019 CBSA. This time, we do not have a new CBSA, so we will have to determine what calibration source and method is appropriate. We will produce draft and final results. Draft results will mostly be internal- and BPA-reviewed to help hone in on the forecast.

## Market Actor Interviews

**Kate D.** noted that the primary goal of these interviews is to corroborate our developed hours-of-use estimates with commercial property managers to verify if our estimates accurately reflect their experience and insights. As we work through the building stock installed stock and tech specs input develop, we might identify some other goals that those interviews can support. For example, verifying the persistence of linear fluorescents and their spaces or other ways they can corroborate our stock estimates. The important thing to note is that this is all a preliminary plan. We are going to hone in on what is needed as we work on the model. We will make sure the findings of these interviews are actionable in this model update. What that means is starting the interviews after we have developed the hours-of-use estimates, so they have something to react to. We will then analyze our findings to determine if we need to incorporate any changes or alterations to our estimates based on what we found. This is subject to change, but the preliminary plan is to conduct interviews in October and November with up to 30 commercial property managers. We will work with BPA to develop an updated plan in around August and September. We will reach out to the expert panel if we need any support from the panel.

Preliminary interview and recruitment plan:

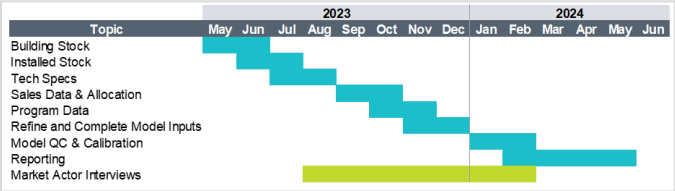
- Conduct interviews in October and November
- Up to 30 commercial property managers
- $100 gift card incentive
- 30-60 minutes
- Conducted via telephone

**Kate D.** asked Lauren if she was thinking along the same lines and if she might come up with anything in the meantime and then asked the group if there were any questions.

**Lauren** mentioned her previous comment from the chat about high-end trim (page 9). She noted that high-end trim is used more than we claim credit for in the programs and it is quite significant. It would be good to get an idea of every precent that they dim and translate it to savings. Lauren would love to hear from the commercial property managers and ask if they did a recent upgrade, and if they did, did they use the total wattage of the fixture or did they use reduced wattage. From her experience, 9 times out of 10 they use a reduced wattage from the start.

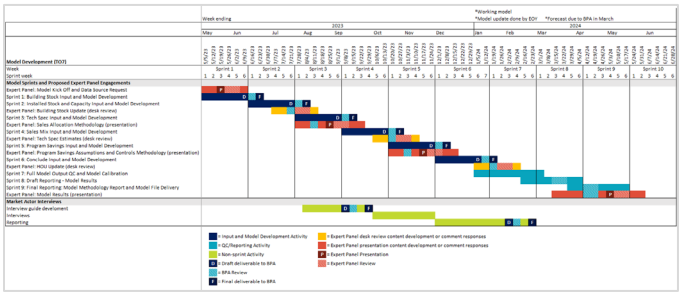
**Kate D.** said that was an excellent point and thanked Lauren for bringing that up.

# Modeling Timeline




**Kate D.** began wrapping up the presentation. Below is the simplified timeline we have tracked during this meeting.

## *Timeline with Tentative Expert Panel Engagements*



Below is the more robust version of the timeline that reflects all the deliverables for the BPA and our tentative plan for expert panel engagements. The only thing I want to point out here is that we are going to alternate between desk reviews (light orange color) and presentations (salmon/red color). We are targeting one engagement per model topic. The long bar in 2024 is the review of final results.

## *Tentative Expert Panel Engagement Summary*

| Topic | Type | Proposed Dates |
|---|---|---|
| Model Kick Off and Expert Panel Engagement Plan | Presentation | May/June 2023 |
| Building Stock Update | Desk Review | July/Aug 2023 |
| Sales Allocation Methodology | Presentation | August/September 2023 |
| Tech Spec Estimates | Desk Review | October |
| Program Savings Assumptions and Controls Methodology | Presentation | November 2023 |
| Hours of Use Update | Desk Review | January 2024 |
| *(Optional) Support of Model QC/Calibration* | *Desk Review* | *February/March 2024* |
| Model Results | Presentation | April/May 2024 |

**Kate D.** reminded everyone that the exact timing and order of the topics below are subject to change, but these are the topics we hope to engage with the panel on. The model KO and expert panel engagement plan is what we are doing today. The building stock update will be coming soon. Then the forthcoming plan ones are the sales allocation methodology and a review of the tech spec estimates. The tech spec estimates will be a desk review. Since we will be doing the interviews after that, we want to run those through the panel and make sure that things look right before we take them to interviews. Then we will do a program savings assumptions and controls methodology. With program savings, based on available program savings and the fact that BPA's program savings are so much more robustly reported than other utilities, we often have to make a lot of assumptions about using the data that we have to cover the data that we do not have. Can we assume that it is reasonable to use BPA's mix and type of program savings as representative of the rest of the region. So, the assumptions that we will be making and any of the implications related to program savings, particularly around dialing in our controls estimate, we will talk to the panel about later in the year. Then we will do a second desk review on specific hours of use that will share out what we learned from interviews and how or if we adjusted those estimates based on interview findings. And then we will

model results. There is also the possibility that we may engage with the panel a little more. For example, in email, we may ask for commercial property manager contacts or asking you to support quality checking or calibration. Those will be ad-hoc requests, Juan Carlos or Kate D. will develop plans for those and let the panel know what is coming a little later.

**Chris W.** asked a question about hours of use. You are trying to ask if hours of operation have changed. So, if an office typically operates at 3,000 hours a year, you want to change it. If you find that nobody was in the office during 2021 and 2022, you aim to limit it to 1,000 hours of operation. Just hypothetically, isn't that control savings? If the hours of the operation are the same, the building operates from 8am-8pm, but the lights are not turned on. That is technically what the controls are supposed to be doing. Is not that control savings versus changing the hours of operation just because somebody is not in the space. That is what controls are supposed to do. You say that the hours changed, but the hours did not necessarily change. How often did the lights were on changed, but that is a function of the controls. If everything goes back to normal, the hours are going to go back to the normal operating hours of 6am-5pm Monday through Friday. You are making that change for a 1-2 year period. But technically, that is control savings because the lights did what there were supposed to do and did not turn on when nobody was there. You are going to see a skew when going the other way, the next time you do this. The final one is going to be funky.

**Kate D.** said that is an interesting question and that we will have to get back to how we parse out what is lighting and what is controls from hours of use. It also depends on what we find when we do that percent of installed stock that is controlled. Following this hypothetical, whatever that percent of controlled stock is, then might be operating in a different way based on those COVID hours of use alteration than in the places controls were installed. I think we will know more about that when we get there. It is a really good flag, and something that we will definitely pay attention to and make sure we characterize as accurately as possible when we get there.

**Kate B.** added that this is a great topic to add to our market actor interviews too.

**Chris M.** One way to think about it is that it is not necessarily a change in hours of use, it is a change in occupant density, which in some ways aligns with what Chris W. said. I think it might be different with different owner groups. I agree that engaging with stakeholders will get some answers. Some places fully shut down, but some stayed open and had very few people going in.

**Kate D.** reminded the panel that if they know of any data sources related to hours of use or occupancy patterns that we can leverage, please submit them in the provided workbook. Otherwise, we will definitely engage with the panel to develop our interview strategy and plan around that.

**Tyler** asked for a clarification. Are you primarily looking for public data sources that can be cited or are you also interested in if someone can you to something that is proprietary or non-public that you could theoretically leverage, would you be interested?

**Kate B.** said we would take both. Public data sources are better because we can cite them. But if proprietary data helps us corroborate assumptions that we have made, that is also helpful to internally build our confidence. We have done that before.

**Tyler** reminded everyone about the workbook we are asking the panel to complete for any other data sources that you know related to building stock, installed stock, tech specs, or any of the other topics we went over today. So, you can get those down in writing and we can document those as we go.

**Juan Carlos** thanked everyone for being engaged and chatting with us. There were lots of questions about controls from Chris W., and I will reach out to you about that.

# Working Session: Sales Mix Allocation Methodology – Aug. 25, 2023

## Attendees

**BPA:** Juan Carlos Blacker

**DNV:** Tyler Mahone, Lorre Rosen

**Cadeo:** Kate Bushman, Kate Donaldson, Eric Dimperio

**Panelists:** Christopher Meek (University of Washington), Chris Wolgamott (NEEA), Paul Sklar (RTF Forum), Kevin Smit (NW Council), Lauren Morlino (Evergreen Efficiency), Geoffrey Cooper (DNV), Wesley Whited (DNV), Gina Hicks (SBW Consulting)

## Introductions

**Tyler** led the panel through brief introductions and then walked through the agenda topics.

## Working Session Agenda

- Panel Objectives and How-To
- Sales Mix Allocation
  - Background and Context
  - Data Sources
  - Methodology
- Review Request


**Juan Carlos and Kate D.** reviewed the model plan summary and where we are in engagements.

## Panel Objectives and How-To

The purpose of the expert panel session is:

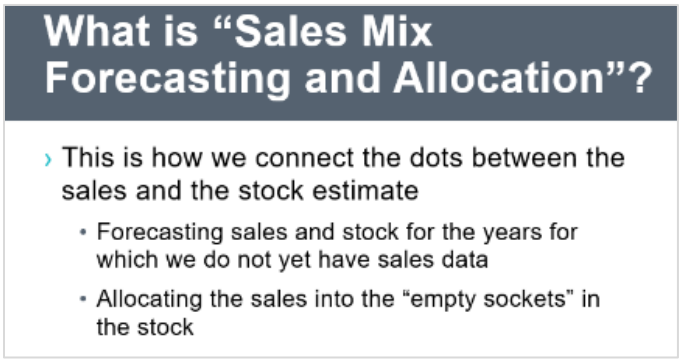
- To share out BPA's non-residential lighting model sales mix allocation methodology.
- To ask Expert Panelists for feedback on the proposed methodology.
  - Provide comments via the provided workbook by September 8th.

**The lightbulb icon indicates when we are looking for feedback or discussion from the panel about a particular topic.**

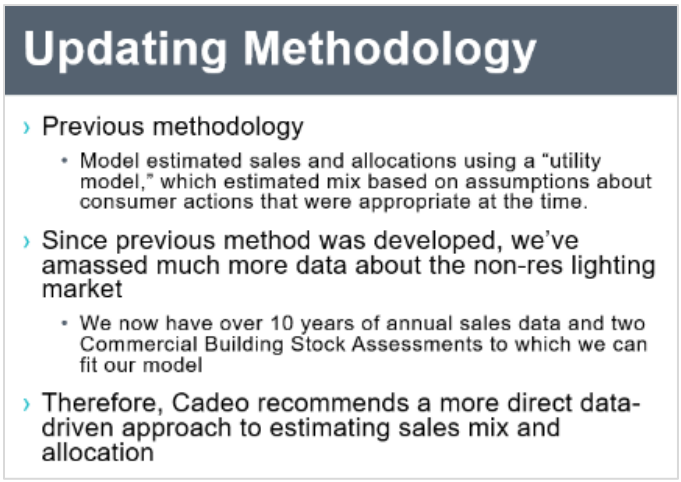
## Sales Mix Forecasting and Allocation

**Kate D.** stated that bringing the sales mix from the collected data into the model and forecasting sales for the full model period is the core aspect of each model. What we are talking about today is a change in sales mix forecasting allocation from previous models to more directly leverage the many years of market data that we've collected. This methodology also builds on the work that we did in the last model to calibrate our modeled stock to the observed stock in the CBSA data. Doing that calibration serves as an anchor point for us to be able to implement the methodology that we are proposing here that us based on our collected market data. Kate explained what we mean by sales mix forecasting and allocation to make sure that we're all clear on that and then explained a few modeling considerations for background.

### *Background and Context*

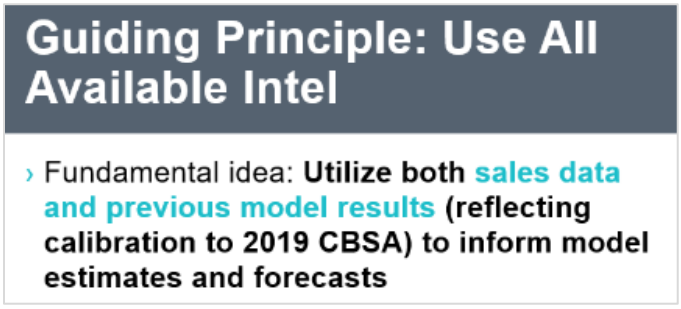



**Kate D.** stated that sales mix forecasting and allocation is how we connect the dots between the sales mix that we collect and the stock estimates that we calculate from available data. We don't always have stock and sales data covering the full modeling. For example, the current model we're working on will go through 2027, and we only have collected sales data through 2022. So, we need to forecast sales and stocks for the for the year that we don't have sales data for yet. We also can't input the sales data we collect from distributors directly into the model. We need to develop a method for allocating an observed sale of a product into the empty sockets, so to speak, in the stock. In other words, we need to make decisions about what application those sales belong in, what sectors they belong in, etc. We allocate the sales data by technology, application, and sector according to our model mechanics.

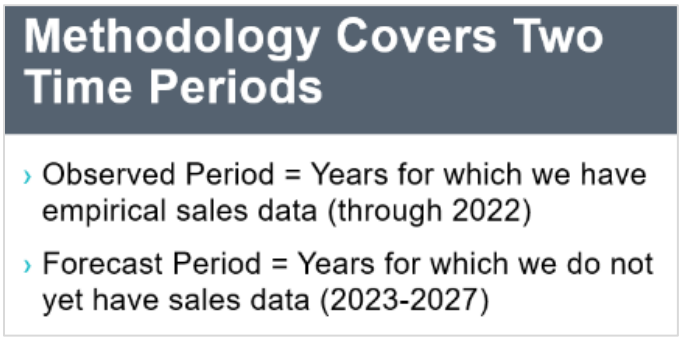



**Kate D.** stated the methodology that we're going to be talking about today is a departure from what we did in the previous model. In previous models, we used a process model which builds up a result from several steps in a process. The process that we used previously was based on economic data and consumer behavior, but it included a lot of outdated assumptions about consumer behavior specifically related to LEDs. At the time that that method was developed, LEDs were in emerging technology and LED product costs were higher. For example, the previous model gave a bit of a boost to LEDs in the sales mix to reflect that some consumers were still choosing the new technology despite higher product cost. That boost is no longer in line with our understanding of market behavior and doesn't reflect the real-time economics of the lower cost of LEDs. We wanted to evaluate this year whether or not we want to move forward with that methodology. One option would have been to recreate that process model using updated economic and consumer behavior data. But we didn't think that that was the best approach because we have so many years of stock and sales data that we can use more directly. In the last model, we did a large model calibration to look at stock and sales together and calibrate the model to best available data being the 2019 CBSA, which gives us a really good

starting point in 2019 for looking at stock and sales together and doing a more data-driven approach. Obviously economic and consumer behavior data is data, but what I mean is our actual market data that we've been collecting and estimating over the years. This year, we propose to leverage our extensive market data in a regression-based approach or a more mathematical model that will model the high-level outcomes or results of the original process. In other words, instead of building up through the steps of a process, we're just going to take the available data that we have and we're going to directly model the end result.

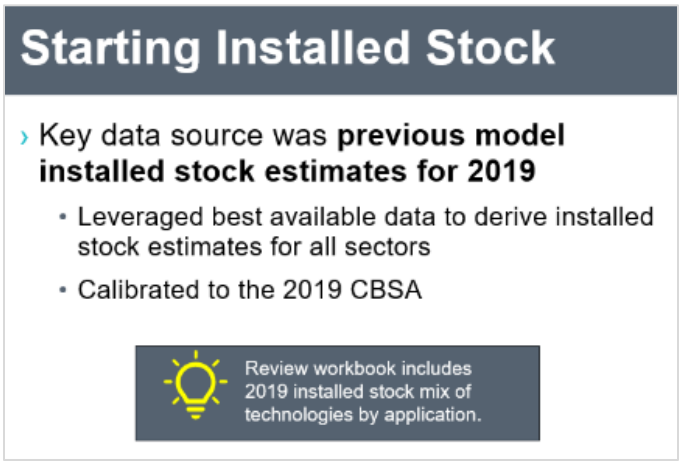



**Kate D.** continued. In order to summarize our guiding principle for the methodology at its most fundamental level, we are going to utilize both sales data and previous model results reflecting that calibration to the 2019 CBSA to inform our model sales and stock estimates and forecasts.



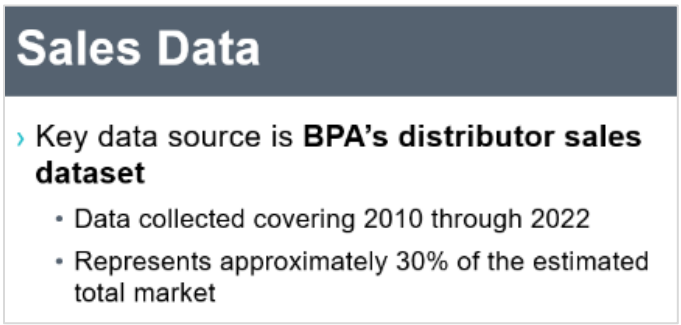

**Kate D.** mentioned that this methodology is going to cover two time periods. The observed period and the forecast period; and our methodology has to address both.

## *Data Sources*

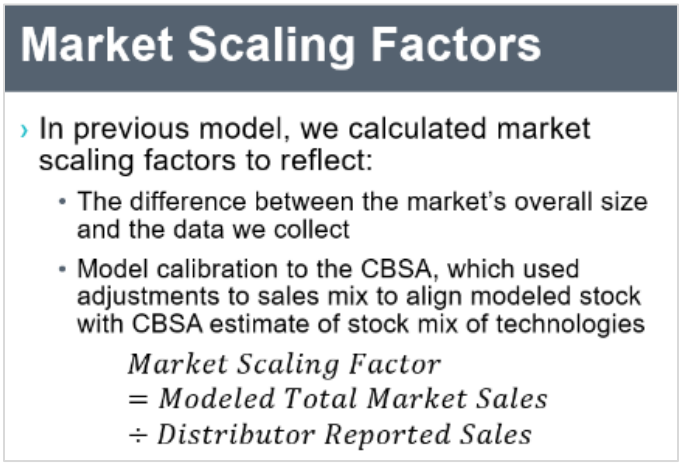



**Kate D.** stated that our starting installed stock in the model is the previous model installed stock estimates for 2019. We're starting with 2019 because that year leverages best available market data to derive installed stock estimates for all sectors. The model 2019 installed stock estimates were calibrated to the 2019 CBSA. They were reviewed by the expert panel at the time and have been regionally accepted as the data year. That's the data at the starting unit that we feel most solid about. It's important to note when you look at the workbook, we have only developed 2019 stock estimates because the year-over-year stock estimates are calculated through the stock turnover model. In other words, our model is going to start in 2019 — and then our stock turnover logic represents when lamps and fixtures need replacement and our sales data which will represent what those lights get replaced with — running that model generates the subsequent year stock estimates. The workbook that we sent the panel to review summarizes the previous model estimates for installed stock mix of technologies by application for 2019 for each model sector. You'll see in the workbook, TO36, which is just what was referred to internally at BPA for the last model, whereas the current model was referred to as TO7. We have a note in the workbook that will make that

obvious, but I just want to put that out there in case that was confusing. And we're going to have panelists review that workbook and provide any feedback or questions on the installed stock estimates along with the content of this presentation.




**Kate D.** stated that in total, we've collected sales data from 2010 through 2022, and we estimate that that data represents approximately 30% of total market sales and that's going to be our starting sales data source. We need a method for converting our collected sales data from just representing distributor sales into estimated total market sales.




**Kate B.** explained the next data source, which we call market scaling factors. Based on our previous model, we calculated this set of values, market scaling factors, to reflect a couple of relationships between our model results and the model input of the sales data. What these values express is the ratio between the modeled total market sales and the distributor reported sales data set, which the panelists recently reviewed.

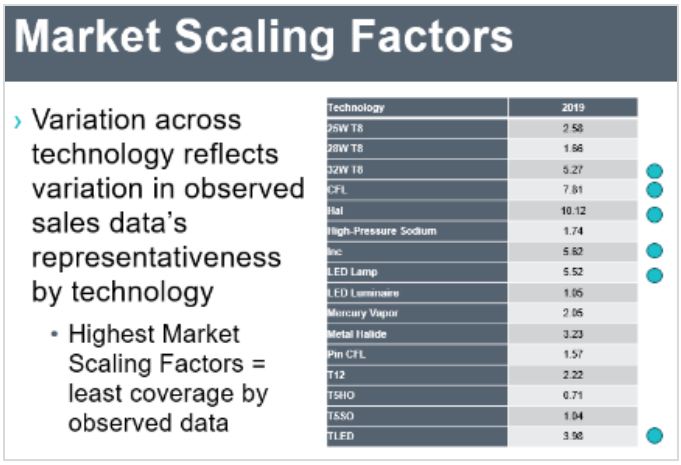
We calculated the scaling factors by aggregating the sales data into technology categories that map to the market model technologies and then dividing the modeled sales in each technology by the observed sales that we collected from distributors.

In this case, when we talk about observed sales, we mean the final post extrapolation set of sales data. The spreadsheet you reviewed recently includes all the extrapolation that we do on that sales data set. The reason we care about these market scaling factors is because they reflect a couple of important pieces of information that allow us to connect the dots between our observed data set and the ultimate model results. The main thing that they account for is the market size.

Our sales data reflect about 30% of the total market size on average. The market size in the model is determined as an output. The market size is an output of the model and it is informed by a bunch of different model parameters including building stock size and our turnover assumptions, product lifetimes — multiple inputs that affect the ultimate total market sales or market size.

The other thing that the scaling factors reflect is the model calibration that we did in the previous round of modeling, which aligned our modeled stock estimates with the results of the 2019 CBSA. And we did that through adjustments to the sales mix. Those were smaller adjustments than the adjustment that would scale up the sales to the total market size, but they are also reflected in these market scaling factors.

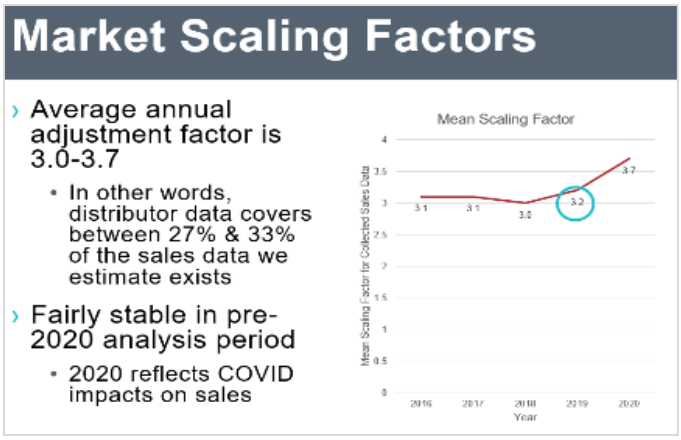
Ultimately, these are kind of an esoteric metrics, these market scaling factors. But the reason we're talking about them is because we think that they are a good reflection of our best knowledge of the relationship between reported sales and total market sales.



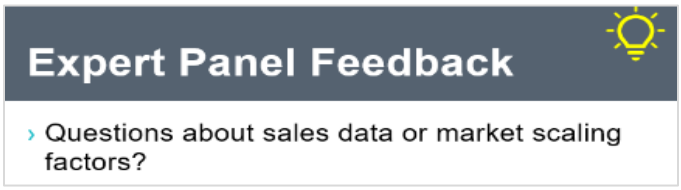

**Kate B.** The table here shows the market scaling factors for 2019 by technology, and you can see that there is some variation across technologies. There is no way to empirically distinguish what the sources of those variations are, but we have some strong speculations. We are fairly certain that the biggest driver in variation across technologies is variation in our observed sales data as coverage by technology category. A clear example of this is a very large technology category, 32 watt T8 lamp. We know those are really common products in the market and you can see for that category; the market scaling factor is around 5. That would mean that the modeled total market sales are five times the observed sales in the distributor data. The reason for this is, within the distributor data, that data source, of course as we know, is limited to just the distributor channel of sales and T8s are also sold through other channels like retail and online. So, we suspect the largest driver of these variations is variations in sales coverage.

**Paul** asked a question. If I understand correctly, a scaling factor below one is, is a little bit hard to explain. You observed more sales than existed in the total market. And there is one case of that good question.

**Kate B.** responded. So, there is one case of that, it's T5 high-output lamps. It's a pretty small category in the product mix. The most likely explanation is simple error in any number of our inputs could have driven that big of a divergence for a small category like T5 high outputs. But a potential logical explanation there would be that some of those lamps, the T5 high-output lamps, could have been miscategorized in the CBSA. It is notoriously difficult to distinguish between different types of linear lamps in an onsite survey, especially in high ceilings, like high-bay applications. We agreed all with your observation there; that inherently tells us something isn't aligning in our data sets. But we are sort of accepting that result in order to keep the model results in line with the CBSA stock mix.

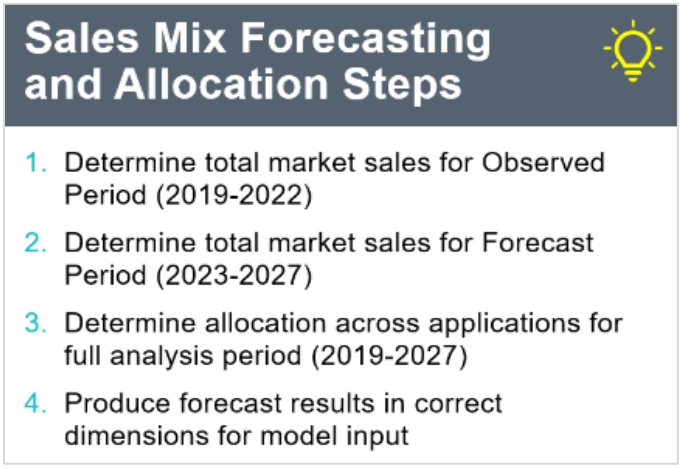



**Kate B.** continued. This graph shows us the average market scaling factors, so we averaged up across all technologies year-over-year for our previous modeling analysis. You can see here that the market scaling factor is fairly stable overtime. particularly in 2016 through 2019. We see that it has a pretty tight range there 3.0 to 3.2. And then in 2020, there were some larger adjustments going on and those are certainly related to COVID impacts on sales that occurred in 2020. The changes appear to be concentrated primarily on short lifetime products, e.g., incandescent lamps. That would imply that reduced hours of use during 2020 may have reduced the frequency of burnout and maintenance replacements of some lamps. The thing to remember as we continue talking through our forecasting methodology is that 2019 is the year in which we have the greatest confidence in our stock estimates due to that calibration to the CBSA, and it's also the most recent year for which we have sales data that were not impacted by COVID. That is why we've got that little blue circle there, and you'll see that we're going to come back to the 2019 market scaling factor in our methodology.

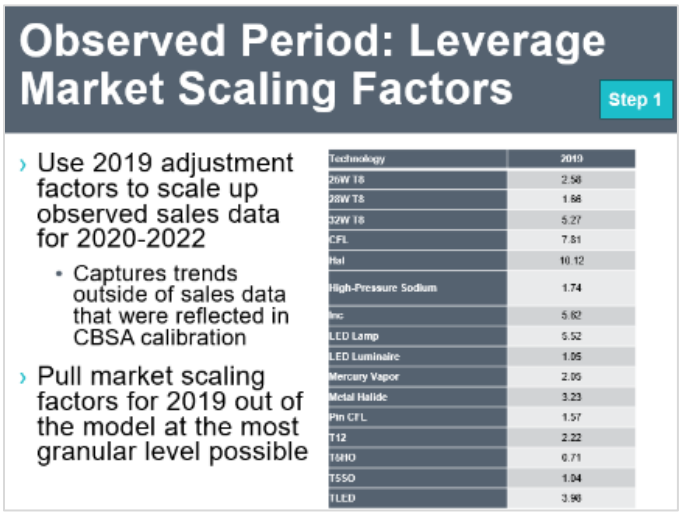



No questions.

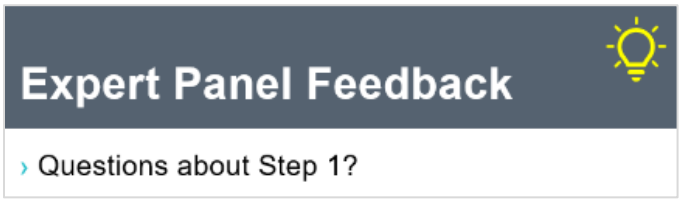
## *Methodology*




**Kate B.** discussed the four steps in this methodology. Remember that we broke things out into an observed and a forecast period related to the years for which we have sales data. The first step is determining total market sales for the observed period. We have our distributor sample of sales, but we don't have total market sales. So, first we have to solve that. The second step is determining total market sales for the forecast period. Those are years that we don't yet have sales data for because those years haven't happened. In the third step, we will determine the allocation across applications in the model for the full analysis. The fourth step is to produce our forecasts in the correct dimensions for the model input. As you're all familiar with the shape of our model, we have a lot of segments by sector, application, and technology. So, we need to state our forecast in the correct dimensions.




**Kate B.** continued. Our proposed method here is to leverage our market scaling factors to adjust / scale up the observed sales data for 2020 through 2022 to the total market sales. Our intention here is to capture the trends that happened outside of our observed sales data and that were reflected in our CBSA calibration and use the 2019 scaling factors. And we'll do that at the most granular level possible to estimate total market sales for the years 2020 through 2022. For our analysis, we'll be reporting results for 2022 through 2027. But 2019, 2020, and 2021 are included in our model to build up the stock, working towards that 2022 stock, which will be the first year of our analysis.




**Geoff Cooper** asked for clarification. So, the scaling factor is designed to make sure you are capturing the full amount of market sales. That's the adjustment of distributor to kind of full market everything, right? How do you get to the conclusion that distributors make up 23 or 33% of all sales. Is that where the CBSA comes in?

**Kate B.** responded. In part, yes. That value, the 30-ish percent value, is calculated as a comparison between the results of our previous model and the collected sales data for that modeling. To get there,

the modeled total market sales are driven by a bunch of different inputs into the model, e.g., stock size, building stock square footage, the turnover mechanics in the model which include product lifetime and retrofit, retrofit rates, and the technology mix that changes over time. As technology mix changes, the mix of product lifetimes change and that also drives how many products are sold in subsequent years in the model. It is a pretty complex build up to that total market sales number, which is why we want to leverage that value here to inform our starting place for market size in subsequent years.

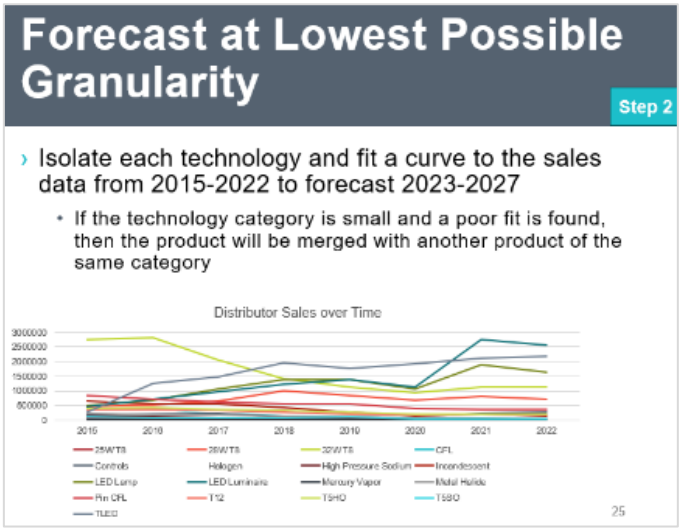
**Geoff** asked how much the rate of turnover could be driving the scaling factors.

**Kate B.** said it is a driver. I'm trying to remember if we included our turnover rate in our sensitivity analysis in the last model, and I don't remember. But I can look into that; and it's a good question.

**Paul Sklar** commented that this is probably the most difficult question for this analysis, what's changed in the overall amount of sales in the region. Of course, I don't have the answer to that; it's impossible to say. What might help to visualize that is a graph of what your model says the overall sales are for the region, whether or not they're going up, down, or whatever.

**Kate B.** said that was a great idea and they would include that graph when they begin analysis.


**Kate B.** stated that Step 2 is kind of the meatiest portion of this forecast because it is where we're doing some forecasting on sales. The forecast period is 2023 through 2027 and our proposed approach here is to use the distributor data set from going back to 2015, in this case through 2022, as the basis for a regression approach to forecast sales fitting to a Bass diffusion curve. The idea here is that we will do this at the most granular level possible. We will forecast the distributor sales and then apply the market scaling factors to the forecasted sales.




**Eric Dimperio** stated that our goal here is to try to forecast the total market stock. But the trends that we're going to be able to observe and forecast are going to come out of the sales data. In this slide, you can see an example of plots of total sales over time aggregated to the categories within the model. When we actually collect the data, we have approximately 150 different technologies. They are at a more granular level than presented here. The goal is to do the forecasting at that lower level of granularity and identify the trends in some of those specific sub technologies.

The only time we won't be able to do that is if there are a few very rarely sold technologies that might not have enough data to get a solid forecast. In which case, we are going to roll it up into sort its nearest technology type. All forecasts are going to be aggregated into the groups that you see in the slide. The goal is to use the data between 2015 and 2022 as the basis driving data for fitting curves.

**Geoff** asked if BPA is accounting for COVID impact during 2020-2022.

**Eric** replied that they are not for the raw sales data. But we're going to forecast on the sales data multiplied by the scaling factors. So, we're actually forecasting our total market sales and we're going to be scaling using the 2919 numbers for those future sales. So, at the market level, we want to be using the 2019 data, but we're not going to be specifically making a correction to the raw sales data to account for COVID.

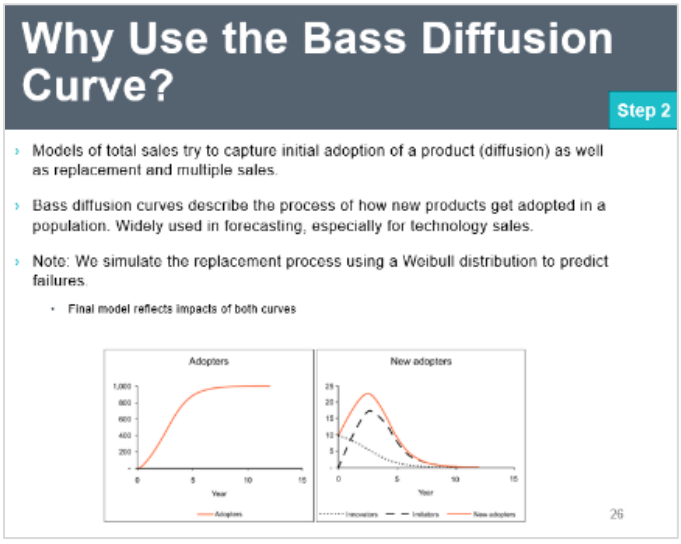
**Kate B.** added that the result of not making a correction for COVID means that COVID impacts that appear in our sales data will be reflected in our downstream stock estimates. The only data source that we have to show us what the impact of COVID was is the sales data that we collect from distributors. And by applying the 2019 scaling factors, we will allow those COVID impacts to appear in our model.

**Tyler** asked a clarifying question. So here, you're modeling the distributor sales, right, and the market scaling factor? Are you holding the market scaling factor steady from 2019 forward? So it's really that ratio of the modeled distributor sales gives you your modeled total market sales because you're holding that ratio the same months.

**Kate B** said yes, that's right.

**Lauren** asked how this accounts for socket saturation. If you're looking back at years and a subcategory is still increasing in volume and then at some point you reach saturation, and it drops. How does the forecast take that into consideration and actually drop the volume versus continue on an upward slope, if that makes sense?

**Eric** responded. Great question. We have varying trends that we might see in these sales whether they stay constant, or they might be dropping. This is where I mean forecasting out into the future without tons of data can be problematic, but we know that something like a linear regression is not going to be appropriate because it can't capture those trends. So, we need a curve shape that has a growing part, the ability to stay flat and a dropping part. And this is where actually there is a handful of different curves that fit those properties as well as come from a theoretical basis that matches our process. At the moment, our plan is to go with the Bass diffusion curve in order to handle that.




**Eric** explained that the Bass diffusion curve was originally created to capture the initial adoption of a product, but it can also be used to model certain replacements. On the lower right hand side of the graphs, we see a plot of new adopters. That's the direct probability curve. In our situation, we can think of it as being an opportunity for a new adopter. So those sales are going to trend up at some point, but then eventually drop off. The total overall sales are not just going to be driven by this curve, because this is going to be used to forecast the sales which we can think of as the storage or that is where we draw from when making replacements in our turnover model. And the replacements are driven by a Weibull distribution. Our final sales are actually going to be a combination of both the Bass diffusion curve and the Weibull distribution.

**Lauren** mentioned that across the country, she is seeing that policies may come in and create an artificial cliff, or often before the cliff, an increase or a run in sales. For example, Vermont will not allow fluorescent products and ballasts because of PCBs as of January 1, 2024. In the future, and in this forecast, how do we account for situations where maybe our original curve is actually steeper and

sooner than we expect because a policy may come in like that. How do we adjust the model to account for things like that, which may be likely.

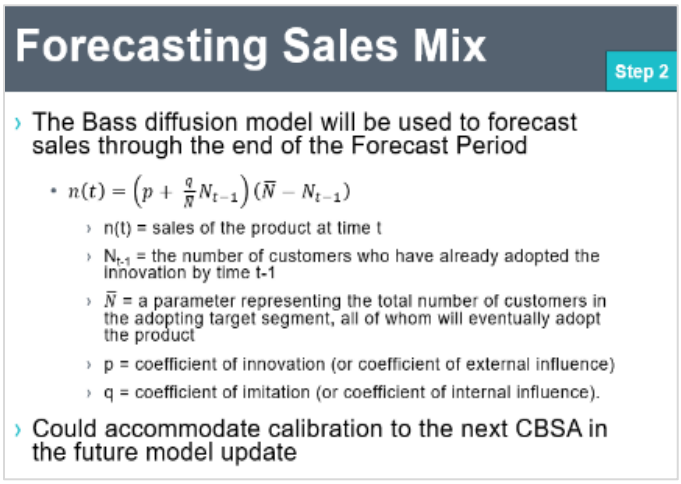
**Kate B.** responded that the BPA is looking at policy that is forthcoming in the Northwest region. Oregon just passed a bill similar to Vermont. The timeline is still not finalized, but the language and legislation is on or after January 1st, 2025. The fluorescent products will be eliminated. And there are some stages: there's like a compact fluorescent stage and a linear fluorescent stage. We are monitoring and collecting information about those policies. There was a similar bill in the Washington legislative session this year that didn't make it through. But people are expecting something to go through in Washington next year too. The plan is to apply some artificial limits in the model to account for those.

This year we won't have any data from other states to refer to because it hasn't happened anywhere yet. There are other states that are a little further ahead than our region. Hopefully when we do our next update, we'll have some market data on how those policies have impacted sales. Of course, certainly in our own sales data that we collect, we will see those impacts. The timing is going to be critical because we will be towards the end of our analysis when those policies go into effect. We will have to do our best to capture those impacts at the right time.

**Lauren** mentioned that looking at other states and what kind of percent lift they saw before would definitely be a great way of doing that.

**Kate B.** said the other policy that we're looking at is the federal standard for general service lamps that started on August 1st. We will do what we've done in the past with changes in standards, which is we believe that the sales that we collect, that our distributors report, are real sales that occur. For example, we still today see some T12 lamps in our sales data that are probably those high CRI lamps that had been exempt from the previous standard. It us nice to be able to see the real world lag on implementing some of those policies through the sales data that we collect. And then at the same time in forecasting, you know we do want to do our best to account for those expected impacts.

**Eric** continued. If there is a particular situation due to policy, there's going to be a change. We have a few different mechanisms by which we can adjust this. At its simplest, we can generate data-based forecasts and always manually adjust them to account for knowledge of the future that the model simply doesn't have. We also have a fairly modular model. It might make sense to insert a process that is somehow modifying these numbers after the fact, as well as injecting artificial future data points in order to train the model to hit certain future points. At some point when we can get new data, new CBSA, that will be a way to update the model having new known data points that we will be trying to fit the curve to.




**Eric** said his hope is not to go too much into the math here. The point is that this is a discrete time representation of that probability distribution from the Bass diffusion curve. It's driven by two major parameters and there's actually a third parameter that needs to be free in our version. The two main parameters determining the shape of the curve are going to be those P and Q, the coefficient for innovation and the coefficient for imitation.

Those are the parameters that tell us how fast this curve goes up, and how fast this curve drops off. If we look at that curve, it always starts at 0. But 2019 is not going to represent time 0 for each of these technologies. They've been in play for quite some time, and so there's going to have to

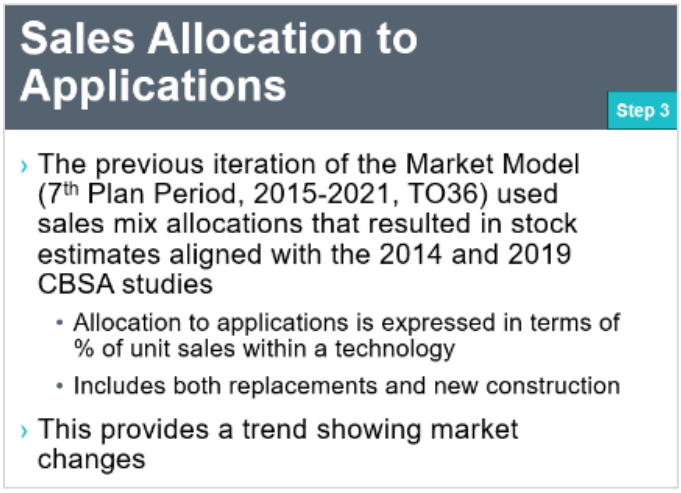
be a free parameter for when and where this curve is taking starting. But the three of those parameters should be enough to properly capture the shape and extend it out to 2027.

Once we actually have all the data, we need to start making these, these are going to have to be evaluated and see are they producing reasonable forecasts. If not, we might need to determine if there is a factor in this curve that we're just not capturing what's causing this. Is there another curve that's going to better capture the sales data? At the moment, there is no reason to believe that this wouldn't be inappropriate forecasting mechanism. There are certain assumptions, like in the market scaling factors, that certain behaviors from 2019 will continue on.

The trends in sales will continue over time. Once we have a new CBSA which will give us another sort of solid point estimate of the market sales in time, we can then calibrate the model to better interpolate between the 2019 CBSA and our future CBSA.

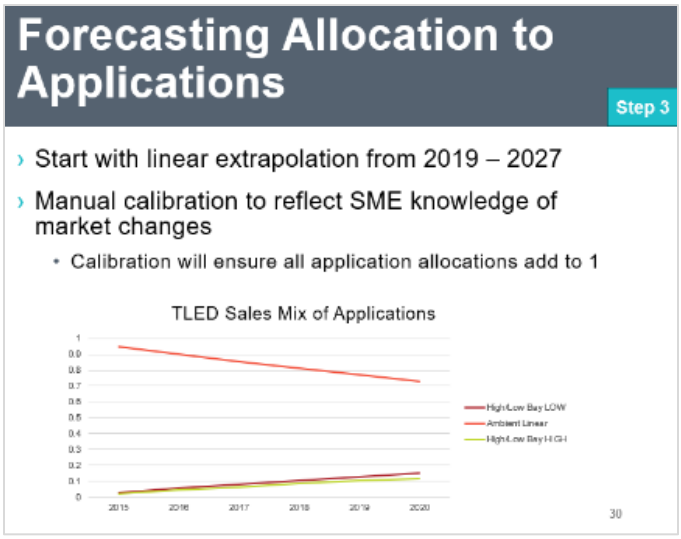

**Tyler** asked if the next CBSA is the next opportunity for calibration of those markets. And when you do that, will you go from holding a constant to creating a line of mark or trend for the market scaling factors or will you just switch to like a new updated recalibrated market standing factor at that point?

**Kate B.** responded that we don't know the answer yet, but certainly we would. Our plan is to do a calibration of the modeled stock to the forthcoming CBSA for that year. The observation year for the next CBSA will be 2024. So, we would calibrate the 2024 stock mix to align with the results of that CBSA and then we still would have our historical anchor in 2019. But just to be clear, that is not happening in this project. That will happen in our 2025 update.




**Eric** discussed Step 3. The next step is our sales data tells us about total quantities of a particular technology, but it doesn't provide us any information on how they are used. That is where we have a sales mix or a sales allocation mix, which is used to decide which technologies are going to be applied to which applications. Those are derived by dividing the known stock into categories aligned with the 2014 and the 2019 CBSA studies.

The goal is to look at our data. As it exists, the distributions have been changing in a linear manner to develop these trends between 2014 and 2019. We are going to do a forecasting method to extend these trends. But we know that they're going to run into failures, and so we're going to have to come up with a manipulation. The next slide will show a visual demonstration.

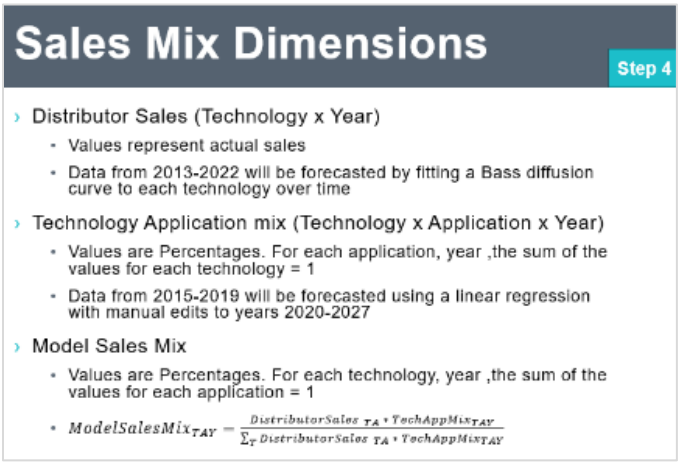



**Eric** continued. This curve is an example of the TLED sales. If we look at the usage, the applications are both high and low bay applications and the ambient linear. For the most part, a lot of our sales mix applications are fairly horizontal flat trends. This was chosen in particular because it does show a distinct trend between 2015 and 2019. We have this going out to 2020, but we're really going to utilize the 2015 to 2019 data for extending these trends. We know that the use in ambient linear has been dropping. We will continue on with a linear extension of these trends out to 2027, but we're going to have to follow it up with a calibration by subject matter expert (SME) just to realize that these trends aren't going to continue ever forever. They're going to have to bottom out at some point. That is going to be a fairly simple linear extrapolation combined with an SME calibration just to make sure that we don't have any sort of absurd trends in this allocation mix. But also, these are percentages. If we add up all the values on this chart for each year within a year, they add up to 100%. This is really telling us for the total amount that we are forecasting, which applications are we going to sort of segment each, each subgroup of the total. We want to partition them to a particular allocation according to this mix.


**Kate B.** added that she thinks this will be easier to react to when we have a set of draft results, which we certainly will want feedback on too.

**Geoff** asked does the Weibull distribution include burnout or only system failure? I was starting to think about at what point are LEDs replacing LEDs and if that's captured as part of burnout now that we're going out to 2027.

**Kate B.** responded that yes, we do include LED for LED replacements. Two model cycles ago, we did not allow for that to happen, and I think we started allowing the allocation of sales into the stock beginning in 2015, if I remember correctly. There is a failure included in our failure curves, the Weibull curves. Those vary by technology, and so we do have lifetime assumptions for LED fixtures and LED lamps included so that would drive some of that LED for LED replacement.




**Eric** continued. So, what do we do with these numbers to combine them? And so just to review our distributor sales; total sales is per technology for a given year. Those are the dimensions that we have. But again, what we're lacking is how are those technologies used, our technology, application mix. Those are the percentages. So, within a single technology and year across all the applications, the values are going to add up to 1. The technology and year connect directly up to the distributor sales, but we need to divide out by or spread out according to the distribution across applications. We can see at the bottom, for a particular technology application and year, we are multiplying our sales by the percentage in the technology application mix. And then we're dividing to

normalize, so that we can make sure that within a particular technology and year the sum total of the technologies within each application will add up to the overall total that we've forecast in our distributor sales. It is a fairly straightforward way of distributing it. Does anybody have any concerns about this overall methodology they want to voice?


**Geoff** said that he likes this approach and that, in terms of a forecast within applications and the distribution of that, it makes a lot of sense. Every assumption comes with some level of uncertainty and the more assumptions that there are, the more uncertainty that there is. So, in this process, are there compounding uncertainties that by simplifying any of the assumptions could reduce some of that and while it might make it simpler, it reduces some of the uncertainty in that. The combination of calibration to CBSA combined with scaling factor combined with the diffusion curve, if I understand correctly, there's a lot of compounding there. Is there anything in there that minimizes some of those assumptions in any way? I don't have a specific recommendation at this point, but those are the kind of thoughts that I've been thinking about as part of this.

**Kate B.** responded that we also are thinking about that, and if you have any ideas for simplification that it would be great to hear them. I definitely agree we're sort of forecasting based on modeled results. We are certainly in the territory of compounding uncertainty which the previous version of the model had that weakness too. This is the nature of any big modeling effort we have. We are combining a bunch of the best available data assumptions we can, but none of that information is perfect. There is always going to be uncertainty, and the more complex the model is the more uncertainty there is.

**Eric** said that to a certain extent, we're breaking this down into different subcomponents so that we can look under the hood and better understand and model these distributions where the data we're receiving is happening at a much higher level. We could just work at that level and have potentially even black box forecasting methods and from that probably walk out with estimates that, at least from a mathematical standpoint, have much less error.

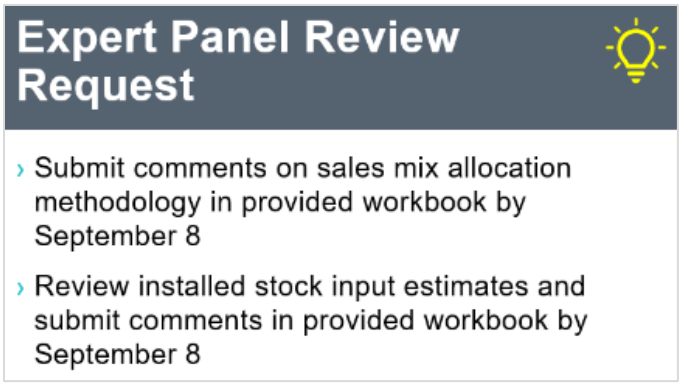
But I think in that case, they might also end up being much less informative. There is a bit of a tradeoff. Yes, those extra sources of error do creep in, but they also give us the ability to look at sales in stock at a much more granular level. But They are assumptions built on assumptions.

**Tyler** asked if anyone feels uncomfortable with this approach and specifically asked if Paul or Kevin had any thoughts on the approach.

**Kevin** said he thinks that overall, it looks good. Once you start seeing the results and you get the practical feedback, I think that's what really does it. You have got a lot of formulas in here, you've got a lot of estimating, forecasting basically a black box to most people. Ultimately, you have to take a look at the results when they start coming out and apply the practical wisdom to make sure that it makes sense. But I think it's a solid approach. The RTF uses the Weibull and those other methods occasionally as well. These are well known methods.

**Lauren** added in the chat that overall, this looks good! It will be important to look at those external factors that could drastically change your forecasts, but this is thoughtful and appropriate analysis in her opinion.

## Review Request




**Tyler** thanked everyone for taking the time to be here today. After the meeting, we will provide the updated slides and workbook for feedback. We are asking for feedback by September 8th. Through the end of the calendar year, we will have at least one more desk review.

**Juan Carlos** thanked the panelists and asked them to really dig in with your stat brains and your market brains and give us any feedback at all on the methodology we're proposing. This is an important part of building the model. So, anything you think might be a problematic or really good, or whatever. We will take any questions, comments, or concerns that you might have.

# Working Session: Sales Mix Allocation Draft Results – Feb. 23, 2024

## Attendees

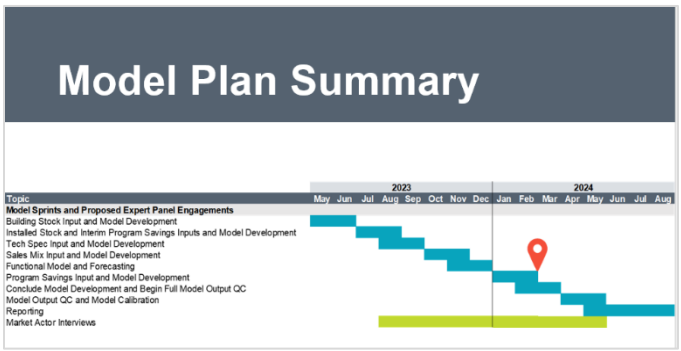
**BPA:** Juan Carlos Blacker

**DNV:** Tyler Mahone, Lorre Rosen

**Cadeo:** Kate Bushman, Kate Donaldson

**Panelists:** Peter Brown (Electrical Transitions), Chris Wolgamott (NEEA), Wesley Whited (DNV), Geoffrey Cooper (DNV), Paul Sklar (RTF Forum), Lauren Morlino (Evergreen Efficiency), Christopher Meek (University of Washington)

**Unable to attend:** Kevin Smit (NW Council)




**Juan Carlos** thanked everyone for attending and provided a summary of the model plan.

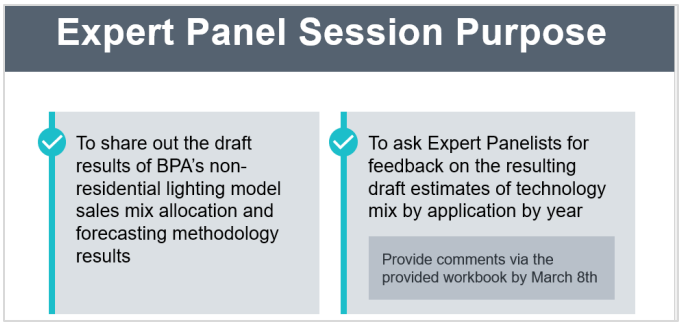
## Introductions

**Kate D.** reviewed the agenda and introduced the purpose of today's expert panel session.

## Working Session Agenda

- Panel Objectives and How-To
- Sales Mix Forecasting and Allocation
  - Refresher on Methodology
  - Draft results for 5 Key Applications
- Review Request
- Appendix
  - Draft Sales Mixes for Remaining Applications
  - Additional Methodology Notes

## Panel Objectives and How-To




**Kate D.** reviewed the purpose of this expert panel session.

## Sales Mix Forecasting and Allocation Methodology Refresher

**Kate D.** noted that the sales mix forecasting and allocation is how we connect the dots between the sales mix we collect, and the stock estimate we calculate from available data from the modeling period. This is a step in the interim model only because we only have sales data from 2019-2022 to inform the sales mix through 2027 or the end of our modeling period. Whereas in the final model update, we will have actual sales from more of the modeling period and we can replace these forecasted sales with actual sales data.

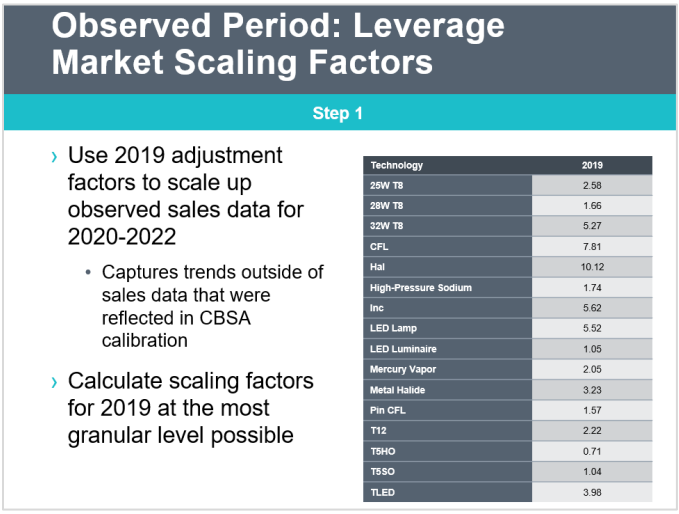
This method reflects the best available sales data from BPA's distributor data collection and stock data from the 2019 CBSA, which is why we are starting the model analysis period in 2019 instead of 2021. 2021 is the baseline year of the 2021 Plan period.

And for the final model update, this method is going to include another calibration of collected sales data to the upcoming CBSA stock data within this modeling period.

**Juan Carlos** added a quick point of clarification. The distributor data collection is done by NEEA with BPA support.

**Kate D.** continued. There are four steps to the data allocation methodology:

1. Determine total market sales for Observed Period (2019-2022)
2. Determine total market sales for Forecast Period (2023-2027)
3. Determine allocation across applications for full analysis period (2019-2027)
4. Produce forecast results in correct dimensions for model input




**Kate D.** continued. We start with sales data collected from 2019-2022 and then we apply our 2019 market scaling factors calculated by technology to the observed sales data through 2022. There are two points to make about this slide. The first point is that we use 2019 only for the market scaling factors because the sales mix for 2019 was calibrated to produce a stock mix that aligned with the CBSA within that year. So, we have the highest confidence in that year's representation of the relationship between stock and sales. The second point is that we believe it is reasonable to apply 2019 to other years in the modeling period because the sales data extrapolation ensures that the portion of the market our sales data represents is

approximately stable over time. One question that came up last time was does that allow us to account for Covid. The answer is yes. We captured the sales disruptions in 2020 and 2021 by allowing the total volume of the sales mix to change in those years by applying the market scaling factor from 2019.

**Chris W.** asked what the scaling numbers mean, 10.12 for example.

**Kate D.** replied that the market scaling factors represent the relationship of the size of our total collected sales data to the size of the total modeled sales data. It is the relationship of the total market that we collect data for and the total market that we model. For example, we believe our sales data is capturing some portion of the 25W T8 market and we multiply that number by 2.58 to get what we think the total market of 25W T8s is in the region.

**Chris W.** asked what the "Hal" stands for, halogens? The metal, screw-in halogens?

**Kate D.** said yes.

**Chris W.** said that his only question is whether you are not allowed to sell those anymore, right? After a certain point, you can't buy halogen lights anymore for the screw-in lamps. So that seems like a really big number, since you can't buy them anymore.

**Kate D.** said that is a great point. We know that there are a lot changing federal and state regulations that will be rolling out between the 2021-2027 time period. Without sales data to reflect the actual market impacts of these changes and regulations, it will be difficult for us to forecast exactly how these regulations are going to come into play because we have to consider things like cross-border commerce and compliance. We are not planning to account for the impacts of those changing regulations in these forecasts in this interim model update. But we will be accounting for them in the final model with actual sales data for the modeling period.

**Chris W.** said that he would expect the numbers to be pretty different then. If the world is doing what we're supposed to do, which it seems like it is because I can't find a halide lamp to buy, we are going to have some big differences in numbers when we do correction on the other side. But I understand why you can't make the corrections. I do fear that you are going to have some fairly wide and big differences compared to what it is now.

**Kate B.** added that on the halogen technology, that category also includes other form factors aside from A lamps. MR16s are the ones that have a high volume in our historical sales data in the halogen category. The way that we apply these scaling factors, if there are zero sales in our observed sales data and we multiply the zero sales times 10, that is still zero. We suspect the driver of that halogen number being so high in this table is that the sales data underrepresented halogen lamps historically. This is probably because there is so much overlap with the residential market for those lamp form factors, like the A lamps and the MR16s, that they don't necessarily show up in the distributor data which is our data source here.

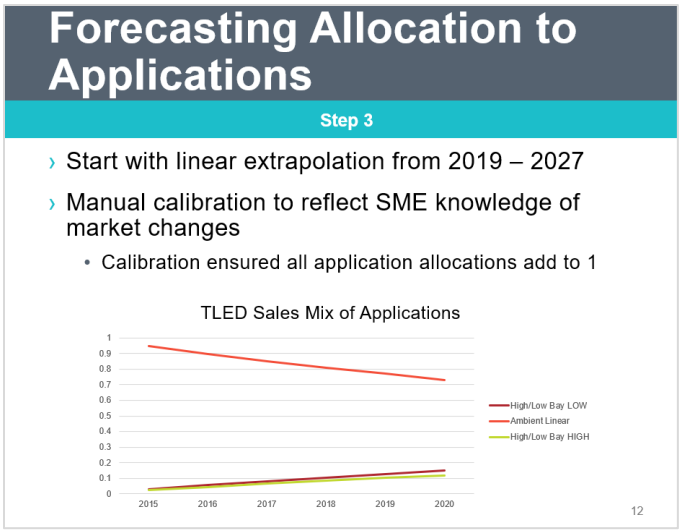
That is a great point, and I think that paying attention to those dynamics as regulations kick in over this time period is going to be very important. We have observed data for the years that have already occurred that will reflect those trends.

**Peter** asked what percentage of the sales data is from distributors or other sources.

**Kate D.** replied that 100% of the data is from distributors.

**Paul** said that he missed the timeline on the final sales model. If you are talking about the sales data that we get at the end of the time period, 2027, then I think that it is too late to make that correction.

**Kate D.** noted that the modeling period goes through 2027. We will be building the final model update somewhere in the 2026-2027 timeframe. We typically build the model update right at the end of the plan period. I think that should be consistent with what we have done in previous plan periods.

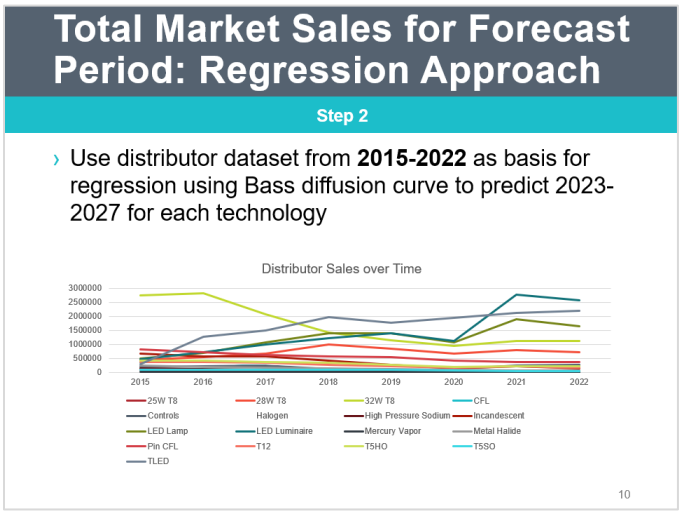



**Paul** said that we can't say what effect the regulations will have, but we do know they will have some effect.

**Kate D.** responded that there is not a way to rigorously or accurately quantify what that effect will be without the sales data showing the actual market implications. Because of that, we thought it was more defensible to not include those changes in this interim model update and just keep the forecast without those regulations accounted for. But we are monitoring which regulations are coming, what applications they are going to impact, and what technologies they are going to impact in those applications. For example, in this year's collected sales data, we are starting to do intelligence gathering around those technologies that are already being impacted by these changing regulations. It is just a time issue of when we are building the interim model update and the information we have today.

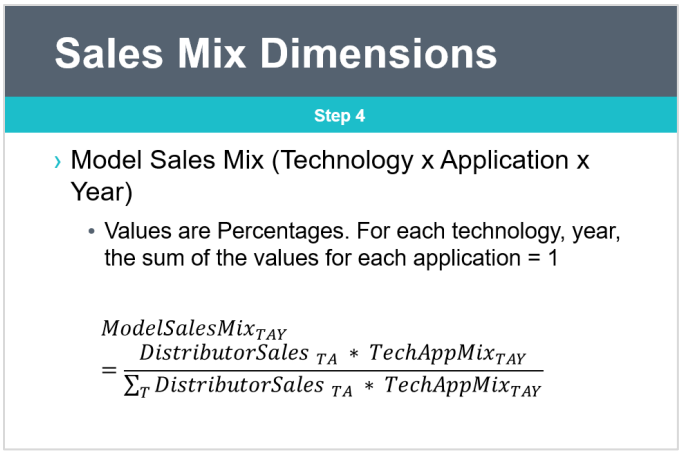
**Paul** replied. When I approach a problem like this, and the answer is somewhere between zero and big, I know that zero is not the answer. I don't know what number it is, but it's not zero.

**Geoffrey** added from the chat window: Sales data is also mostly from distributors, right? The scaling factors are highest in products that customers can purchase outside distributors, so that seems to align with expected.



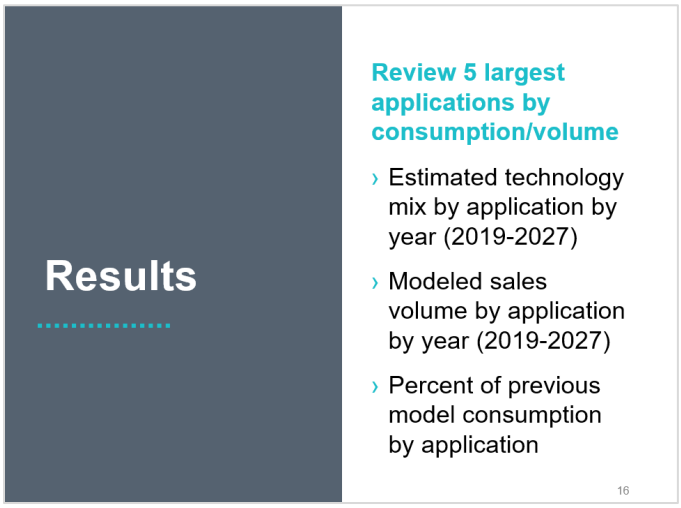

**Kate D.** said that going back to 2015 allows us more years of data to base our regression off of. I want to give you two updates to our planned methodology. First, forecasting using 2020 and 2021 data in the training dataset resulted in some bazaar sales trends since those were anomalous. So, we ended up removing those years from the training dataset only to produce a more reasonable forecast for 2023-2027. But those Covid impacts are still reflected in the actual sales data so the components of the sales mix that are 2019-2022, we just forecasted off of trend lines that excluded Covid to produce more reasonable forecast results. The second change that we made was that for each technology, we used subject matter expertise to generate some target ranges for the 2027 forecast for each technology to make sure that the resulting forecast looked more in line with our expectations. In other words, we reviewed the sales mixes and asked where we expect these technologies to be in 2027 and then applied some of that judgement to the sales mixes.

**Kate D.** continued. So, then we allocated the sales of each technology to our model applications. For example, we allocated TLEDs to all the applications they appear in. To do this, we started with a linear extrapolation from 2019-2027 of each technologies allocation to each application over time. Then we made manual adjustments, again based on subject matter expertise, to ensure that those looked reasonable.




**Kate D.** continued. We compiled two tables as the official model inputs. Those were a forecast of total market sales and a forecast of sales mix allocation to applications. The results of this analysis are the percentage sales mix by application technology and year.

## Sales Mix Allocation and Forecasting Draft Results




**Kate D.** continued. There are 15 total model applications that we develop sales mixes for. We don't have time to review all the applications in this presentation, so we pulled the five largest applications either as a percentage of market consumption or in terms of sales volumes to focus on today. You will have a chance to review all 15 of the application sales mixes in the desk review in the appendix at the end of the deck.

For each application, we will step through slides that include estimated technology mix by application by year for 2019-2027. Some of the trends are going to look odd because they are percentages of the total application sales volume. So, we also include the model sales volume by application by year for the same time period as a reference to show the size of the application over time. As a clarification, these are the total sales volumes that the model requires in each year to result in the necessary application stock size. The point is these are model output that make sure our model stock size is accurate.

Finally, we are going to show the percent of previous model consumption by application. The reason we do that is because it is most important to get the largest consumption application sales mixes correct because that has the largest impact on model results.

For the three largest applications by consumption, ambient linear and the two high/low bay applications, we are also going to look at some northeast state forecasts for LED market share as a point of comparison to verify the reasonableness of our developed sales mixes. There is also a comparison for building exterior in the appendix, which you will see when you review the appendix.

## How to Interpret These Results

- Results depict the draft sales mix by application, which is a work in progress
  - We will continue to refine the sales mixes throughout model QC and as model results are finalized
- Looking for a reasonable-ness check:
  - Are sales mix by application trends what you expect (directionally, proportionally)?
  - Are there applications we should focus for model QC?
- Technology trends need to be reasonable both within and across applications

**Kate D.** As we finalize model inputs and move into model QC, these sales mixes will continue to change. We do a reasonableness check to make sure our sales mixes by application trends are what you expect, both directionally and also proportionately. Or, if there are any places that we should particularly focus our model QC to bring those trends closer to expectations. Finally, we look at the results by application, which gives us the best sense of reasonableness. We can best compare forecasted trends to our expectations within specific applications than if we looked at the market altogether. As we refine a technology trend in one application, it is going to produce a change in that technology's trends in all other applications it appears in. We make sure that changes we make to trends within applications are calibrated across the rest of the applications, so the overall sales trends look reasonable as well.

## Expert Panel Feedback

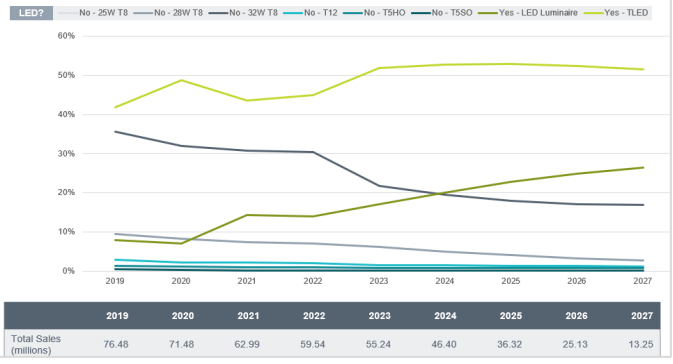
**On each of the subsequent slides (in your feedback in the workbook):**

- Do estimated technology mixes by application by year look reasonable?
- Do you know of any other data sources forecasting market share we should use as comparison data?

**Kate D.** reviewed the assignment for feedback after the presentation. In addition to the two questions on the slide, we will also be asking for your review and feedback on specific technology trends.

## Ambient Linear Sales Mix

41% of previous model consumption




| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 |
|---|---|---|---|---|---|---|---|---|---|
| Total Sales (millions) | 76.48 | 71.48 | 62.99 | 59.54 | 55.24 | 46.40 | 36.32 | 25.13 | 13.25 |

**Kate D.** continued. The largest application by far in terms of both percent of model consumption and sales volume is ambient linear, which accounts for 41% of total market consumption, or it did in the previous model. This application includes all low bay linear lamps and luminaires. Since this is the first graph of the presentation, I want to orient you to it. This graph shows the ambient linear application sales mix by year for 2019-2027. Just a reminder, this is sales or market share, and not stock or installations. These sales mixes are expressed as a percentage of the applications overall unit sales per year shown in the table below the graph. These sales volumes are a model output, and they are also draft, so these will also be changing. But we will include them here again because these sales mixes are calculated as a percent of total unit sales. The size of the application by year might impact the shape of certain trend lines. If you look above the graph, we include a legend that describes each technology included in the sales mix for the application and whether that technology is or is not an LED. LED technologies are in green; all other technologies are in other colors.

**Peter** asked Kate to clarify what LED luminaires include. Does that include kits that go into an existing trough, or is it strictly a whole new luminaire?

**Kate B.** said that it would include retrofit kits. We collect retrofit kits separately in our sales data. In the original data that feeds into this, we separate out retrofit kits from new luminaires, but here we roll them up into one bucket.

**Lauren** asked in the chat window if the kit includes Energy Star luminaires.

**Kate B.** said yes, it would include Energy Star luminaires.

**Chris W.** asked if the table at the bottom represents total sales. The expectation is that 2027, in linear ambient, we are going to have 13 million sales (in units) versus a high of 76 million.

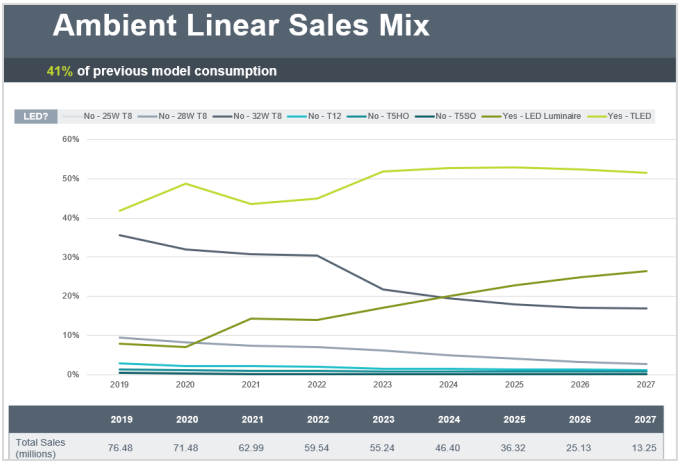
**Kate D.** said yes, and reminded the group that this is a draft and we have not gone through model QC or looked at the stock output of mixes and verified that the stick size is doing what we expected it to. A huge part of why that is expected to happen is because the high rate of LED both TLEDs and luminaires that we have in the sales mix and the strong increasing trajectory that we see of luminaires over time. As more luminaires go in, we expect this application to shrink over time.

**Chris W.** asked is that because you count each lamp as a sale versus a luminaire? You have the same number of places it's got to go, but you are counting each lamp as a sale versus the luminaire. If you have a three-lamp fixture, there are three that would go into it versus a luminaire where there is one that goes into it.

**Kate B.** said yes, that is correct. I think this dynamic is especially obvious in this application where a unit is either a lamp or a luminaire. As luminaires replace lamp-bearing fixtures, the total number of sockets decreases over time.

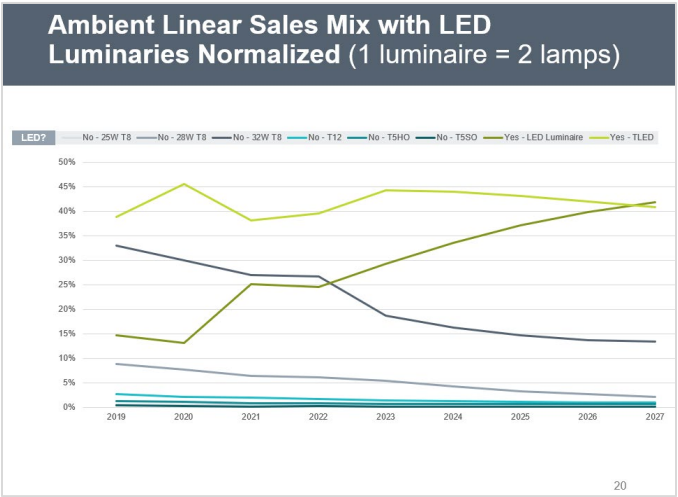
**Geoff** added in the chat:

- Connecticut ambient sales mix for comparison: https://energizect.com/sites/default/files/2022-07/CT%20C2014_CI%20Lighting%20Saturation%20and%20Remaining%20Potential_Phase%201%20Memo_FINAL_20210628.docx
- New Jersey ambient linear sales mix for comparison: https://njcleanenergy.com/files/file/Library/FY23/NJ%20Non-Res%20Lighting%20Market%20Characterization%20FINAL%20Report%2020220630.pdf
- Rhode Island ambient linear sales mix for comparison: https://rieermc.ri.gov/wp-content/uploads/2022/11/rhode-island_ci-lighting-market-characterization-and-adjusted-measure-life-report_final.pdf




**Kate D.** continued. Looking at the results, the dominant technology in terms of the sales volume is TLEDs in the light green at the top. We have generally seen TLEDs increasing in unit sales from our collected sales data through 2022, so you can see that generally increasing trend is reflected here. Looking at LED luminaires in the darker green line, we are forecasting that to increase consistently through 2027. In total, LEDs (both TLEDs and luminaires) are forecasted to comprise just under 80% of ambient linear market share by 2027. We have already talked about the decreasing application size over time, which we would expect given the increased rate of LED sales, which reduces lamp turnover and therefore, sales.

Now looking at 32Ws in gray, which prior to this modeling period, were the dominant technology in this application, these are forecasted to continue their decline to about 17% of total ambient linear sales by 2027. This is a place where the changing federal and state regulations are likely going to impact the market share of linear fluorescents in this application over the course of the modeling period. Those regulations include the federal high color rendering index (High-CRI) linear fluorescent standard and the Oregon state linear fluorescent ban. We are not going to be adjusting these sales mix forecasts in this interim model update to reflect the anticipated impacts. But we are, and will continue to, track the impacts of those regulations through collected sales data and conversations with the distributors. We will provide that data in the next couple of years and then address those impacts in the final model update. When we get the forthcoming CBSA, the data will give us a good indication of what is happening in the stock model period, so we can tie all these different influences together. A list of the changing federal and state standards and those impacted technologies in included in the Appendix for review.



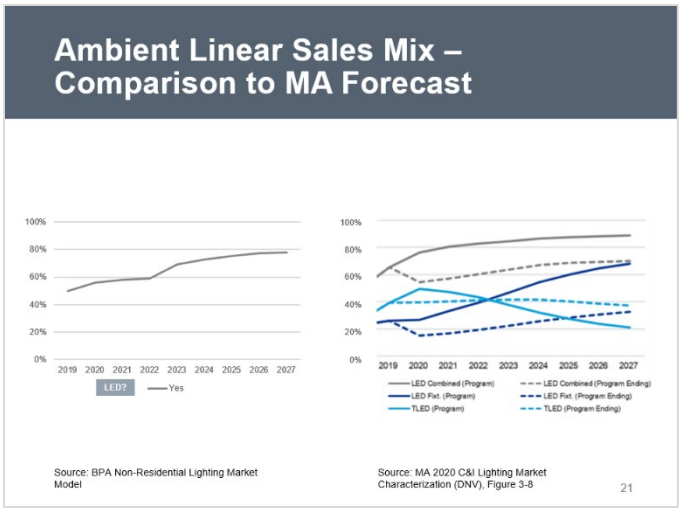

**Kate D.** continued. In order to compare TLEDs and LED luminaires more directly, we normalized LED luminaires in this graph, where one luminaire is equal to two lamps, since that is the most standard luminaire configuration. This is an artificial comparison calculated just for the purpose of this review. This is not actually how it gets recorded or handled in the model, where we can account for both lamp-bearing and non-lamp-bearing luminaires as well as luminaires with more lamps, like four- or eight-lamp configurations. But we are simplifying it here as a reasonableness check on the rate of sales of luminaires to lamps in this application.

When we look at the sales mix this way, you can see that LED luminaires and TLEDs hold a more similar market share by 2027, with luminaires starting to overtake TLED sales by 2027. This also allows us to see the effect of increased sales of LED luminaires more clearly. One reason the application is shrinking is the decrease of lamp-bearing luminaires as they are replaced by LED luminaires.

One other market effect we can see more clearly here is the dramatic decrease or leveling off in luminaire sales between 2021 and 2022. These are strange sales years as the market experienced Covid impacts, and these values reflect actual collected sales data in which we saw this trend. But because we removed those years from our training data forecast, you could see if you drew more of a straight line from 2019 to 2022, the overall trend for the forecast looks closer to what we would expect.

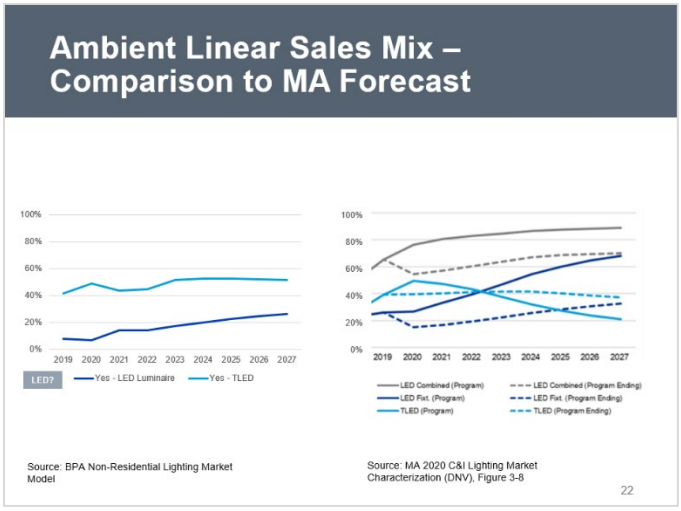
**Lauren** added in the chat: My hypothesis is that the linear fluorescent bans will result in a higher increase in TLED installations than the increase in LED luminaire installations.

**Chris** responded in the chat: I don't disagree with Lauren; however, I think the lack of utility incentives going forward for TLEDs might have a bigger effect on their sales, especially if fixtures can still get incentives.




**Kate D.** continued. Another way that we checked whether this forecast was reasonable was to look at the total LED market share in ambient linear for the model period on the left compared to the forecast in the MA 2020 C&I Market Characterization study on the right. The MA ambient linear forecast is derived differently that how we derived our forecast, but they both look at the same thing, which is market share of LEDs over time. So, we were able to do more of an apples-to-apples comparison. We also don't expect the northeast markets to be exactly the same as the northwest, but what we are looking for here are any big differences between the two to highlight if there is somewhere our forecast may be drastically off.

Looking at the graph on the right, the MA characterization forecasted total LED market share (dark gray line) to fall between 75% and 90% by 2027 depending on the future of state lighting program activity. Looking at the model forecast on the left, when we look at where our forecast predicts total LED market share to end up, our forecast falls within that range. But, where our two forecasts differ is on the market share of TLEDs versus LED luminaires.



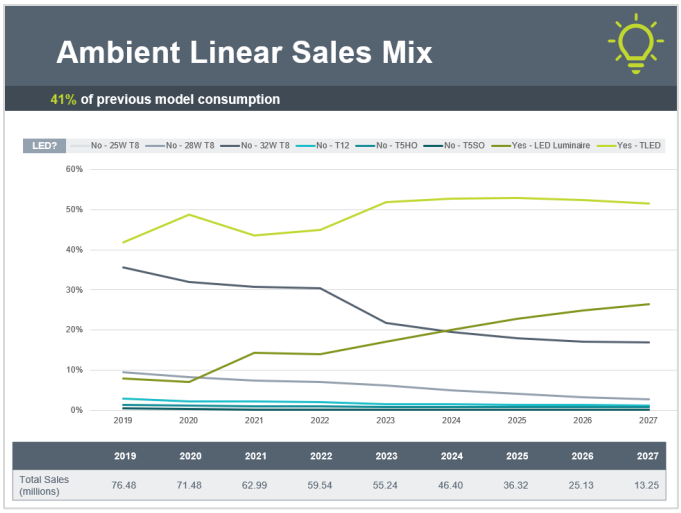

**Kate D.** continued. As a reminder, this is the non-normalized version of the model forecast, so these are the non-normalized LED luminaire and TLED forecasts. In our forecast on the left, sales of LED luminaires in dark blue do not overtake sales of TLEDs in light blue within our forecast period. Whereas in MA, the luminaires start to overtake TLEDs in 2023 in the program scenario (solid line), but in the program-ending scenario (dotted line) luminaires don't overtake TLEDs, but they do trend much closer together than they do in our forecast.

One driver of this difference is the MA forecast starts off with a higher market share of LED luminaires in 2019 than we do. The increase in market share trends is similar between the two forecasts but starting from a smaller initial market share. Obviously, this sets us a few years behind the MA forecast.

We also looked at two additional northeast state forecasts, New Jersey and Rhode Island, and found that their forecasts of LED market share and ambient linear also confirm that our forecast is reasonable. Those forecasts are in the deck, and you can review those comparisons when you review the rest of the slides.

**Peter** added from the chat window: DNV / ComEd study 2023 is similar to NW region LED adoption. ComEd did an internal calculation on loss of kWh savings. 31% decline from 2025-2030.

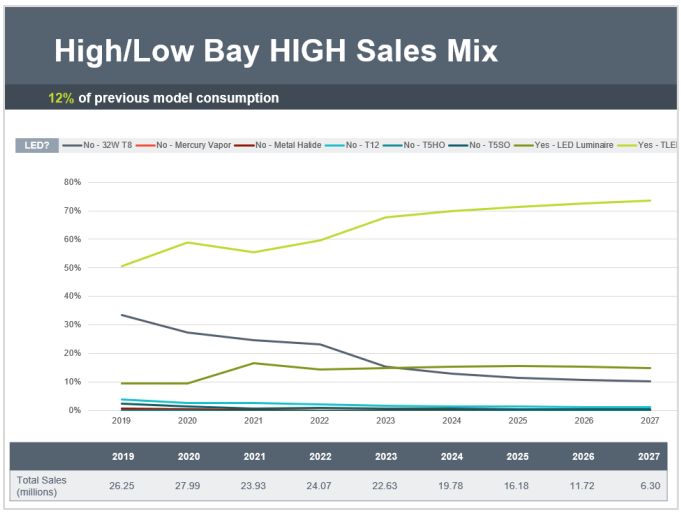
**Geoff** added in the chat window: Other difference with MA is that it's at fixture level, but I would concur that comparison shows reasonable modeled trend here.




**Kate D.** continued. Going back to our first non-normalized slide on the ambient linear application, do you have any questions or comments about the ambient linear forecast particularly around LED luminaires or TLED trends?

**Peter** mentioned that he had a conversation last week with Chris about the impact of ESCO sales for lighting retrofits countrywide and how most of them do not go through any kind of utility incentive program because it is not worth it to them, and a lot of their sales does not go through distribution. I think through 2027 it is fine, but once you go beyond that, as we get to that 80% done and we are in a smaller customer for commercial (under 20,000 square feet, less fixtures), potentially, ESCO sales will have a larger piece of the pie. Geoff Cooper and I are in another study, and we will be looking at that in more detail. ESCO sales are part of the puzzle; I talked to a couple of ESCOs this week. That is why I asked the question about the luminaires and if they included kits. In talking to the ESCOs, they have about 50% of their jobs are TLEDs, 35% are kits, and 15% are new fixtures.

**Kate D.** replied that that we do collect sales data from a couple of ESCOs, but the changing landscape of NRL sales or where those sales are coming from (more lighting consulting, more online sales), we are more aware that our distributors sales data is capturing a specific piece of the market. We still believe that that is the biggest piece, but it is something that we are definitely tracking.




**Kate D.** continued. The next largest application includes bay lighting with a ceiling height of at least 15 feet. We further break out the high/low bay application into high and low lumen outputs, where high is 15,000 lumens and above and low is below 15,000 lumens. We do this to account for the slightly different technology mixes we see within those applications. When taken together, the high/low bay applications account for 24% of the total market consumption from the previous model, with each segment (high and low) accounting for 12%. The key point is that ambient linear and the two high/low bays account for 65% of model consumption. Therefore, getting these three model applications right is extremely important for overall model results.

Looking at the results, the dominant technology in this application is TLEDs in the light green. Part of why they are so dominant in this application is due to an assumption made in our stock turnover logic. At the beginning of the modeling period, there is a high volume of eight-lamp linear fluorescent luminaires that the model, during turnover, replaces with eight individual TLEDs in certain cases, rather than an LED luminaire. This is something that I would like to get feedback on from the panel. Is this replacement scenario realistic or do you have field experience where you can speak to actual replacement options in these instances?

Moving on to LED luminaires in the dark green. These are forecasted to maintain a pretty consistent market share through 2027, hovering at about 15%. This is a place where our forecast could be undercounting LED luminaires. Looking at 32W T8s, the next largest technology type (gray line), these are forecasted to continue their decline to about 10% of total sales in 2027. This does not reflect any forthcoming policies that will potentially reduce linear fluorescent market shares in coming years.

The last thing I want to call out are the high-intensity discharges (HIDs), specifically for this application, the mercury vapor and metal halide (light and dark red in the graph). They are essentially negligible in the sales mix. We think we might be under allocating HIDs for this application, particularly in the early years. This implies that by 2021 nearly all HID fixtures would have been replaced by LED luminaires so that those HIDs are no longer needed in this high-lumen output application. We suspect that that could be understating the market share of HIDs still entering this application. But we would like your feedback on that.

**Chris W.** asked about the HID point. One of the things I feel is missing here is the replacement lamps for the HIDs, the corn cobs, that are going in here. You don't have those in here and they are a part of this high bay/low bay. You have TLEDs and luminaires, but not that.

**Kate D.** replied that those are accounted for in "high/low bay low". Those are mostly accounted for in our other lumen output bin for high/low bay. In that chart, that is what most of the LED Lamp line is. But would you expect to see them in high/low bay high as well?

**Chris W.** said yes, they are selling them there. I don't know the mix because I don't like corn cobs. But they are selling them; there are a lot of them out there. It might be a product that you are missing on this side that accounts for some percentage of the sales. It may not be big.

**Kate D.** said that they can double-check. Right now, all of our LED lamp sales for high/low bay end up in the high/low bay low sales mix, shown on the next slide. When we look at these sales mixes, we can make sure that accurately reflects where those lamps end up.

**Wes** asked about a point that was made on a previous slide. LED luminaires are counted as a single unit; each individual lamp would be counted as a unit. We are projecting about 16 million reduction in units from today or towards the end of the decade. But we are showing that LED fixture adoption is relatively flat over that period. Is that because all the T5HO lamps are moving to TLEDs? Would that be a 70% reduction in total units sold…without a corresponding uptick in the fixture?

**Kate B.** replied that there are two drivers of that decline. One is the transition from lamp-bearing fixtures to LED luminaires. The other is the longer lifetime of LED products that slows down product turnover. That decrease in sales looked surprising to us too, so it is something that we want to review in our QC process and make sure that there is not something else happening in the turnover calculations that is artificially driving down that sales volume in later years.

**Peter** asked. Can you take the distributor sales for high/low by for TLEDs and compare it to incentives that Energy Trust of Oregon is paying out to get an approximate check as far as TLEDs going into high bays versus new fixtures? Because that seems awful high. In my experience, most people will go to a new fixture. The labor is pretty much the same. Is that a way for you to double-check that number?

**Kate D.** said that we collect the distributor sales data at a granular technology level and then we collect there percent of total sales that they sell to each state. So, there is a bit of an assumption game that we would have to play about what percentage of each specific technology ended up in which state. But that is something we could ask out distributor partners about, the ones that have provided sales data year-over-year. We have great relationships and do market intel gathering with them. That is something we could definitely ask what their experience has been with that if we couldn't parse it out of the sales data itself.

**Kate B.** added that she liked Peter's suggestion. I think that we could put together a comparison of the volume of luminaires coming through program data. We don't have perfect insight into that; but we do have pretty good detail from BPA's program data. And we could look at the volume of luminaires going into high/low bay applications through programs and use that as a floor for the quantity of luminaires that need to be in that application. I think that is a good idea.

**Lauren** added that her experience has been the same: high and low bay get replaced with full luminaires at a higher rate than linear ambient. I think that is partially due to economics. It is great economics for a warehouse to do high bay luminaires versus a TLED replacement. The same goes for controls. We also see controls at a higher rate for those customers and advanced controls. Partially, that is because they can get up to 80% savings on their advanced controls if they use them correctly. I think they tend think about the luminaires more than the TLEDs because if they have a good utility or account manager, then they are being sold that great energy savings.

**Kate D.** replied that leveraging program data to understand these real-world replacements and using that to inform the sales mix is a great idea that we can use model QC.

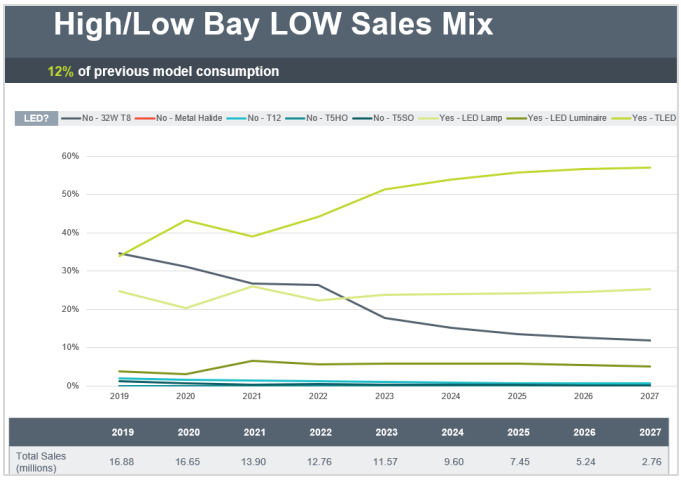
**Peter** added that Energy Trust of Oregon will be able to tell you that 80% of their incentive money goes up through five contractors. If you called each one and asked, what do you think your approximate install rate is for new fixtures versus TLEDs in high bays. They will give you a ballpark number, It is just a quick check to see if everything else matches up. Because they are doing 80% of the installs, they will have a pretty good idea of what is going on.

**Chris W.** asked in the chat: how are you able to tell TLED and fluorescent sales go to the fixture type? You have got your distributor sales, and they say that we have sold a million TLEDs, for example, how do you know where you are putting them? Are you asking them another question, for example, are they going into linear ambient? How are you breaking down those sales?

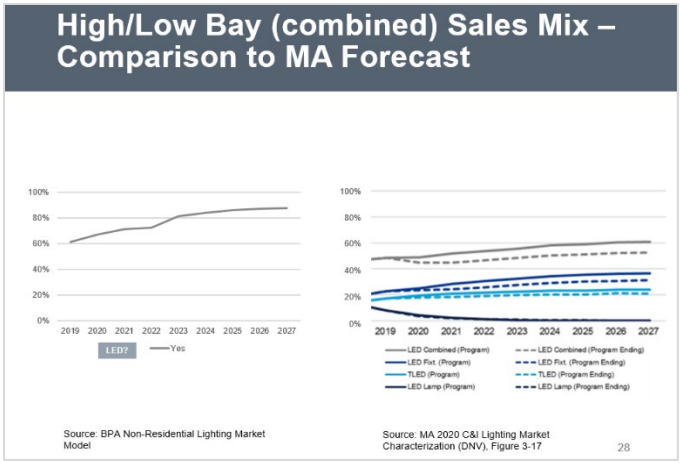
**Kate D.** replied that we use CBSA to map technologies to applications. We look at the stock to understand what would need to happen in the sales mix to produce that stock estimate. The allocation and forecasting piece of the sales mix looks at all of our model applications overall and maps our total sales for the region into those applications to verify that we are seeing the right amount of each technology in each application. We verify that amount with CBSA. This is a moment in time where we are in between CBSAs, so we are doing this forecasted allocation. But when we get the next CBSA, that is when we can true up our allocation in the modeling period.

**Chris W.** said that he thinks this is way too high for TLEDs. In low bay, maybe you could say that. But regarding high output, I have a hard time believing that there are that many high-output TLEDs being installed in this particular market. I think it is important to account for what controls will do to sales in that as controls become more prevalent, TLEDs become less prevalent because they are not as controllable. If controls are forced by codes, they will have to do fixtures or kits versus TLEDs because they are not going to be able to do the controls that are required by code with TLEDs. I think that is going to have an effect on some of this. It is not just federal regulations on what can and can't be sold, I think there are other things that will have a bearing on it as well.

**Kate D.** said that is a great point and it will be great to track that in the sales data over the next couple of years.

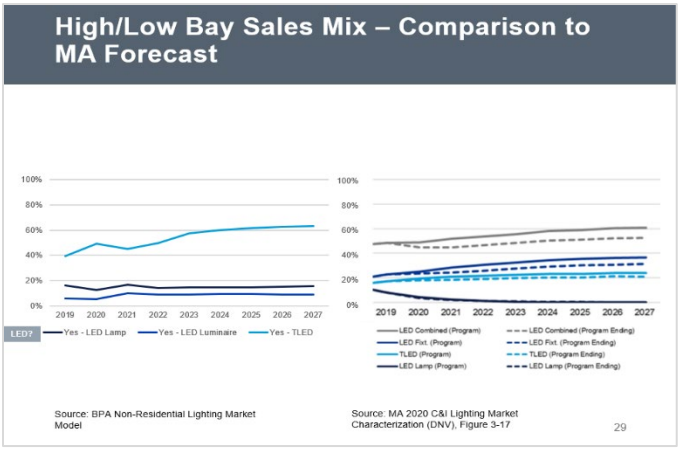



**Kate D.** Looking at the high/low bay low, the dominant technology here is TLEDs. And 32W T8s, the next largest technology type, are expected to continue their decline to about 10% in 2027. The main difference between the low application and the high application is that this application also includes the LED lamps we were talking about, large mogul base corn lamps and other HID replacements that make up about 25% of market share by 2025. Again, LED luminaires are forecasted to maintain a consistent and small percent of market share, about 5%. We could be underrepresenting LED luminaires in this forecast. But I think it will be helpful to look at the MA comparison because it breaks it down by technology and we can see the effects of these different LED technologies in play. Similar to high/low bay high, we are potentially under allocating HIDs to this application to the front part of our model period starting at essentially 0% market share in 2019. There is an implication here that HID lamps have been replaced by LED lamps all the way back to 2019, which might not be accurate.



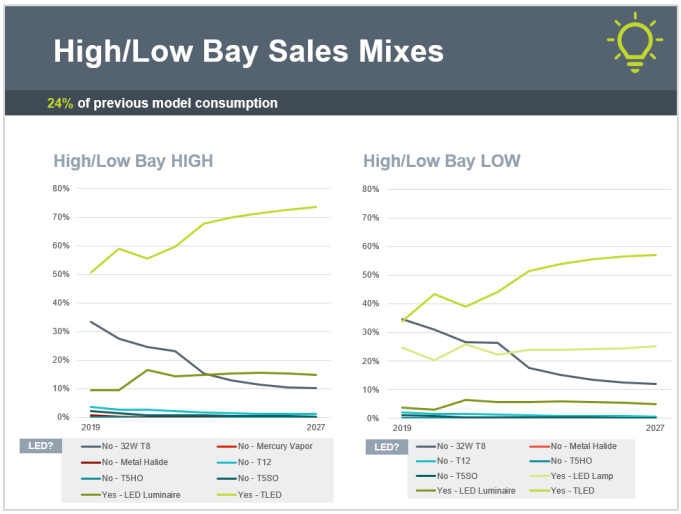

**Kate D.** continued. The Massachusetts report does not break out high/low bay into the lumen bins as we do, so the total sales mix for both applications is combined for these forecasts in our model forecast on the left. MA forecasted total LED market share to fall between about 50-60% market share by 2027 depending on the future of state program activity. But when we look at the model total LED market share by 2027 on the left, we are falling well above that range. Our expected LED market share by 2027 is about 87%. That is largely driven by a difference in specific technology trends.

**Kate B.** noted that Geoff added information about Massachusetts in the chat and that the Massachusetts mix here is at the fixture level, so the unit is a little bit different, and we might need to reassess the comparison so that it is more apples to apples.




**Kate D.** continued. I just wanted to point out that our TLED forecast shows a much higher market share in 2027 than the Massachusetts forecast did. They predict TLEDs at closer to 20%. This can be partially explained by our starting sales mix in 2019, which is based on the northwest. Also, 2019 is tethered to the observed stock in the CBSA. So 2019, for us, is couched in actual market data both stock and sales for the northwest. This might just be a difference from what Massachusetts is seeing in the same timeframe. The bigger question in this application overall is are we undercounting LED luminaires in the forecast years. If we believe that this is the

case, we could force down the TLED market share in those forecast years which would force the LED luminaires market share up in those years. The last thing to look at is the LED lamp forecast, which is the middle dark line. This is very different in Massachusetts, but the Massachusetts study did state that they had not seen as much activity in LED lamps in this application. This forecast makes more sense for their market than it does in the northwest where we have seen more activity for LED lamps. If we do decide to increase the allocation of HIDs to our forecast in these applications in the early years, this would also drive down the market share of LEDs. So, if we do believe that our overall LED market share of about 90% should be closer to Massachusetts' forecast of about 60%—which it sounds like maybe we don't, depending on the reasonableness of using this as a comparison—increasing HIDs in those applications would bring the LED market share down.




**Geoff** added in the chat window: I think we used a 2.4-lamps-per-fixture assumption.

**Peter** replied to Geoff in the chat window: One other potential factor in all LED adoption is the level of increase in electricity rates. A good question to distributors / contractors is do you see an increase in sales due to increasing electricity rates (lowers payback).

**Geoff** added in the chat window: Overall LED high/low bay market share aligns with more recent research DNV conducted after MA. I do not disagree with your overall LED forecast, but the mix between technologies might be a bit off.

**Chris W.** said that the TLEDs are very high. I think your fixtures are way low and your TLEDs are way high for the high side of it. I think it's the same on the low side. I am trying to picture the applications for this high bay/low and what they would be putting in, what the applications are (building types), and why they would be going with TLED versus a fixture. But for the high bay/high, I cannot see that being accurate for TLEDs. It feels way out of whack for me.

**Kate D.** said that it is very helpful to know. It sounds like this is an area to focus on for model QC —this high/low bay high and the relationship between TLEDs, LED luminaires, and HIDs—and playing with those allocations and forecasts to make sure that these look a little bit closer to expectations.

**Lauren** asked a question about how is "LEDs replacing LEDs" included in here. Is that part of total sales?

**Kate B.** responded. We introduced that option in 2015 in the previous modeling period. So, in this entire modeling period, LEDs are allowed to replace LEDs. That is driven by product lifetime and retrofit. There is the option for LED-to-LED retrofit to occur too. So, yes, that is included.

**Chris W.** added that one of the reasons that this looks off is that we are comparing apples to oranges when it comes to TLEDs and fixtures because we are comparing the sales of a bunch of little things versus the sale of one big thing. Especially in this high bay, I would say that if you were to say that the luminaire or fixture sales equals a minimum of four lamps, which is probably small, that quadruples where that number is. Right now, you are counting these high bays where you think there are eight TLEDs going into each one versus one fixture. I think that this throws the graph way off b/c you are not comparing apples to apples on what that fixture looks like, so it makes it look odd.

**Kate D.** asked that if you know of any data for forecasting market share or that we could use as comparisons to couch these forecasts in, that would be really helpful. But I definitely agree that looking

at the sales mixes in terms of unit sales has pros and cons. The way that it forces you to look at luminaires and TLEDs can produce wonky looking line graphs as well.

**Kate B.** asked Kate D. if we calculated in an Appendix slide that normalized mix view like we did on ambient linear. Did we do that for high/low bay?

**Kate D.** said no, but we can if that would be helpful.

**Lauren** added. I do think that in a TLED market, people tend to overbuy TLEDs than they do luminaires. A property manager or operations person in a warehouse may buy extras that don't end up getting installed b/c they want to have them on hand in case something goes wrong. That may be an old mentality, but they do that a lot. I see a lot of TLEDs in closets. You may see overall TLED sales not equating to luminaires ales. They might always be higher, even if you get that comparison correct.

One other thought about the LED replacing LED, I think that with the federal and state changes of laws, the overall quality of products will come down. They won't need to test as much as they had in the past, and utility programs won't be watching them. I think that the opportunity to replace LED lamps with LED may also increase. We saw that on the lamp side over time. The quality has decreased, and lumen depreciation has been a really big problem.

**Kate B.** asked Lauren for clarification. I think what you are saying is that as lower quality LED fixtures enter the stock, over time, those are probably going to have shorter useful lifetimes because of that decreasing quality.

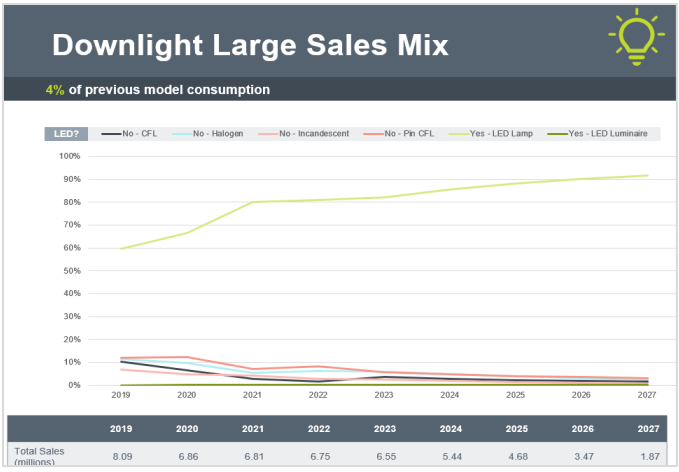
**Lauren** replied, yes, especially with TLEDs or lamps. People will be putting in TLEDs that are supposed to last 8 years and they only last 4 years. Maybe it is just that the lumen depreciation is so bad that they have to replace them.

**Kate B.** said that was a really great point and something we could potentially look at in future studies.

**Lauren** added that if you see a bump in sales at a certain point in time away from when you had a huge bump in sales in a program, that may indicate that your lamps are being replaced.

**Peter** added that the company that bought GE is recovering their investment by dropping the life hours on LED residential bulbs from 25,000 to 15,000 or 10,000. I have even seen 7,500-hour lamp ratings now for LED screw-in bulbs.

**Lauren** added in the chat window: Home Depot/Lowes now sells LED standard flush-mount fixtures (25,000 hr) and LED pro flush-mount fixtures (50,000 hr), same product, better quality.




**Kate D.** continued. Downlight large includes all Directional lamps (pin and screw base, including PAR and R/BR lamps) and downlight luminaires. The dominant technology here is LED lamps, which are forecasted to reach about 92% market share by 2027. LED luminaires have a very low percent of market share on this application at 1%. This could be undercounting LED luminaires because we did see increasing numbers of downlight luminaires reported in the distributor sales data. So, any panelist input on that would be helpful. This is an application where we do expect to see changes with the changing federal and state regulations in the analysis period. Pin-based CFLs would be affected by forthcoming Oregon state regulations. We did not adjust the sales forecast here to predict the impacts of that, but we will account for them. Generally speaking, that is a small percentage of this application. And this application is a small percentage of the model overall.

**Chris W.** asked in the chat window: What does “large” include?

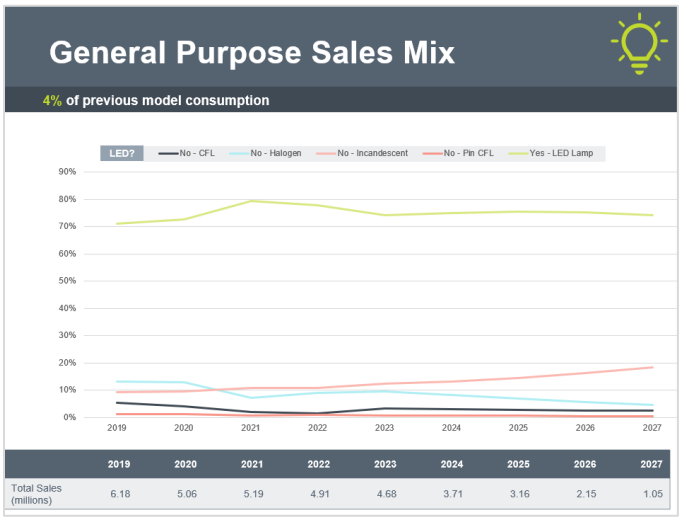
**Chris W.** asked: MR16?

**Kate B.** replied to Chris W. Smaller directional lamps would be allocated to the "Track" applications. MR16s go to Track.

**Lauren** added in the chat window: Just an FYI because I just had to look into all of this for Pacific Power, downlights will continue to be served by ENERGY STAR moving forward, unlike lamps and luminaires.

**Peter** asked if the distributor data is broken out to retrofit versus new construction or is it all lumped together?

**Kate D.** replied that it is all lumped together. Our commercial floor space estimates in the model do account for existing and new construction, but then we do not report any findings from the model stock or sales broken out by new construction.




| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 |
|---|---|---|---|---|---|---|---|---|---|
| Total Sales (millions) | 6.18 | 5.06 | 5.19 | 4.91 | 4.68 | 3.71 | 3.16 | 2.15 | 1.05 |

**Kate D.** continued. The dominant technology here is LED lamps, which stay at a consistent 75% of market share through the forecast period. The increase we see in incandescents is driven by the decrease in overall location size. The absolute unit sales of incandescents in this application are decreasing year over year. But as more LEDs are adopted and the total sales volume decreases, the decreasing amount of incandescents are making up a larger percentage of the decreasing total application size. This is one of those times where the size of the application is driving a trend. When you look at it, you think that it cannot possibly be right. But, when you look at it in terms of unit sales, the trend is going in the direction that we would expect. Relatedly, we do expect to see some changes in this application with the federal general service lamps (GSL) lighting standard, which only allowed sales of non-LED GSLs through summer 2023 and will affect essentially all non-LED technologies in this application. So, we are collecting 2023 sales data now and we are hoping to see the impact of that change in this year’s sales data. But we did not address the sales forecast at this time to predict the impacts of those regulations.

**Lauren** asked how MR16s are categorized. I think this is going to be a problem category when the GSL happens. When I was looking into this, I was expecting them to be considered GSL, but I am still not sure that they are. I think they may be exempt, but it is not clear to me. I think that some of these small categories may have big impacts on the federal stuff.

**Kate B.** replied that in our model, MR16s go to a track lighting application. So, that is not one of the ones that we looked at today. It is a pretty small portion of the total market, which is why we put it on a lower priority. But it is included in the slide. Does anyone on the call know about the exemption with MR16s? I do not know the answer, but that is something that we will want to get to the bottom of as we see this thing roll out.

**Lauren** said she would send Kate B. the language so she could interpret it.

**Chris W.** said that he is still trying to figure out the difference between downlight large and downlight low because you say track light, but track lights have BR lights in them as much as any of the MR16s. is there a lumen output or a product output you are using to define the two?

**Kate B.** replied. There are three directional applications: downlight large, track large, and track small. You are right, those PAR, R, and BR lamps go into both downlight and track large. The driver of the allocation of those lamps between those two applications is the stock data. In the stock data we can see if it is a downlight fixture, like a can fixture, or track head fixture. That is how we determine what portion of the stock belongs in those two applications. Because it is a case of where the same product goes to more than one application.

**Chris W.** replied that he does not think it is a huge market, I was just trying to figure out how you define it.

**Kate D.** continued and discussed the review request and upcoming engagements as shown in the slides below.

**Juan Carlos** added that there will be a third engagement about the next set of sales data later in the summer.

## Review Request

### Review Guidance

- Prioritize the 5 key applications (reviewed today) with the largest impact on model results
- Provide feedback based on market expertise/ expectations as well as based on data

### Expert Panel Review Request

- Review sales mix forecasting and allocation results presentation (including remaining application sales mixes in Appendix)
  - Review slide notes for BPA's interpretation of each application's sales mix over time
- Submit comments on sales mix forecasting and allocation results in provided workbook by March 8

### Upcoming Engagements

- **Controls Analysis Desk Review** – April
  - BPA ultimately determined that currently available controls market data does not meet the needed rigor to include controls in the interim model update. Panelists will review a memo detailing the research team's findings that led to this decision.
- **Draft Model Results Presentation** – July

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Additional Information about GSL Provided by Lauren:

Here is the DOE page on General Service Lamps and the Federal Register that I read. It said the following, but I may not be getting the context right. Let me know if you're able to translate.

As noted in the September 2019 Withdrawal Rule, these definitions were subsequently withdrawn (see section II.D of this document). In the August 2021 NOPR, DOE proposed to amend the definitions of general service lamp and general service incandescent lamp. DOE proposed to define a general service lamp as a lamp that has an ANSI base; is able to operate at a voltage of 12 volts or 24 volts, at or between 100 to 130 volts, at or between 220 to 240 volts, or of 277 volts for integrated lamps (as defined in this section), or is able to operate at any voltage for non-integrated lamps (as defined in this section); has an initial lumen output of greater than or equal to 310 lumens (or 232 lumens for modified spectrum general service incandescent lamps) and less than or equal to 3,300 lumens; is not a light fixture; is not an LED downlight retrofit kit; and is used in general lighting applications. General service lamps included, but were not limited to, general service incandescent lamps, compact fluorescent lamps, general service light-emitting diode lamps, and general service organic light emitting diode lamps. General service lamps did not include:

(1) Appliance lamps;

(2) Black light lamps;

(3) Bug lamps;

(4) Colored lamps;

(5) G shape lamps with a diameter of 5 inches or more as defined in ANSI C79.1–2002 (incorporated by reference; see 10 CFR 430.3);

(6) General service fluorescent lamps;

(7) High intensity discharge lamps;

(8) Infrared lamps;

(9) J, JC, JCD, JCS, JCV, JCX, JD, JS, and JT shape lamps that do not have Edison screw bases;

(10) Lamps that have a wedge base or prefocus base;

(11) Left-hand thread lamps;

(12) Marine lamps;

(13) Marine signal service lamps;

(14) Mine service lamps;

(15) MR shape lamps that have a first number symbol equal to 16 (diameter equal to 2 inches) as defined in ANSI C79.1–2002 (incorporated by reference; see 10 CFR 430.3), operate at 12 volts, and have a lumen output greater than or equal to 800;

(16) Other fluorescent lamps;

(17) Plant light lamps;

(18) R20 short lamps;

(19) Reflector lamps (as defined in this section) that have a first number symbol less than 16 (diameter less than 2 inches) as defined in ANSI C79.1–2002 (incorporated by reference; see 10 CFR 430.3) and that do not have E26/E24, E26d, E26/50x39, E26/53x39, E29/28, E29/53x39, E39, E39d, EP39, or EX39 bases;

(20) S shape or G shape lamps that have a first number symbol less than or equal to 12.5 (diameter less than or equal to 1.5625 inches) as defined in ANSI C79.1–2002 (incorporated by reference; see 10 CFR 430.3);

(21) Sign service lamps;

(22) Silver bowl lamps;

(23) Showcase lamps;

(24) Specialty MR lamps;

(25) T-shape lamps that have a first number symbol less than or equal to 8 (diameter less than or equal to 1 inch) as defined in ANSI C79.1–2002 (incorporated by reference; see 10 CFR 430.3), nominal overall length less than 12 inches, and that are not compact fluorescent lamps (as defined in this section); and

(26) Traffic signal lamps.

See 86 FR 46611, 46624–46625.

Similarly, DOE proposed to define a general service incandescent lamp as a standard incandescent or halogen type lamp that is intended for general service applications; has a medium screw base; has a lumen range of not less than 310 lumens and not more than 2,600 lumens or, in the case of a modified spectrum lamp, not less than 232 lumens and not more than 1,950 lumens; and is capable of being operated at a voltage range at least partially within 110 and 130 volts; however, this definition did not apply to the following incandescent lamps—

(1) An appliance lamp;

(2) A black light lamp;

(3) A bug lamp;

(4) A colored lamp;

(5) A G shape lamp with a diameter of 5 inches or more as defined in ANSI C79.1–2002 (incorporated by reference; see 10 CFR 430.3);

(6) An infrared lamp;

(7) A left-hand thread lamp;

(8) A marine lamp;

(9) A marine signal service lamp;

(10) A mine service lamp;

(11) A plant light lamp;

(12) An R20 short lamp;

(13) A sign service lamp;

(14) A silver bowl lamp;

(15) A showcase lamp; and

(16) A traffic signal lamp.

# Working Session: Interim Market Model Draft Results – Jul. 30, 2024

## Attendees

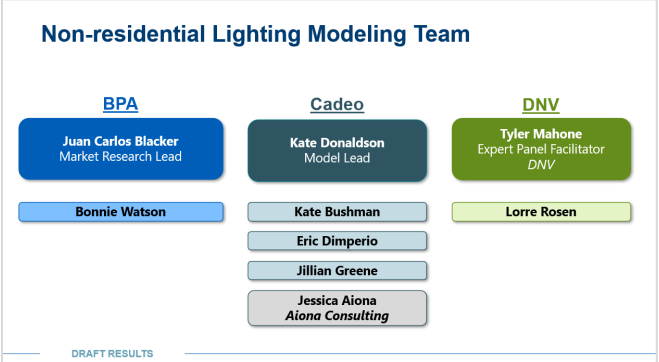
**BPA:** Juan Carlos Blacker

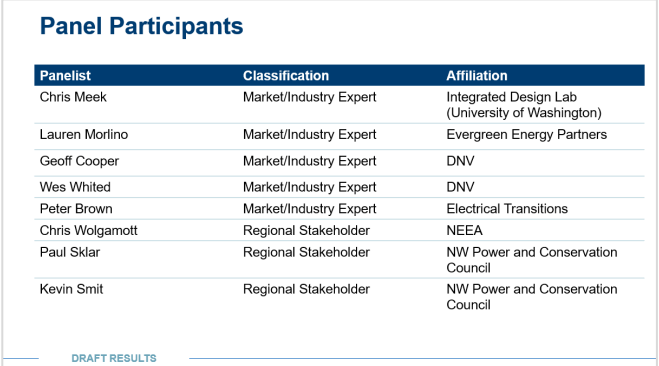
**DNV:** Tyler Mahone, Lorre Rosen

**Cadeo:** Kate Bushman, Kate Donaldson

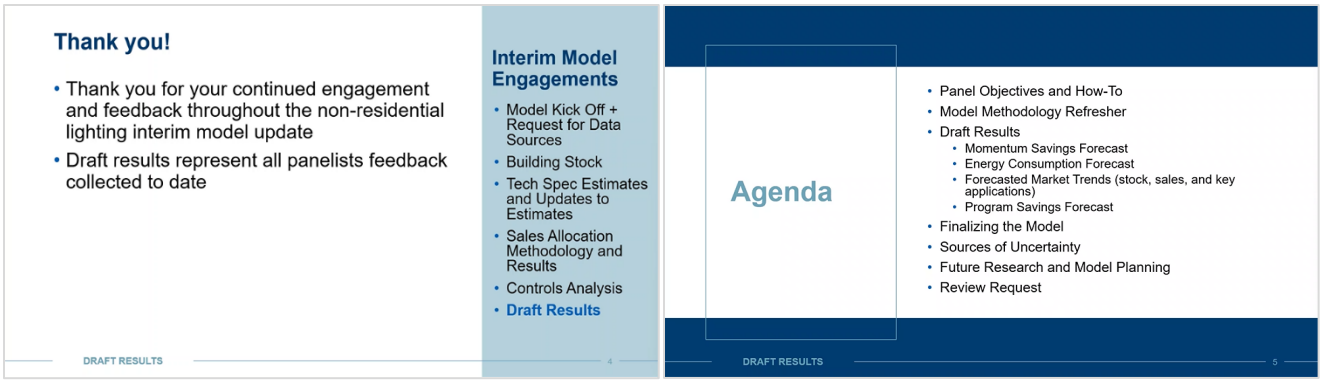
| Invited Panelists | Affiliation | Attended | Did Not Attend |
|---|---|---|---|
| Peter Brown | Electrical Transitions | ☒ | ☐ |
| Wesley Whited | DNV | ☒ | ☐ |
| Geoffrey Cooper | DNV | ☒ | ☐ |
| Lauren Morlino | Evergreen Efficiency | ☒ | ☐ |
| Paul Sklar | RTF Forum | ☒ | ☐ |
| Chris Wolgamott | NEEA | ☒ | ☐ |
| Christopher Meek | University of Washington | ☒ | ☐ |
| Kevin Smit | Council | ☐ | ☒ |

## Introductions



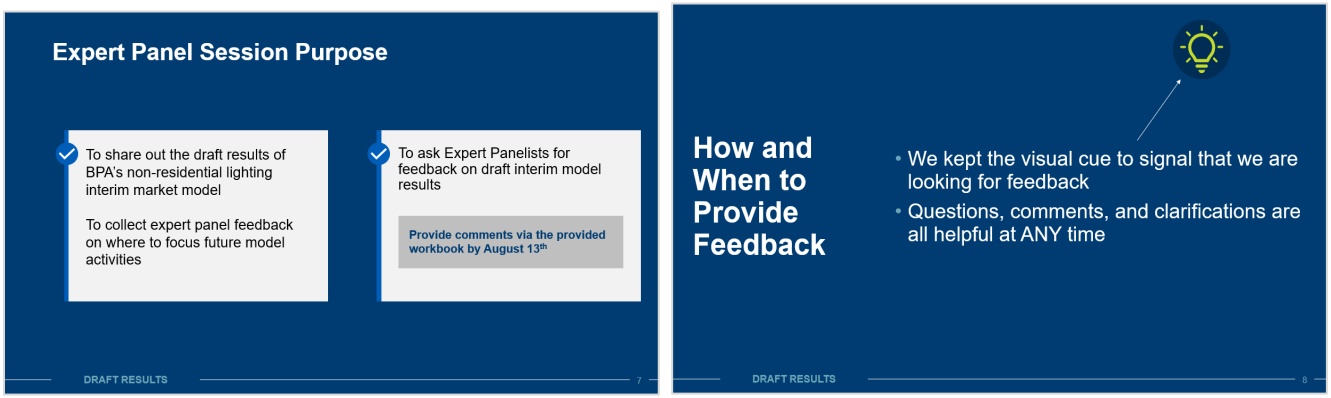




**Tyler** introduced the panel participants and the BPA, Cadeo, and DNV team members.



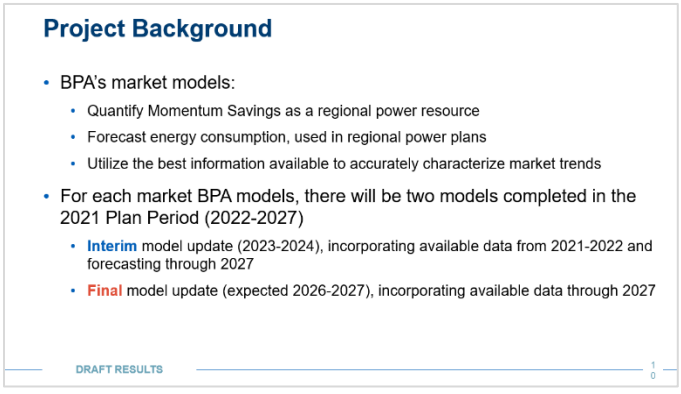

**Juan Carlos** thanked the expert panelists for their feedback and engagement and reviewed the agenda.

## Panel Objectives and How-To



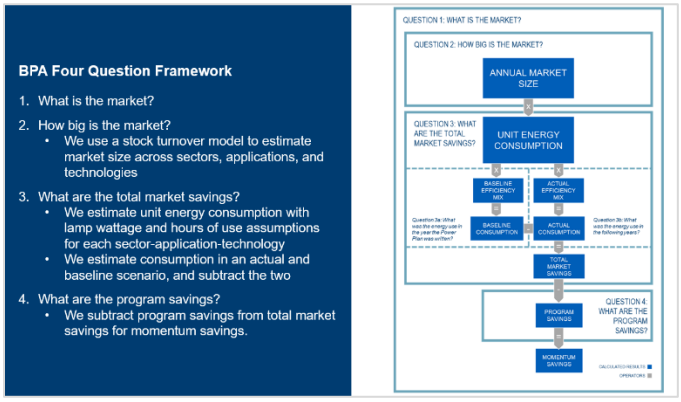

**Tyler** discussed the purpose and objectives for the expert panel and reviewed how to provide feedback.

## Model Methodology Refresher

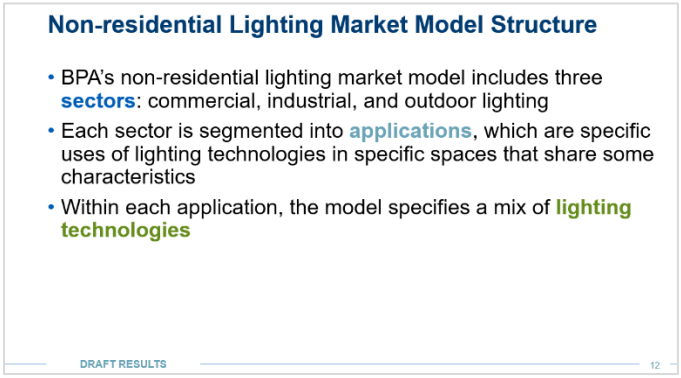



**Kate D.** provided background on the project. I am going to start with a little refresher on the model methodology. You have the model methodology memo in your review package. We are not looking for any feedback on that, but if you want more detail on the methodology or anything I present today, you can definitely look there. For those of you that were here for the model kickoff in February or April 2023, some of these slides will look familiar. The BPA manages the creation and updating of market models for a variety of residential, commercial and industrial markets. These models serve a variety of functions. They help BPA quantify momentum savings, which are energy savings above the Council's 2021 power plan baseline and not reported by programs. Momentum savings are a regional power resource, but momentum savings are just a snapshot of the market, and there is huge value in understanding the market as a whole. These models also forecast energy consumption in a given market, which is then used in regional power planning, and they utilize

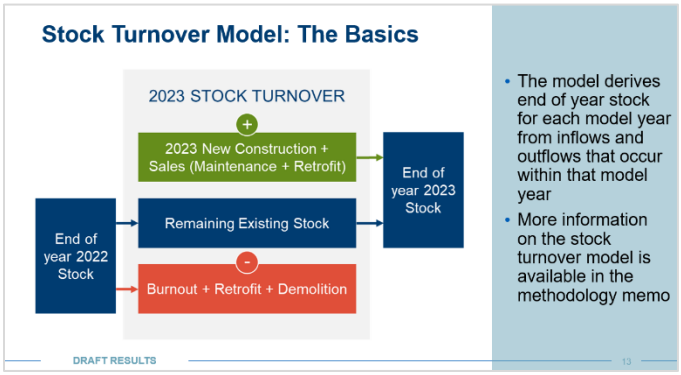
the best information available to accurately characterize market trends. We ultimately do this in two models per plan: an interim model update and a final model update. The interim model update is what we are working on now. It provides energy consumption and momentum savings estimates for 20/21, which is the baseline year and 2022, as well as forecast for future years through 2027. We are planning to complete a final model update at the end of the plan period to replace forecasted data with available data through 2027.




**Kate D.** continued. For all of BPA's market modelling efforts, we follow the four question framework for estimating momentum savings. This framework helps each modelling team define what is important to know about each market being modelled in a standardized way. Each of these four questions is tethered to model inputs, that when taken together, answer the four question framework with a complete model methodology. You can review the framework in these questions and the resulting methodology in more detail again in the methodology memo.

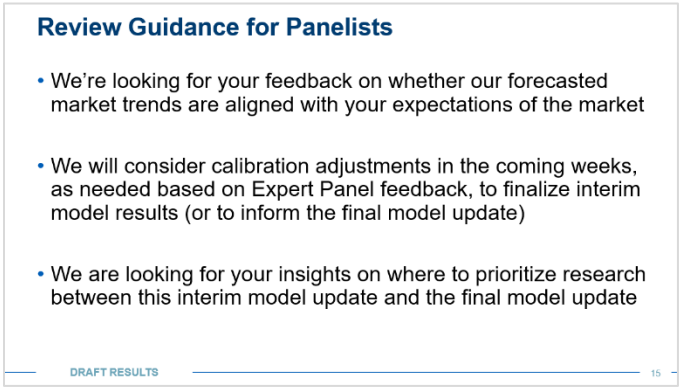



**Kate D.** continued. BPA's non-residential lighting market model includes three sectors: commercial, industrial, and outdoor lighting. As a reminder, we removed indoor agriculture as a sector for the 2021 plan period models. Each sector is then further segmented into applications that are specific uses of lighting technologies in specific spaces that share some characteristics (e.g., the ambient linear application). And then within each application, the model specifies a mix of lighting technologies. For example, the ambient linear application specifies the mix of linear fluorescence, TLEDs, and LED fixtures that make up that application. A full mapping of the models, application sector, and technologies is available in the methodology memo.

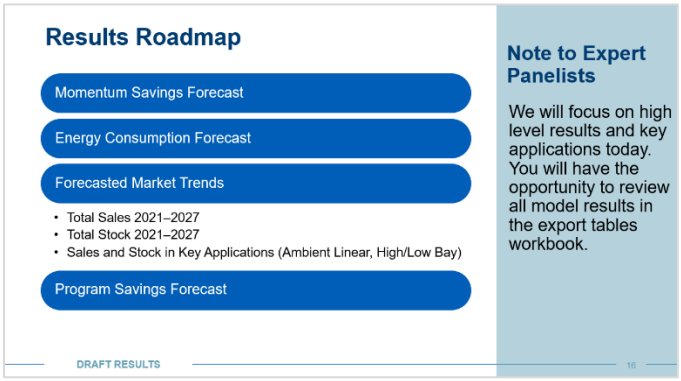



**Kate D.** continued. At the heart of the NRL model is the stock turnover model. It is important to understand some of the basics. The turnover model starts with the end-of-year stock in a given year. In this graphic, it is 2022. Using a variety of inputs and calculations, it performs the following functions. First, it adds new lamps and pictures to the stock through new construction and sales, including both maintenance and retrofit sales. Then it defines the remaining existing stock that does not turn over or enter the stock in that year. Lastly, it removes lamp and fixture stock through burnout retrofits and building demolition. The result is the end-of-year stock for each model year derived from those inflows and outflows that occur within that model year. I want to review this because we will review sales and stock trends side by side in this presentation. I wanted to be clear that those sales trends are used to inform the resulting stock trends.

# Draft Results

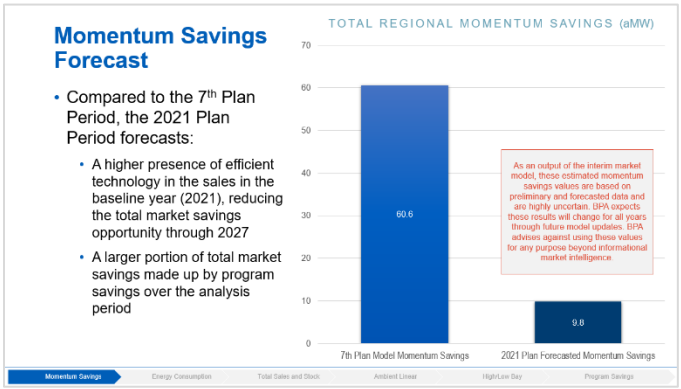



**Kate D.** continued. Before we dive in officially, I want to just provide a little bit of additional review guidance. As we review selected draft results for you today, we are looking for your feedback on whether our forecasted market trends are aligned with your expectations of the market. We are at the end of our modelling. And we are limited in what adjustments we can make to this forecast in the coming weeks. We are looking for any insights into where the results may be glaringly wrong. We do have time to potentially address those items. All of your insights will be valuable to inform any research we perform between the two model updates to ensure that we are producing the best possible final model results. We are also looking for your insights on where to prioritize our time and resources between the two models to again, replace that forecasted data and inform that final model.




**Kate D.** continued. Here is a road map of the results I am going to present in the next several slides. I am focusing the presentation today on the highest importance results to get your feedback on. But you will have the opportunity to review all of the model results in the export tables workbook. We welcome your feedback on any results that we did not cover today in your reviews of that workbook.

## *Momentum Savings Forecast*



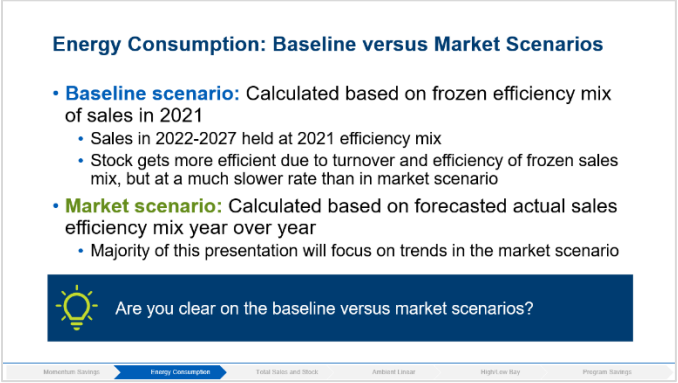

**Kate D.** continued. We will start with the momentum savings forecast. As a reminder, momentum savings are just a snapshot of the market. I am going to talk about this briefly, but we are going to spend most of our time today on broader market trends. The important thing to share about momentum savings is the difference between the calculated momentum savings in the 7th plan period model and the forecast of momentum savings in the 2021 plan period model. Just a quick word on nomenclature. The Council changed the name of what would have been the 8th plan to the 2021 Plan to reflect the baseline year of that plan.

Compared to the 7th plan, the 2021 Plan forecasts a higher presence of efficient technology in the sales in the baseline year, which is 2021, which reduces the total market savings opportunity through 2027 because total market savings are calculated off of the baseline year. And 2021 saw an increase in efficient technologies in the sales mix, in particular as a result of a market bounce back after COVID. That increased efficiency in the baseline year reduces that savings opportunity throughout the analysis.

We are going to talk about those trends in more detail in future slides and you will get to actually see those trends play out. But that is one reason that the forecast is so much smaller for the 2021 Plan. The second reason is that the current model also forecasts a larger portion of total market savings being made-up by program savings over the analysis. We will look at program savings in a little while, but they actually stay relatively flat year to year. As we just discussed, the total market savings are shrinking, which means that program savings are making up a larger portion of total market savings. And as a reminder, momentum savings are calculated by subtracting program savings from total market savings.

Lastly, I just want to provide the caveat that as an output of the interim market model, these estimated momentum savings values are based on preliminary and forecasted data and are therefore highly uncertain. BPA is expecting that these results will change for probably all years through future model updates. We are advising against using these values for any purpose just beyond informational market intelligence.

## *Energy Consumption Forecast*

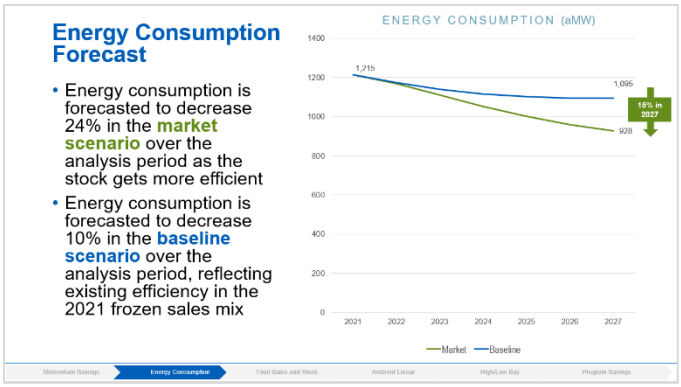



**Kate D.** continued. Before we talk about the energy consumption trends, I want to talk a little bit about the two scenarios we calculate. The baseline scenario is calculated based on a frozen efficiency mix of sales in 2021. In the baseline scenario, sales in 2022 through 2027 are held at that 2021 efficiency mix. The resulting stock does get more efficient in the baseline scenario due to turnover and the efficiency in that frozen sales mix, but it becomes more efficient at a much slower rate than in the market scenario.

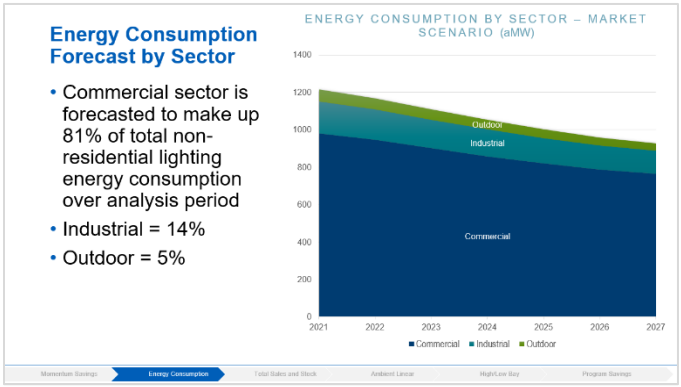
The market scenario is calculated based on forecasted actual sales efficiency mixes year over year. The market scenario is the forecast of what the market will actually look like through 2027. We are going to focus the majority of this presentation on the market scenario to discuss market trends, but we use the baseline and market scenario to calculate total market savings, which is that difference in consumption between the two scenarios in each year. In the export tables workbook, you will see a baseline and market version of nearly every table of model results.

**Peter** asked a question. One question on the baseline says sales of 2021, that was a really weird year. Is that actually 2021 or was some of it a bleed over from 2020?

**Kate D.** replied. Yes, it is informed by the sales that we actually collected for the year 2021. It is kind of an odd year. I mentioned on the momentum savings slide that we did see an uptick in efficiency in that year as we suspect it was part of a market bounce back from COVID. But given that is the best available data that we have for 2021 and that is what the market actually looked like, we are using that for the baseline year. But that is something that we are thinking about and talking about with BPA. As we get more sales data over the next couple of years, we will go back and see what the trend line overall looks like versus just using that spiky 2021 year.

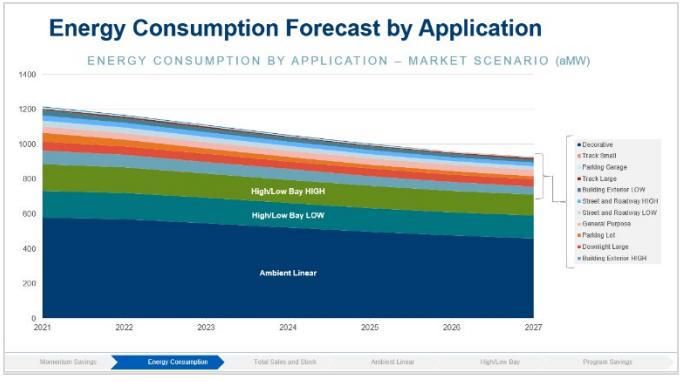



**Kate D.** continued. Looking at the energy consumption forecast from this interim model, the graph on the right hand side of the slide shows the energy consumption year over year in the analysis. In the baseline and the market scenarios, you can see that consumption in the market scenario in green is forecasted to decrease about 24% over the full analysis. As the stock in this scenario gets more efficient, then looking at that baseline scenario in blue, consumption is much flatter, but it is still forecasted to decrease about 10% over the analysis, which reflects that existing efficiency in the 2021 frozen sales mix. Again, this difference in baseline and market consumption is how we derive total market savings. And you can see that the gap between the scenarios is relatively slim versus how it would look if the baseline consumption stayed more truly flat over the analysis. This graph reflects the reduction in total market savings opportunity that we talked about when we looked at momentum savings.




**Kate D.** continued. Looking at consumption in two different ways. The first is by sector. You can see that the Commercial sector makes up the bulk of consumption at about 80% over the analysis. With industrial following at 14% and outdoor following at 5%. This is consistent with previous models and is an indication that getting the commercial market trends forecasted correctly in the model is most important in terms of getting the overall market consumption forecast right.

And then looking at consumption by application, we talked in the sales results presentation in February about ambient linear and the two high low bay applications being the largest application applications by consumption in the previous model. And that trend continues in this model.




**Kate D.** continued. So, similar to getting the Commercial sector right, it is most important in terms of impact to results to get the trends in these three applications. We are going to discuss application-specific trends just from these three applications in the presentation today. But again, you will have the chance to review trends in all applications in the export tables workbook.

**Chris W.** asked. On the ambient linear, are you taking into account the federal or the state, for example, Oregon banning of fluorescence, in your in your modeling here? Because it feels like there would be a steeper “you can't buy it, you can't put it in” type of thing. We know Washington is probably going to do the same thing in a relatively short manner.

**Kate D.** replied. We are not. We talked about that back in the sales mix allocation results presentation. But essentially, with the Oregon linear fluorescent ban specifically, it is one state in the four-state

region. We do not yet know enough about things like cross state commerce or compliance trends. It is more conservative to assume no compliance right now. We will get into this later in the presentation, but this is one of the sources of uncertainty in this model and one of the places that we are going to prioritize research between the two models. But for the purposes of this model, we opted for the more conservative approach in terms of not overstating or understating consumption, which would overstate savings.

**Chris W.** added. Are you taking into account the federal wattage minimum that is coming for general service lamps (GSLs)?

**Kate D.** replied. The best way to account for those changes is through collected sales data. So, we collected 2023 sales data. That is the first set of sales data where compliance to that standard would be reflected, and we will know more in future years about how that is playing out. Right now, we have not accounted for those in the applications that have GSL lighting, but we plan to, by the final model update, use actual sales data to reflect compliance.

**Chris W.** added. It does apply to TLEDs, right?

**Kate D.** replied. I believe there is a high CRI linear fluorescent and there are the TLEDs. I cannot remember off the top of my head. I will have to go back and look.

**Chris W.** replied. I was pretty sure it did not touch fluorescents. It does not say fluorescents have to meet this, but it does say that TLEDs have to meet the minimum. But I could be misremembering that as well.

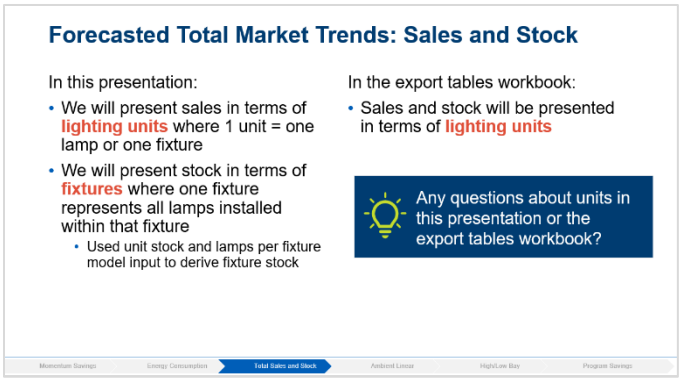
**Kate D.** replied. This is a place where we are going to do quite a bit of market research between the two model updates. We will know more about exactly what products are going to be impacted. We will have sales data to reflect actual market trends. We will be able to really dial this in and get these market impacts correct between the two model updates.


**Kate D.** continued. Did anything we present in the forecasted momentum savings or energy consumption results strike you as out of line with your understanding of the market? Or do you have any other questions about momentum savings or energy consumption before we move on to some broader sales and stock trends?

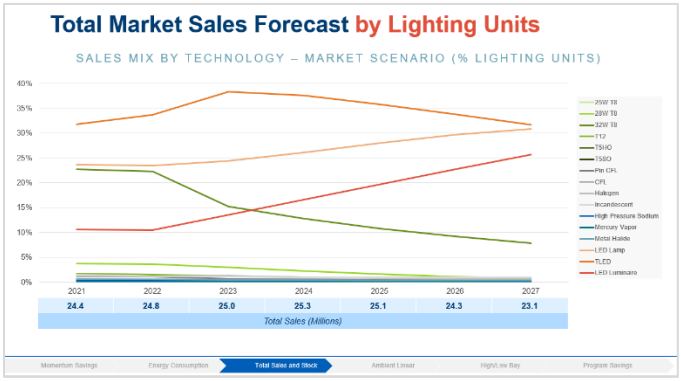
**Peter** commented. I think you are going to see some major trends. I am not sure yet how it is going to impact what we are talking about today.

Wes added in the chat window. To Chris W: I recently connected with Andrew @ ASAP about how to interpret the new GSL language. It does cover all TLED types, but I don't believe the rule kicks in until like May 2028. LFLs are excluded but efficiencies are covered by another (existing) federal rule.

## *Forecasted Market Trends (stock, sales, and key applications)*




**Kate D.** continued. For forecasted sales and stock market trends, I am going to talk through trends for the total market and then for those high consumption applications. But first, I want to make sure that we are all aligned on the units we are going to present these trends in. In this presentation, we are going to present sales in terms of lighting units, where one unit is equal to either one lamp or one fixture, because that is most closely how sales units are reflected in the actual market. Then when we present stock, we are going to present the stock in terms of fixtures, where one fixture represents all of the lamps installed within that fixture, because that is most closely how installed stock is reflected in the market. In other words, what is actually installed in the ceiling. We derive stock at the fixture level using the unit stock and the lamps per fixture model input, which you have seen and can look at in the input development workbook. In the export tables workbook, all of the sales and stock tables and charts are presented in terms of lighting units, but you can always come back to this presentation to view those stock trends at the fixture level as needed for your review.




**Kate D.** continued. This graph shows the total market sales mix forecast by year from 2021 to 2027 for all sectors and all applications. We already talked with you pretty extensively about the sales mix forecast back in February and all of your feedback is reflected in this and the other sales mix forecast. Similar to the previous presentation, these sales mixes are expressed as a percentage of the overall unit sales in the market per year. The table below the graph shows the model output calculating those total unit sales by year values to give the mix above some context of total market size. Also, on this graph and in all other graphs in the presentation, LED technologies are reflected in the reds and oranges. Linear fluorescent technologies are in shades of green, HIDs are blue, and all other low-volume technologies are in gray. Looking at the actual results, TLEDs in that top orange line are forecasted to remain the dominant technology in the total market sales mix through the analysis. But TLED sales are forecasted to decrease in the market share following a forecasted peak in 2023. We have generally seen TLEDs increasing in unit sales from our collected sales data through 2022. And you can see that there is a generally increasing trend here. And you all just reviewed the 2023 sales data. And as a reminder, that is not reflected in this graph, 2023 here is a forecast. But 2023 sales data did show an increase in TLEDs, consistent with the direction of that trend in the model forecast. This forecast does show a pretty aggressive uptick in market share of LED luminaires in that middle red line over the analysis. Reaching just over 25% of total unit sales by 2027. A key point of uncertainty in this forecast is how these LED luminaire and TLED sales trends will evolve. This forecast was informed by expert panel input by the DOE and Massachusetts forecast comparisons, both of which show significant growth in LED luminaires. We will have more actual sales data for the final model update as well as another CBSA to cross reference with stock data to determine how steep that LED luminaire sales trend really is.

A couple more things to point out in the sales. You can see that 2021 starts with LEDs making up a little over 60% of total sales. That is the increased efficiency in the baseline year that we have talked about compared to previous models where LEDs were below 50% market share at the beginning. Again, that increased efficiency is driving the decrease in consumption in the baseline scenario. Altogether, LED technologies are making up about 90% of total market share by 2027 and 32 Watt T8s in that middle green line hang on to about 8% market share by 2027. But all other technologies are pretty negligible in the sales mix by the end of the analysis.

Finally, I just want to call out that the peak and then decrease in total unit sales in 2024. This decrease in unit sales through 2027 reflects the high presence of LEDs in the sales mix and in the resulting stock, which we will talk about next. And as more LEDS enter the market, there is going to be a slower lamp and fixture turnover in the market, resulting in fewer overall sales.

**Peter** added in the chat. I suggest breaking out LED Luminaire types—cans, troffers, flat panels, etc.

**Lauren** asked. It was helpful to know that the TLEDs tracked similarly in the model to actual sales in 2023. What about these other categories? Were those also consistent or were there any discrepancies you were not expecting?

**Kate B.** responded. We did not do a full alignment between the 2023 forecast and the 2023 sales data just because of the timing of when that sales data analysis was completed. But what we did do is review it against our final round of calibration of this forecast to corroborate any trends that looked unusual in the final forecast. The big one that I was initially focused on was that uptick in LED luminaire sales mix in in 2023. You can see on this graph that there is a flat line and then a turn in the forecast. So, for that one, we did look more closely at against the 2023 sales data. And in the 2023 sales data, we saw that LED luminaire sales roughly doubled between 2022 and 2023. That aligns with that forecast quite well. That is something that is definitely one of the key sources of uncertainty here and something that we will have to see what subsequent sales years look like to know how that forecast plays out against reality.

**Lauren** added. I think it is great that we are able to get that live temperature check on these numbers and it sounds like it is going well.

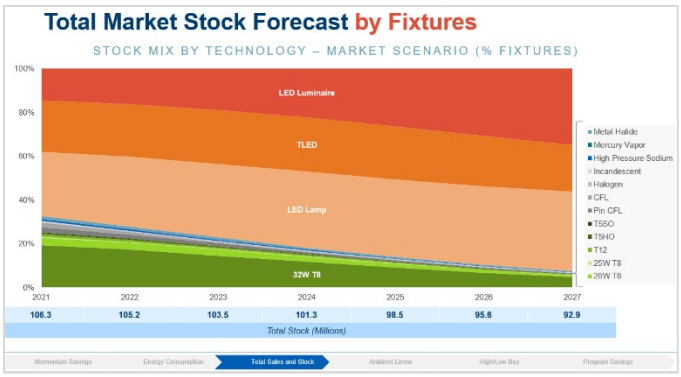
**Peter** added. I have a problem with that increase if we do not know what the incentives were, because that is a huge jump. Now if there is a lot of incentives for people to switch from TLEDs, we are just talking about ambient linear. So going from TLEDs to troffers, that is significant. And to offset that, you have got to have a really good rebate incentive to do it because of the labor difference. The labor cost to put in TLEDs is way less than putting in a new troffer or a new fixture. If you can correlate that with incentive programs just as a check.

**Kate D.** responded. That is an interesting suggestion and something that we can look into between the two model updates to help corroborate this trend. We will also have a CBSA, which is helpful to look at the actual stock and then we can right size the sales trends to reflect the actual stock that we are observing. We are early in the analysis period to be forecasting out. It will be interesting to corroborate the actual the steepness of this curve in the next couple years.

**Chris W.** added. Peter, I was thinking the reverse. I was thinking of the TLEDs because all the utility incentives are going away on the TLEDs versus if they are staying, they are staying for the fixtures. So TLED incentives are going to be eaten up quick because they are not going to be allowed to be given, because there is going to be a federal list, even though it is a ways out, they are going to be less likely to be able to provide that to them. There is not enough there. So I was wondering on the TLED number, if that is not going to see a sharper spike down than what you are seeing because the incentives are going to go away on TLEDs.

**Peter** added. I do not see the incentives for TLEDs being nearly as important as the incentives for LED luminaires because the labor cost is so much more. The other factor is in more mature markets, a lot of incentives are going away as utilities are starting to take funds for infrastructure and everything that is coming with EV load or AI load, etc. That is especially true in the Northwest. Some of the numbers they are throwing around as far as the increase in load, I do not know what that will do to incentive programs. It certainly made a difference in California.

**Kate D.** responded. Yes, it is helpful to see the trends for the sales, but they solidify for me when we look at the stocks. I can move on to the stock graph and walk you through that and then we can circle back on this because I think it is very relevant to what I am about to show you.



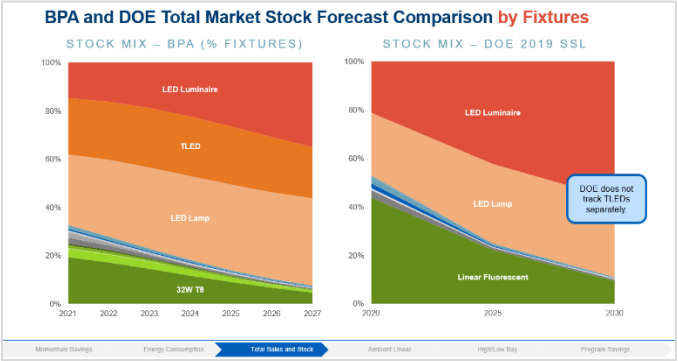

**Kate D.** continued. Looking at that end-of year stock forecast for each year of the analysis period that results from the sales trends as well as the other stock turnover effects that I discussed earlier. Reminder, the stock mix is normalized to the fixture level to represent that average fixture stock in the market. And the non-normalized lighting unit version of this graph is an appendix slide in the export tables workbook. It is just a table, so I wanted to include that in an appendix slide for reference if it is helpful to visualize it. This is probably the most important slide in the presentation. The main forecasted stock trend I want to call out is how large of a percentage of the total stock is forecasted to convert to LED overall in this time period. By the end of 2027, we are forecasting over 90% of the total stock converted to LED technologies. This is the expected market trend and reflects this panel's feedback and other forecasted data sources. But it is still remarkable to see that shift take place in the analysis. All of us on this call have been predicting this shift for a while or hoping for this shift for a while and it is interesting to see it start to play out in the forecast.

I want to talk about the total stock size in millions of units that is presented in the table under the graph. Here you can see that the stock size is forecasted to shrink over the analysis. Which reflects both the long lives of LED products and the stocks slowing stock turnover and the increase in LED luminaires in the stock, reducing the overall number of sockets in the stock in a given year. Looking at some specific technology trends. LED luminaires are really the big story here. LED luminaires are forecasted to make up over 35% of the installed stock of fixtures by 2027. This aggressive growth is mostly playing out in forecasted years. You can see that 2021 to 2022, which are the years based on actual data, there is more gentle growth than in the year to year forecast in 2023 and beyond. This more aggressive curve is again in line with market expectations. But it is going to be interesting to see what that presence of LED luminaires in the stock looks like in the next CBSA as a corroborating point.

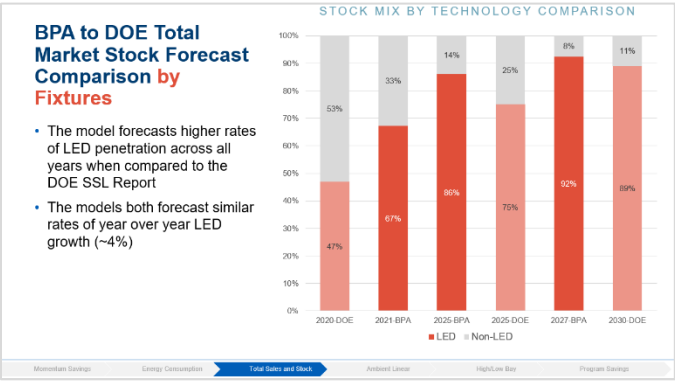
TLEDs are forecasted to retain a little over 20% of the installed stock in 2027. TLED's are forecasted to increase as a portion of the stock mix through 2024 before starting to decrease, but they hang on to a relatively similar chunk of the stock through the analysis. LED lamps are forecasted to continue to increase as a portion of the stock getting up to a little over 35% of the stock by 2027. And 32 Watt T8s are the only other technology that have a meaningful portion of the stock by 2027 at about 5%. All of the other technologies make up a negligible amount of the stock by the end of the analysis.

**Chris M.** asked. Does the LED luminaire include linear and downlights, all LED combined luminaires? You would have a mix of linear and downlights or other type applications?

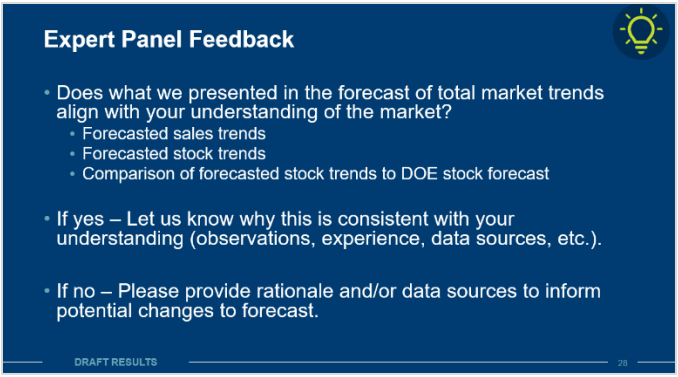
**Kate B.** replied. Yes. We do have them broken out into more detailed categories in the model and in the sales data. If you want to see those more detailed trends, they are in the workbooks.




**Kate D.** continued. Our forecasted stock mix is on the left and the DOE forecasted stock mix from the 2019 solid-state lighting report is on the right. The DOE stock is expressed at the fixture level, as are the BPA results. We are looking at roughly apples to apples there. But it is important to note that the DOE solid-state lighting report does not track TLEDs as a separate technology. We cannot compare the mix of LED technologies like luminaire, TLED, and lamp, but we can do a general comparison of the overall presence of LEDs. There is also a slight difference in dates along the X axis. DOE reports forecast in five-year chunks. Their forecast is showing 2020 to 2030, while ours is showing 2021 through 2027. All of that being said, the DOE is forecasting a similar market trend to the BPA model that we are currently forecasting, with linear fluorescence being replaced by LEDs as market adoption grows. Our forecast is slightly more efficient than the national forecast. By 2025, DOE forecasted that 22% of installed fixtures would still be linear fluorescence, where we are forecasting closer to 12% in 2025. This makes sense because our trends are driven by regional data and aligned with our historical comparisons where the Northwest region has trended more efficient than national stock. It is tough to talk specifically about the LED technology comparisons without being able to characterize TLEDs separately. But it is worth looking at the overall shape of the trend lines in the LED categories in the DOE forecast against the trend lines in the BPA forecast. You see that same aggressive transition to LEDS over a similar time frame and that helps bring a little extra validity to our forecast.




**Kate D.** continued. This graph is the DOE to BPA stock comparison by year in terms of overall percent of LEDs versus non-LEDs. The darker red bars are BPA, and the light red bars are DOE, and they are organized by year chronologically. Our overall presence of LEDs in the model seems reasonable and follows a similar trend to the DOE forecast. Again, the BPA model does project a little higher rate of LED penetration across years, but both project the same rate of year-over-year LED growth at a little over 4% per year. We are getting more efficient, but we are growing in efficiency at the same rate.




**Kate D.** asked the panelists if they had any questions.

**Peter** asked Geoff a question. What was the ratio in the Northeast between T-12s and T-8s? We did a baseline study for ComEd in Chicago in 2012. It was 40% T12s in 2020. In 2019, it was 20% T12s and it was a ratio of about 3:00 to 1:00 at that point. There was 20% T12s and 60% T8s. Then it started to widen out. I am curious to see if there is a way to track T12 to T8 in the Northwest, because as we get into the laggards that last 20 to 25% of what is left, it all slows down. I do not know if that may help you with the forecast overall.

**Geoff** replied. My overall reaction is that the scenarios and the forecast look pretty accurate.

**Peter** added. For the 32 Watt T8, I do not think we are going to have that low a number by 2027. But I could be wrong.

**Geoff** added. It is weird to show sales of T12s, but they continue to persist in the market. They continue to exist at customer premises and based on the assumptions about burnout and needing to replace them, even if they happen to be in closets that might have lower hours of use, they are still out there. From a modeling standpoint, people are getting them from somewhere. Whether it means they are stockpiling or holding onto them in their closets and then installing them, or shipping them in from somewhere else, they continue to persist on that front. Looking at this [Total Market Stock Forecast by Fixtures], you see a minuscule line of it but it is not zero. If we take the lessons learned from the T12 and think about our T8s, I imagine it would follow a similar trajectory. It does not surprise me to see it this small, especially given the ease of converting to TLEDs. Similarly, someone brought up a question about the state-level bans on the sale of non LEDs. And it is going to happen at the state level, not nationally. Does that mean there will not be T8s being sold or are people still going to find a way to get those, hold on to them, buy them in bulk, or get them across state lines? Based on the information we have, I thought these looked pretty accurate, but the lesson of T12 to T8 is interesting to look at as we think about T8 to TLED.

**Peter** added. I suggest you go into a Home Depot or Lowe's in Oregon or Washington and see what is there. That would help you get a better gauge of the laggard market where somebody is going in and buying a case of lamps or they have got a small contract contractor buying a case. Here in Arizona, you can still buy 40 Watt T12 four-footers and 75 Watt T12 eight footers.

**Kate B.** added. Same here in Oregon. I took a photo of 40 Watt T12 in Home Depot last weekend.

**Peter** continued. That is why I am asking the question because it seems in all the state studies that DNV has done, once you get to 80% adoption, it flattens out that curve. You are showing 2021 at 20% for 32 Watt T8s and then in six years you are down to 7 to 8%.

**Geoff** added. When you look at this graph [Total Market Stock Forecast by Fixtures], it is 80% within the submarket, but this shows all markets. This LED lamp is not a replacement for T8s. If you took out the LED lamps, that 32 Watt T8 would be a greater proportion.

**Kate D.** responded. Yes. When we get to the ambient linear, when we get into the specific applications, and when you are looking at the specific applications in the workbook, it gets easier to see within each application how these trends play out and what specific luminaires and LED lamps are included in each application change. These are the total market level.

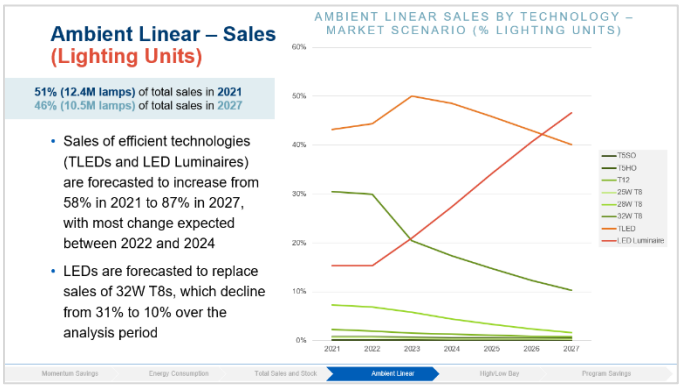
**Lauren** added questions in the chat. 1) Are replacement lamps for Metal Halide and HPS included in this? Or are we only talking full fixture sales? I think those lamps are still sold broadly but are put into existing fixtures. 2) Can you remind me how we account for a LED luminaire with onboard controls (for example, an LLLC fixture)?

**Kate B.** responded in the chat. 1) Yes, the HID sales here reflect lamp sales. 2) We do not track onboard controls /LLLC in this model, though we are exploring being able to add that in a future update based on forthcoming CBSA data.

**Geoff** added in the chat. My one consideration is the decline in total stock since this reflects the fixture level. Is there any information to inform the number of fixtures per square foot with old technologies for fixtures per square foot with new technologies. If you haven't, then maybe that is something you could use CBSA to look at—new vs old. Also, on laggards informed by T12 to T8 vs T8 to TLED -- people with T8 now are not laggards since they went to T8. Will laggards in T12 reflect laggards in T8? Something to consider.

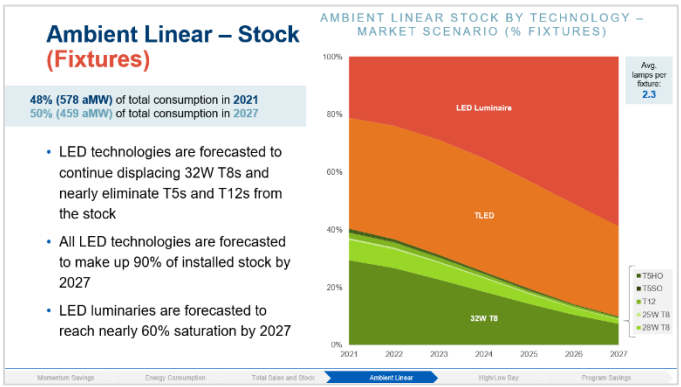
**Kate B.** replied to Geoff in the chat. This is definitely a key question we'll be looking into with the next CBSA. Especially with changing LED form factors, we're interested in revisiting fixture density.

**Lauren** replied to Geoff in the chat. We still see a lot of T12 on site, especially rural locations or farms with old overhead lighting (I'm not talking about indoor agriculture grow lights, more like cow barns, slaughterhouses, plant nursery offices, garages, etc.).




**Kate D.** continued. The largest application by far, in terms of both percent of model consumption and sales volumes is ambient linear, which accounts for essentially half of total market sales throughout the analysis. This application includes all low Bay linear lamps and luminaires. The dominant technology in terms of sales volumes in this application is again TLEDs in orange until 2027 when TLEDs are replaced by LED luminaires in red. As we discussed in total market sales, we have generally seen TLEDs increasing in unit sales from our collected sales data and you can see that here. We are forecasting a relatively steep dip in TLED market share after 2023 as LED luminaires are forecasted to see a very aggressive increase in market share year over year starting in 2022. That line looked aggressive on the total market, but it looks very aggressive here in ambient linear. But a reminder that 2023 here is forecasted sales, not actual sales.

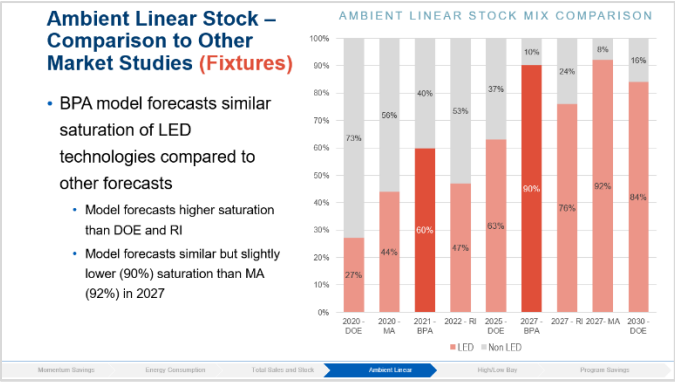
In reviewing the collected 2023 sales, we found a few things that do support this aggressive growth trend in LED luminaires in this sales forecast. First, the unit count of other LED luminaires, which includes the standard ambient linear LED luminaires almost doubled tumbled between 2022 and 2023 in our collected sales data. Second, among ambient linear products, 2023 LED luminaire market share was about 1.3 times the 2022 market share. The products that we include in this category for the sales data reporting do not exactly align with the ambient linear application in the model, but that trend is still strong and relevant as a point of comparison. That being said, the same point of uncertainty stands in the ambient linear application as in the total market trend. Despite this increase in luminaires and decrease in TLEDs being consistent with both your feedback from February and with best available data. We will have to collect more data and see how the interplay between TLEDs and LED luminaires plays out in the collected sales data in the next several years.




**Kate D.** continued. In terms of fixtures in the ambient linear application, the average lamps per fixture is about 2.3, just for reference here. By the end of 2027, we are forecasting over 90% of total ambient linear stock will be converted to LED technologies. This application mirrors the aggressive LED uptick in saturation we saw in the overall market, which makes sense given that this application makes up about half of total market consumption. Looking at some specific technology trends, LED luminaires here are forecasted to make up just under 60% of the installed stock of fixtures by 2027. This aggressive curve is again in line with market expectations, but it is going to be interesting to see what the presence of LED luminaires in the stock looks like in the next CBSA in 2025 because that gets us a little deeper into our analysis and gives us a corroboration of how steep that line actually is. TLEDs here are forecasted to retain a little over 30% of the installed stock in 2027. They are forecasted to increase as a portion of the stock mix through 2023 before starting to

decrease. Again, 32 Watt T8s are the only other technology that have a meaningful portion of the stock by the end of the analysis at about 7%. But 28 Watt T8s make up about 2% in 2027. All other technologies make up a small amount of the stock by the end of the analysis.

**Peter** added in the chat. 50% of school districts nationally still are T8 - per ESCO's that do 90% of the retrofits and most projects are drop shipped and do not apply for rebates.




**Kate D.** continued. This graph compares the BPA model ambient linear stock forecasts again in those darker red bars to the DOE solid-state Lighting report as well as the Massachusetts and Rhode Island commercial and industrial (C&I) lighting characterizations completed by D&B. We looked at those comparisons in more detail with you all back in February. If you want the details of those forecasts, they are in that deck. The BPA model forecasts a similar penetration rate of LED technologies overall in the ambient linear application compared to both the DOE and those two North East studies. The model is forecasting higher rates of LEDs than DOE and Rhode Island, but lower LED penetration than Massachusetts by 2027. Again, we use these comparisons as a reasonableness check for our results. Even though they are not apple to apple comparisons, they give us a sense of if we are on the right track. Does what we presented in the forecast of ambient linear market trends align with your understanding of the market?

**Geoff** commented. On the Rhode Island and Massachusetts comparisons, Massachusetts was significantly higher than the national average given long history of program activity. Rhode Island, even as a neighboring state was significantly below Massachusetts and the national average. What you are showing there in terms of comparison is very logical and makes sense.

**Lauren** added. I agree. In my data in Vermont, we were always higher than the national trend and higher than the Pacific Northwest, which was still higher than the national trend. It goes national trend, Pacific Northwest then Northeast. What you have tracked with my efficiency Vermont data a long time ago.

**Chris M.** asked Kate D a question. On the previous slide you had indicated 2.3 lamps per fixture. Can you elaborate on what that means when it comes to these LED luminaires?

**Kate D.** replied. We calculate average stock at the fixture level for visualizing the model results in these slides. That is derived from the actual unit stock model and from the lamps per fixture model input we use to help generate like total stock size. In something like ambient linear, the average lamps per fixture is a little lower. It is a little over two. You will see when we get to High Bay, the average lamps per fixture is much higher because you have big lamp fixtures reflected there. So that number is a frame of reference of how big the average fixture is in this application.

**Lauren** asked. The TLED sales here, is that total TLED sales by lamp or is that total TLED sales divided by 2.3?

**Kate D.** replied. The sales slide is total TLED sales by individual unit, this is by pure number of TLEDs. Then this stock graph is normalized at that fixture level. When you look at the ambient linear, there are graphs for all of the applications in the Export Tables workbook, and those are going to be at the unit level. This graph will look different when you see it in the export Tables workbook because it is going to be at that lighting unit level. You can compare against this version the stock as needed.

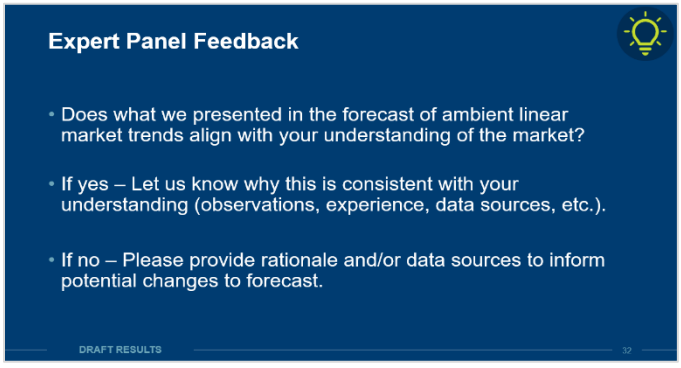
**Geoff** added. If I was drawing conclusions from this graph, the TLED stock is stable in the latter years and any growth that is continuing to replace the older technologies is now accounted for through the LED luminaires. That is where all your new stock is coming from. If that's a valid conclusion here, it seems to align with some of the expectations we would like to see in the market.

**Kate B.** added. I would agree with that perspective. In the sales graphs, we see the peak TLED sales happening and that reflects some market saturation for that technology. We see that continued growth in LED luminaire sales, which then shows up in the stock graph with continued growth in the stock.

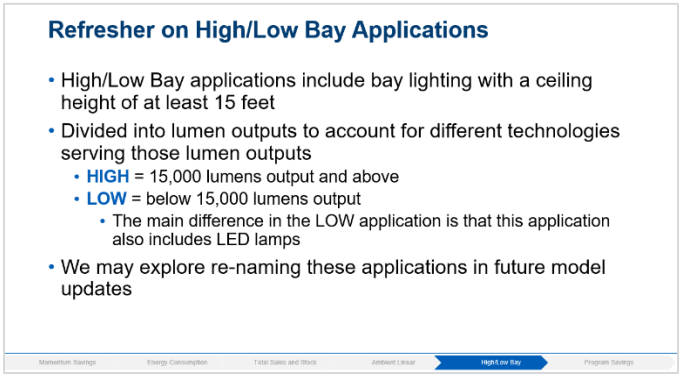
**Wesley** added. Some of this may be a function of DNVs incentive design, we have been seeing those trends in our midstream programs that we implement nationally. Due to utility cost concerns, it is the first place we try to squeeze the incentives are out of the TLEDs, which then allows us to over incentivize the Lumiere, especially if it has control. The trends that you are showing represent the national in our data sets as well.

**Kate B.** replied. We did not explicitly account for the changes in incentives in our forecast. The forecast is a mathematical forecast. It is driven by past data patterns and expectations of that future like with the Bass diffusion curve shape of adoption. Although we are not explicitly accounting for those incentive changes, those changes will affect the future sales data that we collect. We will have that empirical basis for accounting for those changes in future years.

**Lauren** added. I would not recommend trying to forecast the incentives either. Those are going to vary based on the utilities needs and goals. What you are doing is relevant.



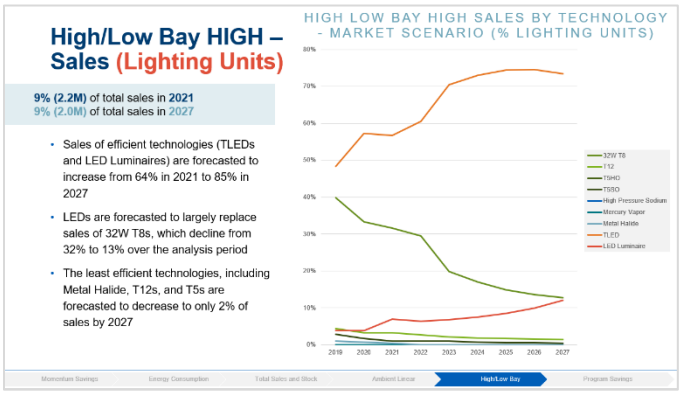

**Kate D.** asked the panelists if they had any questions.



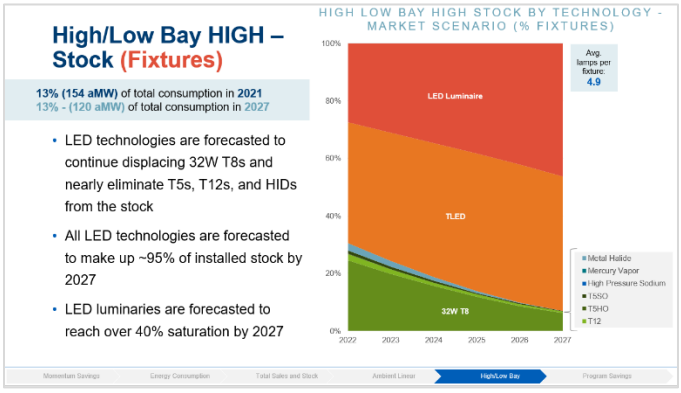

**Kate D.** continued. A reminder on the model nomenclature for the High/Low Bay applications, which include Bay lighting with the ceiling height of at least 15 feet. In the model, we further break out the High/Low Bay application into HIGH and LOW lumen outputs, where HIGH is 15,000 lumens and above, and LOW is below 15,000 lumens. We do that to account for the different technology mixes within those applications. The main difference being that the low lumen output application includes LED lamps as well as TLEDs and other things. Based on feedback we got from you during the session in February, we are going to explore renaming these applications in the future model update to make them less confusing.

**Lauren** asked. Is there a bottom threshold on the Low Bay LOW, like lumens from 6,000 to 15,000, at some point does the linear ambient take that?

**Kate B.** replied. There is not a lumen floor. The way that we allocate to this application is partially driven by the presence of those high ceiling spaces in the building stock. It is a mix of high ceiling spaces in the building stock and the products that go into low base spaces, which do tend to be higher lumen products.




**Kate D.** continued. Sales in the High/Low Bay HIGH application makes up about 9% of total market sales through the analysis. The dominant technology in this application again is TLEDs. Based on your feedback in February, we increased the LED luminaire sales forecast in this application, that lower red line, which is driving that rainbow shape in the TLED line up above. It is a little hard to see in the sales trends, but it is going to be easier to see how that impacts the presence of LED luminaires in the normalized stock graph next, because this is a very high lamps per fixture application. We also talked about this in February, but part of why TLEDs are dominant in this application is because at the beginning of the modelling there is a high volume of 8-lamp linear fluorescent luminaires that the model is replacing with eight individual TLEDs rather than an LED luminaire. This updated forecast is softening that trend.




**Kate D.** continued. The average lamps per fixture in this application is almost 5, reflecting the presence of those big 8-lamp linear fluorescent fixtures. You can see that LED technologies overall are forecasted to nearly eliminate all non-efficient technologies except again 32 Watt T-8s from the stock by 2027.

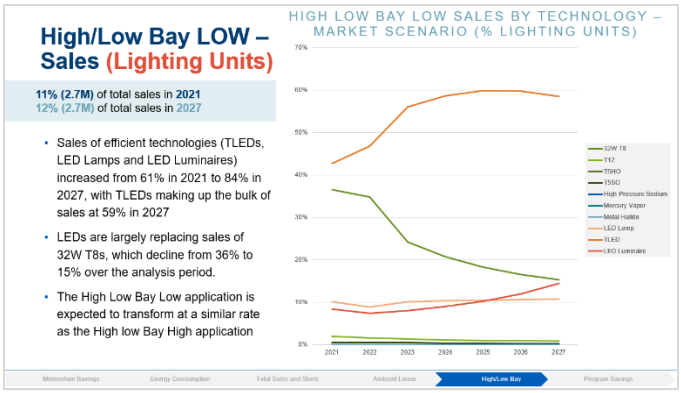
LED luminaires are forecasted to reach just over 40% saturation by 2027 even as TLEDs maintain a large and consistent stock saturation through the analysis. I want to note that HIDs represented in blue are a vanishingly small part of the stock even at the beginning of this analysis. This is something that we talked about in February with the sales mixes and we did consider adjusting in the forecast to increase the presence of HIDs. This small saturation of HIDs in 2021 is consistent with the previous BPA model and is tethered to actual stock data from the 2019 CBSA. Ultimately, we decided to leave HIDs at this level of saturation in the analysis. But that is something we are looking to validate with the next CBSA in 2025.

**Chris W.** added in the chat. What about LED Lamps? The corn cobs are made to replace HID and some work with HID ballasts.

**Kate B.** replied to Chris. Those appear in the "High/Low Bay LOW" application.

**Chris W.** replied. Okay but there are multiple lamps that are at least 15000 lumens and would not be captured in the low right?

**Kate B.** replied. Good question -- thanks for flagging! We will take a look at that in the sales data -- that would be a good thing to capture in an adjustment to the application definitions.




**Kate D.** continued. High/Low Bay LOW makes up around 11 to 12% of total market sales through the analysis period. This application includes LED lamps, which are predominantly things like corn cob lamps and other modal base HID replacement lamps.

The dominant technology in this application is TLEDs in that top orange line. 32 T8s, which is the next largest technology type in green, are forecasted to continue their decline to about 15% of total sales in 2027.

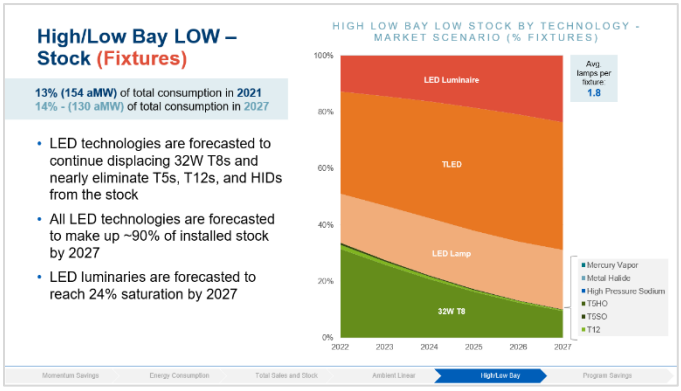
You can see the trend here again of LED luminaires in red increasing in penetration through the analysis. Like High/Low Bay HIGH, it is going to be easier to see how these trends play out in the installed stock on the next slide.

By 2027, 84% of sales in this application will be LEDs and that this application sales are shifting towards LEDs at a similar rate to the High/Low Bay HIGH application. This application has more diverse products in it causing more uncertainty to the lamp versus luminaire trend in this forecast because there are more options. There are more options to forecast, making it less easy to guess their trajectory of these interplaying trends between lamps and fixtures.

**Lauren** added in the chat. I wonder if there is any discrepancy in the data between stock data (15 ft ceiling) and DLC primary use designation (25 ft ceiling): [https://www.designlights.org/our-work/solid-state-lighting/technical-requirements/product-eligibility-primary-use-designations/](https://www.designlights.org/our-work/solid-state-lighting/technical-requirements/product-eligibility-primary-use-designations/)

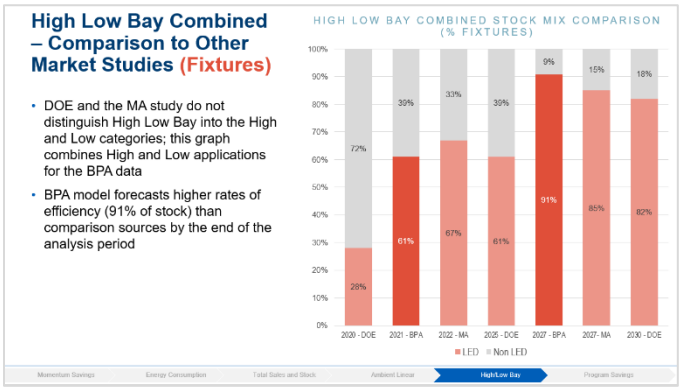
- High-Bay Luminaires for Commercial and Industrial Buildings. Pendant, recessed, or surface-mounted fixtures specific for indoor high ceiling spaces (intended for ceilings ≥25′). For examples, click the blue info button.
- Low-Bay Luminaires for Commercial and Industrial Buildings. Pendant, recessed, or surface-mounted fixtures specific for indoor ceiling spaces (intended for <25′). For examples, click the blue info button.
- High-Bay Aisle Luminaires for Commercial and Industrial Buildings. Pendant or surface-mounted fixtures specific for indoor high ceiling spaces (intended for ceilings ≥25′), in locations that require lighting of aisles. For examples, click the blue info button.

**Kate B.** replied to Lauren. This aligns with our definitions -- the DLC's "Low Bay" category would align with our "High/Low Bay LOW" with 15-25foot ceilings. And this is a great example of why we will most likely re-name these two applications to "High Bay" and "Low Bay" to make it easier to understand in future model updates.

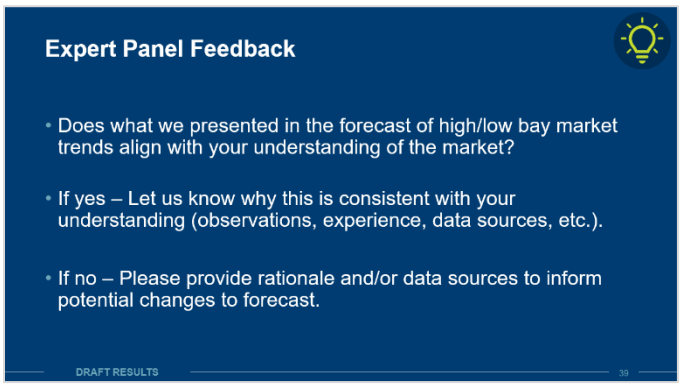



**Kate D.** continued. Looking at the resulting stock forecast in this application, you can see that the average lamps per fixture in this application is lower than High/Low Bay HIGH. It is about 1.8. You can see that LED technologies are overall forecasted to nearly eliminate non-efficient technologies except 32 Watt T8s from the stock by 2027. LED luminaires are forecasted to reach about 25% saturation by 2027 and then TLED saturation is forecasted to remain high of 45% of this application by 2027. LED lamps are making up another 20% of the stock resulting in LEDs

overall comprising about 90% of installed stock in this application by 2027. The bulk of that remaining 10% again is 32 Watt T-8s. The same note about HIDs in the installed stock that we talked about in HIGH applies in LOW with even less HIDs actually forecasted in the installed stock in this application.




**Kate D.** continued. This graph compares the model forecasted stock for both High/Low Bay applications combined to DOE and Massachusetts forecast of the High/Low Bay application. DOE is projecting lower rates of LED penetration with only about 28% LED in 2020, whereas we expect higher rates of efficiency at the start with about 61% LED penetration in 2021. Massachusetts projects an even higher rate of LEDs with 67% in 2022. We are starting from slightly different places in the forecast, but generally we are in the same range. The model does predict the highest rate of LEDs in this application by the end of the analysis. This is consistent with the Northwest traditionally trending more efficient, but we are going to have to verify these trends with additional data in the coming years.




**Kate D.** continued. Did anything I present in the forecast of High/Low Bay market trends misaligned with your understanding of the market?

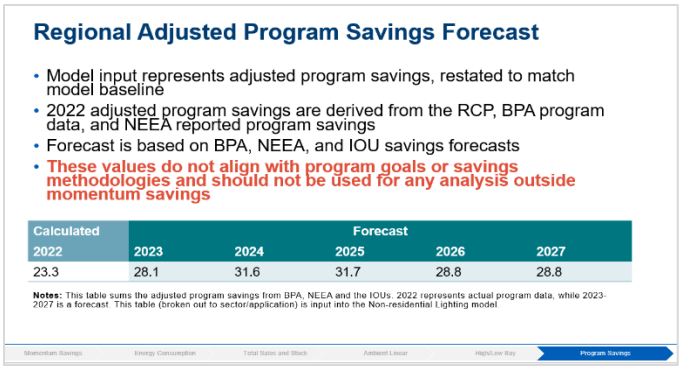
**Lauren** commented. I wonder why your forecast overtakes Massachusetts around 2027. The saturation is higher than in Massachusetts. That goes against what we were saying earlier with the trend. We are getting towards the end of the saturation, and something could be motivating that.

**Geoff** added. The Massachusetts study is from 2019 or 2020. We had limited information at that point in High and Low Bay. We were trying to make adaptations based on information, ambient linear. To your point that it is later in the forecast period, I don't know that Massachusetts is the perfect benchmark. I would not necessarily make the firm conclusion that it will be different in actuality.

**Kate B.** replied. The driver is the historical sales trends paired with that expected adoption curve. With that distance of years and the fact we will have more sales data to work with in future updates, we are in the same ballpark. But it is a good observation and something we will want to look at. Also thinking back to those long tail laggard categories, how large is the long tail over that long-term period?

**Geoff** added. On that previous slide of stock, I do not have any major comments. It largely follows the trend. In states before TLEDs became popular, programs focused on the T5s and my understanding is there is high satisfaction with those. Your saturation here shows very little T5 on that front. Those folks might be fairly happy with their existing fixtures, but it also depends on what was the starting saturation in the area. You can only take away from that, you cannot add to it. If there was a bigger presence of T5s earlier on, I think they are slightly more resistant to change than your T8s.

## *Program Savings Forecast*



**Regional Adjusted Program Savings Forecast**

- Model input represents adjusted program savings, restated to match model baseline
- 2022 adjusted program savings are derived from the RCP, BPA program data, and NEEA reported program savings
- Forecast is based on BPA, NEEA, and IOU savings forecasts
- **These values do not align with program goals or savings methodologies and should not be used for any analysis outside momentum savings**

| Calculated | Forecast | | | | |
|---|---|---|---|---|---|
| 2022 | 2023 | 2024 | 2025 | 2026 | 2027 |
| 23.3 | 28.1 | 31.6 | 31.7 | 28.8 | 28.8 |

**Notes:** This table sums the adjusted program savings from BPA, NEEA and the IOUs. 2022 represents actual program data, while 2023-2027 is a forecast. This table (broken out to sector/application) is input into the Non-residential Lighting model

Momentum Savings | Energy Consumption | Total Sales and Stock | Ambient Linear | High/Low Bay | Program Savings

**Kate D.** continued. We calculated a regional adjusted program savings forecast to be able to calculate momentum savings. Momentum savings result from subtracting program savings from total market savings. These calculated and forecasted program savings values do not align with program goals or savings methodologies and should not be used for any analysis outside of momentum savings. We do have that comprehensive adjusted program savings methodology specific to our model documented in the methodology memo if you are interested. Generally, these numbers are specific to the model so if they look different than what you were expecting, that is why. I want to show that these adjusted program savings are staying relatively flat over the analysis with a slight peak forecasted for 2025 based on how adjusted program savings have been realized in past models and in available forecast. In this modelling period, program savings are making up a larger percent of total market savings, which is driving that momentum savings forecast to be smaller in this plan period that we reviewed back in the beginning. That is not a surprise since programs anticipated the diminishing returns of lighting market programs and are focusing on capturing remaining savings opportunities.

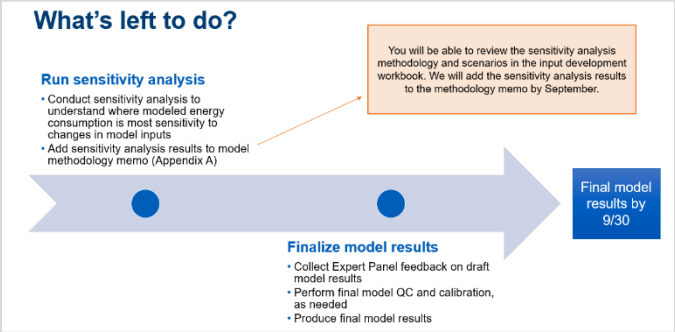
**Peter** commented. I wonder if your 2025 to 2027 numbers require higher incentives to maintain that amount of savings as the pie gets smaller and smaller.

**Kate D.** replied. We used available forecasts based on like BPA, NEEA and investor-owned utility (IOU) savings forecast. That is what is reflected in the 2025 through 2027 numbers here. But we will be replacing these numbers with actual calculated program savings for each year that then we adjust for the purposes of the model. We will know more soon, but that is something that we can think about as we work with program data.

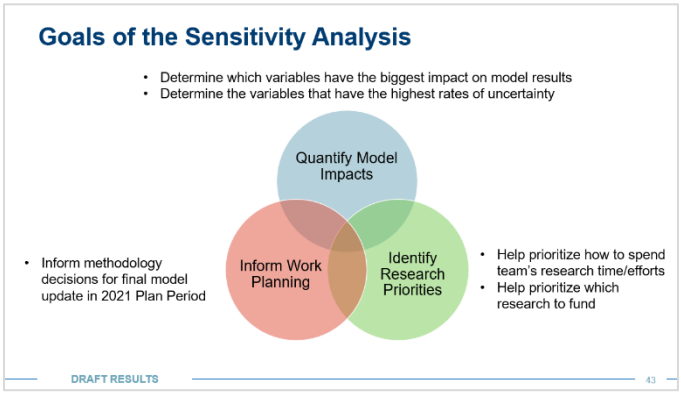
**Peter** added. Just as a baseline, when Geoff and his group did the study for ComEd, they took that projected drop in savings as we got into the laggard group. Off the top of my head, by 2030 overall commercial and industrial (C & I) lighting savings was down by 30 percent. It is the number they came up with. I do not know the methodology, but it was substantial. You just might want to think about that as far as getting into the weeds on where the numbers come from.

**Geoff** added. That largely reflected reduced opportunity. What also compounds this is a change in the baseline and if you put state bands on fluorescent technologies and switch to a TLED baseline or programs that operate in dual baseline framework and have second period savings, that number gets real small real quick.

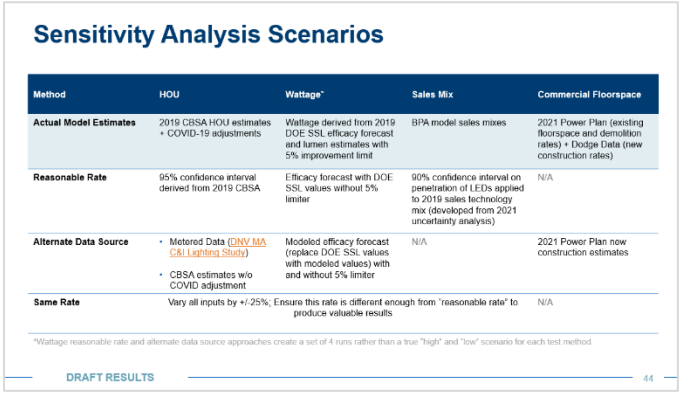
# Finalizing the Model




**Kate D.** continued. We have two main activities left in this modelling. First, we are running a sensitivity analysis and second, we will be finalizing these model results. We have already talked about finalizing model results, but just as a heads up, we will be determining what changes we need to make to finalize these interim results and finalizing the results with any needed calibrations. And we are expecting all of that to be done by the end of September. We have not yet talked with you all about the sensitivity analysis. We are currently conducting a sensitivity analysis on these draft model results to understand where modelled energy consumption is most sensitive to changes in model inputs. The sensitivity scenarios that we are testing are documented in the input development workbook, which you all currently have. The methodology and results of the sensitivity analysis will be further documented in the first appendix of the methodology memo when it is complete. That will be available in the final version in September.




**Kate D.** continued. There are three main goals of the sensitivity analysis. First, to quantify model impacts, as I mentioned, this allows us to determine which variables have the biggest impact on model results and to test the variables that have the highest rates of uncertainty. Second, it helps us identify research priorities. Understanding which model inputs are most impactful or have the highest degree of uncertainty will help us prioritize how to spend research time and effort in the period between the two models so that we can gather additional data or conduct market actor interviews to corroborate estimates. Third and relatedly, we use this to inform methodology decisions for the final model update. We have a finite amount of time and resources to update the model at the end of the plan period, and we want to make sure we prioritize areas of the greatest impact to results over others.




**Kate D.** continued. These are the variables that we chose to study, which were selected because of their potentially high impact on model results. That was hours of use, wattage, the sales mix. These were largely picked because either there was high sensitivity in the previous model or we forecasted most of these model results, so we had to forecast specifically wattage and our sales mixes, and that produces some uncertainty about model impacts.

Looking down the left hand column of the table, these are the methods that we use to test these variables. We tested each variable three ways by a reasonable rate. For example, using a documented confidence interval for the input data source, then by using a fully alternate data source where we could derive the sensitivity scenario, which is a different flavor of the reasonable rate test. Then finally, we tested each variable by the same rate, which was a flat ±25%. That is probably the closest to

understanding true model sensitivity. Varying all the inputs by the same value to see which has the largest impact.

For hours of use, our model estimates for hours of use are derived using the 2019 CBSA estimates. Then we applied COVID adjustments to select building types based on best available data. The reasonable rate test here was the 95% confidence interval derived from the 2019 CBSA estimates. Then the alternate data source test was actually two scenarios. One, we swapped the CBSA estimated hours of use values with metered values from the DNV Massachusetts C & I lighting study. Then we also ran a scenario where we use the CBSA estimates but with no COVID adjustments made.

Next is product wattages. You might recall that model wattages were derived from the DOE solid-state lighting efficacy forecast and then lumen estimates from DOE and informed by other available lighting product data. We also applied a limit to how much wattages could improve over the analysis period using expert panel feedback from you all and market actor interviews that we conducted to come up with a 5% limit. For the wattage scenarios, we just toggled between the previous model efficacy forecast and the DOE efficacy forecast that we switched to for this model. Then with and without that 5% limiter to create kind of four model runs that together comprise the reasonable rate and the alternate data source scenarios.

For the sales mix, we use the model sales mixes for 2021 through 2027. The reasonable rate scenario used a 90% confidence interval on the penetration of LEDs in the 2019 sales mix. That 90% confidence interval then impact sales mix through the remainder of the modelling. That confidence interval came from the uncertainty analysis on BPA's as collected sales data that we conducted back in 2021 and we referenced in the data gaps memo you all just reviewed. We did not test an alternate data source here because there just is no real alternate data source that would be a reasonable best swap for the BPA sales mixes themselves.

In previous models, we used power plan data exclusively to inform the commercial floor space estimates. But for this model update, we use plan data to inform existing regional commercial floor space and demolition rates. We use Dodge data as the best source of new construction rates in the modelling.

We wanted to run a simple scenario here to test the impact to model results of making that switch, mostly so that we could understand how to characterize any variations in the 2021 model results from this interim model update and the 2021 model results calculated in the previous model.

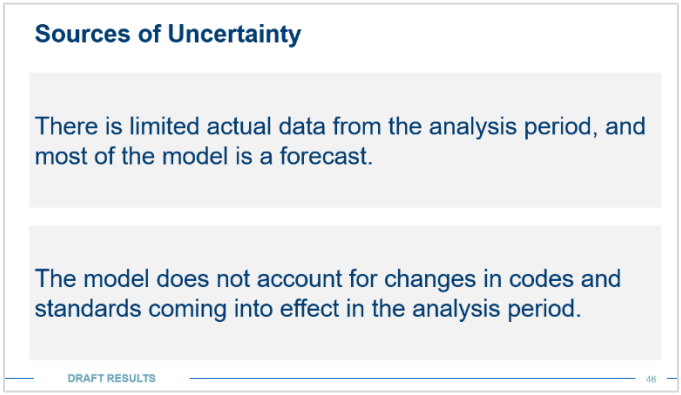
**Geoff** added in the chat. HOU would impact burnout rate and floorspace would impact New Construction/demolition? In any way are you accounting for retrofit rate?

**Kate B.** replied. Correct. We didn't include the retrofit rate in the sensitivity analysis, but that's a good suggestion. Our data source for retrofit rate is the prior CBSA, and we are hoping to use updated data on retrofit rate from the forthcoming CBSA.

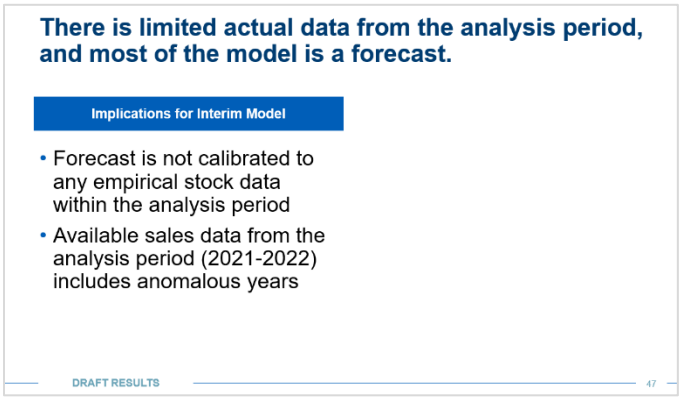
**Geoff** added. New DOE solid state lighting (SSL) report has national HOU estimates that could be another data source for testing. When you talk to distributors and ask about sales, do you ever ask them to estimate how that is going to change in the coming years? Could help provide some evidence for trends.

**Kate B.** replied. Yes, great suggestion, NEEA is asking these questions of some of their key distributor participants this summer, and the research Kate's describing right now will do deeper on that.

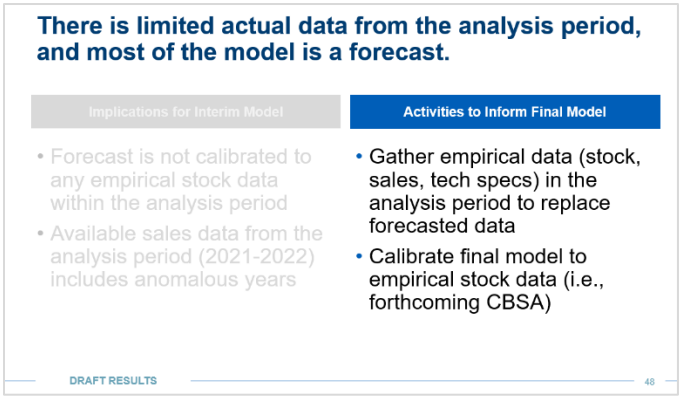
# Sources of Uncertainty



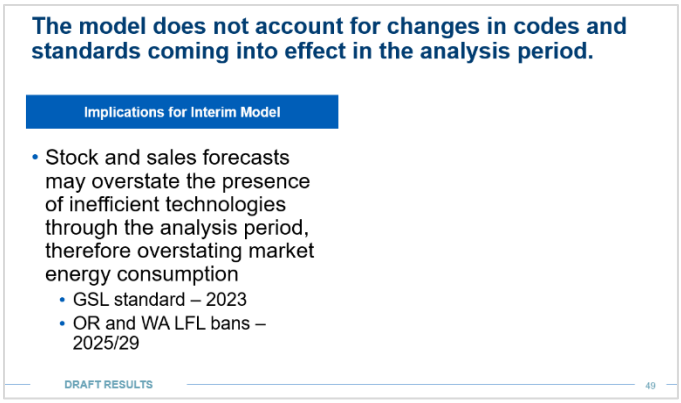

**Kate D.** continued. There are two main sources of uncertainty. First, there is limited actual data from the analysis and therefore, most of the model is a forecast. We have been working closely with you all throughout the modelling period to ensure that our forecasts are as close to expectations as possible and tied to actual data as much as possible but there is still a lot of guesswork that goes into forecasting. Second, the model currently does not account for changes in codes and standards coming into the effect in the analysis. We believe that this was the most conservative choice in terms of not overestimating market savings and therefore momentum savings in the planned period but it does lend some uncertainty to the market trends that we presented.



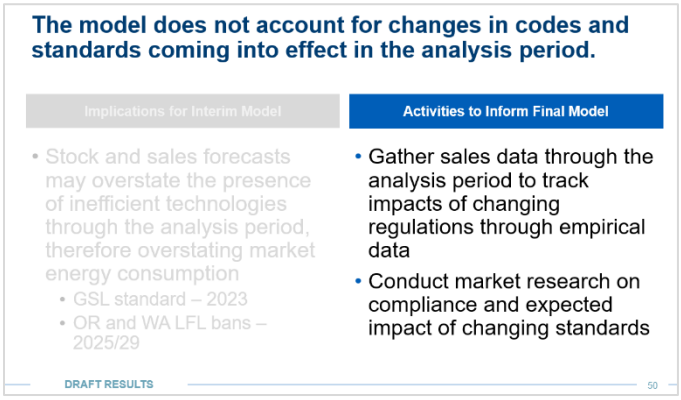

**Kate D.** continued. Talking about limited available data, the implications for the interim model is that the forecast is not calibrated in any empirical stock data within the analysis. The last source of stock data we have is the 2019 CBSA, which falls outside of our analysis. While 2021 to 2022 model results are based on actual data, there is no stock data point to corroborate our modelled stock estimates in those years. Our confidence in this forecast is lower than it would be if we had a CBSA in the analysis period to anchor the results to observe data. You may recall from reviewing the sales data recently and our previous conversations that the baseline year of this model, 2021, is an anomalous year for sales trends. The market saw a big dip in sales volumes in 2020, followed by a big spike in sales volumes in 2021 before dipping again in 2022. We also saw a big increase in efficiency in the spike to 2021 sales volumes. Because that baseline year is an anomalous year, it is a little difficult to predict long term trends and we do not have enough sales data in the analysis period to know how those market disruptions will ultimately play out over the next five years.



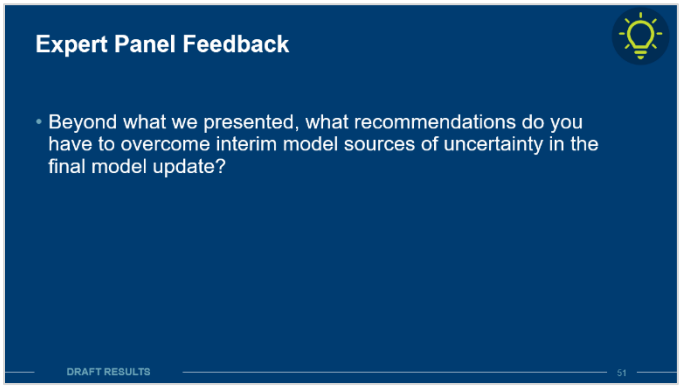

**Kate D.** continued. Our main goal in the final model update is to overcome this source of uncertainty by gathering the best available empirical data in the analysis period to replace forecasted data and to calibrate the final model to empirical stock data, specifically the forthcoming 2025 CBSA. It is worth noting that depending on when the final model update takes place, there may still be forecasted data in the final model results for the analysis period. For example, the previous model that spanned 2016 to 2021 forecasted 2021 due to the timing of model work, but five of six years were estimates based on actual data and the stock was calibrated to a CBSA, which lended overall more certainty to those forecasted estimates.




**Kate D.** continued. Because we chose not to account for changes in codes and standards coming into effect in the analysis period, our stock and sales forecast may overstate the presence of inefficient technologies through the analysis period, which therefore would overstate market consumption. The General Service Lamp (GSL) standard in 2023 and the Oregon linear fluorescent ban in 2025 are the two big things we are not accounting for at this time as the Washington linear fluorescent ban and the future GSL lumen per Watt standard, both are falling outside of our analysis period. We did not make adjustments to sales or stock forecasts because we would have had to assume compliance impacts, and we may have overstated the impact of these changes in the market. The result of that would have been again to overstate savings. BPA chose the more conservative path to understate savings instead.

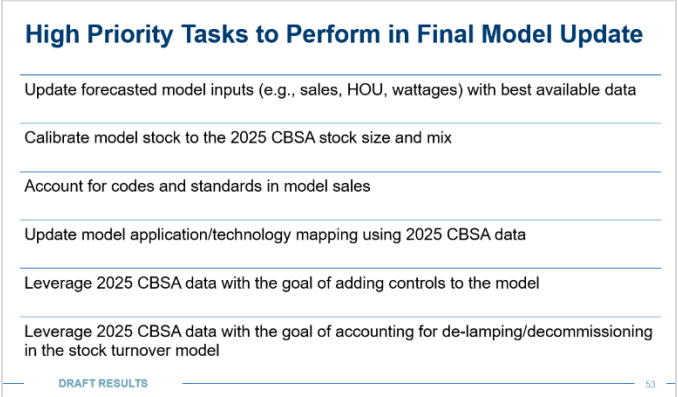



**Kate D.** continued. The only way to accurately capture the impacts of these changing codes and standards is really by gathering and analyzing empirical sales data. But we can also conduct market research on compliance and the expected impacts of these changes and that can help us better predict what market trends to expect. For example, the Oregon linear fluorescent ban only applies to one state. Market actors can help us understand things like do you expect to see an actual increase in linear fluorescence sales before the ban goes into effect? Or what replacement technology are you seeing customers choose instead of linear fluorescence? And to what degree are you seeing cross state commerce of customers buying linear fluorescence in other states than installing them in Oregon?




**Kate D.** continued. Beyond what we presented here, do you have any other recommendations on how to overcome interim model sources of uncertainty in the final model update? I'll put the asterisk here; we have not talked through the future research that we have planned so there may be things that are already on our list.

# Future Research and Model Planning



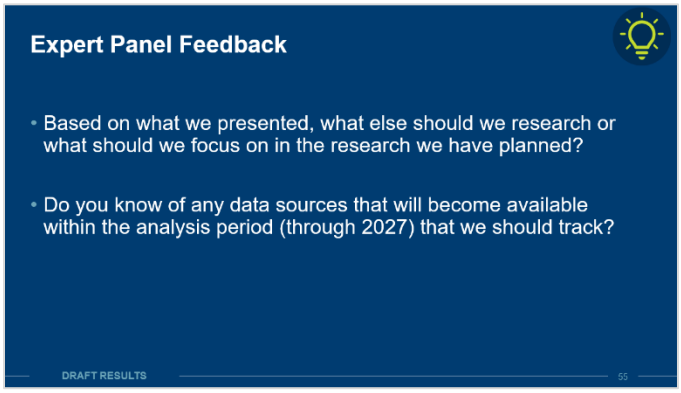

**Kate D.** continued. Given what we know about interim model results and sources of uncertainty, we have started to make some plans on where to spend time both in the final model update and in the period between the two models. This is not an exhaustive list of what we are going to do, but these are the highest priority activities that we will undertake when we do perform that final model update.

We know that we are going to be replacing forecasted model inputs with actual data where possible. We already know some of the inputs that will have new data published in the analysis period, but we will be keeping our eyes out for other data as well. We will have a new source of installed stock data, and we will calibrate our modelled stock to the 2025 CBSA stock size and mix. We will also be able to account for changing codes and standards in the lighting stock using collected sales data to characterize compliance and resulting trends.

We will be using 2025 CBSA data to either verify or update our model application to technology mapping. In particular, we want to investigate the presence of smaller LED form factors in the CBSA stock in applications where LED luminaires are not currently allowed in our model.

There are two ways that we are hoping to leverage the 2025 CBSA to make some methodological changes to the model. First, to add controls to the model. You all read the methodology memo appendix summarizing the current gaps in available data that is preventing controls from being added to this interim model update. We are hopeful that the new CBSA is going to allow us to revisit that methodology. Second, we would like to account for de-lamping, or the decommissioning of lamps in the stock turnover model, to make sure that reduction in sockets is being captured in our total stock size. We need to see if the CBSA data can support that change.


**Kate D.** continued. Thinking about what we are going to do between the two model periods. In addition to the actual modelling activities to take place in a couple of years, BPA is planning a variety of non res lighting market research to pursue in those intervening years. This is also potentially not exhaustive if BPA decides to pursue additional research. First BPA is going to pursue some CBSA data processing that's going to include both lighting stock data processing and control stock data processing to determine a control strategy. In addition to the 2023 sales data collection that's currently in progress, BPA is going to collect sales data from the distributors in the remaining years of the analysis period. That is going to be an important source of data for the final model update. Finally, we do have market actor interviews planned for 2025. For example, attending light fair to talk to lighting manufacturers, but we are also planning some codes and standards market research to better understand the potential impacts of those changing regulations.




**Kate D.** continued. Here is where we would love to hear from you. Any ideas that you have for us on what else we should research or where we should focus in the research that we have planned. We would also love to hear if you know of any data sources that are going to become available within the analysis period that we should be tracking.

**Peter** commented. Geoff, do we want to tell them about what we are working on, the Lighting Plus study? Whether or not some of that information may come available by the end of the year.

**Geoff** replied. There will be a publicly available version of the report available in October. That will include 11 utilities that are participating in that effort. We are doing contractor interviews talking about status of the market in 11 different jurisdictions, including International Organization for Standardization (ISO) in Canada. Most of the focus is on what happens in lighting after light bulbs. They are talking about control strategies and other types of technologies and where there are savings opportunities. But there will be a look at the overall status of the market. That will be a nice comparison point to some of the things that you have here. I am happy to share that once it is available.

**Peter** added. I am still bothered by the jump in luminaires in 2022. When COVID hit, it was almost impossible to get light fixtures or anything out of China. Contractors were ordering two/three/four times the stock they needed for a project, hoping to get just 25% of it. When COVID finally wound down, there was a flood of everything into the marketplace. Up until last year, people were selling their overstock for 5/10/15 cents on the dollar because they had so much. You may want to double-check if that may be part of the reason why there was such a jump in that number at the distributor level.

**Kate B.** replied. That is a good find, thank you!

**Juan Carlos** added. We are very dependent on the CBSA but would like to expand that so if you know of anything available or coming, we would love to know about it as well. Please do share either now or when you're when you're doing your review.

**Geoff** added in the chat. Similar idea, we still do not have a great idea of how much of sales happens outside of distributor sales chain, and I wonder if CBSA presents an opportunity to ask customers where they purchased their recent installations. Still think distributors have the best idea of what sales mix will look like in the near future, so it would be good to ask them about expected changes.

**Peter** added. One area that may or may not show up in the distributor numbers is ESCO work, meaning the people that do public sector jobs. I put in the chat 50% of school districts in the US still have T8s. A lot of those projects get drop shipped. They never go to a distributor. They may get paid for it, but they do not physically show up in their inventory and they may or may not be counting in the numbers you are getting. It is all public information. There is an organization called NIESCO. I do not know if they track things by state and by year. That could be not only a sizable amount of savings that is out there that is not getting recorded, but it could also help you check the numbers and the forecasting you are doing.

**Lauren** added. Along the same lines, I think brick and mortar stores are going to continue to struggle. I think more confidence in the online sales would be great. That has been flagged in the past reviews as a gap. I think it will be a bigger gap in the future. I see more and more online sales or direct from manufacturer to the customer sales happening, so distributors are less involved than in the past. This is more of a problem that we are seeing.

LED to LED is happening in the market. Programs not set up to claim the LED to LED savings are leaving those fixture savings on the table. They are only claiming the control savings because it would require regulatory updates to the TRM and a lot of things that they do not have time to do. Those are happening, but they are not being characterized particularly well.

The other thing I wanted to mention was that onboard control piece; I want to see that data as much as possible in the future because the savings associated with those onboard controls even after installation are considerable. For example, if you later integrate it with an HVAC system that can decrease the HVAC energy consumption later. How are those opportunities being claimed?

Along the same lines, when we did integrated controls, like LLLC incentives, when I was with Efficiency Vermont, it was very hard to tell which integrated control products were sold because it was just a model number. Unless you knew which model numbers you were looking for, it was very difficult to tell. Manufacturers did it differently, some had a model number for the LLLC with the control integrated, and some had two separate model numbers, one for the fixture and one for the Knockout LLLC control. I want to flag that as a potential challenge. It is not super clear on invoices from what I understand.

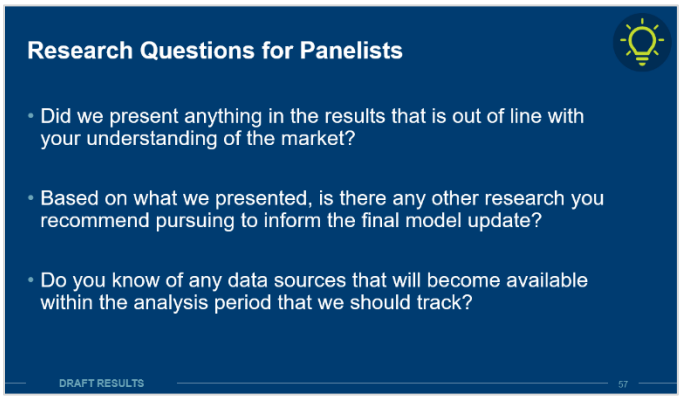
Thank you for potentially looking into it because it is huge.

**Kate D.** replied. All good ideas, Lauren. We are going into a similar level of control sales data limitations investigation there. That is something that we are going to be thinking about as we have better control stock data, hopefully through the 2025 CBSA. It is like, how can we characterize controls potentially in a stock-year to stock year way to get around those sales data limitations.

**Paul** added. I wanted to highlight the hours of use because that runs throughout the model, including the turnover rates. They are probably changing partly because of controls, but also because of the number of hours that people are in the office. I don't have a data source that would help us address that, but it is an unknown in commercial lighting.

**Kate D.** replied. That is something in our input development workbook. You can see how we worked around the COVID impacts to hours of use in our model inputs and how we used best available data in several places to try to recreate what that impact to hours of use was. That is something that we are interested in seeing new and updated hours of use data through the analysis. If we can get any metered or through the CBSA like updated estimates that do capture longer term COVID impacts, that will be helpful.

## Review Request

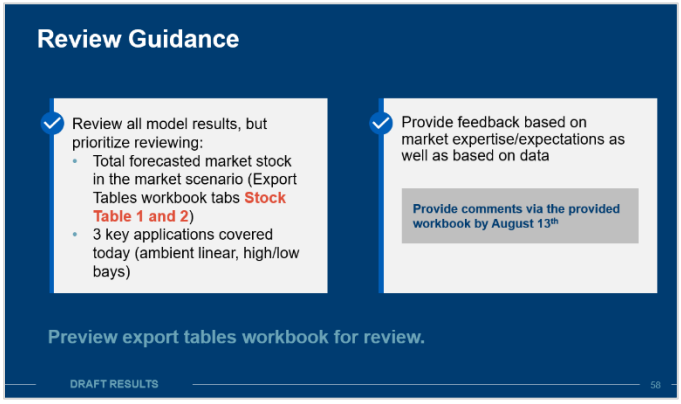



**Juan Carlos** discussed the review request. You already received all the different tables and a copy of the slide slideshow and a copy of the methodology memo. We're going to ask you to look at all of that and give us your thoughts on everything that we've done in the draft results.

The big question we want you to think about is, did we present anything in the results that was out of line with your understanding of the market? Based on what we presented, is there any other research you recommend? Particularly, if there is research out there or data from ESCOs, online, or big box stores. Those are three areas we struggle to get good data from and are always looking for better ideas in there.

And any other data sources that are going to become available soon or through the next bid through 2026, that we could add to our analysis of the final model result.

These are all things that we are looking for you to provide us with information on in your review.




**Kate D.** added. If you have looked at the model results by now, you know that there are a lot of export tables and therefore there is a lot to review. We also have limited capacity to adjust these forecast results before the end of September.

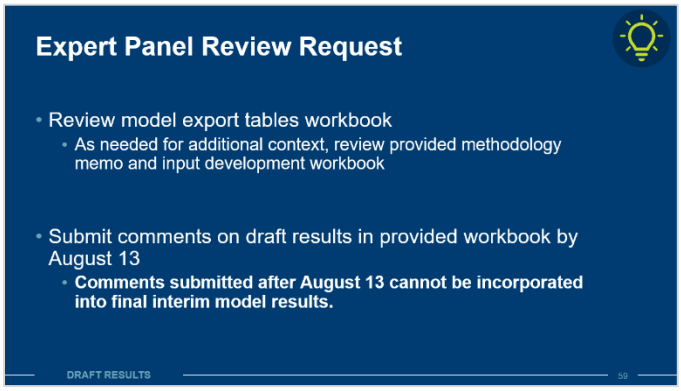
When you review, prioritize first, the overall market stock. That is in stock table one and two tabs. That is that end-of-year stock in each year over the analysis which reflects the impacts and product of the other forecasted market inputs and model mechanics. Getting the total market stock to look right means that the rest of the model probably looks right.

Second, prioritize those three key applications with the largest impact on model results - ambient, linear, and the High/Low Bays. Getting those three right again is most important in terms of overall certainty with the results. We can tweak those remaining smaller applications from there.

So please review all the results if you have time, especially if there is an application where you have specific expertise or somewhere where you want to dive deeper. But if your time is limited, that is where your review feedback will have the highest impact.

Kate D. continued. As usual, you will as that you provide your comments in the comment workbook. There is a table of contents tab. This workbook is organized by application specific tables and then tables that have an overview of specific model topics - savings, sales, consumption and stock. This is the stock mix and stock size by technology in the market scenario.

The application specific tabs have sales, stock, consumption and momentum savings for each application in the model in table and chart format. This is where you will be able to see those more specific technology mixes and technology change examples that we talked about at the application level.




**Juan Carlos** added. Our big request is for you to go through the tables and answer the questions that we have asked throughout this presentation. I hate to do this to you, but we need to get all your review back by August 13th. We are closing up this model in September. To be able to incorporate any of the comments you have, we need that back by August 13th.

Again, we appreciate you for everything you have done. You have been invaluable in this study.

**Peter** commented in the chat. All the charts are "2D". I suggest the possibility of "3D" - meaning having low projection, high projection for the top 2-3 trends (codes, New load impacting rebate programs).