Northwest Nonresidential Lighting Market Characterization 2010-2012

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Prepared for
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Executive Summary

The new DOE federal standards for general service fluorescent lamps (GSFL) caused a great deal of uncertainty among efficiency program managers: How would the market react and how would programs be impacted? Originally, the new standards were expected to eliminate T12 lamps, a major source of non-residential program energy savings. However, as the rule's effective date approached, major lamp manufacturers began to introduce T12 lamps that in fact met the new standards. Moreover, the minimum standards do not apply to high "color rendering index" (CRI) lamps: T12 lamps with a CRI of 87 or greater can still be produced. The market share of these exempt T12s and the redesigned compliant T12s was unknown in the Northwest. This lack of market data complicated Bonneville's characterization of the baseline[1], from which savings should be measured, for T12 and T8 retrofits.

The stakes are not trivial. Linear fluorescent lighting systems represent 70 percent of regional installed indoor wattage in the commercial sector.[2] Retrofits of T12 lamps have been a major source of energy savings activity—not only for BPA-served utilities but for efficiency programs across the country. A baseline set well below the actual market average risked wasting ratepayer funds on energy savings that would be achieved absent the program. Conversely, a baseline set too high risked leaving cost effective savings on the table.

Non-programmatic savings (NPS)—real savings that occur above the Sixth Plan baseline but are not incentivized through BPA, NEEA or utility program activity—was a second major area of interest in this study. Given the dramatic market changes in the non-residential lighting market due to standards and a general movement to more efficient lighting technologies, BPA anticipated significant non-programmatic savings relative to the Sixth Plan frozen baseline.

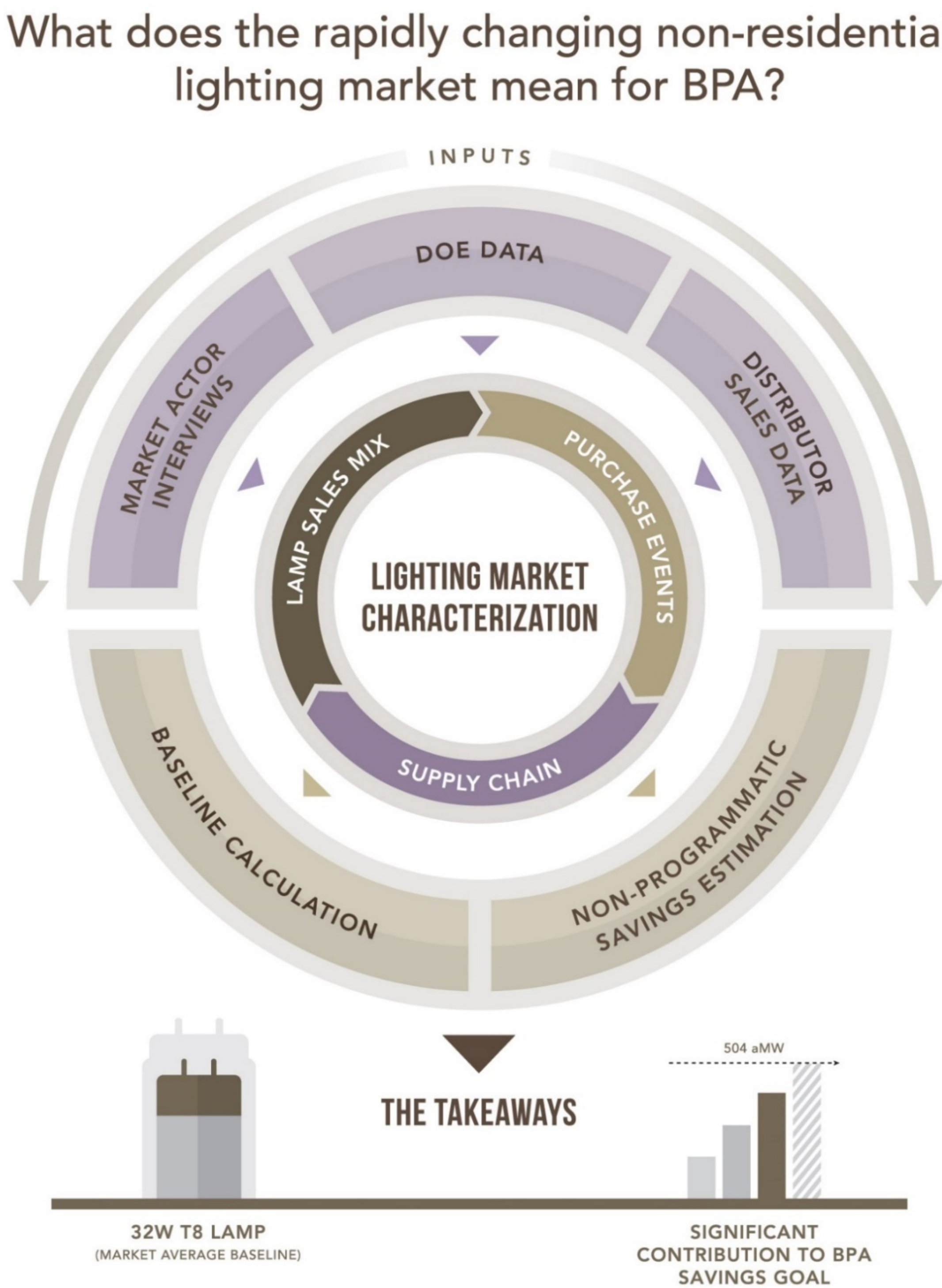
Therefore, this study began with two major research objectives:

(1) Gather market data sufficient to characterize the baseline; and
(2) Estimate the non-programmatic savings in the region for 2010 to 2012.

The strategic question, in a nutshell, was (and still is): What does the rapidly changing non-residential lighting market mean for BPA? The team's approach and takeaways are illustrated by the graphic below.

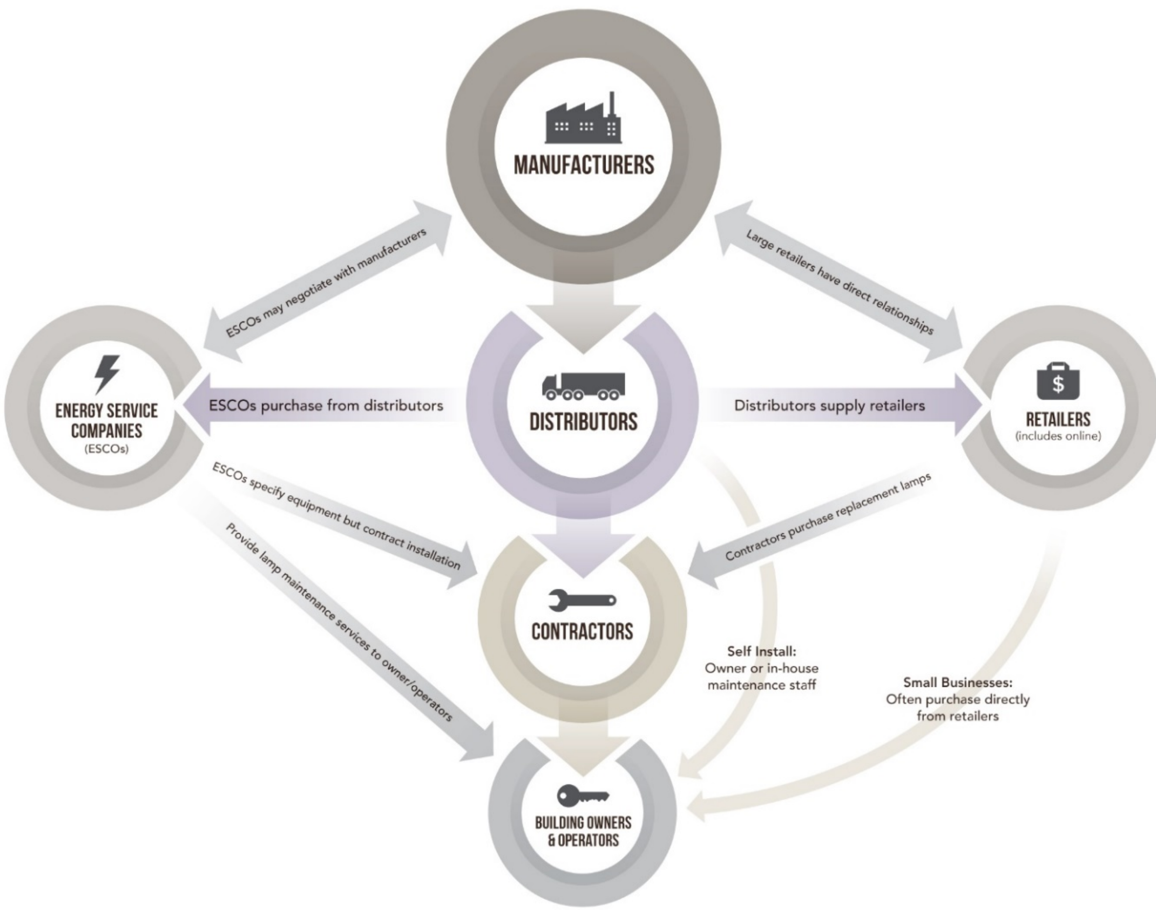
[1] The "baseline" in the context of BPA's commercial lighting program sets the level from which energy savings are calculated and claimed. For a given retrofit measure, a higher baseline (e.g., a more efficient) would yield lower savings than could be claimed from a lower baseline.
[2] The Cadmus Group, Inc. 2009. Northwest Commercial Building Stock Assessment (Report No. 10-211). Portland, OR: Northwest Energy Efficiency Alliance.

Figure ES.1 Project Overview



Baseline characterization. Collaborating with BPA and Northwest Energy Efficiency Alliance lighting program managers, Navigant first characterized the non-residential lighting market structure and identified the primary channels by which lamps flow into the market. The figure below depicts the primary channels through which lamps move from manufacturer to end-user, as found in this characterization. As discussed in more detail in section 3.1, electrical distributors touch the vast majority of GSFL and HID lamps intended for non-residential use. Retailers and ESCOs represent much smaller market segments.

Figure ES.2 Supply Chain Map



Given wholesale distribution is the dominant sales channel for non-residential lighting products, the team primarily targeted lighting and electrical distributors for interviews and data requests. Navigant worked with BPA, NEEA, and Evergreen Consulting Group to develop a sample frame of Northwest lighting distributors and ultimately compiled a list of 39 independent electrical distributors. Using regional expert interviews, phone calls to distributors, and internet research, the team categorized the distributors qualitatively by size (small, medium, or large) and by type of business: lighting specialist;

general electrical; LED focused; general industrial; and distribution and consulting. Navigant targeted 20 interviews, while seeking the greatest share of the sales data possible.

Navigant ultimately conducted 19 90-minute interviews with electrical distributors—three manufacturers, and a major retailer. In addition to the interviews, 11 regional distributors provided full line item, year-by-year lamp sales data for 2010-2012. The other interviewees provided a mix of qualitative and quantitative results, which Navigant used to weight and extrapolate the distributor data in the broader context of the market. We estimate the detailed line-item data received represented 35 percent to 55 percent of the total market, depending on the product. The below figures show the representativeness of the interviewees and data submitters as compared to the entire list of 39 distributors the team originally identified.

Figure ES.3 Comparison of Distributor *Size* in Population, Interviews, and Data Submittal

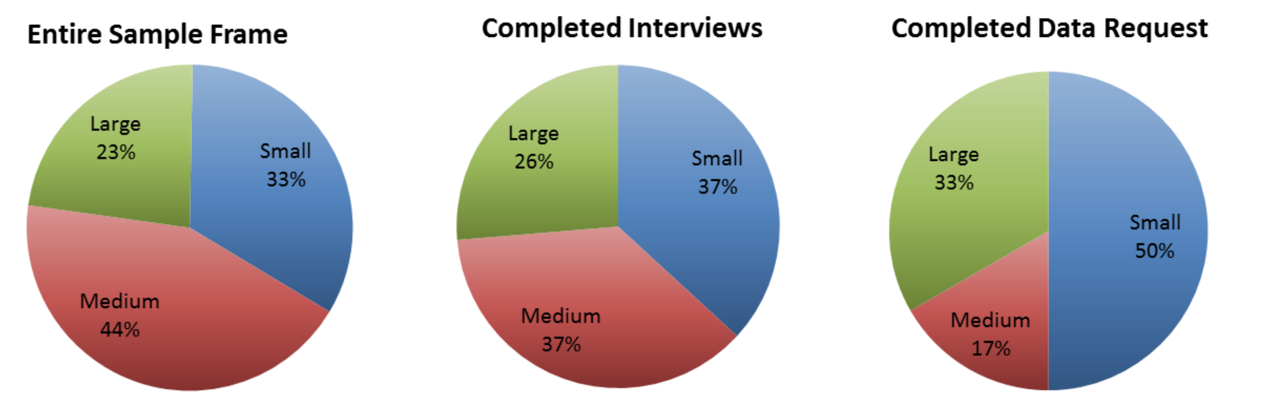
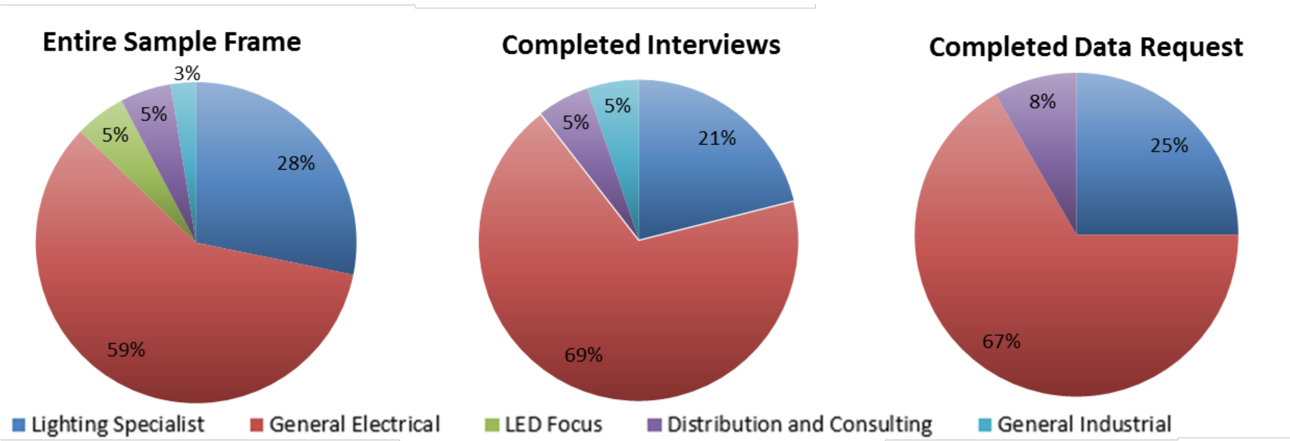


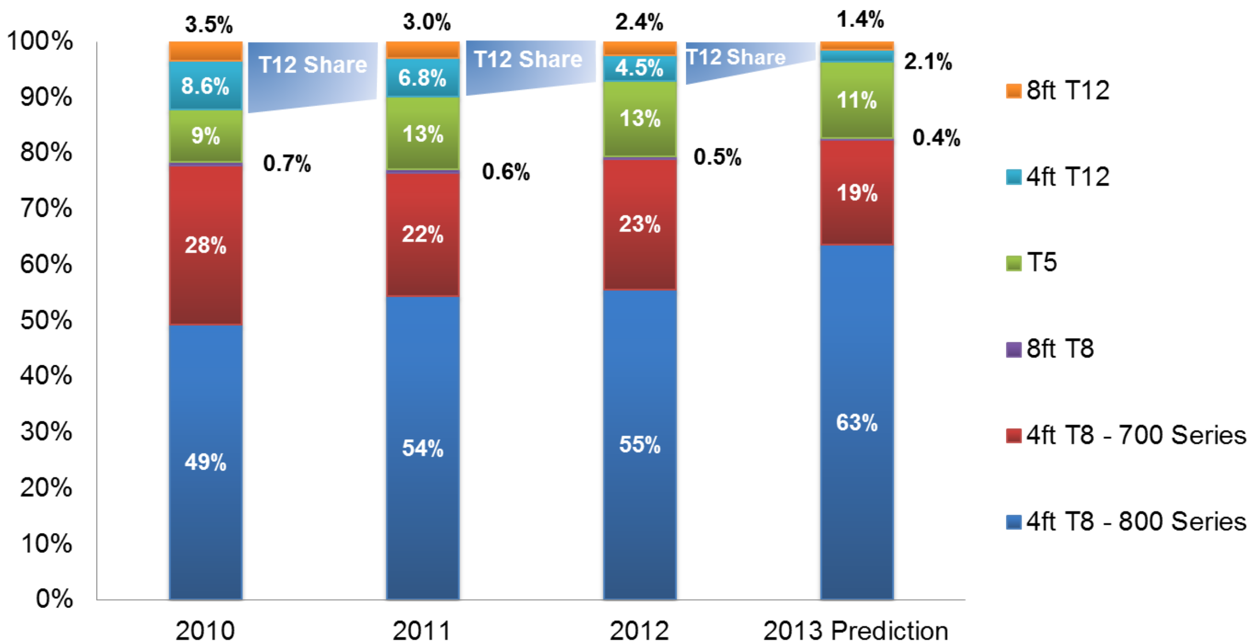
Figure ES.4 Comparison of Distributor *Type* in Population, Interviews, and Data Submittal



Combined with higher level data from a major retailer, manufacturers, and qualitative assessments from the distributors who declined to send in line-item data but did participate in lengthy interviews, the team is fully confident these findings are representative of the market.

The major finding in the data is that 4-foot 32W T8 lamps dominate the non-residential linear fluorescent market and represent the market-average unit, as shown by the Figure ES.5 below.

Figure ES.5 Mix of Linear Fluorescent Shipments, Reported by Distributors



Source: Navigant analysis of distributor data

Prior to this research, BPA's approach—common to the region and nation—had been to calculate savings for program-driven lighting retrofits against an "in-ceiling" or *Pre-Condition* baseline (e.g., a T12). The new data and research suggest it is time to change to a *Current Practice*, or 'shipment-weighted average,' baseline (e.g., a T8).

The direct application of this new market-average baseline will be in Bonneville's 'lighting calculator' spreadsheet tool, which calculates savings and incentives from programmatic lighting measures. The calculator requires a *quantitative* baseline denominated in Watts that could accommodate various permutations of fixture types. Despite access to unprecedented sales data, the computation of the market-average wattage of any given linear fluorescent fixture is nonetheless complex due to the wide variety of lamp and ballast combinations, as well as the circumstances in which a lamp might be installed. Navigant's methodology, which yielded the below fixture (ballast)-weighted averages illustrated in Table ES.1, is described in detail in section 5. The wattages below account for ballast factor and ballast efficiency, making them generally lower than nominal lamp wattages. For context, the actual power draw of a 32W T8 lamp with a standard electronic ballast is only 28 watts.[3]

[3] This difference is due to a number of factors. Ballast efficiency and ballast factor play a role, but part of the reason is also the difference between nominal and actual lamp power draw. Since nominal lamp wattages are determined based on a "reference ballast," the nominal wattage is rarely the same as the actual power draw using a typical

Table ES.1 Average Lamp Wattages by Market Segment

Market Segment	Market Segment Share (% of Lamps)	Average Lamp Wattage (W)	Delta from Overall Average
New Construction	16%	27.2	-1.6
Maintenance	54%	30.0	1.3
Retrofit	30%	27.4	-1.4
All Applications	100%	28.7	0

Source: Navigant analysis

Non-programmatic savings estimation. The second research objective was to estimate regional non-programmatic savings for 2010 to 2012, the first three years of the Northwest Power and Conservation Council's (the Council) Sixth Regional Power Plan (Sixth Plan)[4], which set regional energy conservation targets for the 2010 – 2014 timeframe. As part of its regional commitments, BPA took responsibility for the public power portion of the Council's target (which amounted to 504 aMW[5] for the 5-year planning period). BPA's strategy for achieving this goal included the acquisition of two sources of savings: (1) programmatic savings and (2) non-programmatic savings. Non-programmatic savings are those savings achieved above the baseline assumed by the Council when it forecast conservation potential in the Sixth Plan that are not claimed by programs or NEEA's net market effects.[6] Since there are no current estimates of NEEA market effects for non-residential lighting, all market savings not claimed by programs fall into the non-programmatic category.

Navigant used distributor sales data gathered in the baseline research, as well as other regional and national data sources, to calculate total market savings against the Sixth Plan's frozen efficiency forecast[7]. The team then subtracted out regional programmatic savings[8] to calculate total regional non-residential non-programmatic savings, as shown in Equation ES.1.

modern ballast. Actual wattage is typically lower than nominal wattage for lamps paired with electronic ballasts, but higher than nominal wattage for lamps paired with magnetic ballasts.

[4] http://www.nwcouncil.org/energy/powerplan/6/plan/

[6] NEEA defines net market effects as "savings associated with market change and not counted as Locally Incented or Baseline," where baseline savings are naturally and locally incented savings are claimed through efficiency programs. (NEEA Standard Definitions)

[7] The Council typically uses 'frozen' or constant baseline assumptions in its five-year potential assessments.

[8] Bonneville supplied Navigant with total regional programmatic savings (BPA and IOU) in the non-residential sector, which it gathered through a separate project.

Equation ES.1 Total Regional Non-Residential Non-Programmatic Savings

$$\begin{aligned} &\textit{Non-Programmatic Savings} \\ &\quad = \textit{Total Savings} \times \left(\textit{Pre-Case}^{9}\ \textit{Consumption} - \textit{Estimated Actual Consumption}\right) \\ &\quad - \textit{Adjusted Programmatic Savings}^{10} \end{aligned}$$

Figure ES.6 below depicts the results of the analysis. Note that 2013 and 2014 are projections. Based on its analysis, Navigant estimates the region achieved non-programmatic savings of 85 aMW for non-residential lighting from 2010-2012. BPA's share is 29 aMW. The analysis methodology, inputs, and major assumptions are described in section 6.

Figure ES.6 BPA Share of Non-Residential Programmatic and Non-Programmatic Savings, 2010-2014

	2010	2011	2012	2013	2014	Total
Total Market Savings	12	22	32	41	49	**155**
"Adjusted" Program Claims	10	14	12	12	12	**60**
Non-programmatic Savings	**1**	**8**	**20**	**29**	**37**	**95**

Source: Navigant analysis. Calendar year savings; includes busbar factor. Totals may not sum due to rounding.

[9] The "pre-case" refers to the scenario implied by the Sixth Plan's baseline assumptions.

[10] Because most programs claimed savings against a 'pre-condition' baseline, while the Sixth Plan effectively used a 'current practice' baseline, Navigant estimated and subtracted out programmatic savings consistent with the Sixth Plan's baseline.

1 Introduction and Goals of Research

1.1 *Non-residential Lighting Baseline*

New DOE federal minimum standards for general service fluorescent lamps (GSFL), effective July 2012, created a great deal of uncertainty among efficiency program managers and others in the lighting industry regarding potential program impacts. Unlike some lighting standards, the GSFL standard set efficacy minimums on a lumens-per-watt (LPW) basis, rather than a maximum wattage standard. Originally, the new standards were expected to eliminate the manufacture of T12 lamps, which, at the time the DOE rule was published in 2009, did not meet the LPW minimums. However, as the rule's effective date approached, major lamp manufacturers began to introduce T12 lamps that in fact met the new standards. Additionally, the minimum standards did not apply to "high CRI" lamps: T12 lamps with a CRI of 87 or greater can still be produced. The market share of these exempt T12s and the redesigned compliant T12s was unknown.

The lack of market data beclouded Bonneville's characterization of the baseline for T12 and T8 retrofits. The stakes are not trivial. T12 retrofits have been a major source of energy savings activity in the non-residential sector for BPA's utilities. A baseline set well below the actual market average risked wasting ratepayer funds on energy savings that would be achieved absent the program. Conversely, a baseline set too high risked leaving cost effective savings on the table. Before the new DOE standard, BPA's approach—common to the region and nation—had been to calculate savings for program-driven lighting retrofits against an "in-ceiling" or *Pre-Condition* baseline. Given the change in standards, BPA recognized a change to a *Current Practice*, or 'shipment weighted average,' might be in the best interest of its stakeholders and more consistent with Regional Technical Forum (RTF) guidelines on savings estimation.

The Regional Technical Forum was unable to provide specific guidance on what the baseline should be given the lack of market data. In light of the potentially significant programmatic and planning implications, BPA concluded that any change in its approach to the non-residential baseline should be firmly grounded in market data and consistent with RTF protocols. Therefore, Bonneville contracted Navigant Consulting to develop baselines for GSFL and high intensity discharge lamp (HID) retrofits in their territory. Navigant's guidance was to gather market data from various actors in the distribution chain and "use the new RTF guidelines, RTF lighting protocols, and feedback on baseline methodology to develop a commercial lighting baseline...."[11]

1.2 *Non-programmatic Savings*

Bonneville classifies savings from energy-efficiency market advancements into two primary categories: programmatic and non-programmatic savings. Programmatic savings are those that accrue from utility-sponsored incentive programs and NEEA market transformation initiatives.

By contrast, non-programmatic savings are "defined as electricity savings that are:

[11] Non-Residential Lighting Characterization for BPA Territory project Statement of Work.

- Cost-effective;
- Above the baseline assumed by the Northwest Power and Conservation Council (the Council) for determining conservation potentials in the Sixth Regional Power Plan (Sixth Plan);
- Not incented through utility-sponsored energy efficiency programs; and
- Not part of net market effects claimed by the Northwest Energy Efficiency Alliance (NEEA)."[12]

Non-programmatic savings can be driven by codes and standards (only those not are already captured in the Sixth Plan), baseline adjustments, and market transformation effects.

The Council's supply curves "are indifferent to how conservation is achieved, who pays for conservation or why conservation measures are installed."[13] As such, both programmatic and non-programmatic savings are critical to BPA's overall strategy of meeting its conservation commitment.

Non-residential lighting was thought to be a potentially significant source of non-programmatic savings because the sector has been subject to several recent DOE standards and received significant programmatic support in recent years which have likely built an infrastructure poised for transformation. Consequently, BPA asked Navigant to estimate regional non-programmatic energy savings from non-residential lighting market activity in the Northwest.

The team developed estimates for non-programmatic savings for 2010 to 2012 and projected savings for 2013 and 2014. The methodology, assumptions, and results are detailed in section 6.

1.3 Structure of Analysis and Report

This report describes the process by which Navigant supported BPA's efforts to characterize the baseline for GSFL and HID retrofits and estimate non-programmatic savings. Figure 1 below provides an overview of the three primary data sources that drove the market characterization, the two primary categories of analysis Navigant used in conducting this research, and the major takeaways.

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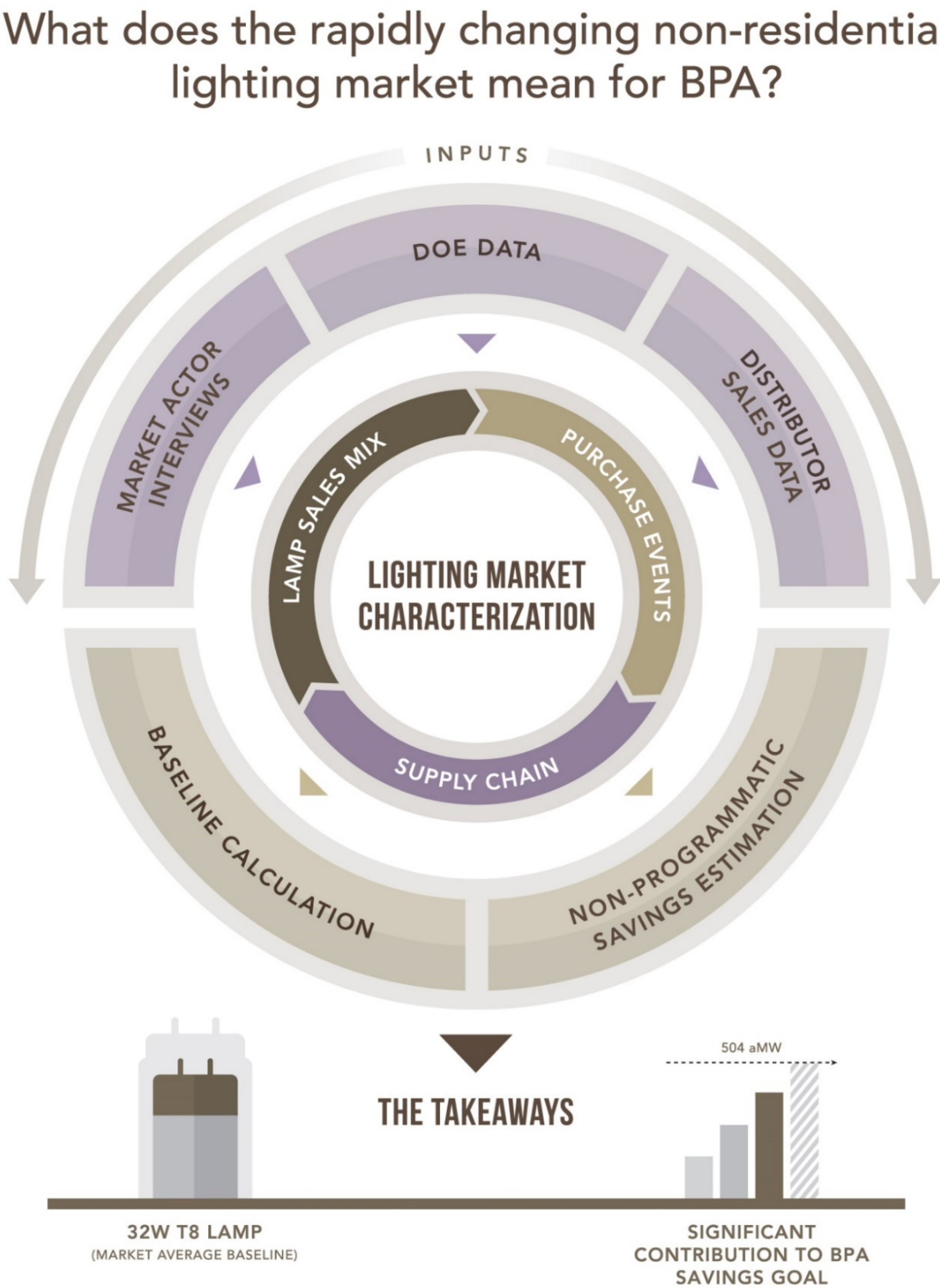
[12] For a more detailed description of non-programmatic savings and how they relate to the Council's conservation supply forecasts, see: "Methodology for Quantifying Market-Induced Non-Programmatic Savings." Prepared by Cadmus Group, Inc. April, 2011.
http://www.bpa.gov/energy/n/reports/evaluation/multi_sector/pdf/Market_Induced_Savings_Report.pdf

[13] Ibid 12

Figure 1 Project Overview



Source: Navigant

As shown above, Navigant gathered data mainly through market actor interviews and data requests from regional electrical distributors, which the team supplemented with technical data and vetted assumptions predominantly from DOE rulemakings and market research. As for the analysis and synthesis of the gathered data and information, the team's efforts fell into two primary activities: (1) a market characterization; and (2) baseline calculations and non-programmatic savings calculations.

1. The market characterization included:
    - An investigation of the supply chain for non-residential lighting;
    - A segmentation of the "purchase events," or reasons why end-users purchase lamps (and the volumes attributable to each event); and
    - A breakout of non-residential shipments by technology type.
2. The baseline and non-programmatic calculations included:
    - A definition of terms, including the term 'baseline' itself, as well as the pertinent market segments (e.g., retrofit, new construction, etc.) in order to understand *what* should go into the market-average baseline.
    - A weighting of various lamp-and-ballast combinations to account for the diversity of linear fluorescent fixtures.
    - The scaling of distributor sales data to account for the total regional market and a comparison to the Sixth Plan's non-residential lighting assumptions.

The sources of data and activities of analysis are discussed in detail in the body of this report.

2 Market Actor Interviews and Data Collection

2.1 Interviews

Navigant interviewed several stakeholder groups and market actors to better understand and characterize the non-residential lighting market. These included:

- Regional lighting experts
- Distributors
- Fixture manufacturers
- Lamp manufacturers
- Internal Navigant lighting experts
- Retailers
- Lighting contractors

Distributor interviews (and the associated data request) provided the most significant quantitative foundation for the baseline research. The interviews with the other groups proved invaluable in that they helped inform assumptions, trigger questions for other parties, and fill in data gaps when necessary.

Originally, it was intended that Navigant interview the stakeholders sequentially. However, as qualitative and quantitative data emerged that answered some questions, raised others, and required new analytical approaches, it became necessary to reach out to other market actors for further investigation from time to time. Navigant developed interview guides for each of the formal interviews (see appendices).

2.1.1 Regional Lighting Experts

The team interviewed eight lighting experts in the region to help inform the following questions:

- **Stakeholder Coordination**. Are there other stakeholders conducting similar studies that we should coordinate with?
- **Distribution Chains.** Does our initial conception of the market distribution chain accurately reflect the flow of lighting products in the Northwest market?
- **Interview Targets and Methodology.** How can we make sure to sample a representative mix of distributors, manufacturers, contractors, and building operators for our interviews and data requests?
- **Data Collection**. What incentive levels would be appropriate for gathering data from the distributors?
- **Northwest Region.** What regional considerations do we need to make?
- **Code Compliance Impacts.** What is the level of energy code compliance in the Northwest? How could this be measured?
- **Regional Technical Forum.** Does our proposed approach align with RTF guidelines for establishing baselines and deemed savings protocols?

With BPA's help, the team attempted to balance the expertise of the interviewees by including experts in regional programmatic activity, research, program implementation, codes and standards, the Regional Technical Forum, and the lighting distribution chain. These interviews helped the team frame the challenges in market actor recruiting, identify potential sources for compiling lists of contractors and distributors, and characterize the supply chain.

2.1.2 Lighting and Electrical Distributors

Based on its prior understanding of the GSFL and HID marketplace, BPA recognized the most important data source for regional current sales data would likely be lighting distributors. The vast majority of product flows through these distributors, or the "wholesale" channel, particularly for the non-residential sector. (The residential sector relies significantly more on the retail "big box" channel.) Consequently, any baseline determination grounded in a market average of current shipments would require significant cooperation from lighting distributors. The team recognized that sales data is highly sensitive and not easily obtained. Furthermore, we recognized we would be requesting detailed historical data that would require a significant investment of distributor time for data gathering, in addition to a 60 min to 90 min interview. In short, it was a significant 'ask' of distributors.

BPA recognized this challenge as well and directed Navigant to work with both BPA research and program staff, as well as staff at the Northwest Energy Efficiency Alliance (NEEA), to craft a value proposition to regional distributors that would encourage distributors—many of whom have been very strong proponents of energy efficiency programs in their own right—to collaborate on this project. To enhance the distributor value proposition of participation (i.e., sharing data), BPA and NEEA decided to broaden the scope of the distributor interviews to include recruitment into a planned (now ongoing) upstream incentive pilot program. For this pilot, BPA and NEEA envisioned a strong partnership with regional distributors; the sales data and interviews needed to understand the market baseline and non-programmatic savings could concurrently provide a data foundation for the pilot and deepen relationships with distributors.

Ultimately, the benefits presented to distributors included:

- The opportunity to help shape a regional upstream lighting program in the future.
- A $500 gift card to compensate for their company's time in retrieving the sales data and participating in the interview.
- A regional lighting and distributor market intelligence report only available to participants, which would contain:
    - A market share analysis highlighting key lighting technology and market trends;
    - A customized snapshot of each distributor's current position relative to other competitors in the non-residential lighting market; and
    - The ability for inaugural partners to request the benchmarking and market data they would like to see in the report on an annual basis.

Navigant also offered to sign non-disclosure agreements (NDA) with the prospective interviewees to provide further assurance that their data would be protected. Under these NDAs, Navigant is legally obligated to protect each distributor's individual company data. Only aggregated data would be provided externally, even to BPA and NEEA.

Navigant developed a “recruiting package,” for distributors, which included a high-quality “sample” market intelligence report, a one-page flyer (shown in Figure 2) on the upstream program development and benefits of participation, a copy of the NDA, the interview guide, and the sales data request form (an Excel workbook).

Figure 2 "One-Page" Marketing Flyer for Electrical Distributors

YOUR PARTNERS IN THE LIGHTING MARKET

- » Want to help shape regional energy efficient lighting programs?
- » Need better market information to exploit new opportunities?
- » Wish you could benchmark your business against other regional distributors?

We invite you to join other electrical distributors in a partnership with the Northwest Energy Efficiency Alliance and the Bonneville Power Administration to help shape a new commercial lighting program.

THE DEAL »

We believe better market data can mean a win-win for electrical distributors and for regional energy efficiency. To that end, NEEA and BPA will soon be conducting an inaugural survey of electrical distributors in the Northwest. This confidential survey — one part data submittal, one part interview — will cover topics related to the current regional lighting market as well as distributor operational metrics. Participants can expect to invest 3-5 hours once per year to help transform the market.

In return for your time, the survey administrator will provide exclusive access to an anonymized summary report highlighting key lighting technologies and market trends, as well as other pressing lighting distributor issues. NEEA and BPA will inform the report with relevant data gained through the millions of dollars these organizations have invested in regional market research, including, for example, data on those sectors most ripe for lighting retrofits, typical turnover rates, and more.

ABSOLUTE CONFIDENTIALITY »

Individual responses will be kept completely confidential by the survey administrator. Our survey administrator will be executing non-disclosure agreements with each survey participant in order to assure your complete confidence. Only **aggregate** market statistics will be released to NEEA and regional utilities—and only to help them support you in the continued growth of the efficient lighting market. Individual distributor responses will be held confidential by the survey administrator.

THE BENEFITS »

- » Gain critical market intelligence
- » Help shape the future of regional energy efficient lighting programs
- » Have exclusive access to regional lighting sales figures, trends in lighting technology adoption, and business benchmarking metrics.

BONNEVILLE POWER ADMINISTRATION

neea

Source: Navigant

The team used the lighting expert interviews and internet research to identify a list of distributors in the region. BPA and NEEA already had some relationships with distributors in the sample (i.e., Trade Allies). For these, BPA and NEEA made initial outreach and often met face-to-face to go over the pilot partnership details and the "recruiting package." For others, Navigant conducted the initial outreach.

Initially, the team targeted 20 interviews. A scientific sample frame would not be possible because not enough was known about the population of distributors. The team gathered an initial list of all known electrical distributors in the region and worked with NEEA program staff, BPA program staff, and the Northwest Lighting Network to categorize the distributors as either "large," "medium," or "small." Navigant attempted to collect data from all large distributors, as well as a mix of some medium and small distributors, serving a mix of geographic and end-use market segments. Figures 3 through Figure 6 illustrate the representativeness of the completed interviews and data submissions as compared to the sample frame.

Figure 3 Comparison of Distributor Focus in Sample Frame, Interviews, and Data Submittal

Figure 4 Comparison of Distributor Size in Sample Frame, Interviews, and Data Submittal

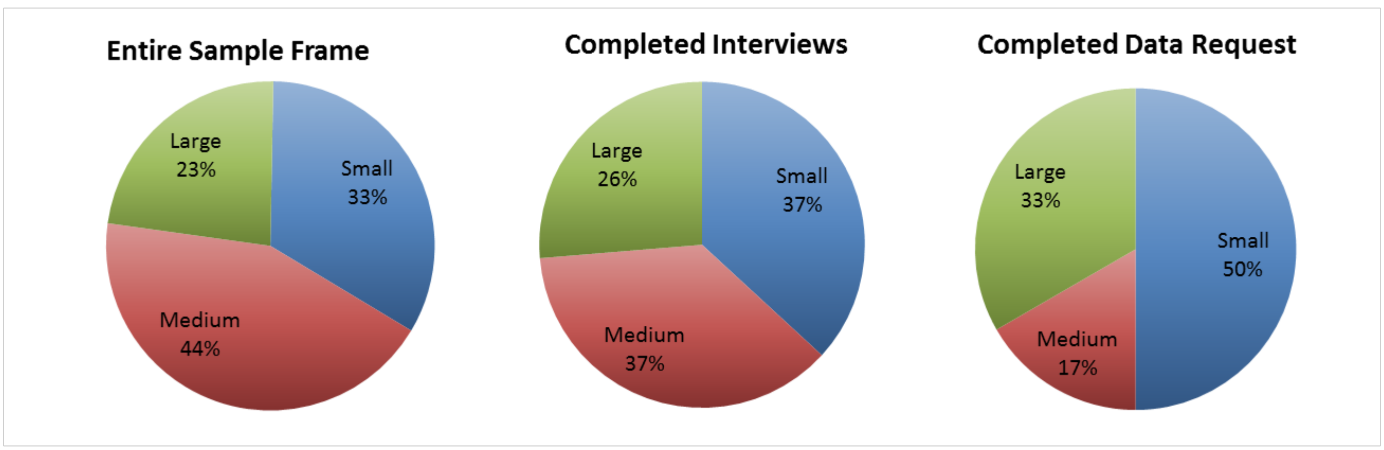


Figure 5 Comparison of Distributor Market in Sample Frame, Interviews, and Data Submittal

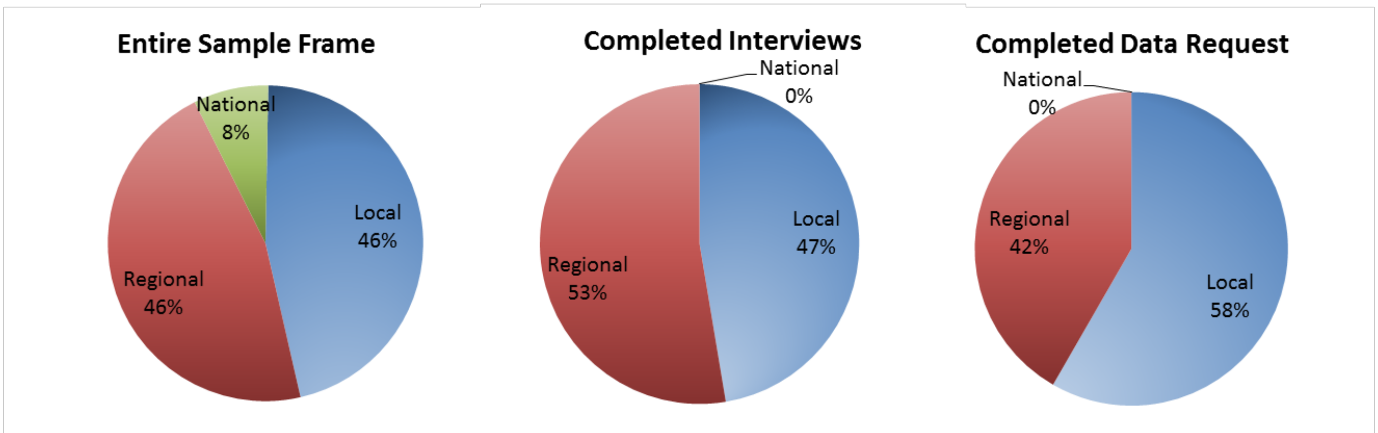
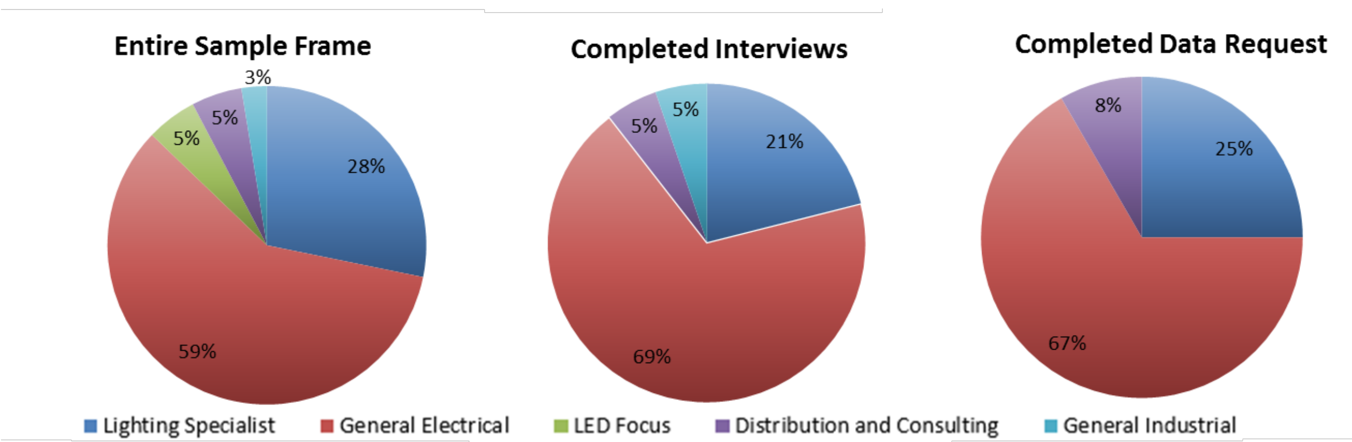


Figure 6 Comparison of Distributor Market in Sample Frame, Interviews, and Data Submittal



2.1.3 Other Interviews

- **Lighting Manufacturer.** Clearly, manufacturers have great insights in to market channels, characteristics, and nationwide trends. Navigant attempted to interview all three major lamp manufacturers and completed one interview. The team also supplemented this information with publically available data from past GSFL, fluorescent ballasts, and metal halide lamp fixture DOE lamp rulemakings, which was drawn from extensive manufacturer interviews.**ixture Manufacturers.** Navigant interviewed two major fixture manufacturers.
- **Retailers.** Navigant interviewed a major lighting retailer.
- **Internal Subject Matter Experts.** Navigant relied on the technical experts in its lighting group, which supports the Department of Energy as it conducts analyses in support of federal appliance standards rulemaking process.
- **Lighting Contractors.** BPA hosted a networking event in Bellevue, Washington, for lighting maintenance contractors. On behalf of BPA, Navigant conducted a kiosk web survey for contractors at the event.

2.2 *Regional Sales Data Collection*

The team's data collection efforts centered on a shipment data request (Excel Workbook) sent to those distributors in the region that participated in the survey. Navigant requested sales data for most product lines (and all major lines) in the fluorescent and HID technology families for 2010 to 2012. Navigant also requested data on the most popular LED product lines. Given the heterogeneity in the LED market, the team queried staff at BPA and NEEA to understand what LED technologies and fixture types appeared to be most popular (in order to best structure the data request form). The team also consulted with Navigant's solid state lighting team, which performs large market analyses for the Department of Energy, in order to optimize the tradeoff between distributor burden and the comprehensiveness of the data, and to reduce the chance of distributors' misinterpreting the product lines in the data form.

The data form itself consisted of a workbook with five tabs:

1. Cover sheet with instructions
2. Background information. This tab requested basic information on the company itself, where it was located, which branches the data represented and in which states.
3. Lamps. This was the most important tab for the project's purposes (partial screenshot is shown in Figure 7). The lamps tab requested complete sales data (in terms of units sold) for each of 2010, 2011, and 2012 for:
    a. 26 fluorescent lamp product lines
    b. 31 high intensity discharge product lines
    c. 28 LED product lines
    d. The "Lamps" tab also asked distributors to project sales growth in 2013 (as a percentage of 2012 sales) for each broader product family (e.g., 4ft T12s, 4ft T5 High Output, etc.)

Figure 7 Image of Beginning of Lamps Section of the Survey

Lamps		Annual Unit Sales					
	Lamp Type (Note: The listed wattages are meant to be representative of the most common models within each lamp type. Because the specific wattage for some lamp types varies by OEM, please include units within a Watt or two of the listed wattage, if there are any.)	2010 Qty (# of units)	2011 Qty (# of units)	2012 Qty (# of units)	**Sales Forecast** In the next 12 months, how do you think sales will change compared to the previous 12 months? [Answer for each lamp type (e.g., T12)]		
4ft	T12 [Main Category]	Exam. 10000	9000	8000		increase in each year by:	%
	34W [Category Subtypes; should sum to Main Category Total]	*5,493*	*6000*	*7000*	x	decrease in each year by:	25.0%
	40W	*3,333*	*3000*	*1000*		stay the same	
	Other	*1,174*	*0*	*0*	*Comments: T12s are dying out...*		
	T8 - Standard 700 Series					increase in each year by:	%
	32W					decrease in each year by:	%
	Other					stay the same	
					Comments:		
	T8 - High Performance 800 Series or Better					increase in each year by:	%
	25W					decrease in each year by:	%
	28W					stay the same	
	30W				*Comments:*		
	32W						
	Other						
	T5					increase in each year by:	%
	Standard Output - 28W					decrease in each year by:	%
	High Output - 54W					stay the same	
	Other				*Comments:*		
8ft	T12					increase in each year by:	%
	Slimline - 60W					decrease in each year by:	%
	Slimline - 75W					stay the same	

Source: Navigant

4. Ballasts. Similarly, this tab requested sales data for each of 2010, 2011, and 2012 for:
    a. 17 fluorescent ballast product lines
    b. 8 HID ballast product lines
5. Market and Sales. This tab requested information on stocking practices, sales by customer segment and market segment, and lighting brands stocked.

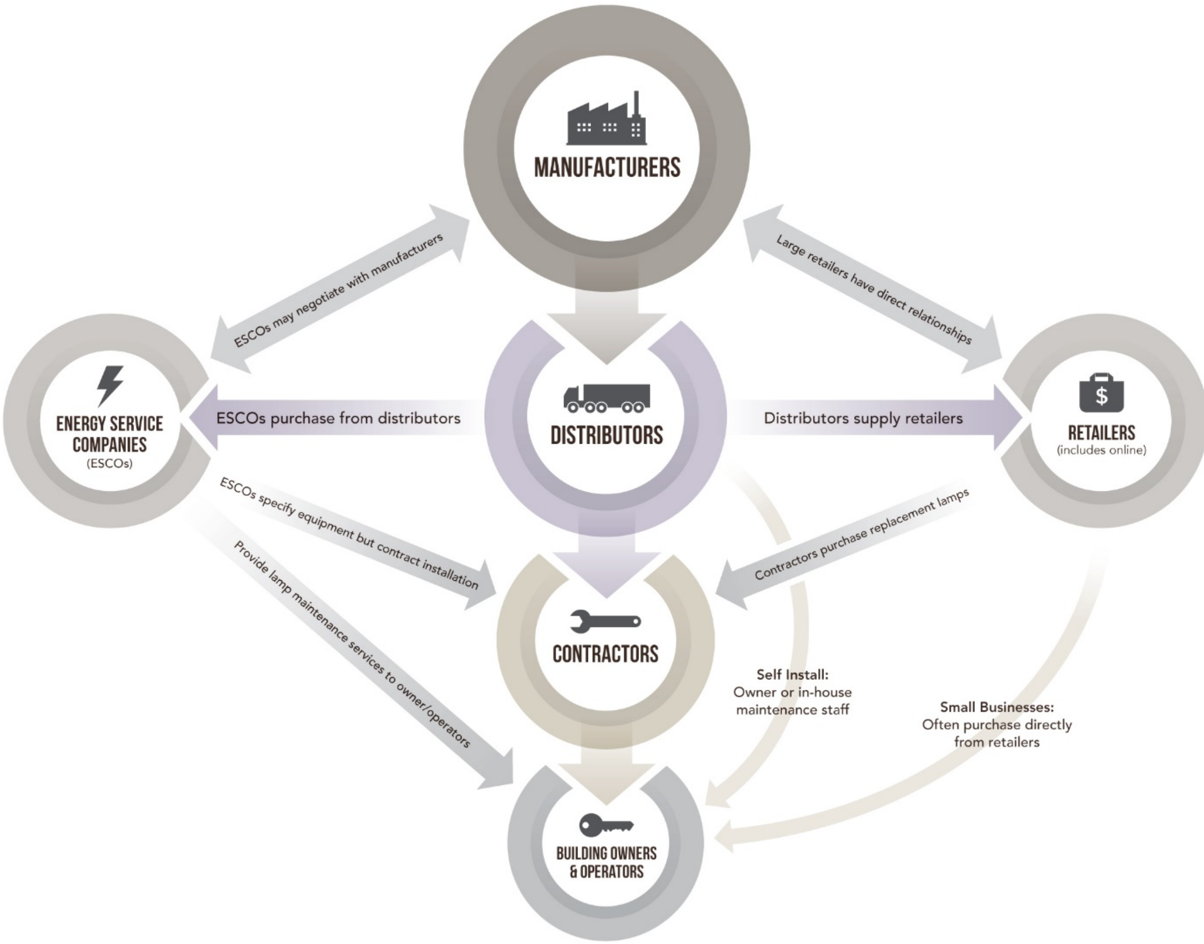
3 Market Characterization

Navigant used the lighting expert interviews to identify the major distribution channels that serve the Northwest lighting market, as well as the main types of "purchase events" that 'pull' lamps and ballasts through each channel. The team used clarifications and insights from the distributor interviews to corroborate and add nuance to the lighting expert interview findings. This section discusses these major distribution channels and what sectors of the lighting market rely on them.

3.1 Market Structure: Supply Chain Mapping

Navigant used the interview findings to create a supply chain map illustrating the key channels in the market. While the map applies to lamp sales in general, it most specifically describes the linear fluorescent market. It's worth first stating the obvious: the non-residential distribution chain is extremely complex. As shown in the supply chain map in Figure 8, Navigant found that the majority of lamps flow from manufacturers to end users through distributors and contractors. While retail sales to contractors and end-users also constitute a sizeable fraction of the market, although, in terms of linear fluorescent lamps, much of the volume ends up in the residential sector. A relatively small number of lamps also flow through energy service companies (ESCOs) as well, although typically the lamps physically flow through distributors, even if the procurement deal is made between the ESCO and manufacturer directly. Lastly, distributors indicated that up to 10 percent of lamp sales in the region could be from online retail or other distribution sources. Two distributors also reported that the online sales channel is particularly strong for LEDs due to the fact that many LEDs are manufactured abroad and the nascent market is extremely fragmented, factors that make the internet a more likely channel for distribution.

Figure 8 Map of Lighting Distribution Chain in the Northwest



Source: Market Actor Interviews, Navigant Analysis

3.2 *Market Segmentation: Purchase Events*

Navigant defines purchase events as a list of discrete situations that could drive the purchase of a lamp. The three main purchase events identified are: (1) maintenance activity; (2) renovations, remodels and new construction; and (3) energy efficiency upgrades or retrofits. In some portions of the analysis, Navigant further divided the maintenance event into spot replacements and group replacements (defined below), and also considered new construction an event separate from renovations and remodeling. Table 1 also illustrates which purchase events generally follow each unique chain.

3.2.1 Maintenance Spot Replacements

This purchase event captures lamps and ballasts purchased due to routine maintenance procedures: namely, the replacement of failed lamps and ballasts. Through the expert interviews, Navigant identified two main sub-events for this category: small business spot replacements and large business spot replacements.

Small Business Spot Replacements. This sub-event covers purchases by a small business owner or building maintenance staff to replace a few lamps at a time. The most common path for this sub-event: an end-user (small business owner or staff) will purchase lamps from a retailer to replace failed equipment. Alternatively, the end-user may purchase from a lighting maintenance contractor who is on-call and/or performs monthly service check-ins. The key decision maker in this event is most likely the end-user, although they may be influenced by retailer product offerings or contractors (if used).

While this category is labeled as "small business," some other businesses and building types may also be included, namely independent stores and municipal or school buildings.

Large Business/Large Office Spot Replacements. Larger businesses will typically either have in-house lighting or electrical staff or contract with local electrical or lighting contractors to take care of day-to-day maintenance. These businesses are also more likely to have purchased replacement lamps in bulk to have on-site in storage. In contrast to the small business case, these purchases are more likely to have come from distributors than retailers. The key decision makers for this event include the building owner, maintenance staff, and contractor (if used).

3.2.2 Maintenance: Group Replacements

Some large businesses, namely national chains, retail, and Class A office buildings, will often replace all lamps and/or ballasts at once on a schedule based on a fraction of rated equipment lifetime (typically 70 percent to 90 percent). Companies often hire a specialized lighting contractor who will come in and replace all of the lamps according to this schedule. The lamps installed in this event are typically purchased from distributors. Rarely, they may also come directly from the manufacturer. The key decision making likely occurs either at the building ownership, property management, or corporate level. Facilities with high-bay lighting requiring a lift for lamp and ballast replacements are also more likely to use group replacement maintenance strategies, and schools may group relamp over the summer and support with spot replacements throughout the school year.

3.2.3 Renovations/Remodels and New Construction

These events are often grouped together because both of them will likely trigger local energy codes, and involve some design component. In contrast to replacing failed equipment or performing an efficiency upgrade, the lamp purchase in new construction and renovation is triggered by a decision unrelated to the building's lighting system (i.e., the space is being renovated or remodeled or a new building is being built). The key decision makers in these events are typically building owners, tenants, design professionals, or corporate leadership. In addition to manufacturers and distributors, design professionals such as lighting designers and architects may also influence the decision making in these events.

3.2.4 Retrofit

Navigant defined this event as lamp and/or ballast replacement for the purpose of increasing lighting system efficiency. In other words, intent matters. End-users typically hire a lighting or electrical contractor to perform the retrofit; the contractor in turn usually purchases equipment through a distributor. One manufacturer, Sylvania, had a direct sales program where end-users could work directly with the manufacturer to do a retrofit, though Sylvania recently announced plans to divest that business unit. Energy service companies (ESCOs) also play a role in some retrofits. Key decision makers for this event are the end-user and contractor, who may be influenced by distributors, manufacturers' representatives, ESCOs, utility programs, or lighting designers.

Table 1 Distribution Chains and Associated Purchase Events

Common Supply Chain Feature	Unique Chains	Possible Purchase Events
Manufacturer or Distributor supplies End-Users	Manufacturer →End user	Retrofit Renovation/Remodel New Construction
	Manufacturer→Distributor→End user	Maintenance: Spot Replacement Retrofit
Manufacturer or Distributor supplies Contractors	Manufacturer→Distributor→Contractor→End user	Maintenance: Spot Replacement Maintenance: Group Replacement EE Upgrade
	Manufacturer→Distributor→Lighting Contractor→End User	Renovation/Remodel New Construction
	Manufacturer→General Contractor/Builder→Lighting Contractor→End User	Renovation/Remodel New Construction
Manufacturer or Distributor supplies Retailers	Manufacturer→Distributor→Retailer→Contractor→End user	Maintenance: Spot Replacement
	Manufacturer→Distributor→Retailer→End user	Maintenance: Spot Replacement
	Manufacturer→Retailer→Lighting contractor→End User	Renovation/Remodel New Construction
Manufacturer or Distributor supplies ESCOs	Manufacturer→Distributor→ESCO→Contractor→End user	Retrofit
	Manufacturer→Distributor→ESCO→End user	Retrofit
	Manufacturer→ESCOs→Contractor→End user	Retrofit
	Manufacturer→ESCOs→End user	Retrofit

3.3 Maintenance Market

One of the major findings of the market characterization was the importance of the maintenance market to all lamps sales. We define the maintenance market as lamp replacement (replace on burnout), group-relamping, and ballast failure. Given the lifetime of linear fluorescent lamps and typical operating hours in the non-residential applications, it is not surprising that lamps turn over more quickly than buildings, implying that sales to the maintenance market should be higher than lamps to the other purchase events like retrofit, new construction, renovation and remodeling.

Given the magnitude of the maintenance market and the upstream distributor program described in section 2.2, BPA elected to further research the lighting maintenance market as part of this project. Distributor and other market actor interviews had revealed the role of lighting maintenance contractors in serving the maintenance market. Therefore, BPA hosted a networking event in Bellevue, Washington, for lighting maintenance contractors, at which Navigant conducted a kiosk web survey intended for lighting maintenance contractors. The event also included open-ended discussion sessions with groups of market actors including distributors, manufacturer representatives, energy services companies,

The major takeaways from the event include the following:

- Company size. Lighting maintenances companies have myriad different structures. Some are small 1-5 employee firms serving a small network of clients while others are divisions within larger energy services companies or commercial property managers.
- Business model. Company business models are diverse, but in general, lighting maintenance contractors are in the business of performing a service, not selling a product. The pure-play lighting maintenance firms are less interested in making sales of high-value product than they are in providing responsive and convenient service.
- Installation decision. Contractors will typically install either what the customer has in the ceiling (if it is not obsolete) or what the customer specified. If the customer is a large organization, such as a regional or national chain, the decision maker is usually the client. If the client is a small business with one or just a few locations, the installer will likely default to most cost-effective option. Property maintenance firms often play a very large role in the market. Their decisions are constrained by the operating budgets they have with their clients (building owners).
- Lighting maintenance contractors procure their lamps through distributors the vast majority of the time. Some larger contractors may negotiate a purchase agreement with a manufacturer directly, but the products still flow through a distributor who would receive a fixed markup on the product.
- Because the intent of the upstream program discussed above was to increase the penetration of reduced-wattage linear fluorescent lamps, the team asked several questions specifically about their use. Contractors had a mixed reaction to the lamps. In general, they tended to favor the 28W (4-foot T8) over the 25W because some had experience performance issues associated with the latter.

3.4 *Shipment and Product Mix*

In general, electrical distributors were very responsive and forthcoming in their data submittals. Eleven distributors provided line-item sales data as requested in the form Navigant prepared and emailed to them. Sales data and trends were the clearest for those technologies that were of primary interest in this study: linear fluorescent, HID, and, to a lesser extent, LEDs. The most striking takeaways from the data include:

- The dominance of the 32W T8 in the 4-foot linear fluorescent market; these T8s compose 78 percent of all linear fluorescent 4-foot and 8-foot sales.
- The rapid decline of T12 and 8-foot lamps.
- The rapid growth in LED sales and popularity, among LED options, of the reflector lamp applications.
- Distributors' expectations for a slow-down in all HID technologies.

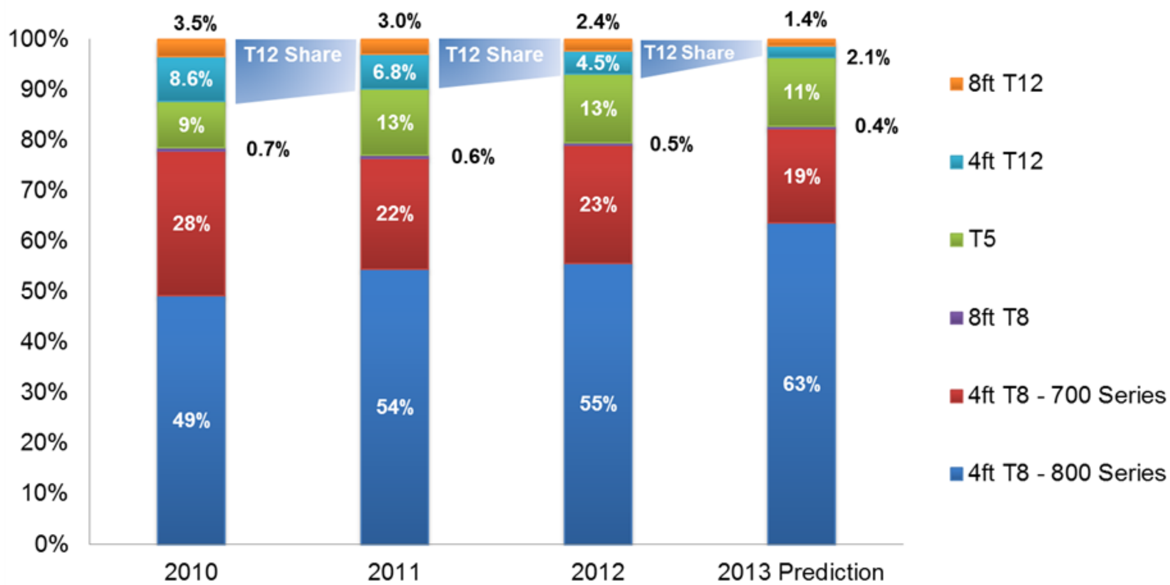
These trends were supported qualitatively during interviews with distributors who supplied data, as well as those who did not. For example, some distributors mentioned they planned to stop stocking T12 lamps, as the technology phased out. The following figures graphically depict the major trends found in the data.

We estimate the detailed line-item data from distributors represented 35 percent to 55 percent of the total market, depending on the product. It should be emphasized that the data presented below represents one distribution channel (distributors/wholesale). While most non-residential lighting products flow through this channel, it is not necessarily reflective of all channels. As discussed in sections 5 and 6, in the calculation of the baseline and non-programmatic savings, Navigant combined this detailed distributor data with higher level data from a major retailer, manufacturers, and qualitative assessments from the distributors who declined to submit line-item data but did participate in lengthy interviews.

3.4.1 Linear Fluorescent Lamps and Ballasts

As shown in Figure 9, T12s represent a small and decreasing share of linear fluorescent lamp sales. The total share of T12s (four foot and eight foot) in 2010 was reported to be just 12 percent, and had decreased to 6.5 percent by 2012. In contrast, by 2012 T8s comprised 78 percent of linear fluorescent shipments with increasing shares of high-performance T8s.

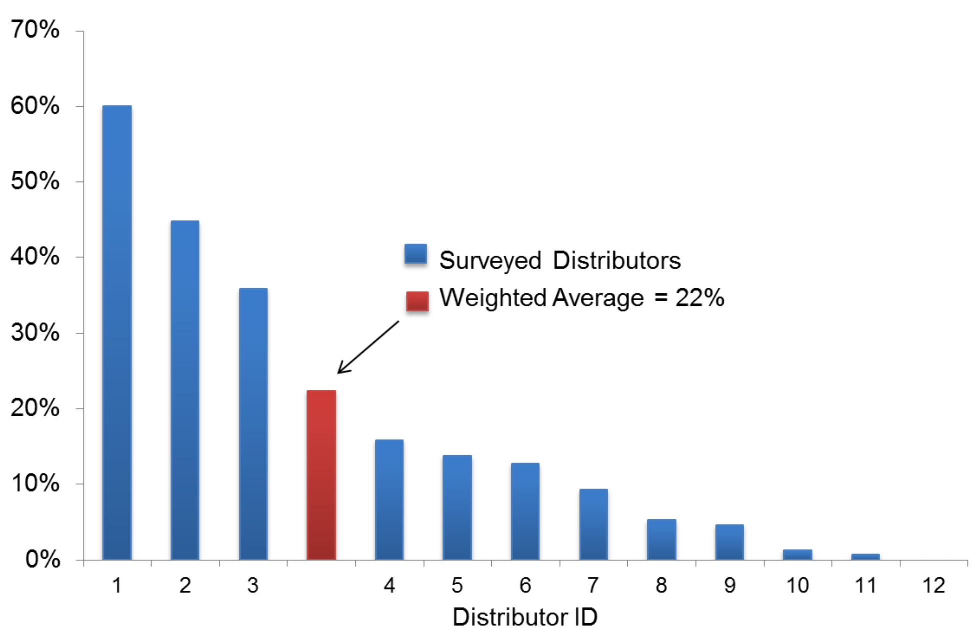
Figure 9 Linear Fluorescent Sales by Lamp Type, Distributor Data



Source: Navigant analysis of distributor sales data

Distributors' sales of reduced-wattage T8 lamps (as a share of all four-foot T8 lamps) were highly variable, ranging from 0 percent to 60 percent. (Reduced wattage lamps include 28W and 25W lamps, as opposed to the standard 32W T8 lamp.) The larger distributors tended towards the middle of the distribution, evidenced by Figure 10, which shows this distribution as well as the weighted average share of 22 percent.

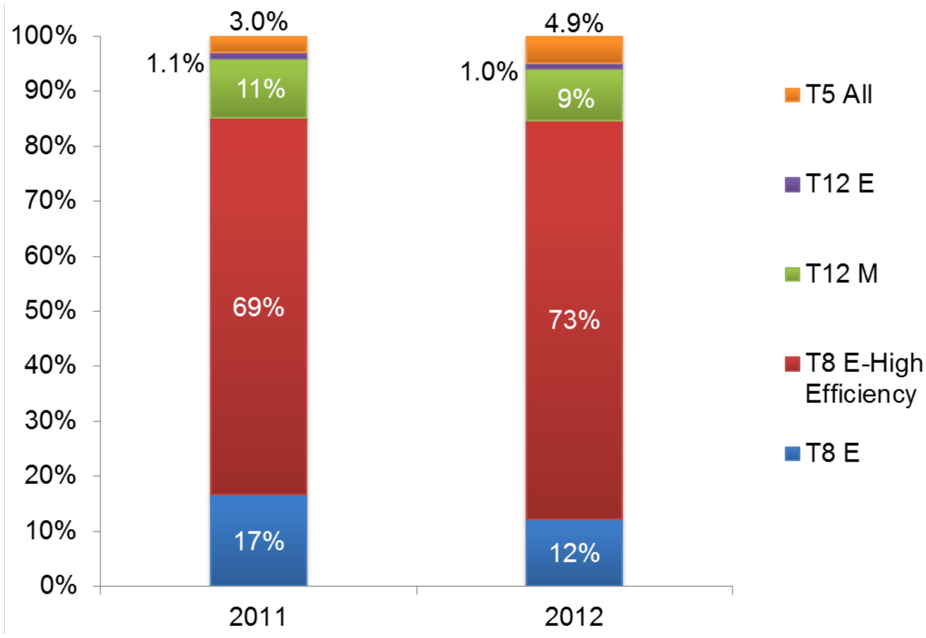
Figure 10 Reduced-Wattage Lamps, As a Share of All 4-foot T8 Lamps, By Distributor



Source: Navigant analysis of distributor data

Ballast shipments are also dominated by T8 technology, with 85 percent of fluorescent ballasts sold for T8 systems.

Figure 11 Ballast Shipments by Technology

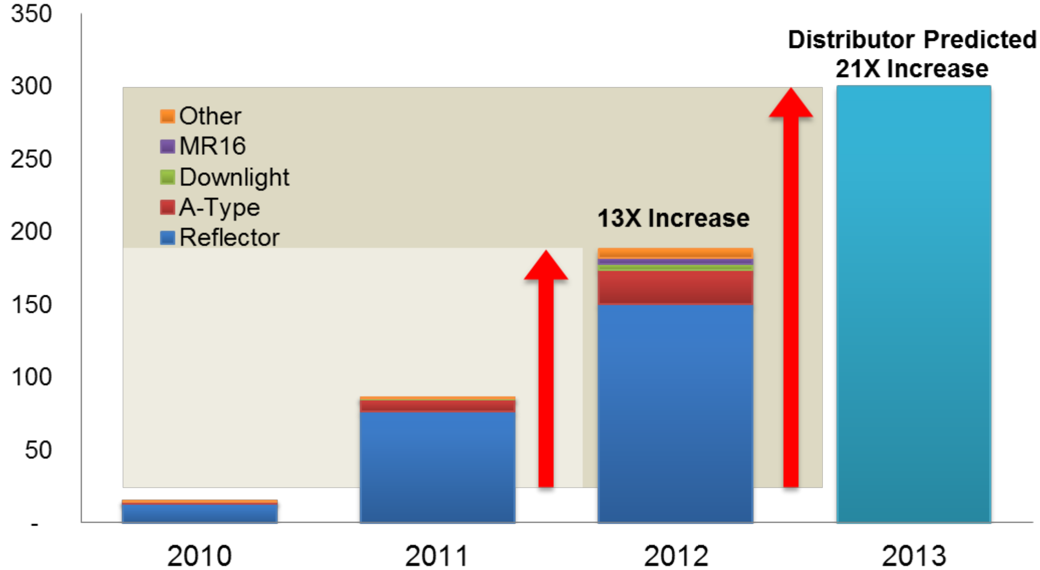


Source: Navigant analysis of distributor data

3.4.2 LED Systems

LEDs are the fastest growing lighting technology in the Northwest. According to the survey results, 2012 distributor LED lighting sales were 4 percent of all non-residential reported lamp sales in the Northwest. This total represents a thirteen-fold increase from 2010 to 2012 and survey participants expect shipments to increase further (21 times 2010 levels) in 2013.

Figure 12 Reported LED Shipments (000s of units)

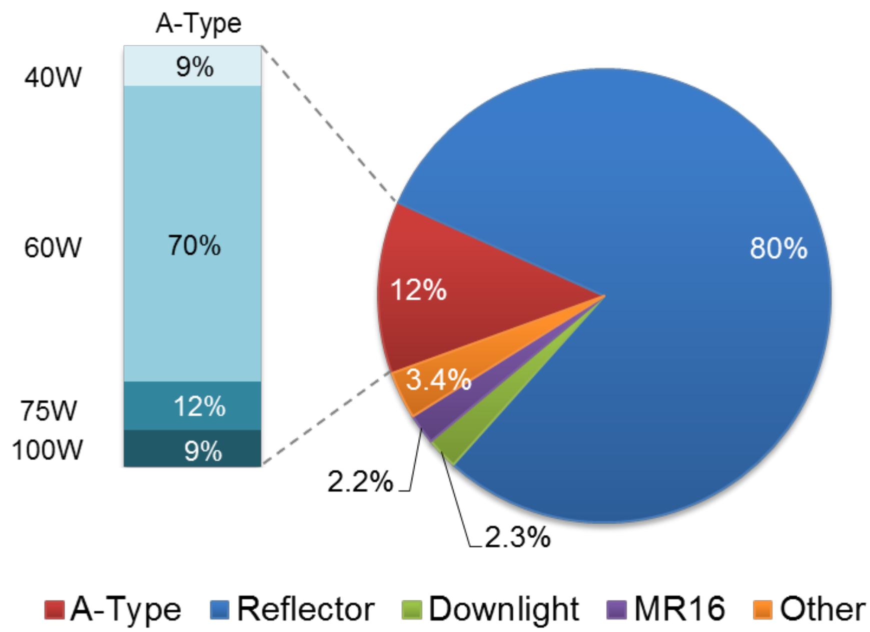


Source: Navigant analysis of distributor data

In 2012, the vast majority of reported LED shipments were reflector and A-type screw-in lamps. Combined, these two product types represented 92 percent of all 2012 LED reported shipments. The remaining 8 percent included LED downlight fixtures, MR16 lamps, as well as several other product types.[14] However, only a few distributors reported sales of lamps in the other categories; it is unclear whether that is because they did not sell any lamps in those categories or because they chose not to submit data. Based on the other secondary sources that speak to the popularity of MR16 LED lamps, the team does not believe the distributor data on LEDs captures the actual market mix for that technology and recommends further research in this area.

[14] Other LED product types include: Wall packs, high/low bay fixtures, troffers, linear fluorescent lamp replacements, roadway fixtures, bollard lighting, track fixtures, and outdoor area lighting.

Figure 13 LED Shipments by Product Type (by unit count)

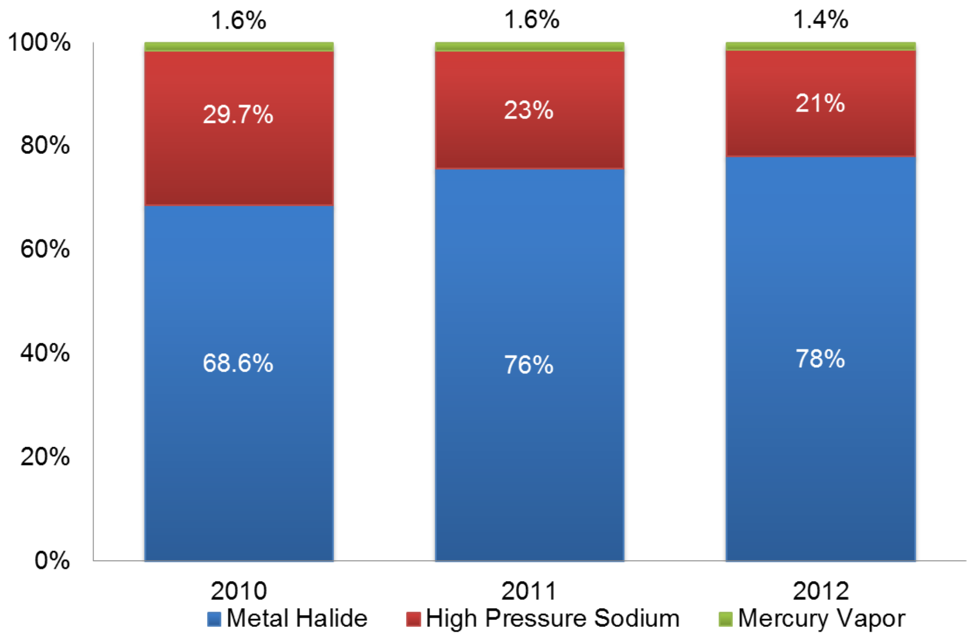


Source: Navigant analysis of distributor data. Wattages shown are incandescent equivalents.

Since 2010, the market share of distributor metal halide shipments has increased from 69 percent to 78 percent in 2012, while HPS have declined—presumably moving to metal halide and LED alternatives. In 2010, HPS lamps comprised 30 percent of all HID sales but that number had fallen to 21 percent by 2012.

3.4.3 HID Systems

Figure 14 HID Market Share by Technology

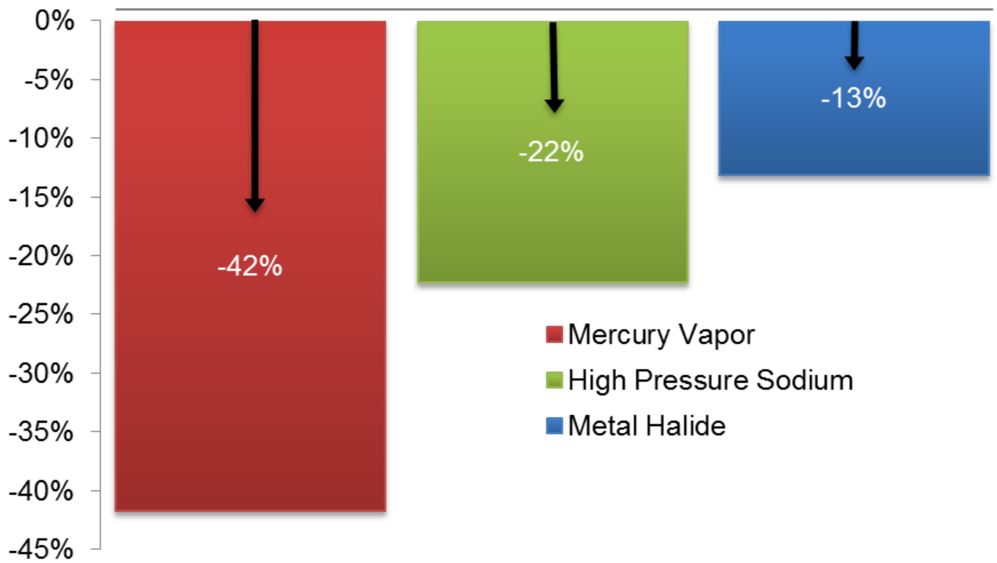


Source: Navigant analysis of distributor data

Ceramic metal halide sales have gained share in the lower wattage categories (<150W), while probe start and pulse start dominate the higher wattage categories. At very high wattages (1000W or greater), sales are almost exclusively probe start lamps. Only a few thousand mercury vapor lamps are now sold as the federal ban on mercury vapor ballasts, effective in 2009, appears to have largely had its intended effect.

Interestingly, distributors predict that all HID lamp sales will decrease in 2013 due to the increased availability of LED and continued migration to linear fluorescent alternatives, specifically T8 and T5 systems. On average, respondents expected mercury vapor lamps to decrease by 42 percent, HPS lamps by 22 percent, and metal halide lamps by 13 percent in 2013, as compared to 2012.

Figure 15 Average Annual Decline in HID Sales Expected for 2013, by HID Lamp Type



Source: Navigant analysis

4 Baseline Definition

This project initially expected that any baseline methodology would be informed by new RTF Lighting Protocols. However, the protocols could not be completed in time to inform the report. Furthermore, as the project began, it quickly became clear that any baseline methodology would require many important decisions that hinged heavily on definitional issues for which there was little precedent. These included:

1. How should the baseline be expressed?
    a. Lamp watts, system watts, or LPD?
2. Which purchase events should the baseline include?
3. Which market segments (e.g., new construction, retrofit, etc.) should the baseline include?
4. Which purchase events flow into each market segment?

Navigant worked closely with BPA as it hosted other regional lighting experts on several webinars and workshops to answer these questions. It is important to note that for many of these issues, there is no "right answer." The group settled on the definitions and an approach described below as the best balance between programmatic needs (i.e., a baseline expressible in a lighting calculator), analytical rigor, and consistency with the lighting market's dynamics.

4.1 Arithmetic Baseline

BPA sought a quantitative or "arithmetic" baseline for its programs. That is, the baseline for fluorescent lamps should be expressible as the market average wattage of all units shipped. Given lamps are shipped for different reasons (e.g., lamp burned out, renovation, etc.) as both a standalone product and part of a system, and given the choice of which lamp will be purchased is different depending on the reason for the purchase, the 'market average' unit takes on significant complexity one layer beneath the surface. To resolve this complexity, the team segmented shipments into various purchase triggers, or "purchase events," which characterize the choices a customer has—and thus form the basis for a 'market average' calculation.

4.2 Purchase Events and Market Segments

As discussed in the previous section, there are several reasons why commercial and industrial customers purchase new lighting equipment. In a typical programmatic retrofit, building owners and building operators are replacing significant portions of their lighting equipment with higher efficiency lamps, ballasts, and/or fixtures. However, the total lamp and ballast shipment data that Navigant received from distributors did not only include these purchases. On average, manufacturers indicated that 50 to 60 percent of lamp sales go to the maintenance market, and this share is higher for technologies that are becoming obsolete, such as T12s. In order to provide BPA with information specific to customers they target with lighting programs, Navigant used the below purchase event definitions to divide the market before calculating a baseline.

As described in section 3.2, Navigant defined five main purchase events which characterize the situations that prompt customers to purchase new lamps and/or ballasts: new construction, renovation and remodeling, group replacements, and spot replacements. Table 2 further breaks down these purchase events into "market measure applications" with more specific definitions.

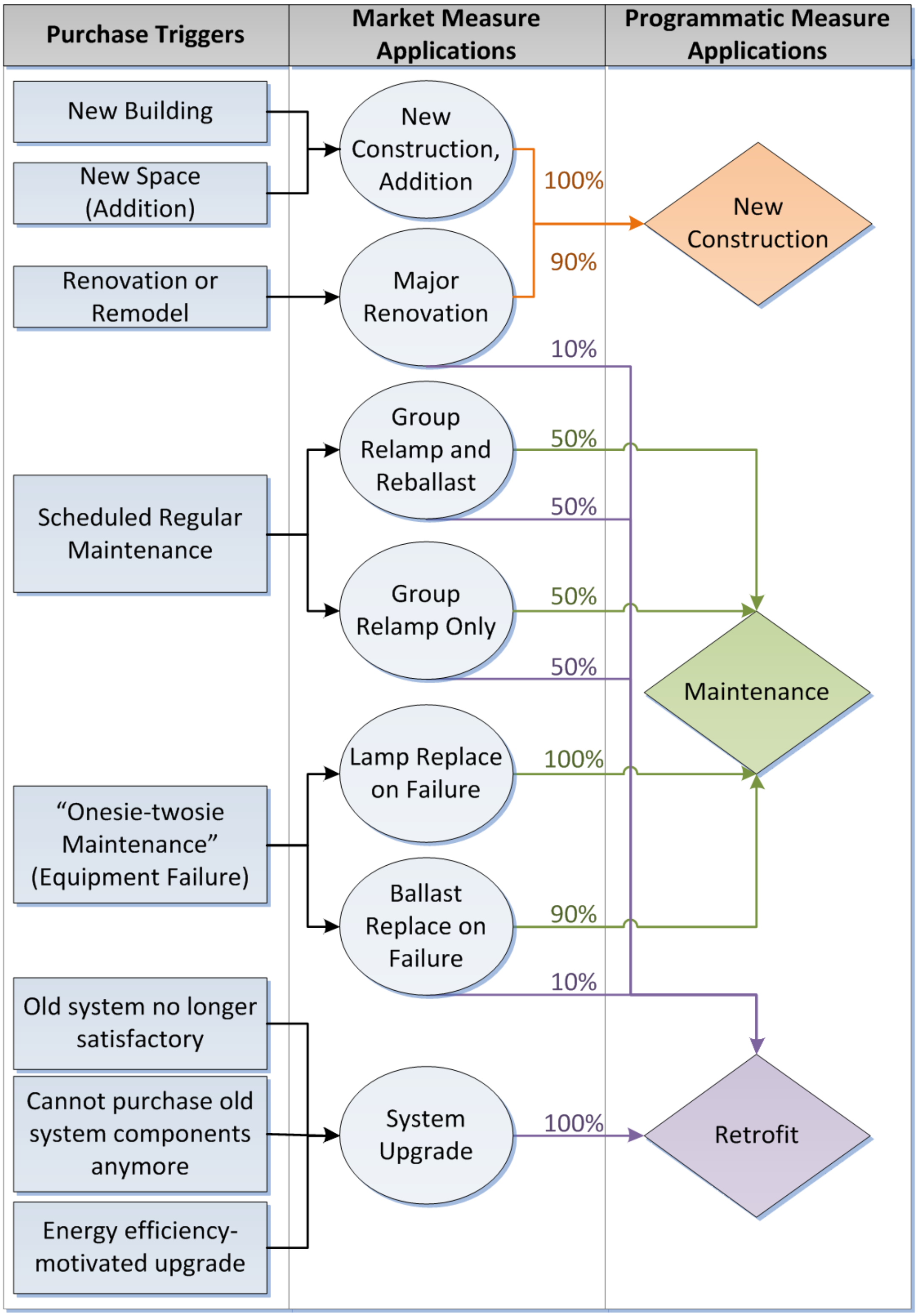
Table 2 Purchase Event and Market Measure Application Definitions

Purchase Event	Market Measure Application	Definition
New Construction	New Construction, Addition	Lighting equipment is installed in entirely new lighted space.
Renovation and Remodeling	Renovation and Remodeling	Existing lighting fixtures are removed and new ones installed as part of larger project (e.g., tenant improvement or space-use change).
Maintenance: Group Replacement	Group Relamp and Reballast	All lamps and ballasts in a space are replaced; however fixtures remain in place.
	Group Relamp Only	All lamps in a space are replaced; however ballasts and fixtures remain in place.
Maintenance: Spot Replacement	Ballast Failure	The ballast in a fixture fails and is replaced (along with the existing lamps).
	Lamp Failure	The lamp in a fixture fails and is replaced. The ballast continues to operate.
Retrofit	Lighting Upgrade	The lighting systems in a space are upgraded because they are no longer satisfactory, equipment is not available, or for energy efficiency purposes.

Source: Navigant analysis

Navigant then sought to map these purchase events into typical programmatic measure applications or "baseline buckets" in order to determine which purchase events should be included or excluded from a given baseline estimate. The three baseline buckets are new construction, maintenance, and retrofit. Although maintenance activity is not a market area that efficiency programs have historically targeted, it represents a large portion of lamp sales and also gives some indication of installed stock technologies. Figure 16 shows the mapping from the market measure applications (and examples of purchase "triggers" which could lead to each application) to programmatic measure applications.

Figure 16 Market Measure and Programmatic Measure Applications



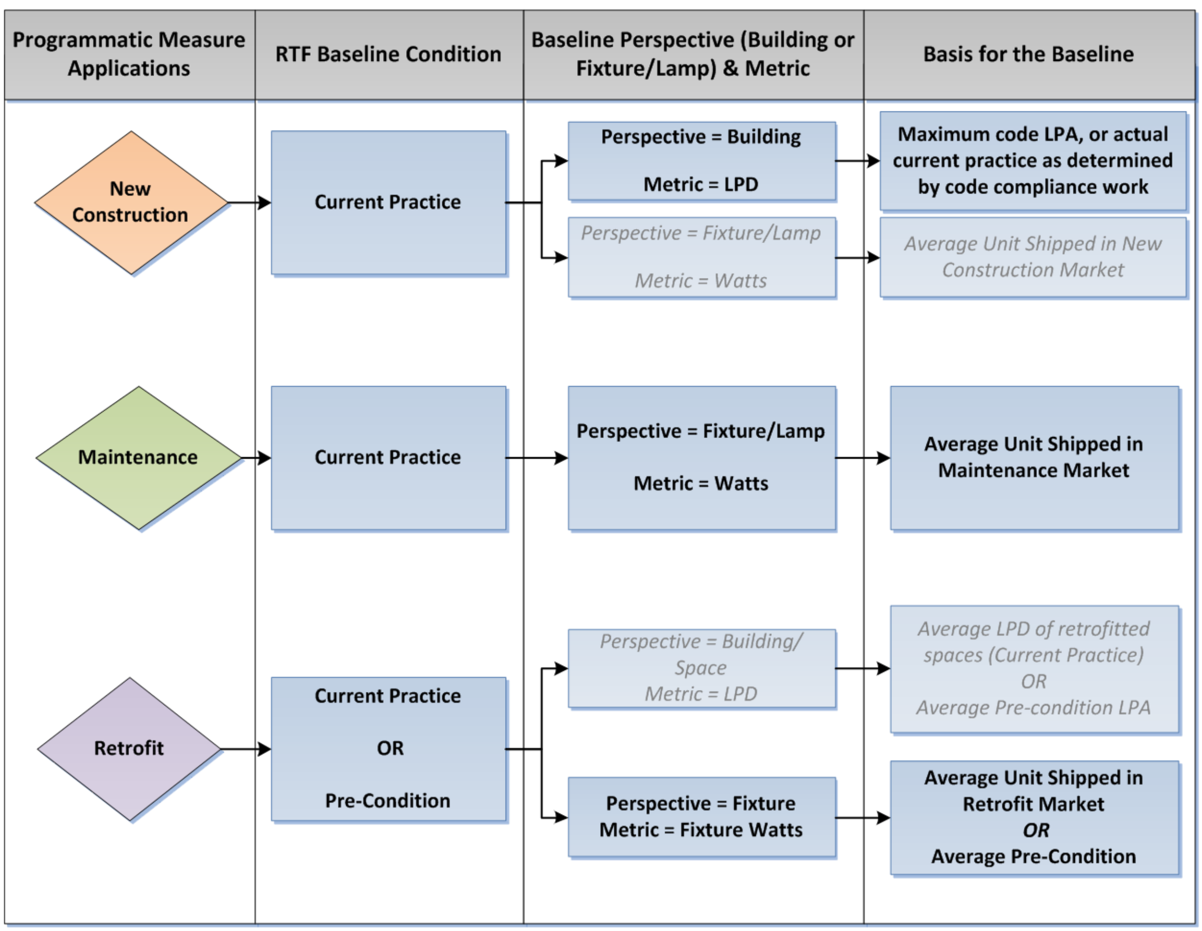
Source: Navigant analysis

4.3 *Baseline Type and Metrics*

The team also identified the applicable RTF baseline definition for each bucket, as well as what perspective and basis the energy efficiency industry typically uses to define each bucket's baseline. For example, the appropriate RTF baseline condition for new construction is the *current practice* baseline (as opposed to *pre-condition* baseline). This new construction baseline is typically expressed in lighting power density (LPD)—e.g., the current lighting energy code for grocery stores is 1.2 watts/square foot. The LPD metric applies not to the fixture but to the space. In contrast, most lighting programs aimed at retrofits have historically used a *pre-condition* baseline where the baseline metric is defined by the wattage of the replaced fixtures (as opposed to an LPD). In other words, not only is the typical baseline *metric* different between new construction and retrofit, each metric describes a different scope: in one case, the scope is the building space; in the other, the fixture. Given the team's task was to find the arithmetic market average, these distinctions were important in the answering the question of what exactly should be averaged.

Figure 17 shows the traditionally preferred and possible (italicized) RTF baseline conditions, perspectives and metrics, and calculation bases for each programmatic measure application.

Figure 17 Baseline Conditions, Perspectives, Metrics, and Bases



Source: Navigant analysis

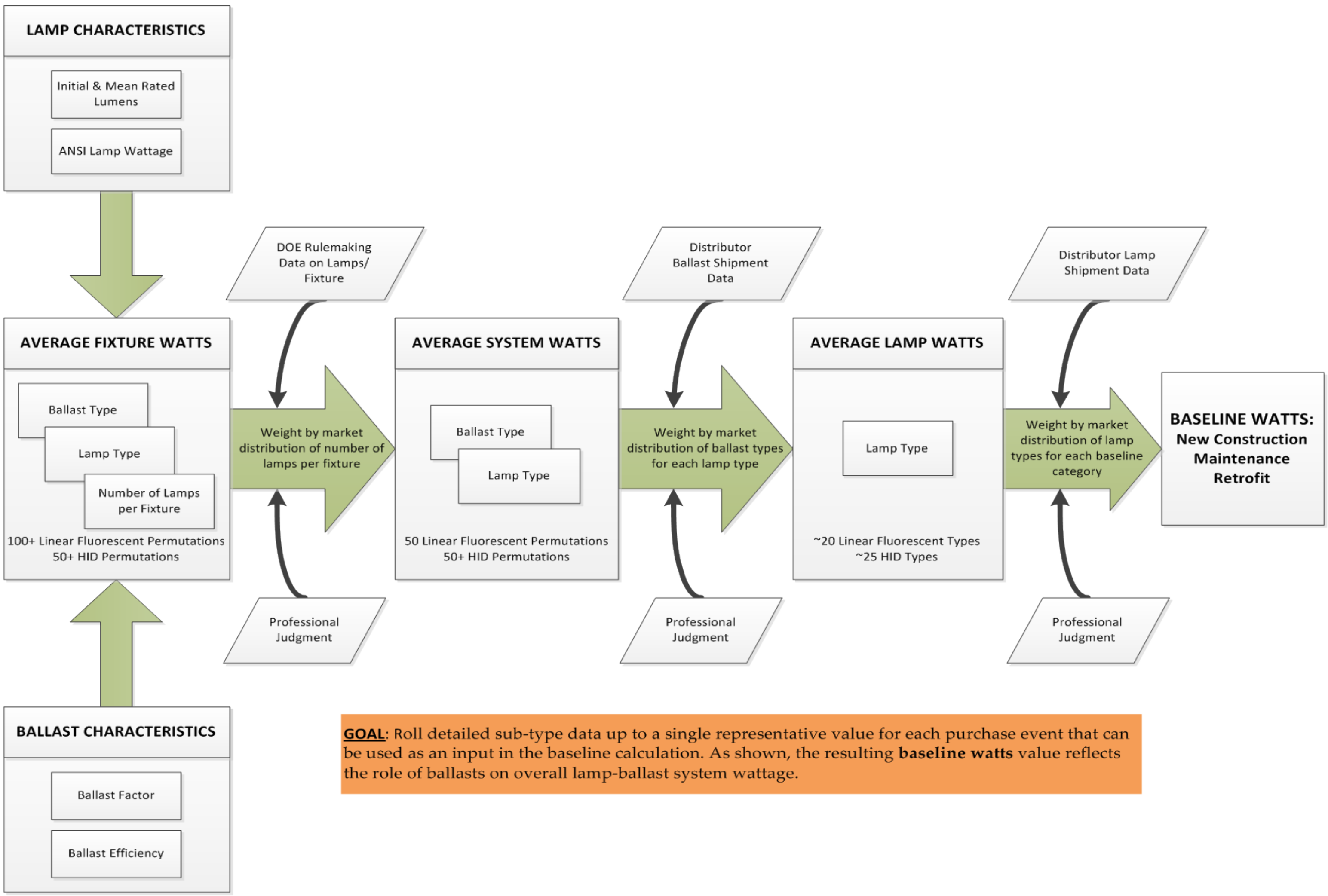
5 Baseline Methodology and Computation

This section provides a detailed description of the methodology Navigant used to calculate the baseline results. Navigant took the following analysis steps to transform the distributor shipment data into market average baselines:

1. Determine ballast factor and ballast efficiency for each ballast type in the data request for all possible fixture types (one, two, three, and four-lamp fixtures).
2. Determine total fixture wattage (lamp and ballast) for all unique fixture permutations in the distributor data request.
3. Determine weight of one, two, three, and four-lamp fixtures for each unique lamp-and-ballast combination.
4. Calculate average fixture wattage per lamp for each unique lamp-and-ballast combination.
5. Determine weight of each ballast pairing for each unique lamp type.
6. Calculate average fixture wattage per lamp for each unique lamp type.
7. Use shipment data and professional judgment to determine weight of each lamp type in each baseline category (e.g., "new construction, retrofit, maintenance").

Navigant used professional judgment to apply qualitative interview information and internal lighting expertise to raw shipment data. For example, distributors and manufacturers indicated that all T12s shipments were associated with maintenance activity. They also expected a higher proportion of reduced-wattage lamps go to retrofit and new construction activities as compared to, for example, standard T8s. Navigant used these insights to weight which the lamp types' allocation to the baseline buckets. Ultimately, due to the dominance of the 32W 4-foot standard T8, the allocation had a very small impact on the overall average baseline wattage. This process is illustrated in Figure 18 below.

Figure 18 Baseline Wattage Calculation Process



5.1 *Ballast Factor and Ballast Efficiency Inputs*

The ballast type, efficiency and ballast factor substantially influence a given linear fluorescent system wattage and efficacy. It follows, then, that the baseline (which is denominated in system watts/per lamp) calculation must account for the distribution of ballast types, efficiencies, and ballast factors. Table 3 shows the list of unique ballast types for which Navigant requested distributor data.

Table 3 Unique Ballast Types

Unique Ballast Types in Data Request	
T12 Electronic	T8 Slimline Electronic
T12 Magnetic	T8 Slimline Magnetic
T12 Slimline Electronic	T8 High Output High Efficiency Electronic
T12 Slimline Magnetic	T8 High Output Electronic
T12 High Output Electronic	T8 High Output Magnetic
T12 High Output Magnetic	T5SO High Efficiency Electronic
T8 High Efficiency Electronic	T5HO High Efficiency Electronic
T8 Electronic	T5SO Electronic
T8 Magnetic	T5HO Electronic
T8 Slimline High Efficiency Electronic	

Source: Navigant analysis

In general, each ballast type can be associated with various ballast factors and ballast efficiency inputs. Navigant used data from the most recent DOE ballast rulemaking[15] for the ballast factor and ballast efficiency inputs.

5.1.1 Total Fixture Wattage

Navigant combined the ballast data with ANSI-rated lamp wattages[16] for each unique lamp type to calculate average fixture wattages for all unique fixture permutations. Navigant used the following equation to determine the average watts per lamp based on actual system power draw using the following equation:

$$System\ Watts\ per\ Lamp = \frac{System\ Input\ Power}{\#Lamps}$$

Where:

$$System\ Input\ Power = \frac{(\#Lamps \times Ballast\ Factor \times ANSI\ Lamp\ Arc\ Power)}{Ballast\ Luminous\ Efficiency}$$

[15] http://www.regulations.gov/#!docketDetail;D=EERE-2007-BT-STD-0016

[16] Navigant used the ANSI-wattage values it collected during the DOE fluorescent lamp and fluorescent ballast rulemakings to reflect actual lamp power consumption on a given ballast type. This approach enables the baseline to be expressed in terms of the average lamp on the average ballast in system Watts/lamp.

Table 4 System Watts Equation Input Variables

Variable	Description	Notes
System Input Power (W)	Actual power draw of the lamp and ballast system	This is the value that manufacturers report in specification sheets for lamp and ballast combinations, and thus aligns with typical lighting calculator inputs.
# Lamps	Number of lamps per ballast system	-
Ballast Factor	Measure of actual lumen output for a given lamp relative to its rated lumen output[17]	Regional lighting calculators typically combine both of these factors, which are largely independent of each other, into a single "ballast factor."
Ballast Luminous Efficiency	Ratio of actual power to lamp to input watts to the system (independent of lamp)	
ANSI Lamp Arc Power	Actual lamp draw when operated at high frequency according to ANSI test standards[18]	This metric differs from the nominal lamp wattage.[19]

Navigant performed this calculation for all of the permutations shown in Table 5 below.

[17] Lawrence Berkeley National Laboratory, http://ateam.lbl.gov/Design-Guide/DGHtm/ballastfactor.htm

[18] It is more appropriate to use the high frequency test results for lamps typically operated with electronic ballasts (which is the case with nearly all shipped T8 lamps to the commercial sector).

[19] As noted in Table 4, nominal lamp wattage is not the same as actual power draw from the lamp, for reasons other than ballast factor alone. The difference between nominal lamp wattage and the ANSI lamp arc power stems from the way manufacturers are required to test and report performance to the DOE; it is also linked to the fact that most lamps now operate on electronic and not magnetic ballasts. To illustrate this distinction, consider the standard T8, which has a nominal wattage of 32W. The ANSI wattage for this lamp on a magnetic ballast if 30.8W (~4% difference), but the ANSI wattage for this lamp on an electronic ballast is only 29W (9% difference).

Table 5 Unique Fixture Permutations

Lamp Type	Ballast Options	Lamps per Fixture Options
34W T12	Electronic Magnetic	One and Two Lamp
40W T12	Electronic Magnetic	One and Two Lamp
60W T12 Slimline	Electronic Magnetic	One and Two Lamp
75W T12 Slimline	Electronic Magnetic	One and Two Lamp
95W High Output T12	High Output Electronic High Output Magnetic	One and Two Lamp
110W High Output T12	High Output Electronic High Output Magnetic	One and Two Lamp
32W 700 Series T8	High Efficiency Electronic Electronic Magnetic	One - Four Lamps
25W 800 Series T8	High Efficiency Electronic Electronic Magnetic	One - Four Lamps
28W 800 Series T8	High Efficiency Electronic Electronic Magnetic	One - Four Lamps
30W 800 Series T8	High Efficiency Electronic Electronic Magnetic	One - Four Lamps
32W 800 Series CEE Qualified T8	High Efficiency Electronic Electronic Magnetic	One - Four Lamps
32W 800 Series Not CEE Qualified T8	High Efficiency Electronic Electronic Magnetic	One - Four Lamps
59W T8 Slimline	High Efficiency Electronic Electronic Magnetic	One and Two Lamp
86W T8 High Output	High Output High Efficiency Electronic High Output Electronic High Output Magnetic	One and Two Lamp
28W Standard Output T5	High Efficiency Electronic Electronic	One and Two Lamp
54W High Output T5	High Output High Efficiency Electronic High Output Electronic	One - Four Lamps

Source: Navigant analysis

5.1.2 Distribution of Lamps per Fixture Weighting

Navigant used the percentages in Table 6 to assign weights to each type of ballast (one, two, three, or four) for a given lamp type. These weightings are consistent with the shares used in the recent DOE ballast rulemaking, which were based on manufacturer submitted data and manufacturer interviews.

Table 6 Lamp per Fixture Weights

Category	One Lamp	Two Lamp	Three Lamp	Four Lamp
All T12	5%	95%	0%	0%
All T8	10%	40%	20%	30%
T5 Standard Output	5%	95%	0%	0%
T5 High Output	5%	45%	15%	35%

Source: Navigant analysis

5.1.3 Ballast Type Distribution

Navigant determined the distribution weight of each ballast permutation by calculating the shares of each ballast type (magnetic, electronic, and high-efficiency electronic) from the distributor shipment data. The term "high-efficiency" electronic ballasts was intended to mean electronic ballasts which meet the high-performance specifications set by the Consortium for Energy Efficiency (CEE), but the team learned that distributors market a number of electronic T8 ballasts as "high-efficiency," so caution should be taken in interpreting the share of electronic versus high-efficiency electronic ballasts. Navigant re-allocated some of these weights for individual lamp types to account for the fact that certain lamps are more likely to be paired with certain ballasts. For example, it is unlikely that an 800 series high performance T8 lamp would be paired with a magnetic ballast (and more likely that it would be paired with high-efficiency electronic ballast). Navigant primarily relied on professional judgment for these allocations, also referencing distributor interviews and BPA programmatic data. Navigant maintained overall shares within each category (e.g. T8 four-foot ballasts) that matched the distributor shipment data. These shares are shown in Table 7.

Table 7: Ballast Shares in Distributor Shipment Data

Ballast Category	Ballast Type	2010 Share	2011 Share	2012 Share
T12 4ft	Electronic	35.3%	60.4%	78.5%
	Magnetic	64.7%	39.6%	21.5%
T8 4ft	High Efficiency Electronic	69.6%	73.6%	81.7%
	Electronic	30.4%	26.4%	18.3%
	Magnetic	0.0%	0.0%	0.0%
T5 4ft	High Efficiency Electronic	33.1%	40.7%	45.0%
	Electronic	66.9%	59.3%	55.0%
T12 8ft Slimline	Electronic	19.8%	73.8%	92.0%
	Magnetic	80.2%	26.2%	8.0%
T12 8ft High Output	Electronic	56.9%	91.2%	97.1%
	Magnetic	43.1%	8.8%	2.9%
T8 8ft Slimline	High Efficiency Electronic	14.1%	15.7%	22.9%
	Electronic	85.3%	83.3%	76.3%
	Magnetic	0.6%	1.0%	0.8%
T8 8ft High Output	High Efficiency Electronic	17.4%	19.2%	16.2%
	Electronic	82.6%	80.8%	83.8%
	Magnetic	0.0%	0.0%	0.0%

Source: Navigant analysis

5.1.4 Average Watts per Lamp

Navigant calculated average watts per lamp for each lamp and ballast combination. The team then used the ballast distributions by lamp type from Table 7 to calculate one weighted-average lamp wattage for each unique lamp type. For example, the change in wattage per lamp for 34W T12s over the analysis period from 2010 – 2012 reflects the shift in market share from mostly magnetic ballasts to mostly electronic ballasts. These final results are shown in Table 8.

Table 8: Fixture Wattage per Lamp, 2010-2012

Unique Lamp Type	2010 Average Watts per Lamp	2011 Average Watts per Lamp	2012 Average Watts per Lamp
34W T12	36.9	34.9	33.4
40W T12	46.8	46.4	45.5
60W T12 Slimline	68.7	60.3	58.0
75W T12 Slimline	86.9	83.4	71.0
95W High Output T12	95.7	90.2	89.7
110W High Output T12	128.8	113.0	107.2
32W 700 Series T8	27.8	27.8	27.7
25W 800 Series T8	23.1	23.1	23.1
28W 800 Series T8	24.8	24.8	24.8
30W 800 Series T8	26.2	26.2	26.2
32W 800 Series CEE Qualified T8	27.6	27.6	27.6
32W 800 Series Not CEE Qualified T8	27.7	27.7	27.7
59W T8 Slimline	54.8	54.9	54.7
86W T8 High Output	74.3	74.3	74.3
28W Standard Output T5	30.8	30.7	30.7
54W High Output T5	57.9	57.9	57.9

Source: Navigant analysis

5.1.5 Lamp Type Weightings

As described in Section 4, Navigant used five "purchase events" to categorize lamp sales. Interviews with lighting manufacturers indicated that lamps are sold to these purchase events as shown in Table 9.

Table 9 GSFL and HID Lamp Sales by Purchase Event

C&I Lamp Purchase Events	GSFL	HID
Maintenance: Spot Replacements	50%	70%
Maintenance: Group Replacements	10%	5%
Retrofits	20%	5%
New Construction	5%	5%
Renovation and Remodel	15%	15%

Source: Navigant analysis

Navigant adjusted these distributions for individual lamp types based on insights from manufacturer interviews to account for the fact that different channels (e.g., retail vs. distribution) flow product to different purchase events (e.g., the retail channel primarily provides product for the maintenance market). Table 10 and Table 11 show the adjustments and final overall distributions for GSFL and HID lamps.

Table 10 GSFL Purchase Event Weighting by Lamp Type

Lamp Type	New Construction	Renovation and Remodeling	Retrofit	Spot Replacement	Group Replacement
All T12 and All 8ft	0%	0%	0%	90%	10%
700 Series T8	5%	15%	20%	45%	15%
800 Series T8 Not CEE Qualified	5%	15%	20%	45%	15%
800 Series T8 CEE Qualified	7%	17%	40%	22%	14%
T5	8%	18%	30%	30%	15%
Overall GSFL	4%	12%	21%	50%	12%

Source: Navigant analysis

Table 11 HID Purchase Event Weighting by Lamp Type

Lamp Type	New Construction	Renovation and Remodeling	Retrofit	Spot Replacement	Group Replacement
Mercury Vapor	0%	0%	0%	100%	0%
High Pressure Sodium	5%	15%	0%	70%	10%
Metal Halide Quartz Probe	5%	15%	5%	70%	5%
Metal Halide Quartz Pulse	5%	15%	10%	65%	5%
Metal Halide Ceramic Pulse	5%	15%	20%	55%	5%
Overall HID	5%	15%	7%	67%	6%

Source: Navigant analysis

5.2 *GSFL Baseline (Low and Medium Bay Applications)*

For the GSFL baseline, Navigant summed shipped units and the corresponding shipped watts by purchase event from four-foot T12s, T8s, standard output T5s, eight-foot slimline T12s and slimline T8s. Navigant standardized the units to a four-foot lamp basis by multiplying eight-foot lamp units by a factor of 1.8. The team estimated this factor by comparing the average lumen outputs of comparable four-foot and eight-foot lamps. Navigant then calculated the average wattage per lamp by dividing the sum of shipped watts per purchase event by the sum of normalized shipped units per purchase event.[20] Table 12 shows the total shipments and resulting average wattages.

Table 12 Market Average Wattages by Purchase Event

	New Construction Sales	Renovation & Remodel Sales	Retrofit Sales	Spot Replacement Sales	Group Replacement Sales
Total Lamps	182,198	507,466	832,369	2,005,005	501,672
Total Watts	4,936,961	13,787,988	22,393,247	60,752,695	13,934,271
Percent of Market (Lamps)	5%	13%	16%	54%	13%
Average Watts/Lamp	27.2	27.3	27.0	30.5	27.9

Source: Navigant analysis

[20] Note that the total watts and units shipped are not total market shipments and only represent the data received from distributors.

After several discussions with regional lighting experts, Navigant then binned the purchase events into the three broader programmatic segments of maintenance, retrofit, and new construction. This process was described in greater detail in Section 4. The market segments were formed to match the energy efficiency community's programmatic framework for the market.

Table 13 Mapping Purchase Events to Baseline Categories

Programmatic Segment	New Construction Sales	Renovation & Remodel Sales	Retrofit Sales	Spot Replacement Sales	Group Replacement Sales
New Construction	100%	95%	0%	0%	0%
Maintenance	0%	0%	0%	95%	50%
Retrofit	0%	5%	100%	5%	50%

Source: Navigant analysis

Finally, Navigant calculated weighted average baselines for each category (and overall) using the mapping in Table 13. Table 14 shows the resulting market average wattages per lamp.

Table 14 Average Lamp Wattages by Market Segment

Market Segment	Average Lamp Wattage	Delta from Average
New Construction	27.2	-1.6
Maintenance	30.0	1.3
Retrofit	27.4	-1.4
All Applications	28.7	0

Source: Navigant analysis

5.3 "High Bay" Baseline (predominantly HID)

5.3.1 Pre-condition Baseline

BPA also asked Navigant to investigate the market average lamps sold in the high-bay market. This market has been historically dominated by various HID technologies, but new LED, fluorescent, and even some induction lamps are becoming increasingly popular. Because of this mix of technologies and because of the diverse applications in which HIDs are operating, determining a "market average" is much more difficult for the HID market. Furthermore, there has been no recent legislation that clearly demarcates a baseline HID technology type or performance level in the same manner the 2012 DOE standard was expected to phase out T12 technology. Navigant recommends continuing to use a pre-condition baseline for HID retrofits for the following reasons:

- Sales data indicates most HID systems are still viable options for customers in a range of purchase events.
- As stated above, there has been no major legislation targeted at eliminating any HID technologies in recent years. With the exception of a very small share of installed mercury vapor

ballasts, no installed HID technology is obsolete or effectively obsolete. Thus, outside of programmatic retrofits, a typical consumer is probably fairly likely to continue using an existing HID system in any replacement scenario (thus, making it an appropriate pre-condition baseline). Furthermore, lamp replacements (maintenance applications) dominate shipments.

- HID and competing technologies are very application-specific. This makes it difficult to cleanly parse technologies into appropriate bundles for baseline calculation, and also means that customers' realistic choices of technology for a specific application cannot be reasonably reflected by purely blended market average baseline.

Despite a pre-condition baseline being the appropriate baseline at this time, Navigant thoroughly investigated the HID market and developed a methodology that could be used in the future to calculate an appropriate *current practice* baseline. This analysis, presented in more detail in Appendix A, produced some interesting insights in HID trends. These trends, which Navigant found to support the use of a pre-condition baseline for now, are as follows:

- Mercury vapor lamps are the least efficacious technology and also show very low sales. This is the only HID technology that is effectively "obsolete."
- Probe-start HID sales still dominate sales in applications requiring greater than 10,000 lumens per lamp.[21] The large share of sales for this technology show that it is far from obsolete.
- Ceramic pulse lamps are quite popular at lower lumen outputs, but do not hold much share in higher lumen applications.
- High-pressure sodium (HPS) lamps shares are moderate across lumen outputs, and this technology generally falls in the "middle of the pack" in terms of efficacy, except at high lumen outputs where it is a leader.
- Unsurprisingly, T5 high output systems are also prevalent in high-bay applications, especially in the higher lumen ranges. This aligns with the BPA programmatic data which showed a large volume of 400W HID to four-lamp T5 retrofits.
  While T8s exceed most other systems in terms of efficacy, sales in this high-bay market remain moderate.

[21] Per fixture for linear fluorescent technologies

6 Non-Programmatic Savings

BPA classifies savings from energy-efficiency market advancements into two primary categories: programmatic and non-programmatic savings. Programmatic savings are those that accrue from utility-sponsored incentive programs and NEEA market transformation initiatives.

Non-programmatic savings are defined as:[22]

- Cost-effective;
- Above the baseline assumed by the Council for determining conservation potentials in the Sixth Plan;
- Not incented through utility-sponsored energy efficiency programs; and
- Not part of net market effects claimed by NEEA.

This section describes Navigant's approach to and results of estimating non-programmatic savings that have accrued in the commercial, industrial, and outdoor lighting markets in the Northwest from 2010-2014.

6.1 Conceptual Overview of Non-Programmatic Savings Estimation Methodology

General. At the highest level, the methodology for estimating non-programmatic savings is based on Equation 1:

Equation 1 Non-Programmatic Savings

$$\begin{aligned} &\textit{Non-Programmatic Savings} \\ &\qquad = \textit{Total Savings } \times (\textit{Pre-Case Consumption } - \textit{Estimated Actual Consumption}) \\ &\qquad - \textit{Adjusted Programmatic Savings} \end{aligned}$$

Beginning with the last term in the equation, "adjusted programmatic savings," BPA provided Navigant with annual regional programmatic savings from non-residential lighting programs throughout the region. However, because most programs claimed savings against a 'pre-condition' baseline, whereas the Sixth Plan effectively used a 'current practice' baseline, it was necessary to adjust the programmatic savings for the baseline misalignment to avoid double-counting. Therefore, Navigant estimated and subtracted out programmatic savings below the Sixth Plan's baseline. This resulted in the "adjusted" programmatic savings used in the final calculation.

That left the challenge of estimating the remaining term on the right side of the equation: *total market savings*. Plainly stated, how much energy was saved in each year relative to the Sixth Plan baseline, regardless of how it was achieved?

[22] Bonneville Power Administration. Methodology for Quantifying Market-Induced Non-Programmatic Savings. Prepared by Cadmus Group, Inc. April, 2011.

Key Assumption. It is worth noting first that the methodology used to answer that question depends on one key assumption: that lumen density[23] remains constant on average throughout the 2010-2014 time period. That is, relative to their starting point, existing buildings on average across the region will not over- or under-light following lighting replacements or retrofits—lumens per square foot remain flat. The assumption serves as a means of comparing the Sixth Plan baseline with the actual market progress. Its specific application is described in detail below.

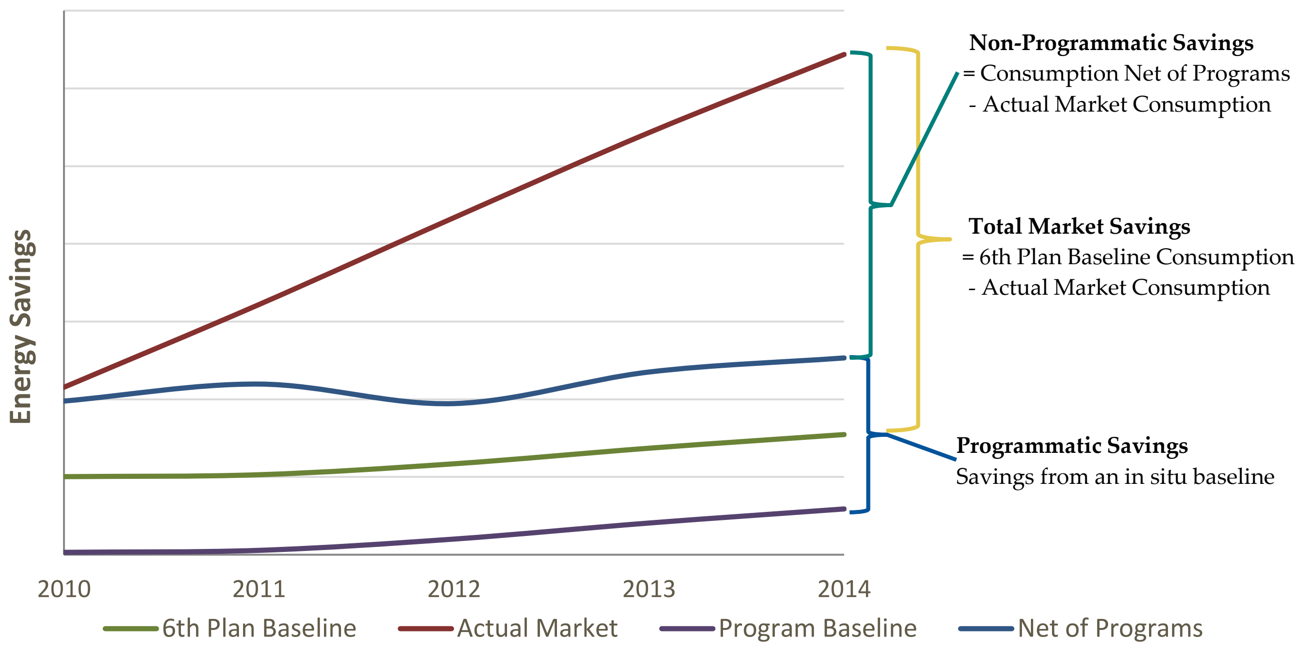
Total market savings. The method for estimating total market savings was to subtract in each year: a) the first-year consumption of "newly installed watts" actually installed in the market based on shipment data from b) the first-year energy consumption of "newly installed watts" that *would have* been installed under Sixth Plan baseline assumptions. "Newly installed watts" included wattage associated with all lamp sales in all non-residential sectors and purchases events.

Navigant estimated the amount of "newly installed watts" under baseline (pre-case) conditions by multiplying the total floor area receiving new lamps in a given year by the lighting power density (watts / ft^2) of that floor area from the Sixth Plan. The team used efficacy characteristics of lamps shipped in 2010 (the base year for the "frozen" baseline) to arrive at an estimate of total demand for lumens in each year. Navigant used the efficacy characteristics of lamps actually shipped in the market during each year of the study period to calculate the "newly installed watts" for the post-case, by assuming that the total *lumen density* (lumens/ft^2) remains the same in the pre- and post-case for each year of the analysis. The team then applied weighted average hours of use, an HVAC interactive effects factor, and a busbar losses factor to the resulting wattage estimates to calculate total savings.

A high-level overview of the approach Navigant used to estimate non-programmatic savings is depicted in Figure 19. A more detailed step-by-step discussion of the method is included in the section that follows.

[23] Note the distinction between lighting power density (LPD) and lumen density. Our assumption makes no statement about LPD. It simply states that, on average, spaces will continue to be lighted to the same level brightness on average.

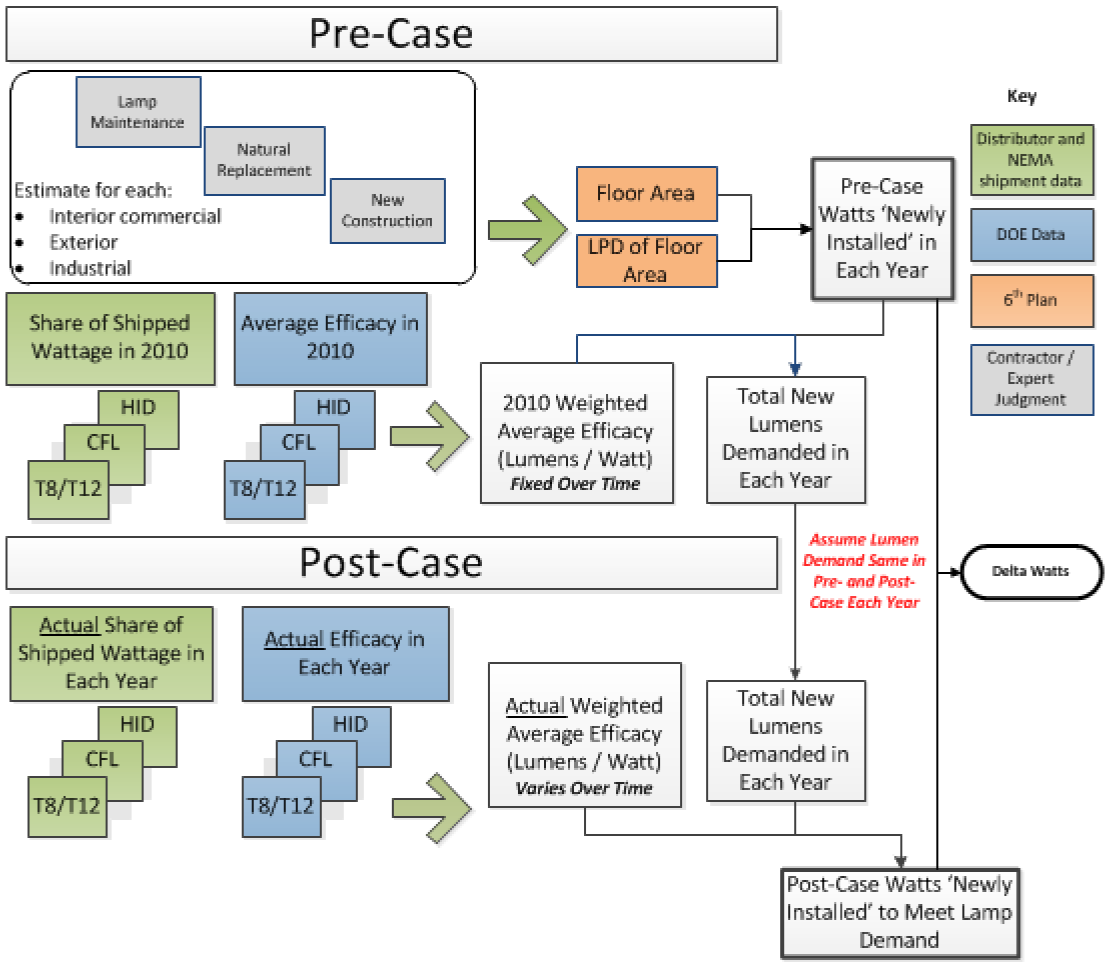
Figure 19 Summary of Non-Programmatic Savings Estimation



6.2 Description of Method for Calculating Non-Programmatic Savings

Navigant used the following seven-step process for deriving non-programmatic savings. This process follows the logic shown in Figure 20.

Figure 20 Non-Programmatic Savings Calculation Methodology



Step 1. Calculate the weighted-average efficacy of year-by-year installations in the *pre-case*. The weighted-average efficacy of lighting installed under baseline (beginning of 2010) conditions was a key factor in the algorithm used to calculate both pre-case watts "newly installed" in each year, and total lumen demand in each year. The sub-steps involved are described below, and are summarized in a schematic diagram presented in Appendix B. These steps also mirror the process used to determine the average wattage per lamp as described in Section 5.

- **Step 1a. Characterize the efficacy of lamp-ballast systems**. Navigant used data from the most recent DOE lamp and ballast rulemakings[24] to detail the typical system efficacy characteristics for all lamp-ballast combinations likely to be found in commercial and industrial buildings. The suite of lamp-ballast combinations characterized in the analysis reflected the broad range of

[24] Data from the 2009 General Service Fluorescent Lamp DOE rulemaking, and from the 2011 Fluorescent Ballast DOE rulemaking will be referenced. Navigant was the lead DOE contractor on many technical analyses for these rulemaking processes.

scenarios present in the market, including all practical permutations of ballast type, lamp length, wattage, and quantity of lamps per fixture.

Output: A data table including detailed characteristics for all practical combinations of lamps and ballasts that would have been installed in 2010.

- **Step 1b**. **Roll up sub-type characteristics to produce a representative efficacy for each lamp type**. In order to roll detailed sub-type data up to a representative value that can be used as an input in the analysis algorithm, Navigant completed a series of weighting steps as described below. Although the output of this step in the analysis is a single weighted-average efficacy for each lamp type, as detailed in the description that follows, these lamp-level efficacy values represent a roll-up of other values that reflect the role of ballasts on overall lamp-ballast system efficacy.
    - The team applied representative weights to reflect the **market distribution of each "number-of-lamps-per-fixture" scenario within each lamp-ballast sub-group**. For example, for four-foot T8 800 series lamps used in combination with standard electronic ballasts, Navigant accounted for the portion of those lamps that were used in 1-lamp, 2-lamp, 3-lamp, and 4-lamp fixtures. To complete this step Navigant used the engineering analyses from the aforementioned DOE rulemakings, and applied professional judgment as needed.

      Output: Representative efficacy for each lamp-ballast sub-group (e.g., a single, representative efficacy value for all 800 series 32W T8 lamps used with standard electronic ballasts)

    - The team applied representative weights to reflect the **market distribution of different ballast pairings for each lamp type**. For example, for four-foot 800 series 32W T8 lamps, Navigant accounted for the portion of those lamps that are paired with standard electronic, high efficiency electronic, and magnetic ballasts. Navigant used ballast shipment data as a starting point for these weights and applied professional judgment as needed (e.g., 800 series lamps are more likely than other T8 series to be paired with high efficiency ballasts).

      Output: Representative efficacy for each lamp type (e.g., a single representative efficacy value for all four-foot T8 lamps of a given series and wattage)

- **Step 1c**. **Weight the lamp-level efficacy data to reflect each lamp's share of the market.** Navigant referenced the distributor sales data collected as part of this assignment, as well as DOE rulemaking shipment data, to estimate the distribution of sales by lamp type for the entire region. The representative efficacy value for each lamp type was weighted accordingly, and Navigant calculated a single weighted average efficacy value to represent all lamp sales in each year.

  Output: A single weighted-average efficacy value for each year of analysis.

Given the frozen baseline assumption of the Sixth Plan, the team held the weighted average efficacy estimated for the beginning of 2010 constant in each year of the analysis period (2010 to 2014), while the data for 2010, 2011 and 2012 provided the basis for the "market actual" efficacy moving forward as described in Step 2.

Step 2. Calculate the weighted-average efficacy of year-by-year installations in the *post-case*. This step included all the same components as Step 1 detailed above. The key difference was that in Step 2c., Navigant relied on distributor sales data to produce lamp market share weighting factors that are representative of sales ***in each post-case year of the analysis (2010-2014)***. Since sales data were only collected from distributors for 2010 to 2012, Navigant forecasted 2013 and 2014 values by linearly extrapolating the trends in efficacy from 2010 to 2012. Note that the goal here was to identify the share of installed lamps by lamp type, not the absolute number of lamps installed.

Step 3. Estimate "newly installed watts" in each year for the pre-case. Three factors drive this calculation: (1) the installed stock of floor space in the northwest; (2) the turnover rate of that floor space as it relates to lighting; (3) the LPD of the floor space after it has been serviced. With some modifications as noted below, Navigant calculated newly installed Watts using the following Equation 2:[25]

Equation 2 Newly Installed Watts for the Pre-Case

$$\textit{Pre-Case Newly Installed Watts} = \textit{Pre-Case LPD} \times \textit{Affected Floor Area}$$

Because of the difference across sectors, Navigant calculated newly installed watts separately for commercial interior floor space, industrial interior floor space, and outdoor illumination.

- ***Step 3a. Estimate pre-case LPD.***

  Commercial. To calculate lumen demand and pre-case watts "newly installed" for the commercial interior component of the market, Navigant relied on LPD and floor area assumptions used in the Sixth Plan modeling effort.

  Outdoor. Navigant used a similar approach to calculate lumen demand for the outdoor component of the market, starting with data available in 2009 Commercial Building Stock Assessment (CBSA) on exterior lighting associated with buildings, and then drawing on data from the DOE's 2010 Lighting Market Characterization[26] regarding the relative size of various exterior market sub-components (e.g., street lighting, parking, etc.) to "scale-up" the CBSA data to incorporate other key sub-sets of the exterior market that were not analyzed in the CBSA.

  Industrial. For the industrial market, Navigant estimated regional industrial square footage by scaling down national industrial floor space based on the ratio of the number of employees in

[25] Although the LPD inputs do not change in each year, the weighted-average efficacy does change. Therefore, the results of the analysis will reflect an effective decrease in LPD over time.
[26] http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf

the industrial sector nationally compared with the Northwest.[27] Navigant estimated the industrial LPD (which is not included in the CBSA) by applying the ratio of warehouse and manufacturing lighting power allowances (LPAs) in ASHRAE 90.1-2007 to the Sixth Plan "warehouse" LPD. Navigant chose warehouse as a base for this extrapolation given that it is also a high-bay application and often utilizes similar technology.

- ***Step 3b. Affected Floor Area.*** Navigant applied assumptions from the Sixth Plan modeling effort somewhat differently than in the Sixth Plan analysis, reflecting the different goals, data requirements, and scopes of the two efforts. The Sixth Plan modeling effort was intended to estimate the portion of the market that efficiency programs could affect in each year. Therefore, it focused only on the following sub-markets:

    - turnover of full lighting systems at the end of their useful lifetimes ("natural replacement or NR");
    - new construction; and,
    - retrofits.[28]

  A new construction-based LPD was used for all of these sub-markets.[29] In contrast, Navigant's analysis made use of distributor sales data that encompassed sales to *all* submarkets, including the lamp maintenance market (lamp replacement on burnout). Therefore, Navigant expanded on the Sixth Plan floor area assumptions to reflect additional activity (i.e., lamps sales) that occurs in the lamp maintenance market.

  The Sixth Plan modeling files include input assumptions for the total floor area for each building type in the region, as well as mean LPDs for existing floor area. Navigant applied these assumptions to account for the lamp maintenance market into the overall analysis. Navigant used the following equation to estimate the lamp maintenance floor area turnover in a given year:

Equation 3 Lamp Maintenance Floor Area Turnover

$$Maintenance\ Market\ Turnover\ (ft^2) = \frac{Total\ Existing\ ft^2 - NR\ Turnover\ ft^2}{Average\ Lifetime\ of\ a\ Typical\ Lamp\ (years)}$$

A schematic flow diagram of this step is presented in Appendix A.

[27] Navigant plans to extrapolate based on U.S. Census data on industrial employment for each state in the region. Navigant is currently exploring potential data sources for industrial LPD. This will likely need to be confined to just the manufacturing segment of the industrial market given data limitations.

[28] The Sixth Plan analysis also factored in some constraints on ramp-up of program impacts, reflecting practical limitations, such as budgets.

[29] That is to say, the LPDs assumed as the baseline in these events were based on LPDs taken from a study of newly constructed buildings, which, lacking other data, were used as a proxy for the "current practice" baseline in the Sixth Plan.

Step 4. Calculate pre-case lumen demand. As noted earlier, for the purposes of this analysis, Navigant defined the size of the market in terms of lumen demand. Navigant calculated lumen demand using the following equation:[30]

Equation 4 Pre-Case Lumen Demand

$$Pre\text{-}Case\ Lumens\ = Pre\text{-}Case\ Average\ Efficacy\ (Step\ 2) \times Pre\text{-}Case\ Newly\ Installed\ Watts\ (Step\ 3)$$

Step 5. Calculate post-case "newly installed watts" in each year.
Navigant calculated post-case "newly installed" watts in each year by dividing pre-case lumen demand (calculated in Step 4) by weighted-average efficacy for that year (calculated in Step 2).

Step 6. Calculate "delta Watts" and total market savings. For each year of the analysis, Navigant subtracted post-case "newly installed" watts from pre-case "newly installed" watts to arrive at market savings in terms of watts ("delta watts"). To convert this to first-years savings in aMW, Navigant used the following equation:

Equation 5 Watt Savings and Total Market Savings

$$Annual\ aMW = \frac{MW\ \times\ Annual\ Operating\ Hours\ \times\ HVAC\ Interactive\ Factor\ \times Busbar\ Factor}{8760}$$

Table 15 Inputs for Calculation to Convert New Watts Installed to aMW

Input	Value	Description
MW	Variable	Millions of "Newly Installed" Watts
Hours	4,062	Weighted average operating hours for non-residential lighting
HVAC Interactive Factor	0.998	Weighted average interactive factor accounting for electric heating and cooling benefits and penalties
Busbar Factor	1.09	Accounts for transmission losses to reflect savings at generation

Step 7. Subtract programmatic savings. As noted earlier, BPA provided the Navigant team with non-residential programmatic savings data (in aMW for each year). To estimate BPA's share of non-programmatic savings, Navigant scaled down the market by 42 percent to approximate sales to BPA utilities only before subtracting BPA's non-residential programmatic savings.

Reconciling the Council baseline with programs' baselines. The team had to adjust the programmatic savings before subtracting them from the total market savings because of a difference in the baselines used by the Council as compared to programs. The Sixth Plan used a current practice baseline for non-residential lighting. This baseline assumed existing systems convert naturally at a given annual replacement rate to new, more efficient systems. These new systems represent the current practice,

[30] Although the LPD inputs do not change in each year, the weighted-average efficacy does change. Therefore, the results of the analysis will reflect an effective decrease in LPD over time.

which the Council freezes as the baseline over the planning horizon. This baseline, expressed in lighting power density (LPD), was intended to represent the market average lighting efficiency of newly installed lighting systems on a normal replacement cycle. In contrast, regional non-residential lighting programs used a pre-condition baseline. That is, programs calculated energy savings using a baseline characterized by the existing lighting system in the building, rather than what would have been installed on average.

As discussed above, Navigant estimated total market savings by calculating the improvement in lighting efficacy over the Council baseline for the entire non-residential lighting market. Then the team subtracted programmatic savings from this total; the remaining savings are the non-programmatic savings. However, because the program baseline and the Council baseline are not the same, without some analytical reconciliation, program savings are actually larger than the calculated total market savings, an illogical result. This occurs, again, because most program savings are calculated based on a pre-condition (i.e., "as found") baseline, which is lower than the current practice baseline assumed by the Council in the Sixth Plan. The savings below the Council baseline are, in effect, early retirement savings—the difference between the pre-existing condition baseline and the current practice baseline. It became necessary, therefore, to reconcile the baselines.

Analytically, Navigant approximated the pre-existing condition baseline for programs using the 2009 Commercial Building Stock Assessment. Navigant then used this average pre-existing condition baseline to for linear fluorescent (the bulk of program savings) to determine the share of program savings that used LPDs above the Council baseline and the share that were consistent with the Council baseline. The difference in programmatic savings determined by using the pre-existing condition baseline LPDs and the current practice baseline LPDs was approximately 22 aMW per year for the entire region and 9 aMW per year for public power from 2010 through 2012.

6.3 Non-Programmatic Savings Results

Overall, Navigant estimates that BPA will achieve 95 aMW in non-programmatic savings from 2010 to 2014. As shown in Table 16, annual non-programmatic savings in 2010 are just 1.3 aMW, but grow to 37 aMW by 2014.

Table 16 Annual aMW Savings in BPA Territory, 2010 – 2014

	2010	2011	2012	2013	2014	Total
Total Market Savings	12	22	32	41	49	155
Adjusted Program Savings	10	14	12	12	12	60
Non-Programmatic Savings	1	8	20	29	37	95

Navigant estimated the 2013 and 2014 programmatic savings based on the average savings from the previous three years. The total market savings for 2013 and 2014 are based on a linear extrapolation of the change in efficacy between 2010 and 2012 calculated from the distributor shipment data.

Appendix A Potential HID Baseline Methodology

Navigant recommends continuing to use a pre-condition baseline for HID replacements for the time being. However, this approach may not be appropriate in the future as newer technologies become more dominant and certain HID product types become "obsolete." This appendix describes an approach to creating a market average baseline for the "high-bay" market, or the market that has been historically served by HID.

Navigant began by collecting data on where current HID sales are going and what technologies are replacing old HID systems (either for replacement or retrofit applications). As described in section 5.1.5, manufacturers estimate that 75 percent of current HID sales are serving the maintenance market. As for the other 25 percent, Navigant used two data sources to help determine what technologies are taking share from HID lamps in the new construction and retrofit markets: first, non-residential program data from BPA's lighting program; and second, the shipment data collected from distributors. The programmatic data was used to help inform several aspects of the analysis, including:

- What efficient technologies are replacing HID systems and in what shares?
- What other non-HID technologies are these efficient technologies replacing and in what shares?
    - The answer to these questions implies the share of each efficient technology to attribute to the high-bay market.
- For linear fluorescent technologies, what are the most common fixture configurations that replace HID systems (e.g. two, three, four lamp)?
    - The answer allows for the distribution lamps to different systems, which compete with different HID technologies in a range of lumen 'bins.' (E.g., A two-lamp linear fluorescent system will compete with a different mix of HID technologies than a six-lamp system.)

The programmatic data made clear that significant diversity exists in the HID replacement market. As shown in the table below, CFLs, higher efficiency HID, induction, LED, T5 and T8 systems are all replacing HID existing systems and no one technology is dominant.

Table 17 Efficient Technologies Replacing HID in BPA Programs

T8	T5	LED	Induction	CFL	HID	Total
22%	28%	10%	6%	18%	16%	100%

Source: BPA Program Data, Navigant Analysis

In contrast, as shown in Table 18 four-foot T8 systems are the dominant replacement for the other commonly retrofitted existing high-bay technology: eight-foot linear T12 systems. Even for retrofitted high-output eight-foot systems, T5 systems only make up only 9% of the retrofits.

Table 18 Technologies Replacing Eight-foot Regular and High Output T12 Systems

4ft T8	8ft T8	Other	Total

4ft T8	8ft T8	Other	Total
95%	4%	1%	100%

Source: BPA Program Data, Navigant Analysis

The programmatic data also showed that although T8 systems make up a significant portion of HID retrofits, these retrofits are dwarfed by the T8-to-T12 projects: only 3.6% of T8 systems replace HID, and only 8.7% replace high-output eight-foot T12 systems. Thus, Navigant estimates that only 12% of T8 sales are serving the high-bay market. In contrast, HID replacement drives almost 75% of T5 retrofits, and combined with high-output eight-foot T12 replacements over 90% of T5 sales are serving the high-bay market. Table 19 and Table 20 show these distributions.

Table 19 Technologies Replaced by T8 Systems in Program Projects

8ft T12	8ftHO T12	4ft T12	HID	T8	Inc.	Total
10%	9%	63%	4%	18%	16%	100%

Source: BPA Option 1 Utility Program Data, Navigant Analysis

Table 20 Technologies Replaced by T5 Systems in Program Projects

8ftHO T12	HID	4ft T12	Other T5	Inc.	Total
15%	75%	3%	2%	5%	100%

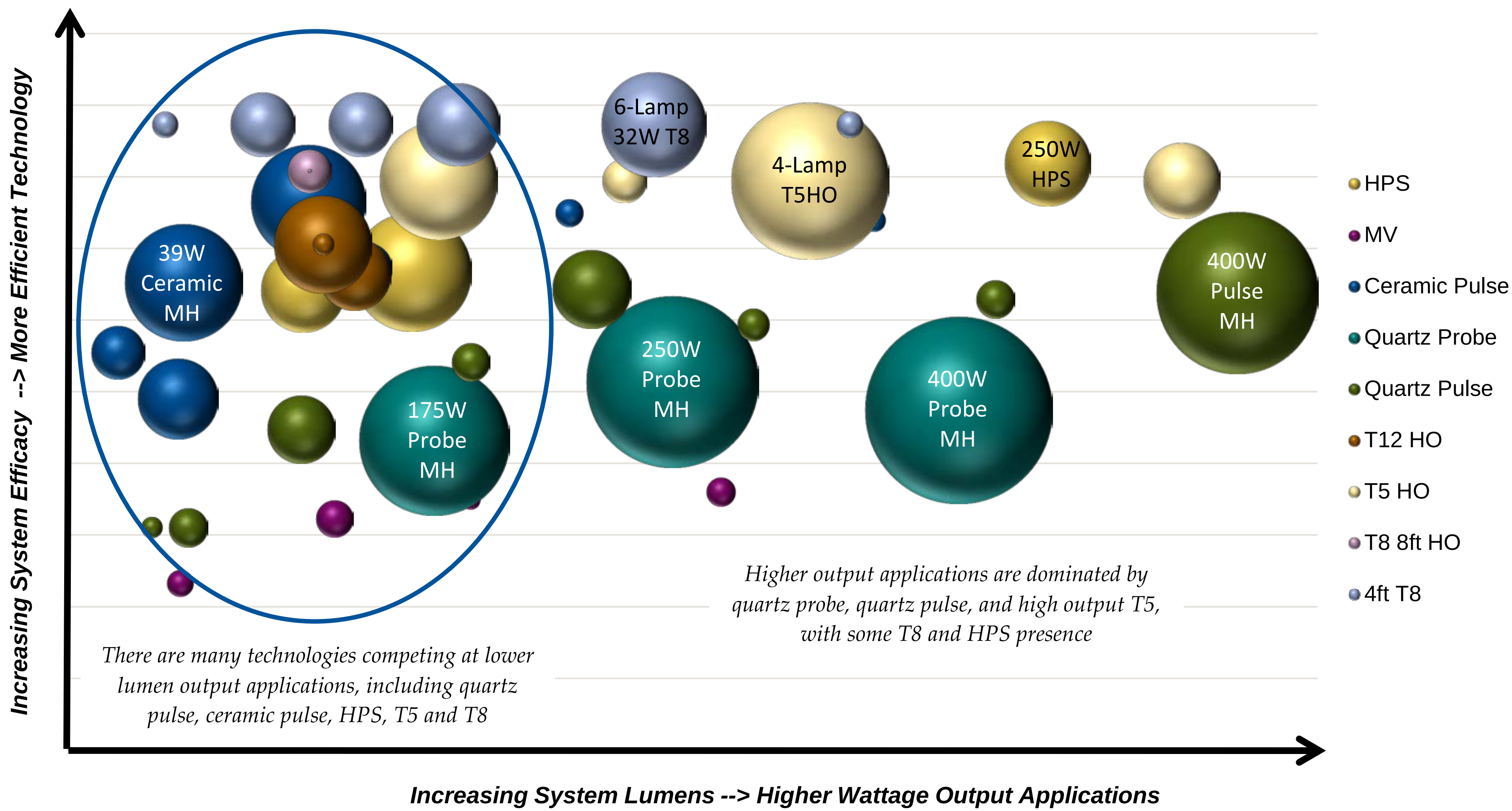
Source: BPA Option 1 Utility Program Data, Navigant Analysis

Navigant compared these data to the shipment data from distributors for HID, eight-foot high-output, T5 and four-foot 32W T8 fluorescents. Navigant used the percent of T8 retrofits penetrating the high-bay market from the programmatic data to determine how much of the 32W shipment data to include.[31] Figure A.1 shows the distribution of HID sales across technologies, organized by lumen output (x-axis) and efficacy (y-axis). The size of each circle represents the relative sales of a given wattage per technology. While the figure illustrates the diversity in this market, it also shows that the number of competing technologies is greatest at the lower lumen output levels where ceramic pulse sales are strongest. Navigant did not include CFL or LED sales in this comparison due to lack of consistent data, but the lower lumen ranges are also where these technologies are encroaching more on HID sales. Navigant did not collect any data on induction lamps, but as shown in the programmatic data these are likely a small portion of the market.

In the higher lumen range (10,000 lumens and above), the picture is clearer: metal halide probe lamps still dominate the HID sales, although T5s and some T8s at lower lumen applications are also a significant portion of sales. The three largest probe wattages are (from left to right) 175W, 250W, and 400W. The most common T5 system which appears in this range is a four-lamp fixture.

[31] Programmatic data showed that 32W lamps were the most common used in HID retrofits

Figure A.1 High-Bay Market Sales by Technology



This chart demonstrates the range of efficacy levels of technologies competing for a continuum of applications, increasing in wattage. Each circle represents the relative sales volume of a given technology in 2012, as reported by Northwest distributors.

Navigant observed the following key trends from this analysis:

- Mercury vapor lamps are the least efficacious technology and also show very low sales. This is the only HID technology that is effectively "obsolete."
- Probe-start HID sales still dominate sales in applications requiring greater than 10,000 lumens per lamp.[32] The large share of sales for this technology show that it is far from obsolete.
- Ceramic pulse lamps are very popular at lower lumen outputs, but do not hold much share in higher lumen applications.
- High-pressure sodium (HPS) lamps shares are moderate across lumen outputs, and this technology generally falls in the "middle of the pack" in terms of efficacy, except at high lumen outputs where it is a leader.
- T5 systems are also a big player, especially in the higher lumen ranges. This aligns with the programmatic data which showed a large volume of 400W HID to four-lamp T5 retrofits.
- While T8 systems exceed all other systems in terms of efficacy, sales in this market remain moderate.
- Although pulse-start metal halide fixtures are consistently more efficient than their probe counterparts, only the 400W sales are strong (far right large circle).

The final step in determining a market average baseline for high-bay technologies would be to group the technologies shown in Figure A.1 by lumen output and/or application type (e.g. outdoor, high-bay, etc.) and determine the market average efficacy in each group, providing a step function that could provide a market average baseline efficacy based on the lumen output and/or application of the proposed technology in a retrofit. The program could then calculate the watts saved by subtracting the equivalent baseline watts from the actual wattage of the proposed equipment as shown in Equation A.1:

Equation A.1 Watt Savings

$$\Delta\, Watts = Baseline\ Watts - Actual\ Efficient\ Watts$$

Where:

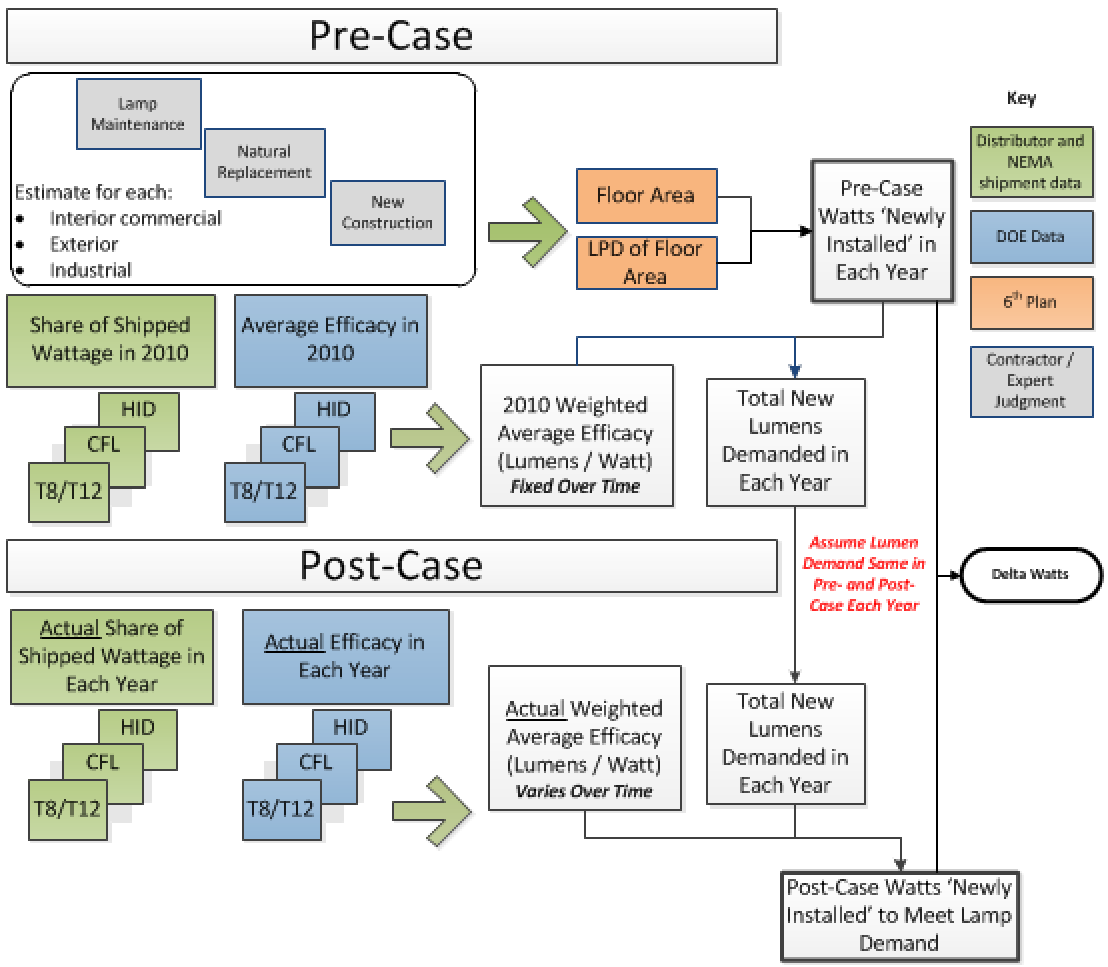
$$\text{Baseline Watts} = \frac{\text{Efficient Lumens}}{\text{Baseline Efficacy}\ \left({}^{\text{L}}/_{\text{W}}\right)}$$

Determining this step function will be simple, but determining how to group competing technologies will be more complex and require subjectivity and professional judgment regarding the emergence of LED technologies.

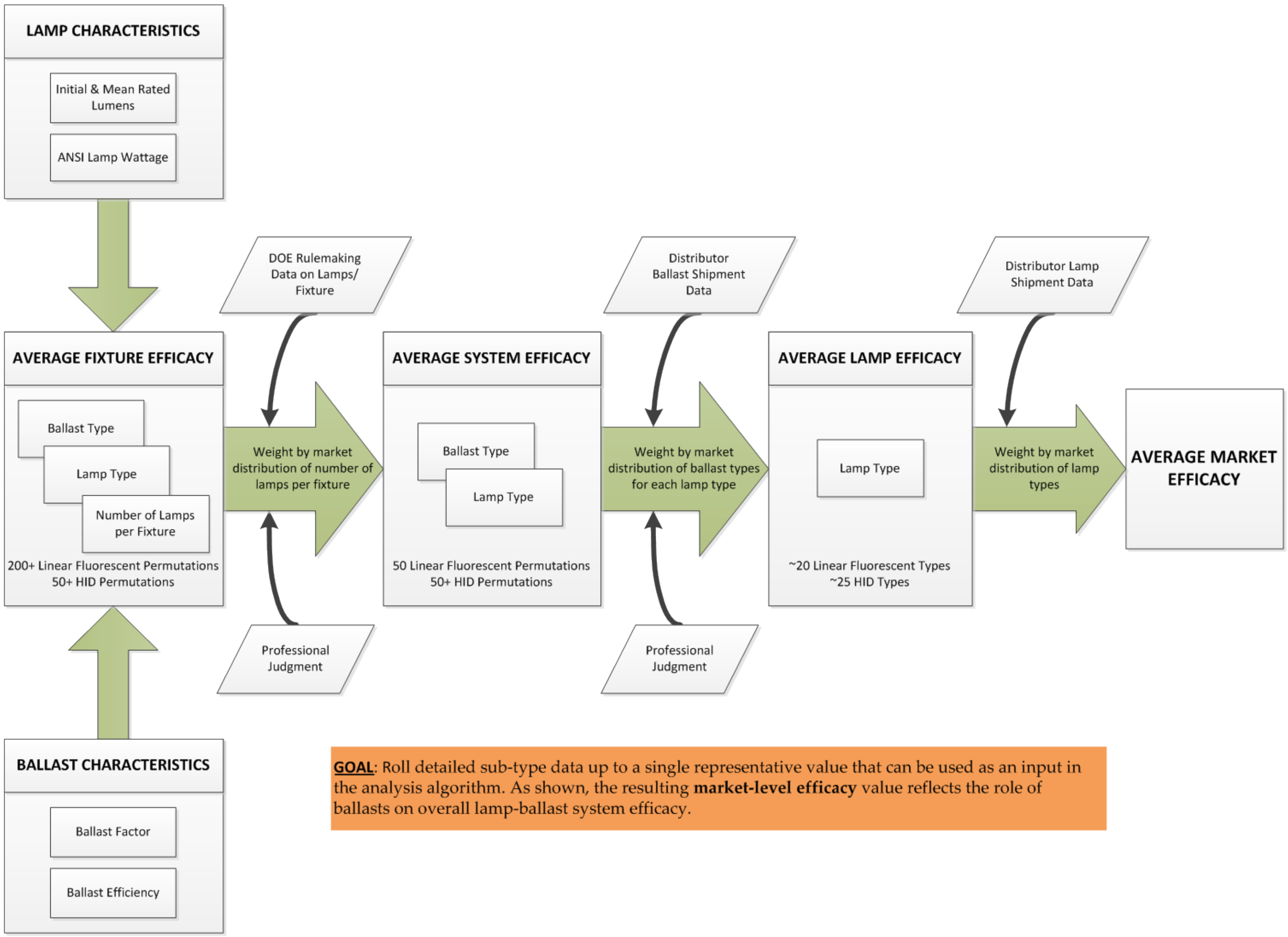
[32] Per fixture for linear fluorescent technologies

Appendix B Non-programmatic Savings Estimation Analysis Schematics

B.1 Schematic of Non-Programmatic Methodology

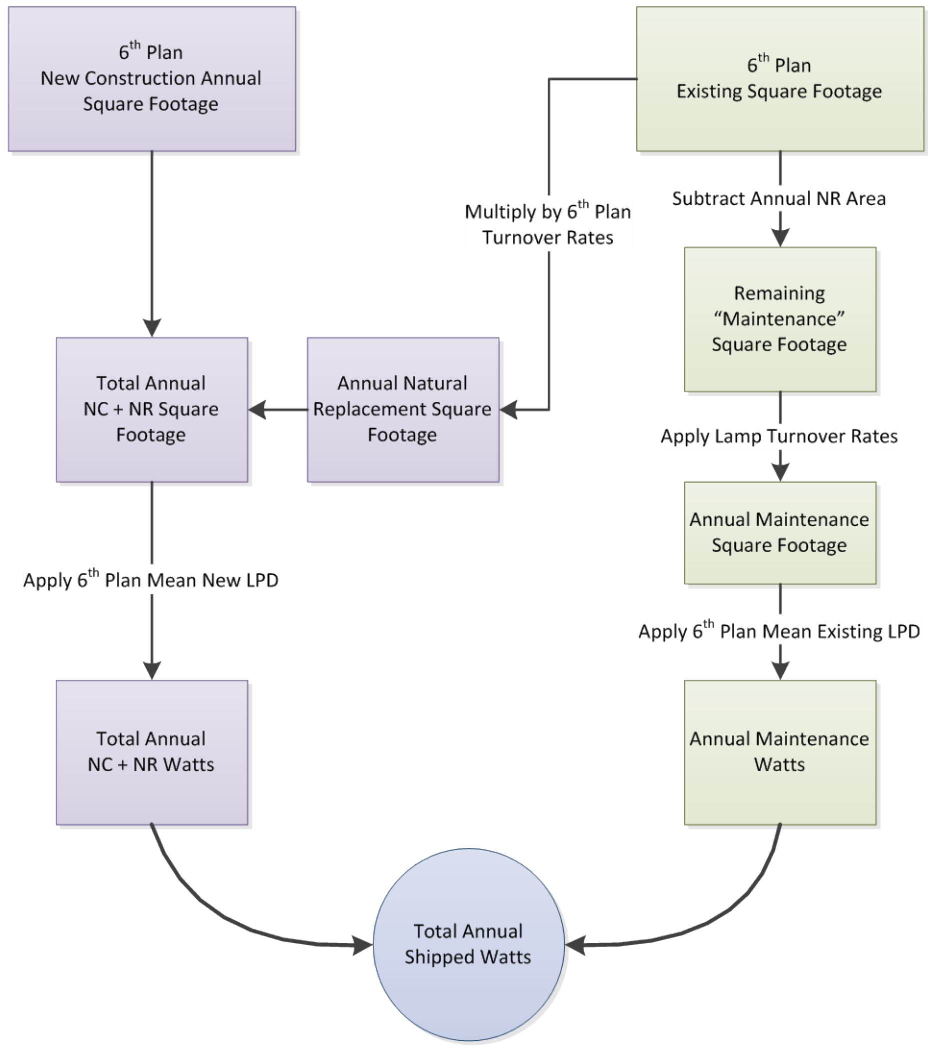


B.2 *Schematic Summary of Step 1 of Non-Programmatic Methodology*



GOAL: Roll detailed sub-type data up to a single representative value that can be used as an input in the analysis algorithm. As shown, the resulting **market-level efficacy** value reflects the role of ballasts on overall lamp-ballast system efficacy.

B.3 Schematic Summary of Step 3 of Non-Programmatic Methodology (Interior)



Appendix C Northwest Lighting Experts Interview Guide

BPA Non-Residential Lighting Market Characterization

Interview Guide for Northwest Regional Lighting Market Experts

Contact Name:	
Company Name:	
Company Phone:	
Company Address:	
Today's Date & Time:	
Attendees:	
Notes:	

INTRODUCTION

This interview is meant to inform our efforts to successfully complete a "Non-Residential Lighting Characterization" for BPA's territory. For context, the goals for this project are as follows:

1) Characterize the commercial lighting market baseline in BPA's territory.
    a. Find the market average for what is being installed for:
        i. New Construction
        ii. Retrofits of T-12 systems
        iii. Retrofits of T-8 systems
        iv. Retrofits of HID applications
2) Establish a deemed savings value that will be approved by the RTF.
3) Estimate the non-programmatic savings associated with lighting market activity.

At this stage of the project, we hope to learn more about the Northwest lighting market, including its market participants, the common distribution chains, and other characteristics. We also hope to get your perspective on our plans for data collection and analysis. The following questions are meant to guide the discussion to these ends.

STAKEHOLDER COORDINATION

We understand other organizations may have similar or related efforts planned or underway in the region. We recognize the importance of minimizing burden and confusion among the trade allies (as well as non-program participants) as we request data and conduct interviews. When possible, we hope to complement and not duplicate any other regional lighting efforts.

1. *Are you aware of any similar ongoing or planned projects among energy efficiency organizations or utilities in the Northwest? If so, what are the goals of these projects and what data are they seeking?*

DISTRIBUTION CHAINS

We are considering framing this analysis around five primary "purchase events" in order to characterize the likelihood of various systems being installed. We see five major drivers ("events") behind all lamp purchases:

- Lamp failure
- Ballast failure
- Retrofit (defined as occurring for energy efficiency reasons)
- Renovation or fixture replacement
- New Construction

2. *Do you believe these events are comprehensive of the market (represent the totality of shipments)? If not, what is missing?*

3. *Do the below distribution chains, grouped by "purchase event," appear appropriate and comprehensive of non-residential lighting market sales? Are there any listed below that you consider unlikely or inaccurate? Please keep in mind that "Retailers," as contemplated below, could be either brick-and-mortar or web-based.*

New Construction

- Manufacturer→Builder (General Contractor)→Lighting Contractor→End User
- Manufacturer→Builder (General Contractor)→Architect/Lighting Designer→Lighting Contractor→End User

Renovation and Fixture Replacement

- Manufacturer→Distributor→Contractor → End User
- Manufacturer→Retailer→Contractor → End User

Retrofit

- Manufacturer→Distributor→Contractor → End User
- Manufacturer→Retailer→Contractor → End User

Ballast Failure

- Manufacturer→Distributor→ Building Operator→ End User
- Manufacturer→Distributor→ Contractor → End User
- Manufacturer→Retailer→ Contractor → End User
- Manufacturer→Retailer→ End User

Lamp Failure

- Manufacturer→Distributor→ Building Operator→ End User
- Manufacturer→Distributor→ Contractor → End User
- Manufacturer→Retailer→ Contractor → End User
- Manufacturer→Retailer→ End User

4. *How are lighting decisions made in the non-residential **new construction** market? That is, who decides which lighting systems to install and who touches those systems as they are 'pulled' down the new construction chain? Are there any specific entities or organizations you would recommend we speak to (builders, designers, etc.) to better understand the new construction purchase event?*

5. *Would you say that ballasts and lamps follow the same distribution chains? If not, how are they different and why?*

INTERVIEW TARGETS

We plan to interview and request data from distributors, lighting contractors, building operators, and manufacturers and we seek your input on how best find the appropriate mix and sample of interviewees.

Distributors. At this time, we expect to speak with 10-20 distributors in the region. We seek to gather sales data covering as much of the market as possible while ensuring we cover each of the purchase events. We are cognizant of the need for these distributors to be representative of the region, both geographically and across the purchase events listed above. We also want to ensure that our interview sample is NOT biased toward "program participants."

6. *How are distributors currently involved in energy efficiency programs in the Northwest, if at all?*

7. *Do you, or does anyone you could put us in contact with, have market share estimates of distributors in the region? (For our purposes, we define market share as total lamps sales to the region, rather than share of energy efficient retrofit activity.) If so, please provide any estimates you have.*

We currently have the following list of distributors (and contacts):

[Removed]

8. *Do you think these distributors are generally representative of the entire market, including all of the purchase event types we discussed above? Why or why not?*

9. *Please provide any more distributors (with contact names and information, if possible) with whom you recommend we speak.*

To complete this project, we will need to understand what lighting technologies are being installed in the market and, for some purchase events, what they are replacing. We plan to interview 30-40 lighting contractors and building operators (as well as request they maintain a journal of installations for two weeks—more on that below) to gather this information.

It will be important to speak with, and get data from, a sample of contractors and building operators that is representative of all installations in the market. For example, we understand that the installation data from a contractor who works exclusively in industrial settings or large office buildings would not be representative of market activity. Similarly, lighting contractors only doing fixture renovations will not report what is installed during the (typically most frequent) lamp failure purchase event.

10. *Beyond building size, space-type, and purchase-event, are there any other parameters we should consider when we develop our sample of contractors and building operators?*

With lighting contractors, in particular, we are concerned that interviewing contacts made only through the Trade Ally Network or utility program participant lists would bias any findings.

11. *We have a list of lighting contractors from the Trade Ally Network. We also plan to also reach out to contractors in the National Electrical Contractors Association. What methods would you suggest to broaden that list to the greater population of contractors?*

12. *Could you please speak generally to how representative of the lighting market the Trade Ally Network is or is not? That is, does it include the majority of lighting contractors doing the majority of installations in the market, whether incented or not? Does it include large and small contractors serving large and small businesses? Does it include contractors serving all "purchase events" listed above? How are contractors recruited to the network?*

We also plan to interview building operators. Our current understanding is that they would be in a position to help us understand what is occurring in the lamp failure and ballast failure purchase events (i.e., maintenance market), in particular. A significant share of lamp sales goes to this market segment.

13. *Do you agree that building operators would be an appropriate part of the distribution chain to speak with, given the goals of this project? If not, who would be able to speak to the maintenance market?*

14. *How would you recommend we select building operators to interview? Would it be appropriate to randomly select buildings using the CBSA and then request interviews with their operator?*

Retailers also supply a portion of the non-residential lighting market.

15. *Do you or does anyone you could put us in contact with have contacts with retailers that may be able to share sales data on or insights into the non-residential lighting market?*

Manufacturers and manufacturer reps can occasionally provide sales data or insights into market trends.

16. *Do you have contacts with manufacturers or manufacturer reps that may be able to share sales data or insights into the non-residential lighting market?*

17. *Is there anyone else in any field that you believe we should talk to for this project (architects, lighting designers, etc.)?*

As mentioned above, we are considering framing this analysis around five primary "purchase events" in order to characterize the likelihood of various systems being installed in the four baseline cases at issue in the project. We currently have a good understanding of the distribution of shipments across these purchase events for the non-residential lamps types. We plan to establish through interviews and lighting journals the likelihood of various systems being installed in each of those purchase events. Our preliminary thinking is that we will allocate the region's total shipments (calculated from distributor data requests) among the purchase events (70% lamp replacement, 10% new construction, etc.). Then we can apply the likelihood of each purchase event to the likelihood of each system being installed within each purchase event to establish the market-weighted baseline characterizations.

18. *Do you have any specific reaction to this methodology?*

DATA COLLECTION

As mentioned above, data collection will be critical to the success of this project. We will need to calculate total market shipment data for fluorescent lamps and ballasts, as well as installed stock data. More specifically, this data will have to be broken out by lamp diameter (T12, T8, and T5), lamp length, Wattage, and efficiency. Ballast data would have to be broken out by magnetic/electronic, lamp diameter, and ballast factor. In addition to interviewing market actors like distributors and contractors, we will be collecting NW lighting market data from all other data sources available. We are aware of the CBSA and DOE data sources, as well as several utility-funded evaluation studies.

19. *Are there any other sources of NW lighting market data that could be useful for this project? Do you or does you organization have any data (or contacts?) that you could share that would help us successfully achieve the goals of this project?*

Again, we plan to interview the major lighting distributors in the region to gain access to shipment data.

We understand the challenges associated with persuading market actors to share shipment data. As such, we plan on offering distributors a $200 incentive, an offer to sign an NDA, and, for those who participate, a memo characterizing their market share based on our analysis.

20. *Do you think the $200 incentive, NDA, and market share memo will be sufficient motivation to distributors to provide shipment data? If not, how would you change or add to this approach to improve our chances of successfully collecting shipment data for the Northwest region?*

Again, we plan to interview 40 to 50 lighting contractors and building operators to understand what products are currently 'in the ceiling' and what is going in their place. Again, we understand the challenges associated with persuading market actors to share their time in this effort. As such, we plan on offering a $200 incentive and an offer to sign an NDA, in exchange for the contractor keeping a two week "journal" of the jobs they complete. We will provide the contractors a clear template for the journal data required.

21. *Do you think the $200 incentive and NDA will provide sufficient motivation for contractors to keep a two-week journal of their jobs? If not, how would you change or add to this approach to improve our chances of successfully collecting installed stock and installation data for the Northwest region?*

NORTHWEST REGION

22. *Would you expect the Northwest region to be substantially different than the national average, in terms of average installed efficacies, lighting power densities, shipped efficacies? If so, why and how so?*

23. *Is it fair to assume that the Northwest's lighting market is roughly representative of BPA's service territory in terms of product mix?*

24. *Do you have a sense for how the commercial lighting market has changed in the last five years in the Northwest region? (For example, have certain technologies taken share from others? Has there been a migration to greater efficiency? A downtick or uptick in retrofit activity?)*

    a. *How would you advise we go about confirming these trends, or finding evidence to support them?*

CODE COMPLIANCE IMPACTS

Many lighting projects trigger building energy codes in effect in the Northwest. For example, in Washington any project which retrofits more than 10% of the fixtures in a space must comply with the current energy code. For several reasons, including uncertain levels of enforcement, there are concerns that many lighting 'jobs' that trigger code do not in fact comply. The level of noncompliance is unknown but clearly could impact the technology installed.

25. *Based on your experience, do you have any sense for the level of compliance with when lighting retrofits trigger building codes in the Northwest?*

26. *Do you have any ideas on methods of estimating the compliance with building codes? For example, we are considering having contractors gather the information to be able to calculate LPD as the percentage of the total space affected. Do you have any specific reactions to that?*

REGIONAL TECHNICAL FORUM

As discussed earlier, we are attempting to determine the baseline for four "purchase events": new construction, T12 retrofits T8 retrofits and HID retrofits. We are considering the baseline to be the average (non-incented) fixture installed during each of these events. To be clear, the baseline is not the lowest efficiency, but the market average that is installed without incentives.

27. *Is this definition of the "baseline" consistent with how the RTF would define it? If you are not familiar with the RTF's procedures, how would you define "baseline" in these cases?*

28. *How does the RTF define "retrofit" in terms of the above purchase events? For example, does "T12 Retrofit" refer exclusively to early retirement? Or does it include replace-on-burnout? Again, if you not familiar with the RTF's procedures, how would you define "retrofit" in these cases?*

29. *We expect that a single Unit Energy Savings value may not be adequately descriptive of the average energy saving for a High Performance T8 lamp or lamp fixture. Do you agree? Why or why not?*

30. *Should savings be prescribed by lamp or by fixture? Why?*

OTHER

31. *Is there anything else you think we should discuss that may help us in this project?*

Appendix D Northwest Electrical Distributors Interview Guide

Annual Survey of Northwest Electrical Distributors

Sponsored by NEEA and BPA

March 2013

Contact Name:						
Company Name:						
Company Northwest Coverage: (determine prior to interview)	**OR**	**WA**	**ID**	**MT**	**No.CA**	**Notes**
Company Phone:						
Company Address:						
Today's Date & Time:						
Attendees:						
Notes:						

INTRODUCTION [SKIP THIS SECTION IF ALREADY DISCUSSED WITH NAVIGANT]

1. We'd like to start off by making sure we're on the same page in terms of geographic scope and timeframe. Our perspectives are:
   - **a.** Geographic Scope: Our study is concerned with typical practices in the Northwest (NW), **which we define as WA, OR, ID, and MT.**
   - b. Timeframe: For all questions in this guide, you can assume the time period we are referring to is the calendar year 2012, unless we specify otherwise. If it strikes you that 2012 was different in some way with respect to the question, please let us know.
2. Ideally, we'd like your feedback (and data) to be specific to this region and timeframe. Will that be possible?

3. From what perspective will you be speaking and providing data?

   - *a. The entire company?*

     - i. If yes, does the company have any branches outside the Northwest?

            1. If so, how many?

   b. *All NW branches and no others (preferred if possible)?*

      i. If yes, how many branches?

   c. *Specific subsidiary/ies or branch/es of company within the Northwest region.*

      i. If yes, which subsidiaries and/or branches?

   d. *A specific group within a company (e.g. energy efficiency division)*

4. *If contact does not represent all Northwest locations:* Do you have contact information for someone we might be able to speak to at <Company’s> other locations?

5. And what is your role within <Company/Branch>?

General Company & Market

For the purposes of this interview, we are defining the “non-residential” market as commercial and *industrial* buildings, including exterior lighting. We are primarily interested in the sales of <u>linear fluorescent, HID, and LED systems</u> within the Northwest. Again, for the purposes of this interview, we are defining the Northwest as all of WA, OR, ID, and MT.

1. With that definition, about what percentage of <Company’s> lighting sales is non-residential versus residential?

2. How many employees does your company have?
   a. Supporting NW operations
   b. Company as a whole

3. Does your company have a specific energy efficiency group or department? Do you have a ‘maintenance’ group? A ‘new construction’ group? Other market-oriented departments?

   a. If yes, are there marketing staff dedicated specifically to any of these groups?

4. Can you provide a rough estimate of the total volume of non-residential lighting <all of/this branch of> <Company> sold in the Northwest in 2012, either in terms of number of units sold or dollars, whichever is easier for you to speak to?

5. Roughly what percent of all non-residential lighting sales in the Northwest market flow through your company? In other words, what is your estimated market share in <the Northwest/your state> for non-residential lighting sales?

<u>Non-Programmatic Activity (lighting sales that are not part of utility incentive programs)</u>

1. Do you participate in any energy efficiency incentive programs? If yes, which one(s)?

2. Are you signed up as a trade ally for any energy efficiency programs?

3. Roughly what percentage of ALL of your high efficiency lamps and ballasts (e.g., high performance T8 systems) sales occur OUTSIDE of energy efficiency incentive programs? That is, they are not incentivized?

4. What portion of these non-incentivized high-efficiency units do you estimate replace less efficient equipment vs. replace the same equipment (i.e., a HPT8 lamp replacing a HPT8 lamp)?

    a. Has this changed over the past couple of years? If so, how?

5. Roughly what percentage of lighting *projects* (as opposed to the maintenance market) in existing buildings occurs outside of energy efficiency incentive programs? Why do these projects not access energy efficiency program incentives? (E.g., Project doesn't qualify for incentives, decision maker unaware of applicable programs, etc.?).

6. How would the market share for high efficiency lamps and ballasts be different if the region's efficiency incentive programs were not available?

<u>Maintenance Market and Installations Practices</u>

We've identified five different types of "purchase events" that drive non-residential lighting sales. These "causes" of lamp and ballast sales include:

- New construction;
- Renovation/remodeling projects that replace entire fixtures (e.g., major tenant improvement);
- Lighting upgrades made for energy efficiency purposes (*and may be called a "retrofit" and may or may not be incentivized by a utility program*);
- Routine maintenance for lamp and ballast failures (also known as 'onesie-twosies' or 'spot replacements');
- Maintenance: Scheduled end-of-life or 'group relamping' (e.g., replacing all lamps in a space when they reach 70% of rated life)

1. We’re interested in learning more about the last two events in this section (routine maintenance and group relamping). Can you speak to how each of the business types below operates with respect to their routine lighting maintenance activities? For example, do they typically replace lamps and ballasts on a schedule or only when they burn out?

Understanding the Lighting Maintenance Market			
Business Type	**More likely to:**	**Who makes decision on what to install?**	**Who typically does the installation?**
	(A) Group relamp & re-ballast. (B) Only replace when lamps fail.	Possibilities: (1) Electrical Contractors, (2) Internal Building Maintenance Staff, (3) Lighting Maintenance Contractors, (4) Building Owners or Operators, (5) Other	
Large Commercial Office			
Small Commercial Office			
Large Retail			
Small Retail			
National Chains (National Accounts)			
Independent Businesses			
Schools			
Hospitals			

Effects of the Federal Standard Change

Now I'd like to discuss the impact of the federal standard change for general service fluorescent lighting that occurred on July 14, 2012, which increased the efficiency requirements of linear fluorescent lamps manufactured after this date.

7. How do you think the market changed for non-residential lamp and ballast sales between 2010 and July 14, 2012? *(Which technologies gained share, which lost share, etc.?)*

8. How do you think the market has changed since July 14, 2012?

9. How do you expect the market to change between now and around this time next year?

10. When a 40W T12 lamp burns out, non-residential customers typically respond by replacing it with which of the following (please estimate likelihood based on your understanding of the market)?

Replacement Option:	Likelihood:
New Compliant T12 Lamp	%
Exempt High CRI T12 Lamp	%
High Performance T8 System	%
Standard T8 System	%
T5 System	%
Other (please specify)	%
Total	100%

11. Of those moving to T8s from T12s, which lamp wattage will be most common? Which efficiency series?

For those purchases replacing T12 lamps with T8 lamps, the estimated distribution by wattage and efficiency is:			
T8 Lamp Wattage	Wattage Distribution	T8 Efficiency Series	Efficiency distribution
32W	%	**700 Series**	%
28W	%	**800 Series**	%
25W	%	**Other (High CRI, Specialty)**	%
Total	100%	**Total**	100%

12. Are you seeing any significant growth in the sales of high-efficiency fluorescent ballasts either in response to the new lamp standards, or upcoming (2014) changes in efficiency standards for ballasts?

13. What share of your fluorescent ballast sales are High Ballast Factor, Normal Ballast Factor, and Low Ballast Factor?

Fluorescent Ballast Factor Distribution	
Ballast Factor	Sales Distribution
High	
Normal	
Low	
Total	100%

14. Are any specific lamp types are more frequently paired with High or Low Ballast Factors?

<u>Sales Channels</u>

1. Prior to this interview, I sent you our map of the non-residential lighting supply chain. *[See end of interview guide.]* Do you feel this map reasonably reflects the lamp supply chain and relationships between lighting market actors in the Northwest? If not, how would you propose changing it?

2. What percentage of Northwest (i.e., WA, OR, ID, and MT) non-residential lighting sales do you think occurs through channels like Sylvania's direct sales program?

3. Are you aware of non-residential lighting sales occurring in the Northwest through online retailers (perhaps from overseas)?

    a. If so, roughly what portion of the market's sales do you think are occurring through this channel?

    b. How do you foresee this changing over the next few years?

Market Actors & Relationships

1. What type(s) of contractors (e.g., general, lighting maintenance, or electrical contractors) do you typically work with on non-residential lighting projects in existing buildings?

2. Can you describe how these relationships form and the types of business transactions that occur with the contractors?

3. Can you describe your relationship with representatives from lighting and fixture manufacturers?

4. Do you currently have any partnerships with ESCOs?

5. Do you sell to any national accounts (e.g., Target, Wal-Mart, etc.)?

    a. Where do most of these customers purchase their lighting equipment? Direct from manufacturers? In-region or out-of-region sources?

Technologies & Stocking

1. What/who would cause you to begin stocking a unit or lamp technology that you were not stocking before? Can you describe any recent changes in stocking practices with respect to lighting technologies? What do you need to do to make a change to, say, begin stocking a new LED?

    a. Are there any lighting products you currently stock but are considering dropping?
    b. Are there any lighting products you do NOT stock but are considering adding?

2. What share of your stock sales are subject to Special Pricing Authorizations, if known?

3. What portion of your lighting sales are “warehouse” sales versus “direct from manufacturer” sales?

Marketing & Business Practices

1. Does your company track inventory turnover rates (or days sales outstanding) for all sales? If so, how granular is your tracking capability? That is, does your company track by turnover rates for all sales, lighting sales, product category, or down to the SKU?

    a. What is your inventory turnover (times per year)?

2. Is there a maximum threshold for turnover (number of days in inventory) that your company targets for lamps and ballasts? If so, what is the threshold? Does it vary by lamp type (linear fluorescent vs. LED troffers vs. incandescent)? If so, how?

3. Is it typical to use a higher markup on high-efficiency lamps/products than standard efficiency lamps/products? (E.g., The price to your customer for a HPT8 is [1.3*COGS[33]] while a standard T8 lamp is [1.2*COGS].

4. Do you use co-op marketing funds?

5. Do you have dedicated marketing (distinct from sales) staff?

6. Do you currently offer financing options?

7. Do you currently offer online transactions?
    a. What percentage of your lighting sales is transacted online?

Follow-Up

1. What do you think your organization needs from the utility efficiency business to help push more efficient options in the NW over the long term? What kinds of tools, resources, rewards, or incentives can help?

2. Do you have any additional thoughts on the non-residential lighting market in the Northwest that we did not discuss today, but you feel are important for our efforts?

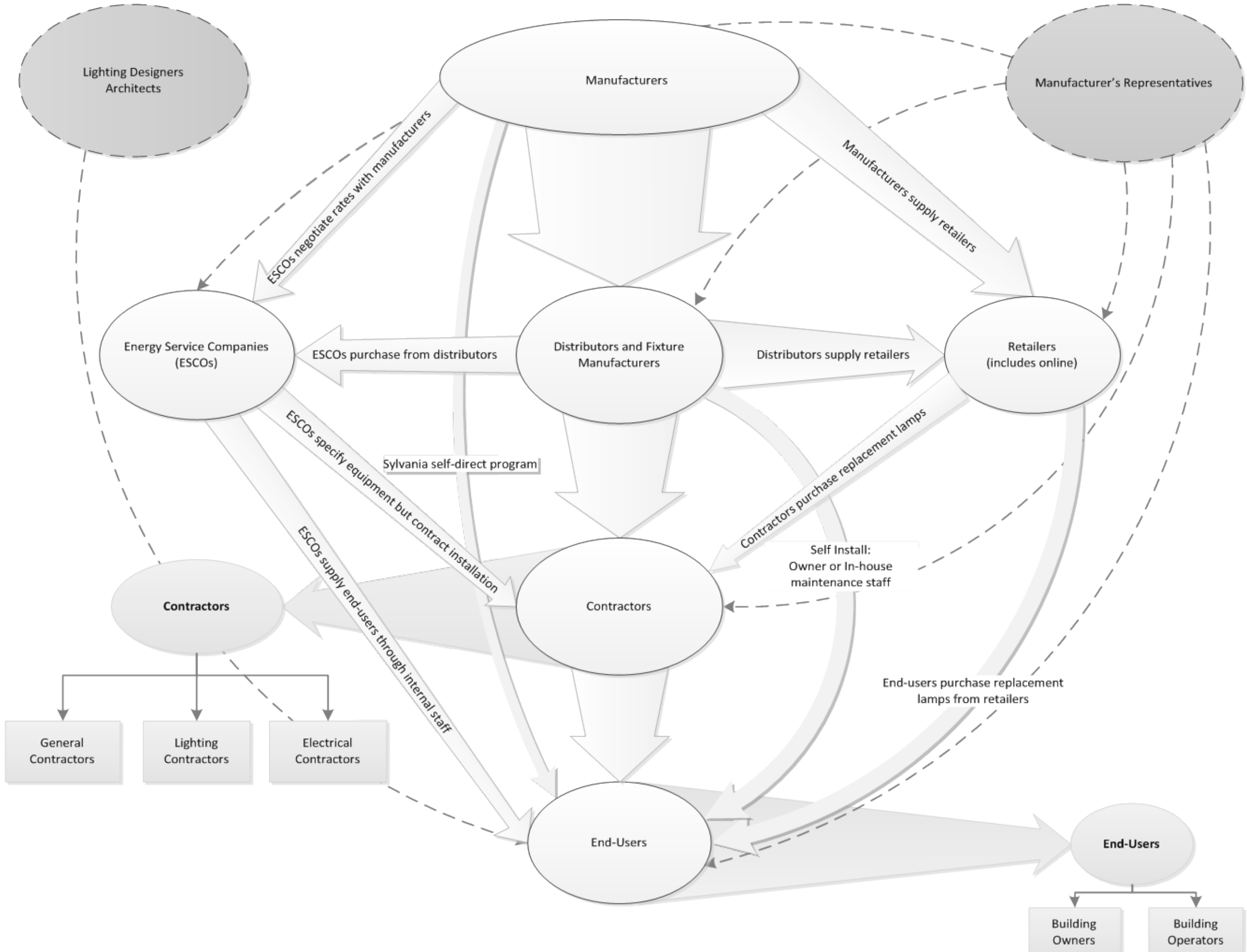
[33] Cost of Goods Sold

3. What questions should we ask NEXT YEAR for this survey? What other metrics or topic areas would be helpful or interesting for you to compare your business against your peers?

Topic Area	Suggested Metric/Question
E.g. Financial	Gross margin percentage.

C

Non-Residential Lighting Supply Chain



Appendix E Fixture Manufacturers Interview Guide

BPA Non-Residential Lighting Market Characterization

Interview Guide for Fixture Manufacturers

Distribution Channels

1. Roughly what share of product that flows through each channel?

Fluorescent Fixtures	Distributor	
	Retailers	
	Direct	
	Other	
	Total:	**100%**
HID Fixtures	Distributor	
	Retailers	
	Direct	
	Other	
	Total:	**100%**
LED Fixtures	Distributor	
	Retailers	
	Direct	
	Other	
	Total:	**100%**

2. In any of these channels, do you ship fixtures with the lamps and/or ballasts (presumably the share of units shipped with ballasts is much greater) or are those installed later by another party in the distribution chain? If so, what share would you assume by channel (roughly)?

		Share of Fixtures in category Shipped with Lamps (%)	Share of Fixtures in category Shipped with Ballasts (%)
Fluorescent Fixtures	Distributor		
	Retailers		
	Direct		
	Other		
HID Fixtures	Distributor		
	Retailers		
	Direct		
	Other		
LED Fixtures	Distributor		n/a
	Retailers		n/a
	Direct		n/a
	Other		n/a

3. Does any channel typically serve a certain type(s) of customers? (E.g, Retailers -> small contractor; Direct -> Wal-Mart, etc.)

4. How are your manufacturer representatives involved in the product flow? (Do they specify and sell jobs? Do they partner with distributors?)

5. We are investigating the rate of fixture turnover. Does your company have estimates for turnover rates based on historical experience? (E.g., Retail typically refurbishes once every X years.) How do these rates vary by building type or building ownership type?

6. In the nonresidential sector, how likely is each of the following reasons to be the cause of the purchase of a given fixture? In other words, of all your fixture sales, what share is being driven by each cause?

Fluorescent	**Ballast Failed**	
	Renovation/Remodel	
	New Construction	
	Retrofit for Energy Efficiency	
	Other	
	Total:	**100%**
HID	Ballast Failed	
	Renovation/Remodel	
	New Construction	
	Retrofit for Energy Efficiency	
	Other	
	Total:	**100%**

7. To your knowledge, are T12 fixtures specified for new construction anymore? Major renovation and remodeling?

8. Do you manufacture LED fixtures/luminaires?

Appendix F Lamp Manufacturers Interview Guide

BPA Non-Residential Lighting Market Characterization

Interview Guide for Lamp Manufacturers

Contact Name:	
Company Name:	
Company Phone:	
Company Address:	
Today's Date & Time:	
Attendees:	
Notes:	

<u>Distribution Channels</u>

6. In the non-residential sector, please indicate the share of product that flows through each channel.

Fluorescent	Distributor	
	Retailers	
	Direct	
	Other	
	Total:	**100%**
HID	Distributor	
	Retailers	
	Direct	
	Other	
	Total:	**100%**

7. Does any channel typically serve a certain type(s) of customers? (E.g, Retailers -> small contractor; Direct -> Wal-Mart, etc.)

8. How are your manufacturer representatives involved in the product flow? (Do they specify and sell jobs? Do they partner with distributors?)

9. What share of 4ft MBP lamp shipments would you assume go to the residential sector?

10. We are investigating the rate of lighting stock turnover. Does your company have estimates for lighting turnover rates based on historical experience?

11. How do these rates vary by building type or building ownership type?

12. In the nonresidential sector, how likely is each of the following reasons to be the cause of the purchase of a given lamp? In other words, of all your lamp sales, what share is being driven by each cause?

Fluorescent	Lamp Burned Out	
	Ballast Failed	
	Scheduled End of Life[34]	
	Renovation/Remodel (new fixture)	
	New Construction	
	Retrofit for Energy Efficiency	
	Total:	**100%**
HID	Lamp Burned Out	
	Ballast Failed	
	Scheduled End of Life	
	Renovation/Remodel (new fixture)	
	New Construction	
	Retrofit for Energy Efficiency	
	Total:	**100%**

13. To your knowledge, are T12 fixtures specified for new construction anymore? Major renovation and remodeling?

14. What share of 4ft MBP T8 lamps are reduced wattage (<32W)?

Shipment Data

15. We are specifically interested in shipments to the Northwest region (Oregon, Washington, Montana, and Idaho). Are you able to provide shipment data by region? [If yes, send distributor data collection form to them.]

[34] By "scheduled end-of-life," we mean the intentional replacement of lamps or lamps and ballasts at a given point in the lifetime of a set of installed lamps (before they have failed); this event is distinct from a lighting redesign that would change out fixtures as well.

16. To the best of your knowledge, does your company have a greater or lower share of the market in the Northwest than you do nationally?

    a. Lamps:
    b. Ballasts:

17. How does the efficiency of the technologies sold in this region compare to the nation as a whole? More/less efficient or about the same?

Appendix G Lighting Retrofit Issues Analysis and Research Plan Memo

To: Carrie Cobb, BPA

From: Rob Carmichael, Laura Tabor

Date: 10/29/2013

Re: Code Compliance and Market Research Plan

G.1 Introduction

Recent changes to regional building codes have called into question the level of code compliance associated with lighting retrofits. These code changes have lowered the 'code-triggering' threshold of lighting retrofit activities. For example, in Seattle, when more than 20% of a space's fixtures are replaced, the current-code LPD requirements apply to the *entire* space. In Oregon, the threshold is 10% of fixtures or 50% of lamps and ballasts. Table 21 displays the regional code-triggering thresholds by jurisdiction.

Table 21 Code Triggering Thresholds for Lighting Retrofits in the NW

Building Energy Code	Code-Triggering Threshold (Retrofitted Luminaires / Total Luminaires)	Citation	Caveats and Notes
Oregon	10%	2010 OEESC Section 101.4.2	# of fixtures replaced must exceed 10 before code is triggered.
Washington	60%	2009 WSEC Section 1132.3	
Seattle	20%	2009 SEC Section 1132.3	Lamps and ballast change-outs ARE considered fixtures.
Idaho	50%	2009 IECC Section 101.4.2	Lamp and ballast change-outs are NOT considered fixtures.
Montana	50%	2009 IECC Section 101.4.2	Lamp and ballast change-outs are NOT considered fixtures.

Given the reality that enforcement activity is often underfunded and understaffed, these code changes raise a critical question for energy efficiency program administrators and planners:

> **What is the rate of LPD compliance in the Northwest when lighting projects in existing buildings trigger code?**

The answer has major implications for policy planning and program design. High rates of compliance could mean code could be used to characterize the baseline in retrofit situations, which, in turn, would weigh heavily on the cost-effectiveness of retrofit programs. A low compliance rate would not only buttress the argument for continued programmatic activity, but also may signal opportunities for high-return investment on regional resources (e.g., more education, enforcement, etc.). As a recent NEEA lighting strategic report concluded,

> **"A lack of reliable information on code compliance in lighting retrofits hinders development of an informed market strategy."**[35]

Despite the clear consequence of the code compliance question, planners should appreciate the challenges inherent to any approach designed to answer it. Given the challenges of gathering LPD data at all, let alone LPD data from a sample of retrofitted spaces that is statistically representative of the market's activity, Navigant recommends a phased research approach that will move the ball forward, enriching the regions understanding of the market, while mitigating the risk of jumping into a large field study. The first phase, described in detail in this memo, would consist of two parallel efforts: (1) A feasibility test of a field study; and (2) Market actor interviews. The rationale for a feasibility test is self-evident. The rationale for the market actor interviews is threefold: first, to qualitatively assess the magnitude of the uncertainty regarding compliance[36] (and hence for planners to make a more informed cost-benefit decision regarding a large field study); second, to support the myriad lighting program and planning implications in the region with better market actor and C&I end-user decision rationales and behavior. This latter point could yield the most strategic value of the entire effort, given the change the lighting market will see over the next decade in the transition to LEDs. Stakeholders, program managers and planners will need deep insights into market structures and behaviors to respond effectively to what most expect to be a rapidly changing market.

In Section 1 Navigant summarizes the region's research findings to date as they relate to code compliance following lighting retrofits. In Section 2, we detail the aforementioned phased approach to the research.

[35] http://neea.org/docs/default-source/reports/northwest-regional-strategy-for-commercial-lighting-energy-efficiency.pdf?sfvrsn=8

[36] By asking about standard practice with respect to pulling permits, doing LPD calculations, drivers of retrofits, frequency of exceeding thresholds, etc.

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Memorandum

G.2 Existing Research

The Northwest has already invested considerable resources to investigate the regional non-residential lighting market. This section recaps findings from existing research as it relates to the non-residential lighting market, code compliance, and a plan for determining current code compliance rates. Despite the regions extensive research, most findings are only obliquely helpful in the retrofit compliance question, and mostly insofar as the research highlights challenges associated with gathering the necessary data (and thus signaling what will *not* work).

Navigant reviewed the following studies for insights into this question:

- Commercial Building Stock Assessment (2009), Cadmus for NEEA
- Baseline Characteristics of the 2002-2004 Nonresidential Sector: Idaho, Montana, Oregon, and Washington (2008), Ecotope for NEEA
- Northwest Regional Strategy for Commercial Lighting Energy Efficiency (2013), NEEA
- Current State of Lighting Retrofit Programs and Standard Project Practices in the Northwest Region (2013), HMG for NEEA
- Comprehensive Commercial Lighting Initiative Pilot Evaluation Report (2013), HMG for NEEA
- Compliance Rates of Lighting in Commercial Buildings (2011), PNNL for NEEA
- BPA's Nonresidential Lighting Market Characterization (as yet unpublished), Navigant for BPA

This memo also draws on discussions led by Bonneville with NEEA and the Regional Technical Forum, as well as conversations with Mike Kennedy.

While no research has been conducted to assess the compliance following lighting retrofits per se, some large studies, including NEEA's ongoing update to the CBSA, are collecting detailed lighting equipment and LPD measurements. As is the case with the previous CBSA (2009) and the Baseline Characteristics Study (2008), the data from these studies fail to inform the retrofit compliance question, particularly given the code changes are relatively recent.

Still, findings from previous market actor interviews help shape the approach, which begins with the <u>hypothesis that compliance following retrofits is low.</u> This follows from NEEA's Commercial Lighting Market Strategic Plan, which was based on regional energy efficiency practitioners' opinions and experience: “Overly complex, poorly understood, and largely unenforced codes are believed to be relatively ineffective.”[37]

This belief is supported by the fact that, “only 16% of trade allies calculate lighting power densities (LPDs) for different retrofit options before making a final decision.”[38] One would imagine the percentage is much lower for those who are (a) not trade allies and (b) conducting the retrofit outside of utility programs. Moreover, this highlights a major concern as it applies to the representativeness of previous research findings: the interviewees are typically trade allies who one would imagine are more likely to be biased towards the energy efficient side of the equation. Any programmatic data on retrofits, even when an LPD calculation is required, would likely fail the same representativeness test.

Table 22 shows the average lighting power density (LPD), in Watts per square foot (W/sf), following the retrofit. For comparison, the table also shows the ANSI/ASHRAE/IESNA 90.1-2010 (ASHRAE) model code LPD values for each building type. Although the LPDs for most of the building types are well below ASHRAE limits, the average LPD for completed office retrofits of 1.24 W/sf is substantially higher than the ASHRAE limit of 0.90 W/sf. However, these comparisons should be used with caution, as the sample sizes for each building type are relatively small, and may not be representative of all retrofit projects for that building type.

Table 22: Average Post-Retrofit Lighting Power Density (LPD)

Building Types	Average LPD (W/sf)	ASHRAE 90.1-2010 LPD (W/sf)
All Projects	0.81	N/A
Retail	0.71	1.40
Manufacturing	0.63	1.11
Warehouse	0.42	0.66
Office	1.24	0.90

Notes: ASHRAE LPD shown represents the “Building Area Method” used for calculating whole building LPDs

Figure 21 LPD Data from a Sample of ETO Program Files

[37] http://neea.org/docs/default-source/reports/northwest-regional-strategy-for-commercial-lighting-energy-efficiency.pdf?sfvrsn=8 (p. 18)
[38] http://neea.org/docs/default-source/reports/current-state-of-lighting-retrofit-programs-and-standard-project-practices-in-the-northwest-region.pdf?sfvrsn=8 (p. 46)

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G.3 The Path to Answers

Ultimately, given the lack of concrete information, a phased approach to conducting this research would best balance the urgency of the need for an answer with the risk of a large field project, which a statistically robust quantitative result would necessitate.

Navigant proposes a two-pronged exploratory approach in as the initial phase of the research:

(A) Feasibility and scoping study on the prospects for collecting post-retrofit[39] LPD data in a statistically representative sample of retrofits; and
(B) Market actor interviews.

Feasibility and Scoping Study

Feasibility and scope should be assessed in accordance with the following:

Feasibility

Three questions should be tested in the feasibility study:

(a) Can we draw a representative sample from the population?
(b) Can we gather the data required to test compliance with high confidence?
(c) If yes to the above, at what cost?

<u>Can we draw a representative sample from the population?</u> Specifically, this means can we *identify* AND *gain access* to a representative sample of buildings by building type. As a starting point with respect to the sample frame, we have an updated distribution of building types in the commercial

[39] In the case of code compliance, by "retrofit," we really mean *any event that triggers the code's lighting requirements*. Obviously, this definition is broader than the lighting 'jobs' completed through programs. Strictly speaking, events that trigger code have a very precise definition (in terms of share of fixtures changed in a space, as shown in Appendix [insert table of code triggers]), but could occur for any number of reasons, including the following events:

- Tenant improvements
- Renovation and remodels
- Lighting upgrades that include ballast replacement (in some jurisdictions)

sector from the CBSA (Table 2), so we know how to stratify among buildings types. We'll also have the sample frame used by the CBSA to draw on.

Table 22 CBSA Population Estimates by Building Type

Building Type	Estimated Population
Assembly	8,506
Food Service	4,314
Grocery	2,006
Hospital	118
Lodging	2,132
Office	12,543
Other	24,842
Residential Care	598
Retail	16,169
Schools	1,729
University	68
Warehouse	5,923
Total	78,948

But can a research team feasibly randomly identify buildings that have triggered code AND gain access? We see two options to test this question:

1. Randomly sampling within the desired strata, using a phone screen with a script of questions that would identify buildings that have taken a lighting action that would have likely triggered code.
    a. Example of questions in the script: Have you recently renovated or remodeled a portion of your facility that included the removal/upgrading of lighting fixtures?
        i. If yes, about share of the fixtures would you say were altered in the space?

(Note: We are assuming that the researcher would bias the sample if we directly asked if the building had done anything that had triggered code.)

2. Follow up with those facility managers from the CBSA which said they had renovated the lighting fixtures and/or ballasts in the time since the relevant code became effective. Figure 2 shows the question that was asked of facility managers during the CBSA. Based on preliminary data from the current CBSA, 16% of building interviewees (61/387) said lighting fixtures had been replaced in the last TWO years.

Building Renovation History

	Lighting Ballasts	Lighting Fixtures	Lighting Controls	HVAC	HVAC Controls	Refrig.	Windows	Roof Insulation
Were any of the following systems ever replaced or renovated?	**Y** N	**Y** N	Y **N**	Y **N**	Y **N**	Y N	Y **N**	Y **N**
How many years ago? (years)	8	8				n/a		
What percent of each system was impacted? (%)	100	100						
Are you anticipating replacing or renovating the following systems in the next 2 years?	Y **N**	Y **N**	Y **N**	**Y** N	**Y** N	Y N	Y **N**	**Y** N
Is there someone who we can contact with additional questions about building change history?	Name		Phone		Email			

Figure 22 Renovation History Portion of Current CBSA Data Collection Instrument

While the second option is more attractive given the building manager would be familiar with the CBSA, Navigant suggests testing the feasibility of each method as a precaution against the number of candidates from the CBSA sample being too small or its data too uncertain. (In the event the CBSA data becomes available and provides a sufficient sample size—the contractor could rely strictly on that approach.)

The team conducting the feasibility study should thoroughly document the process and the troubles in order to demonstrate the feasibility or lack thereof. The question is not only 'can it be done?' but also 'at what cost?' Some metrics to track include:

- Number of calls per acceptance.
- Effort (in hours) required by consultant to gain each acceptance.
- Document the typical pushback and difficulties (e.g., couldn't get the right person on the phone, no one answered, stopped returning emails, bad phone number, etc.).

The feasibility test should include testing of potential incentives ($50-$200 gift cards) for participation. The test should include at least five site visits to different building types.

Can we gather the data required to determine compliance with confidence? The next challenge to test is whether auditors could feasibly gather the data required to determine compliance, even if an auditor is granted access. We'll need to collect the following data shown below in table 3.

Table 23 Data Requirements for Code Compliance Determination

Information Needed	Why Necessary	Notes on Expected Difficulty
Applicable Building Energy Code	Code varies in region. Need to know the threshold for code triggers and applicable LPA.	Easy. Gathered during phone screen.
Reason for renovation	If the space-use changed, lighting power requirements of the new space type apply.	Easy. Gathered during phone screen.
Whether any exceptions apply.	There are several exceptions to the codes, which could apply in any given case.	Could be difficult as there are many exemptions and it may be difficult to get the right people on the phone. We recommend simplifying by ignoring this technicality.
Share of fixtures retrofitted in each space-type.	To determine whether code-triggering threshold was crossed. *Note:* For Oregon, will need to make sure that [altered fixture count > 10] as well.	Getting someone who'll know this on the phone will likely be difficult, particularly if the job took place a few years ago. Two options: 1. Record number of fixtures that were changed/replaced in each space-type AND total number of fixtures in space-type. 2. *Less Precise:* Record approximate share of fixtures replaced in each space type.
Type of Space, for each space subject to lighting renovation.	LPA values vary by space-type. Thus, space-type necessary for compliance determination.	Moderate.
Floor Area (SQFT), for each space subject to lighting renovation.	LPD formula input	Easy.
Lighting Power (W) of the entire space-type where code was triggered.	LPD formula input	No. Fixtures (for each fixture type) (Easy) No. of Lamps in Fixture (Easy) Lamp Wattage (Moderate) Ballast Type, if applicable (Moderate) Ballast Factor, if applicable (Difficult—team should make the assumption that it is normal ballast factor)

In terms of data collection, judgment will be required by Bonneville and its contractor as to what level of assurance of data quality and integrity is "good enough." Letting the perfect be the enemy of the good could easily derail the effort in collecting the above data.

Note that data on the previously installed technologies is NOT strictly required in order to determine compliance. While ex ante LPD data would be useful, it is also ripe with more data quality concerns, (if it's possible to obtain at all). If we accept that reliable pre-condition data is an unrealistic expectation[40], the question is whether we can gather accurate ex-post data necessary to determine compliance.

[40] We think getting this pre-condition data is unrealistic. This would require either a set of the building's lighting plans (as they existed prior to the retrofit, which could have been years ago) or some very detailed documentation from the retrofit itself (like a lighting calculator file). In the case of the lighting plans, there would still be no guarantee that—indeed, it would be unlikely—that the plans accurately represented the pre-condition at the time of the retrofit, since the lighting systems could have undergone any

The raw data necessary to make calculate LPD and make a compliance determination is listed in Table 23. If the contractor can get on site, then they should be able to gather the necessary data to compute LPD—not perfectly complete data, but reasonably comprehensive along the lines of what CBSA is gathering. Still, even with being able to gather the LPD at the site, we will likely need to make two simplifying assumptions regarding two questions. First, in which spaces did the 'lighting event' take place? Assumption: the entire building or floor, as the case may be. Second, has the lighting in the space changed since the retrofit? Assumption: No. Obviously, the contractor should attempt to get answers to these in the interviews, but that may be unrealistic.

Again, the contractor should diligently document its progress and challenges with the data collection portion of the feasibility test.

- Time (effort) required per building
- Questions the building manager was and was not able to answer
    - Changes since last retrofit?
    - In which spaces did retrofit occur?
    - Reason for retrofit?
    - Was permit pulled?
- Document any data quality concerns in the LPD calculation
- Document whether the lighting event definitively triggered code or whether the auditor was unable to determine definitively.

Scope

The second part of this initial phase is to establish the full study's scope, in order to answer the "at what cost?" question.

1. Establish the Population of Interest
2. Establish the Dimensions of Interest (Building Type, State, Vintage, Building Size, Rural v. Urban, etc.).
3. Establish the "Answer" Desired (binary compliance rate or distribution of LPDs)
4. Determine Desired Levels of Precision and Confidence.

Population of Interest

The population of interest is the square footage of non-residential buildings that became subject to the newer, more stringent LPD requirement due to lighting retrofits. Each building type is effectively a separate population.

A subtle point that should be noted is that BPA and other stakeholders should **NOT** assume that the square footage by building type is proportional to the square footage subject to the retrofit codes by building type. This is because the frequency of lighting events (that trigger the retrofit code) likely varies by building type. Analysts often refer to this as the 'lighting market turnover,' or 'floor area

number of changes prior to *the* retrofit that triggered code. With respect to detailed documentation of the retrofit event itself, even the regional lighting calculators do not gather all the necessary data.

turnover,' and it represents one of the biggest assumptions in lighting market analyses, including the 6th Plan, which assumes turnover between 5% and 12% depending on the building type. Whatever compliance rate is found in, say, a sample of lighting jobs in the retail sector, the results will only be truly interpretable *for planning purposes* if we *also* know the rate at which such jobs in the retail sector occur. The frequency of these events must be known in order to estimate the impact of retrofit codes (and the lost opportunity associate with noncompliance). Currently, we have only anecdotal best-guesses on these turnover rates (retail has relatively quick turnover for marketing purposes while warehouses do not). Therefore, answering this question should be a key component of the market research portion of this phase of the research.

Establish Dimensions of Interest

Stakeholders should determine the dimensions along which they would like to see stratified results beyond building type. Do we need to see compliance rate by building size? By state? By vintage? By rural versus urban?

Clearly, more dimensions require a larger sample size and increase study costs. Yet the costs may not be proportional to the value of the information. For example, it may be that market research would reveal there is unlikely to be a great difference among vintages or across building size, or that compliance in certain building types need not be sampled. Therefore, BPA's contractor should use the market research to attempt to learn where the greatest uncertainty and impact lie.

Establish the "Answer" Desired

What specifically is the answer to this research? Is it: What share of lighting jobs is compliant? Or is it: XX% of the square footage retrofitted was non-compliant by an average of 25% above the maximum allowable LPD. In a workshop with NEEA and BPA, both expressed a desire for a continuous distribution of LPDs was preferred over a binary answer on compliance. In other words, planners indicated a desire to know how *far* below code (or above) the LPDs were.

Determine Precision and Confidence Desired

Bonneville should require their contractor to produce cost estimates at various levels of confidence and precision to select the optimal balance of cost and robustness for its purposes. These costs should be informed by the feasibility test and hours required to accomplish those tasks.

Targeted Market Research

Navigant recommends BPA use targeted market actor research to complement the nuts-and-bolts of the site-visit feasibility testing. There are many lighting market actors capable of providing insights (though not answers) into the core question of compliance rates in retrofits. Ultimately, the aim of the interviews with market actors and stakeholders is threefold:

(1) establish which building types, if any, deserve the most attention in the full code compliance study;
(2) confirm the necessity for, and inform the structure of, the larger field study in Phase 2;
(3) significantly improve the region's understanding of the decisions and practices in the C&I lighting market (particular from the perspective of the end-user).

In its Lighting Market Characterization, BPA uncovered the product mix, distribution chain, and upstream practices in the lighting market. We now know, at the macro-level, which lighting products move, in what shares, and through what channels. The in-depth market actor interviews envisioned here would complement that supply side research with a demand side perspective: how are lighting decisions made for any given building type, by whom, how often, who is contracted to support them, what are the intervention points, etc.? Essentially, the result will be a market characterization by building type… a behavioral segmentation of end-users. Not only would the programmatic insights be extremely valuable for program design but the resulting research and analysis could be directly fed into future reports to distributors who'd benefit from learning more about the demand side of their market (i.e., their customers). This research could be a carrot (and another point of engagement) for continued relationship development with distributors and manufacturers, ultimately supporting the upstream program infrastructure that NEEA's Commercial Lighting Strategy Report highlighted as one of the two core strategies for the region. Additionally, this largely qualitative analysis would prove a great complement to the quantitative CBSA results expected next year. The latter would provide the hard quantitative description of the buildings, the latter an understanding of how that got that way—and how they could be transformed.

These core research questions, including those related to retrofit code compliance, include:

- Frequency of lighting retrofits by building type (discussed above)
- Reasons for retrofits by building type (aesthetics, wear and tear, more/less light, better light, energy savings, etc.) different answers for different building types would provide valuable program design insights, as well as planning insights.
- What is the turnover rate at the building types with the greatest share of the floor space?
- What portion of this turnover is associated with programmatic activity?
- Where is code compliance most and least likely? By state and by building type and by vintage?
- Are there any outside-the-box means of identifying buildings that recently had lighting retrofits?
- How actively to lighting maintenance contractors sell retrofits? Are they effectively maintenance contractors until they are retrofit contractors?
- Define the lighting contractor's 'standard practice'—if there is one; not just for programmatic "retrofits" but for all code-triggering changes? What share are pulling permits? How many contractors even know about the codes?
- Define 'standard practice' for decision making by building type and by ownership structure.

The strategy here requires moving beyond of the traditional trade ally interviews—after all, it is outside the trade allies where the most uncertainty lies.[41]

There are many market actor groups that would help answer the above questions. Below is an unscientific framework for evaluating which market actors should be emphasized based on their ability to: (1) Inform our knowledge of the retrofit code compliance and (2) Inform our knowledge of the end-users' and installers retrofit decisions and behaviors; (3) Add a new or unique perspective to our current market understanding (i.e., build on, rather than repeat, past research). Additionally, too often market research starts locally and ends locally. Navigant suggests this effort include attempts to contact Chief Sustainability Officers at major chains to help understand how decisions are made across a corporation's

[41] BPA (and perhaps NEEA) should consider initially reaching out to the most familiar and friendly trade ally contractors—perhaps working with Roger Spring of Evergreen to pinpoint some likely candidates—to attempt to get the "skinny" on what they think about the state of code compliance in retrofit situations. BPA and NEEA staff could use their takeaways to steer the direction of more in-depth research. Navigant has included a set of code compliance questions in its survey to of lighting contractors to be deployed on Oct. 3. BPA can also use these results to inform exactly which market actors should be emphasized in interviews.

property footprint. Do the major retailers require renovations every two years in order to stay fresh, etc.? The bolded market actors score the highest on this account and should be the focus of interviews.

Table 24 Selecting Market Actors to Interview

Market Actor Category	Regional vs. National Interview Candidates?	Relevance to *Retrofit* Code Compliance?	Relevance to End-Users' *Retrofit* Decisions?	New Perspective to add to NW's Past Research?	Ranking (High=3; Med=2; Low=1)
Non-Trade Ally Contractors	**Regional**	**High**	**High**	**High**	**9**
Building Operators	**Regional***	**Med**	**High**	**High**	**8**
Trade Ally Contractors	**Regional**	**High**	**High**	**Low**	**7**
Lighting Maintenance Contractors*	**Both**	**Med**	**Med**	**High**	**7**
Corporate Property Managers/Sustainability Officers	**National***	**Low**	**High**	**High**	**7**
Code Inspectors	Regional	High	Low	Med	6
Fixture Manufacturers	Both	Low	Med	High	6
Utilities	Regional	Med	Med	Low	5
Property Mgmt. Firms	Both	Low	Med	Med	5
Lighting Designers	Regional	Low	Med	Med	5
Government	Regional	Low	Med	Med	5
Architects	Regional	Low	Low	Med	4

*Have trade associations that would have relevant contacts or be good interview targets themselves.

Navigant recommends first targeting the trade associations of the high-priority market actors above, gleaning a solid understanding of how their members operate. Then the researchers should move on to actual market actor interviews. We recommend at least 30 interviews per key group to account for various demographics and differences in operating models across building types.