Shedding light on the commercial lighting market and opportunities for growth

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ABSTRACT

Since the introduction of LEDs and other high-efficiency lamps, utility sponsored energy efficiency programs have relied heavily on lighting incentives for their savings portfolio. With the introduction of the U.S. Department of Energy's new EISA regulations, which require all lamps sold to meet the stricter 45 lm/W standard, utilities have had to refocus their lighting programs.

As part of an evaluation of a Pacific Northwest business lighting program, ADM Associates conducted a market characterization study of the region's commercial lighting climate. The study included interviews with 17 market experts, including utility program staff, manufacturers' representatives, and researchers. In addition to reaffirming previous research that demonstrates that lighting savings have waned due to LED market saturation and that program design and incentive structure affect program effectiveness, this analysis also revealed that lighting controls feel novel to trade allies and customers. Interviewees from all backgrounds cited cost, lack of awareness, and skepticism towards new technology as the primary barriers preventing lighting controls from market penetration.

Based on these findings, evaluators recommended three main action areas for the promotion of lighting controls: 1) highlighting the non-energy benefits of lighting controls (e.g., occupancy, usage, and productivity data); 2) increased trainings and trade ally engagement surrounding lighting controls; and 3) lucrative incentive structures that make controls more affordable and enticing to customers. When developing commercial lighting programs, particular focus should be placed on engaging small businesses and rural communities, as these constituents are often slower to adopt new technology.

Introduction

According to the U.S. Energy Information Administration, in 2022 approximately 11% of the commercial sector's electricity usage and 4% of the country's entire electricity usage was from commercial lighting (Energy Information Administration 2024). Moreover, more detailed data from the 2018 Commercial Buildings Energy Consumption Survey suggests that lighting is the third largest energy consumer in the American commercial buildings, following space heating and ventilation (Energy Information Administration 2023). Due to lighting's large energy usage and relatively inexpensive upgrade costs, utility sponsored commercial and industrial energy efficiency programs have historically relied heavily on retrofit lighting programs to garner energy savings for their energy efficiency programs (BriteSwitch 2024; Shook and Choi 2022). Traditionally, retrofit lighting programs include incentives for customers to upgrade their lighting systems from incandescent bulbs and fixtures to LED bulbs and fixtures, as well as for the installation of lighting controls ranging from standard occupancy sensors to more advanced luminaire level lighting controls (LLLC).

Data suggest that LEDs experience higher adoption rates than lighting controls (DOE 2020) and that LEDs are approaching market saturation. Moreover, the new Energy Independence and Security Act (EISA), which went into effect in July 2023, limits the savings that can be garnered from conversions to LEDs (Young 2023). In response to the increasing LED market saturation and the reduction in potential savings from LEDs due to EISA, utilities have

sought alternative lighting related energy-savings measures and are placing a larger emphasis on lighting controls.

The following analysis was part of a larger evaluation of a Pacific Northwest based business lighting program. In addition to documenting the program's structure, delivery, and implementation strategy, evaluators sought to understand the larger commercial and industrial (C&I) retrofit market and identify opportunities for growth and development. This evaluation uses in-depth, semi-structured interviews to reveal stakeholders' perspectives regarding the current state of the commercial and industrial lighting retrofit programs, and changes needed to drive future energy savings. The analysis represents the results of interviews with 17 market actors involved in the commercial and industrial retrofit lighting market.

Methodology

As part of an evaluation of a Pacific Northwest business lighting program, ADM Associates conducted a market characterization study of the region's commercial lighting climate. This market characterization task relied on in-depth, semi-structured interviews with market experts. Interviews sought to gather feedback from business lighting professionals about the current state of the commercial and industrial lighting market and existing opportunities to push the market to adopt more efficient lighting and lighting controls.

Research Questions

Table 1 outlines the research questions used to guide the market characterization study and interviews more specifically.

Table 1: Market Characterization Research Questions

Topics	Questions
Lighting market	What is the current state of the lighting market globally, nationally, and in Oregon in the commercial, governmental, industrial, and indoor agriculture sectors?
	What are the remaining opportunities for the program in the lighting market for commercial, industrial, governmental, and indoor agriculture sectors?
	What is the current state of the lighting controls market in the Pacific Northwest?
	How must the lighting market adapt to changing market conditions?
Program operations	How are general program operations working now?
	How well can the program adapt to big external changes that impact the market?
	How can the program design be improved to have more impact on the market?
	What incentive levels are necessary to keep the lighting market moving towards efficient products with strong program activity?

Sample Frame and In-Depth Interviews

Evaluators identified market experts through a combination of internet searches, referrals, and manufacturers' representative groups. Evaluators sought to recruit representatives from Pacific Northwest based utilities, leading lighting and lighting control technology researchers, as well as local, regional, and national distributors and manufacturers' representatives.

Market experts and manufacturers were identified through a variety of sources including contacts provided by the utility client, the Manufacturers' Agents National Association (MANA) directory, and online research. In total, evaluators contacted 77 market experts and manufacturers across a diverse set of fields and backgrounds (Table 2). Evaluators made up to three phone or email contact attempts with each market expert and manufacturer; it was determined that one contact was a bad fit (focused on residential lighting), six were not interested in participating, and 53 did not respond to recruitment efforts. Evaluators conducted 17 market expert and manufacturer interviews. About one-third of the interviewees represented Pacific Northwest based utilities or federal power administration (35%, n=6), while the remaining nine were manufacturers, lighting-focused non-profit organization staff, trade association representatives, and research institution staff (Table 2).

Table 2: Market Expert and Manufacturer Interview Composition

Interviewee Type	Contact Attempted	Interviewed
Manufacturer's representatives	42	5
Utility	10	5
Federal power administration	1	1
Trade associations	8	2
Utility associations	7	0
Distributors	4	0
Non-profit organizations	3	2
Energy data company	1	1
Research institutions	2	1
Total	77	17

Evaluators used a semi-structured interview guide to conduct the interviews. This guide was meant to highlight key questions and research topics but allowed for follow-up questions and conversation pivots based on market experts' and manufacturers' responses and experiences. Table 3 summarizes the key research questions and some of the associated questions included in the interview guide.

Table 3: Research Objectives and Associated Questions

Research Questions	Sample Interview Questions
Lighting Market	
What is the current state of the lighting market globally, nationally, and in Oregon in the commercial, governmental, industrial, and indoor agriculture sectors?	From your perspective what do you think is the current state of the retrofit lighting and lighting controls market in the C&I sector Oregon, the Northwest, and nationally?
	How, if at all, do the technological developments in C&I lighting differ across various markets?
What are the remaining opportunities for the program in the lighting market for commercial, industrial, governmental, and indoor agriculture sectors?	What energy efficient lighting technologies are being widely adopted in the C&I sector?
	What type of lighting controls, if any, are being widely adopted in the C&I market? How does the adoption of lighting controls differ across market segments?

What is the current state of the lighting controls market in Oregon?	What market segments, if any, are lagging the market in general in adoption of energy efficient lighting and controls?
	Where are the remaining lighting opportunities for energy efficiency programs in Oregon and the Northwest?
General Program Operation	
How are general program operations working now?	What changes, if any, in lighting program administration have you seen in the last two or three years?
	How, if at all, have lighting programs you are familiar with changed the mix of prescriptive vs. custom measures?
How well can the program adapt to big external changes that impact the market?	What do you see as the main barriers to markets' adoption of energy efficient lighting?
How can the program design be improved to have more impact on the market?	In the current lighting market, what, if anything, should efficiency programs be doing differently to engage with: • Customers • Contractors • Distributors
	Moving forward, where do you see the C&I retrofit lighting market going in the next few years?
Program Operations and Experiences	
What incentive levels are necessary to keep the lighting market moving towards efficient products with strong program activity?	What incentive structures or amounts (as a percentage of a project) seem especially helpful in encouraging sustainable program participation? How, if at all does it differ by lighting measure?
Is midstream ready to take on much larger project volumes?	What are the trends, if any, you see in how lighting programs are being administered?

Results

The following section describes the results of the interviews, starting with a review of the current state of the C&I lighting market, summarizing the potential for growth, and concluding with a section forecasting the future state of the lighting market.

Theme 1: Current State of the C&I Lighting Market

When discussing the current state of the C&I lighting market, interviewees focused on four main topic areas: 1) LED market saturation, 2) a growing focus on lighting controls, 3) program design, and 4) incentive models.

Approaching LED Market Saturation

Irrespective of background, interviewees reported that the C&I retrofit lighting market is at an inflection point. Eight interviewees specifically indicated that the market is rapidly nearing saturation for LED retrofits, and there was consensus that the *"low hanging fruit is picked over and done"* (Table 4). These interviewees – who represented multiple industries – agreed that most bigger businesses have already transitioned from to LEDs and thus, the remaining savings potential for LED retrofits is among smaller businesses, which often are slower to adopt new technologies and are more wary of change. Among the remaining respondents who did not indicate LEDs are nearing market saturation (n=8), only two believed there was still ample market opportunity left for LED retrofits.

Table 4: Interviewees' Perceptions of Market Saturation

Interviewee Type	Nearing Saturation	Room for Growth	No Opinion
Manufacturer's representatives (n=5)	3		2
Utility (n=5)	3	1	1
Federal power administration (n=1)	1		
Trade associations (n=2)			2
Non-profit organizations (n=2)	1		1
Energy data company (n=1)			1
Research institutions (n=1)		1	
Total	8	2	6

Some interviewees (n=7) explained that although all business types were initially reluctant to adopt LEDs, as the technology advanced, demand for LEDs *"exploded in 2016 and all the big projects happened."* However, by 2018 and 2019 momentum had waned, and lighting-related savings have been on the decline ever since. Across the six interviewed utility and federal power administration representatives, only one representative did not express some degree of concern regarding the future of their commercial and industrial retrofit lighting programs, noting they still have a healthy pipeline of projects each year. The one utility representative that did not express concern with the future represented a municipally owned utility; the other utility representatives – who did express market saturation concerns – represented another municipally owned utility (n=1), three investor-owned utilities (n=3), and a federal power administration (n=1).

Growing Focus on Lighting Controls

According to everyone interviewed, lighting controls are the next big opportunity in lighting (n=17).

Table 5 provides examples of interviewees' direct quotes regarding lighting controls.

Table 5: Interviewees' Perceptions of Lighting Controls

Interviewee Type	Quote
Utility representative	"Lighting controls is the bleeding edge, where we need to be putting effort."
Utility representative	"The future is going to be around the controls aspects. We want to do more classes and demystify controls."

Interviewee Type	Quote
Utility representative	"If we don't get controls integrated in more projects in the next eight years, we'll have stranded savings opportunities."
Manufacturer's representative	"Controls are baby stage, whatever is before infancy."
Trade association representative	"Lighting control has a bright future but unclear what the ceiling will be. All lighting should be controlled, but what degree of automation and advanced capabilities?"

Lighting controls include a wide range of measures that help end users modify and customize the lighting in their facility. Controls range from measures as simple as occupancy sensors to advanced controls that rely on a network of sensors that communicate with each other and use artificial intelligence to optimize lighting usage. When discussing the potential for lighting controls, respondents were quick to emphasize the differences across the lighting control types. There was general agreement among interviewees that simple controls (e.g., occupancy sensors, dimmers), are more palatable to end users than advanced controls due to simple controls' ease of use and minimal installation requirements. However, interviewees also acknowledged that the energy savings and non-energy benefits from advanced controls are far more robust than those from simple controls (n=14). Interviewees agreed that the industry is at a *"critical point with anything going forward; if they don't include controls, they're limiting their savings."* One interviewee went as far to say that *"nothing should be installed without controls."*

According to one of the non-profit representatives, although *"less than 7% to 8% of lighting projects nationwide use controls, the number grows every year."* All of the utility representatives and the federal power administration (n=6) echoed this notion, emphasizing that there is ample room for growth for lighting controls in their service territories. One representative explained that although lighting controls have become standard in new construction and are increasingly common in residential programs, they are *"almost non-existent in the [commercial] retrofit market."*

Interviewees from all backgrounds cited cost, lack of awareness, and skepticism towards new technology as the primary barriers preventing lighting controls from penetrating the commercial and industrial retrofit market (n=14). Many customers do not understand or appreciate the potential benefits of controls, but even those customers who do, often find it difficult to justify the cost. According to one trade association representative:

> *"[Lighting controls are] controlling a smaller load, so there's less savings potential. Lighting controls only control 10% to 20% of your [total electric] load. So, even though percentage savings is very high, it's very high on a lower number because LEDs are so efficient."*

Representatives from the two non-profits and the one research institution have been working collaboratively to reframe the narrative around lighting controls – particularly advanced lighting controls – and standardizing procedures, but they reported that confusion persists. All interviewees admitted that lighting controls will not thrive unless contractors are engaged. Although some interviewees speculated that contractors will eventually come to accept lighting controls as the technology becomes more commonplace in new construction (n=7), all respondents recognized that energy efficiency programs should place more attention on getting contractors to accept and install lighting controls. Five utility and federal power administration representatives explained that, despite their efforts to promote controls among their trade allies, trade allies are still hesitant due to the time needed to install the controls – both simple and

advanced – and the amount of time needed for various maintenance calls and response to customer complaints. Moreover, two interviewees emphasized a generational divide, particularly when it comes to advanced controls:

- *"It's a generational thing. It's just what you grew up with. You don't want to learn and that's part of it. So people understand occupancy sensors. If it's on like a wall switch."* –Manufacturer's representative
- *"Some people are less familiar with app-based technology. Lot of things coming together, old guard ready to retire, new folks are more comfortable with app-based tech."* –Non-profit representative

One tactic some interviewees (n=5) suggested might help spread the adoption of advance lighting controls is to focus on non-energy benefits. Recognizing the return-on-investment argument is weak when relying solely on energy savings, interviewees emphasized the data gathering potential of advanced controls. Moreover, four interviewees believed that educating end-users on the non-energy benefits will increase demand. Examples of non-energy benefits of advanced lighting controls include asset tracking, space utilization, indoor positioning and wayfinding, room scheduling, remote diagnostics, external systems integration, security, and futureproofing (University of Oregon and BetterBricks 2021).

Multiple interviewees (n=3) provided anecdotal examples of how advanced lighting controls can help manufacturing facilities track productivity, increase flexibility in lighting design for offices, and improve safety and efficiency in healthcare settings (

Table 6). Moreover, examples of non-energy benefits derived from secondary research are summarized in Table 7 (Hounsell 2021; Solum 2022; University of Oregon and BetterBricks 2021).

Table 6: Interviewee's Perceptions of the Non-Energy Impacts of Lighting Controls

Interviewee Type	Quote
Non-profit representative	"Nothing else gives you that granular info about occupancy in the buildings."
Trade association representative	"We need to drive up cost effectiveness by incorporating non-energy benefit…you've got to bring a lot of ROI and value to the project that is over and beyond the energy savings."
Utility representative	"Nobody loves their system because it saves them [money]. They love their system because they can log into a remotely and get an alert when somebody is in the facility outside of their normal operating hours, right or you know, get some fault detection."

Table 7: Non-Energy Benefits of Lighting Controls

Benefit	Description	Applications
Space utilization	Advanced lighting controls provide users with real-time data on room availability, as well as general occupancy and vacancy data, allowing occupants to better utilize space.	Prioritize building rooms/areas for specific uses and adjust lighting levels (and temperature if lighting controls are integrated with HVAC) accordingly. Examine utilization trends to inform maintenance and cleaning schedules of rooms and areas.

		Track occupancy levels to control for pathogen transmission.
Asset Tracking	Controls can track the location and utilization of specific objects and tools throughout a building. May also include smart watches and smartphones that are on occupants.	Track the location and usage of movable equipment such as AV equipment, computers, wheelchairs, diagnostic equipment, defibrillators, ventilators, etc. Track exposures to toxins and pathogens via wearable devices and/or smart phones.
Security and safety	Infrared mapping, motion detection, fire/smoke detection, and security monitoring.	Quickly inform occupants of intruders, fire and smoke, and other safety concerns. Changing lighting levels to promote wayfinding and reduce falls at night in healthcare and senior settings.
Comfort	Pair lighting controls with HVAC system for thermal comfort and ventilation. Circadian dosing	Demand response ventilation based on occupancy sensors to better predict CO levels. Changes to lighting levels throughout the day based on circadian rhythms to promote sleep hygiene.
Student outcomes	Lighting impacts students' focus, mood, learning experience, and social-emotional well-being.	Teachers adjust and control classroom's lighting based on activity and time of day. Ideal lighting settings vary for lectures, group work, presentations, and playtime.

Program Design

Interviewees had a wide range of opinions and experiences regarding current trends in lighting program administration. Across the six utilities and federal power administration representatives, two utilities had lighting specific programs, while the other four utilities integrate their lighting offerings into the rest of C&I offerings portfolio. One utility with a lighting-specific program indicated that the utility made the switch a few years ago to better accommodate customers and contractors and streamline participation. The representative noted that the switch was initially a huge success, as the lighting program was regularly *"the cash cow"* of the overall C&I portfolio and regularly exceeded goals; however, the representative noted that the program has struggled to attract participants more recently.

Interviewees also expressed varying opinions regarding the use of midstream versus downstream programs, as well as custom versus prescriptive measures. Manufacturers' representatives preferred the midstream and prescriptive programs, noting that these models minimize the number of people the utility needs to connect with, reduces paperwork for the end

user, and capitalizes on distributors as natural marketers of the program. One manufacturers' representative explained:

> *"for midstream programs, the utility has to work with less people to like explain how the program works because there aren't as many distributors as there are end users…midstream [is] definitely the best approach, it just nine times out of 10, it will work."*

Additionally, although the two manufacturers' representatives recognized the importance of custom programs for niche projects, they generally indicated that prescriptive programs are easier to administer and promote. One manufacturers' representative noted that direct-install programs are particularly successful in suburban and urban areas, as the measures are typically free to customers and contractors can go from one business to another installing upgrades with minimal travel and paperwork:

> *Need direct installers to come out and just switch [the products]. [Small businesses] will be happy with getting anything; they're not going to say no to free. They're not adopting, because they don't know about it. They're too focused on just keeping business alive.*"

There was less agreement among utility representatives, than that seen among manufacturers' representatives, regarding midstream versus downstream programs and custom versus prescriptive program models. Although three utility representatives recognized the benefits of a midstream model, some noted that they have witnessed a move away from midstream lighting programs, as LEDs have become less lucrative and there is a stronger focus on lighting controls and other measures that require a more hands-on and custom approach (n=3). Additionally, one utility representative noted that when you move towards midstream:

> *"you have to be all in, otherwise…it feels disjointed for the customers, having midstream for some things and downstream for others."*

Lastly, some utility representatives were in favor of strong prescriptive programs, as those are easier for customers to digest (n=4), while other utility representatives preferred custom projects, noting that many projects cannot fit in a prescriptive box (n=2).

Incentive Structure

All six of the interviewed utilities and federal-power-administration representatives indicated they use an incentive model based on kWh saved, rather than a flat rate for each measure. While respondents agreed that *"free is best,"* they acknowledged that is not always feasible and instead emphasized the importance of covering at least 60% to 70% of the cost. One manufacturers' representative noted that incentives are not considered worthwhile to end users unless there is no longer than a two-year return on investment period:

> "*some stuff is so expensive and savings are not high enough to overcome that initial cost. There's got to be an incentive for the initial cost hurdle. Facilities aren't burning as many hours per day, so much harder to reach savings.*"

Additionally, utility representatives noted that there is sometimes a disconnect between incentive amounts and the demand for the measure (n=2). One representative explained that there is low demand for some measures even though incentives cover a large share of their cost.

Relatedly, multiple interviewees emphasized the need for tiered incentive programs for lighting and lighting controls (n=3). These respondents noted that different types of lighting and lighting controls garner varying amounts of savings, and the incentive structure should reflect these differences (Table 8). Moreover, according to the trade association representative the programs that are most successful in encouraging uptake of lighting controls are those that

"really put the foot on the control scale" by not only increasing incentives for controls, but also decreasing incentives for non-control measures, thereby making controls even more enticing.

Table 8: Interviewees Opinions of Incentive Structure

Interviewee Type	Quote
Non-profit representative	"A lot of people lump [controls and LLLC] together and give the same incentive for both. The savings for LLLC is much higher than other controls; we need to incentivize better to optimize savings."
Trade association representative	"Why was [northeastern state program] so successful? Because the incentives are so big. People moved in and set up companies specifically, to target and address [incentives]. The big manufacturers set up warehouses just to service that incentive. So if you can throw enough money at something, then yeah, the spaghetti starts to stick to the wall, but if you're like most utilities you can only step on the scale so much."
Manufacturer representative	"Tiers also help…the more efficient the lamp, the more we're going to incentivize you as well, which is fair. You want them to convert and you want to incentivize them more to do so."

Theme 2: Potential for Growth

Throughout the conversations, interviewees talked about the *"need to build demand, to build the market"* and identified areas for growth within the lighting and lighting controls retrofit market.

Engaging Trade Allies

As mentioned previously, the market cannot grow without buy-in and engagement from trade allies. In addition to increased training on different types of lighting control options, contractors need to better understand the benefits of lighting upgrades and lighting controls, so that they can better explain and promote options to their customers.

> *"we need some good evidence of the benefits and have installers, distributors, and sales reps who really can explain to [the] commercial and industrial base the benefits and really demonstrate the use of it."*

A few interviewees underscored the importance of workforce development and training trade allies on how to implement lighting controls (n=4). For example, one trade association representative commented:

> "*we have to retrain an entire workforce. Take a lighting contractor into energy management consultant or SEM advisor. Modify skill set and shift business practices or they're going to go out of business…Need to transition them [to] energy consultants and providers. That's the future of the energy efficiency space. Period. There's no other place to go.*"

Encouraging Adoption Among Hesitant Customers

Interviewees also underscored the importance of better educating the public about the various lighting and controls technologies and their benefits (both energy- and non-energy related), as contractors will be more inclined to get on board if customers are requesting the measures (n=5). Utility representatives and manufacturers' representatives talked about

diversifying their marketing strategies, using a mix of social media, print ads, on-site visits, and community events.

Focusing specifically on untouched markets and saving opportunities from LED retrofits, interviewees from across industries noted slow adopters remain. One manufacturers' representative commented that *"there's a large chunk of the market that needs to adopt."* In general, interviewees identified smaller businesses and rural businesses as the most common non-adopters, citing skepticism of new technology, lack of knowledge, and lack of resources as the primary reasons for non-adoption. Another manufacturers' representative also explained that geographic differences exist beyond the standard urban-rural divide, with coastal areas being more inclined to upgrade than the middle of the country, as the middle of the country has access to cheap and affordable electricity and thus there is less of a financial incentive to upgrade.

Despite the challenges associated with engaging small and rural businesses, some of the interviewees were hopeful that these customers could keep the lighting market and savings potential going for the next couple of years: *"smaller buildings make up huge potential for savings. They're smaller, but there's so many of them that they add up. Similar to residential in that way."* Market actors emphasized the importance of education. Suggestions of type of education opportunities varied from contractor training, attending community events, educational promotional materials, and engaging community leaders. For example, one manufacturers' representative emphasized the "*Need to convince people that the LED claims we make now are grounded in scientific fact and not extrapolations.*"

Upgrades for Early Adopters

In addition to targeting slow adopters, interviewees noted potential savings can be accrued from upgrading early adopters to newer LED technologies (n=5). Respondents explained that many of the early adopters switched to LEDs around 10 years ago; in that time the technology has improved, and some savings can be garnered by upgrading old LEDs to newer LEDs. Respondents did note that the savings potential from older LED to newer LED is not as robust as that from older lighting technology to LEDs. Interviewees recognize that upgrading first generation LEDs to second generation LEDs will not fully account for the savings lighting programs have reaped for the industry. Instead, there is growing recognition that lighting programs will need to adapt in the coming years. According to one utility representative,

> *"lighting programs as they currently exist need to scale down in size based on budget and savings. They will continue to exist (first generation LED folks can be replaced), but they will become supplementary program instead of the primary program in commercial and industrial. [Utilities]should be looking at next lowest hanging fruit.*"

Theme 3: Moving Forward

When asked to speculate on where they see the commercial and industrial retrofit lighting market going in the next few years and what the industry needs to do to adapt, interviewees reemphasized the need for the industry to focus on lighting controls. All interviewees agreed that education is paramount to the broader acceptability of lighting controls (n=17). One non-profit representative commented:

> "*education, education! Talk [controls] up to large customers and key clients and accounts. They're the rock on top of the hill; we need to give it that push. If people install it, others will, and [the rock] will start to roll. We have a small roll but need more*."

Another avenue to promote advanced lighting controls is through demand response programs. Demand response programs incentivize participants to limit their energy consumption during peak demand periods to reduce stress on the grid (Dilouie 2014; Pacific Northwest National Lab 2022; Yao-Jung et. al 2020). When lighting control systems are connected to the broader utility-connected building automation system, lights can automatically dim or turn off in response to signals from the utility indicating a demand response event or peak price increases. Because these networked lighting controls can also track occupancy and asset data, the system can be designed so that lights are dimmed and shut off based on both utility signals and real-time space utilization (Yao-Jung et. al 2020). This demand response application of lighting controls highlights the cost saving potential of lighting controls from both energy efficiency and load shedding lens.

Aside from promoting lighting controls, interviewees were unsure how the retrofit lighting market should proceed. All utility representatives noted that this is a question that concerns them, and they expressed interest in hearing what other utilities are doing to tackle this problem. Interviewees across industry backgrounds agreed that without technological developments, programs will likely need to pivot away from lighting and towards other measures like HVAC. For example, one utility representative asked:

> "*When everyone has LED, then what? At that point…I don't know. This program is lighting. Once we've returned all LEDs to their lowest possible, and they're already so low, the lighting program goes away. You'll just be replacing 1-to-1. It's a little scary because it's the largest piece of commercial and industrial and a large piece of overall portfolio.*"

Discussion/Conclusion

Evaluators interviewed 17 market actors involved in the C&I retrofit lighting market in the Pacific Northwest. Market actors represented a variety of business types including utilities, trade associations, manufacturers, non-profit organizations, energy data companies, and research institutions.

All interviewees agreed that the commercial and industrial retrofit market is evolving. After years of utility sponsored energy efficiency programs relying on lighting retrofits as their major savings generators, lighting retrofits are becoming scarcer. Although this scarcity is a result of successful energy efficiency programs, market transformation campaigns, and an overall acceptance of LED technology, it has created concern among those interested in energy efficiency regarding the longevity of the once-lucrative C&I retrofit lighting programs. This concern was highlighted by five of the six utility representatives interviewed, both non-profit organization representatives, and the research institution representatives, as well as corroborated by externally collected 2019 Commercial Building Stock Assessment data (Cadmus Group, 2020).

Using Oregon as a test case, data from the 2019 Commercial Building Stock Assessment provides quantitative data that supports interviewees' perceptions that LED fixtures are inching towards saturation (Cadmus Group, 2020). According to the 2019 Commercial Building Stock Assessment 4: Final Report, 79% of the surveyed Oregon facilities had at least some LEDs, and on average, 39% of fixtures in any of these building contained LEDs (Cadmus Group, 2020). These percentages varied considerably by building type and urbanization level (Table 9) and it is likely that LED share of fixtures has only increased since 2019.

Table 9: Estimated Penetration of LED Lighting in Oregon, from 2019 CBSA

Group	Number of Surveyed Facilities	Percentage of Surveyed Facilities with LEDs	LED Percentage of Fixtures
Building Type			
Lodging	19	95%	44%
Restaurant	23	91%	47%
Residential care	11	91%	41%
Grocery	21	90%	47%
Other	8	88%	71%
Retail/Service	38	87%	42%
Mixed commercial	19	84%	40%
Assembly	12	83%	41%
Office	42	74%	37%
Warehouse	18	67%	38%
School	20	55%	19%
Hospital	15	53%	18%
Urbanization			
More rural	22	82%	45%
More urban	236	78%	39%

Additionally, data from the other parts of the Pacific Northwest based business lighting portfolio evaluation that this market characterization stemmed from, show that savings from the portfolio's downstream, small business direct install, and midstream programs have been on the decline since 2018 (

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Figure 1: 2016-2021 Trends in downstream lighting savings for an Oregon-based program

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Figure 2: 2016-2021 Trends in small business direct install lighting savings for an Oregon-based program

) and were below goal in 2021 and 2022 across all three pathways. These data support the concerns voiced by market experts regarding market saturation and dwindling savings opportunities from LED measures.

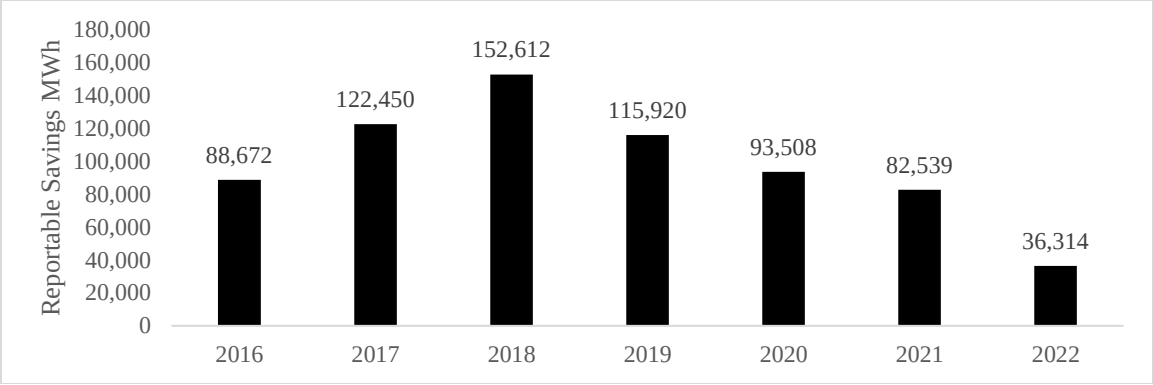

Figure 1: 2016-2021 Trends in downstream lighting savings for an Oregon-based program

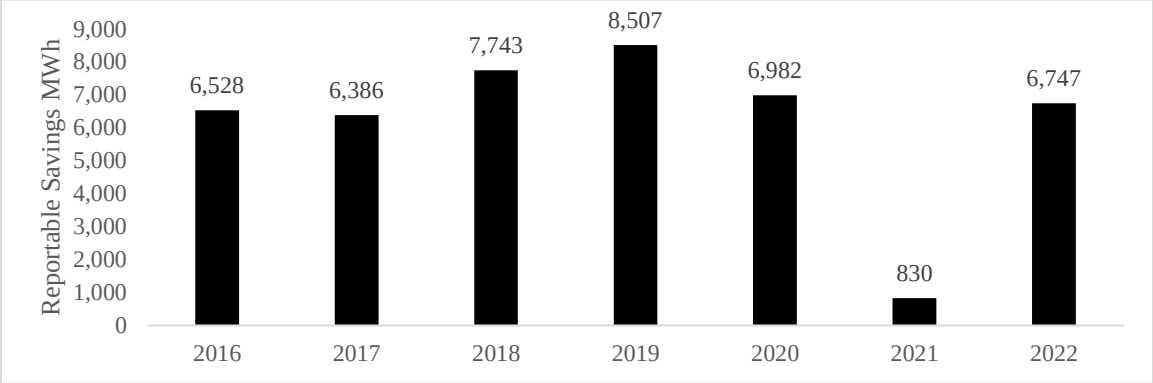

Figure 2: 2016-2021 Trends in small business direct install lighting savings for an Oregon-based program

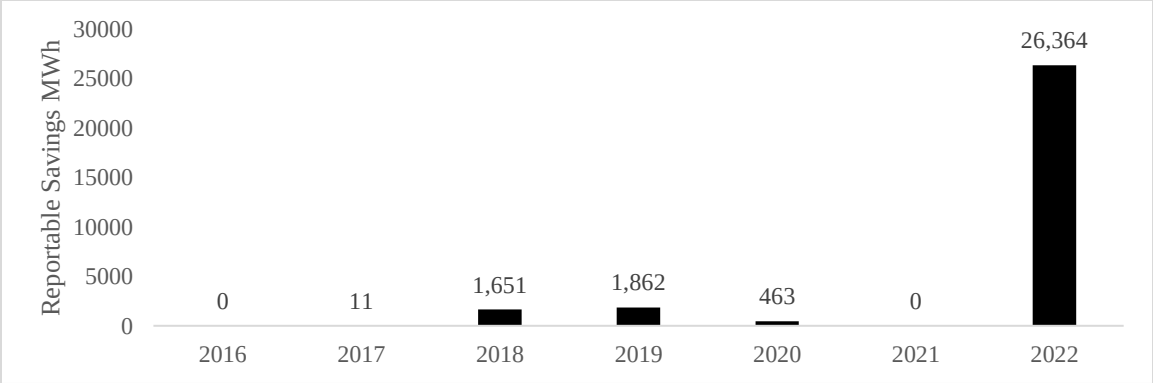

Figure 3: 2016-2021 Trends in midstream lighting savings for an Oregon-based program

Future Opportunities

In response to the changing C&I retrofit lighting program landscape, interviewed representatives are exploring opportunities for market growth and adaptation. Across all 17 interviews, lighting controls were cited as the next step in the lighting movement. Despite the large market potential of lighting controls, interviewees cited a variety of concerns about gaining widespread adoption of controls. These concerns included cost, lack of awareness, and skepticism towards new technology. Although multiple interviewed representatives are actively

working to educate stakeholders about lighting controls, particularly advanced lighting controls, opportunity for improvement exists.

Based on comments from the representatives interviewed, evaluators recommend three main action areas for the promotion of lighting controls: 1) highlight the non-energy benefits of lighting controls (e.g., occupancy, utilization, and productivity data); 2) increase lighting control focused trainings, education, and trade ally engagement opportunities; 3) develop lucrative incentive structures that make controls more affordable and enticing to customers. Moreover, when developing commercial lighting programs, particular focus should be placed on engaging small businesses and rural communities, as these constituents are often slower to adopt new technology.

Recommendation 1: Highlight the non-energy benefits of lighting controls.

During the interviews, some respondents highlighted the wide breadth of non-energy benefits advanced lighting controls provide businesses. These non-energy benefits range from asset tracking, and space utilization to indoor positioning and wayfinding, room scheduling, remote diagnostics, external systems integration, security, and futureproofing. When pitching advanced lighting controls to customers, utilities, contractors, and lighting professionals should focus on these non-energy benefits, as they may help to mitigate concerns regarding the return-on-investment timelines and energy saving estimates.

Recommendation 2: Increase lighting control focused trainings, education, and trade ally engagement opportunities.

Many of the interviewed representatives underscored the importance of trade ally buy-in and engagement when promoting newer technologies, like lighting controls. If trade allies are not convinced of lighting controls' worth and utility, they will not promote these measures to their customers. Therefore, the authors recommend utilities, distributors, and other program implementers develop and provide more training and education opportunities that teach trade allies about lighting controls' energy and non-energy related benefits, as well as how to properly install and manage these systems, so that trade allies are more knowledgeable and more confident when discussing options with their customers.

Recommendation 3: Develop lucrative incentive structures that make controls more affordable and enticing to customers.

As with most energy efficiency related programs, measure cost persists as a substantial barrier to lighting control market penetration. When developing incentive structures, implementers should strive to cover as much of the measure cost as possible, in order to reduce the financial burden on the customer and further promote adoption. The individuals interviewed in this study noted that customers are unlikely to invest in new measures and technologies if the return-on-investment is more than two years. Moreover, interviewed individuals suggested program implementers incentivize lighting controls based on their energy saving potential, explaining that advanced lighting controls are more expensive but also have more cost saving potential, and should therefore have a higher rebate level.

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